MINUTA DE DECRETO FEDERAL

RESERVAS PARTICULARES DO PATRIMÔNIO NATURAL (RPPN)

Regulamenta no âmbito das unidades de conservação (UCs) federais o art. 21 da Lei no 9.985, de 18 de julho de 2000, que dispõe sobre o Sistema Nacional de Unidades de Conservação da Natureza (SNUC).

O PRESIDENTE DA REPÚBLICA, no uso da atribuição que lhe confere o art. 84, inciso IV, da Constituição, e tendo em vista o disposto no art. 21 da Lei no 9.985, de 18 de julho de 2000.

CAPÍTULO I

Seção I

DAS DISPOSIÇÕES PRELIMINARES

Art. 1º A Reserva Particular do Patrimônio Natural (RPPN) é uma unidade de conservação de domínio privado, criada pelo poder público com o objetivo de conservar a diversidade biológica, gravada com perpetuidade, a ser gerida e especialmente protegida por iniciativa voluntária do proprietário do imóvel urbano ou rural, na forma da lei e seus regulamentos.

Parágrafo único. A RPPN somente será criada em áreas de posse e domínio privados.

Seção II

DOS OBJETIVOS E USO

Art. 2º A RPPN tem como objetivo a proteção dos recursos ambientais representativos da região.

Art. 3° A RPPN poderá ser utilizada para o desenvolvimento de atividades de cunho científico, cultural, educacional, recreativo e de lazer, observado o objetivo estabelecido no artigo anterior.

Seção III

DA INSTITUIÇÃO

Art. 4º O Governo Federal, por meio do Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio), prestará orientações necessárias visando avaliar o interesse público na criação da RPPN, dando prioridade aos requerimentos que correspondam a imóveis inseridos em áreas prioritárias para a conservação de ecossistemas e espécies, mosaicos de áreas protegidas, zonas de amortecimento de unidades de conservação e em corredores ecológicos.

Parágrafo único. O Governo Federal, no processo de criação da RPPN e após a criação da RPPN, não cobrará do proprietário taxas ou qualquer tipo de exação referente aos custos de suas atividades específicas.

Art. 5º Poderá ser criada a RPPN em propriedade hipotecada desde que o proprietário apresente anuência do credor da hipoteca.

Parágrafo único. Poderá ser criada a RPPN em propriedade penhorada, desde que o proprietário apresente autorização judicial, para a criação da unidade de conservação.

Art. 6º As propriedades tituladas pelo INCRA ou outro órgão público competente que contiver cláusulas resolutivas de alienação do imóvel, podem ser instituídas como RPPN desde que apresente anuência do órgão responsável pela emissão do título.

Art. 7º A área de RPPN não será computada como parte do imóvel para cálculo do Grau de Eficiência da Exploração (GEE) e do Grau de Utilização da Terra (GUT).

Art. 8º A RPPN poderá ser criada em parte de território quilombola titulado desde que haja consulta e anuência da comunidade quilombola.

Art. 9º A criação de RPPN em propriedade situada em terreno de marinha pressupõe a anuência da Secretaria do Patrimônio da União.

Art. 10 A RPPN poderá ser criada em áreas parcialmente degradadas, observado o parecer técnico de vistoria mediante o compromisso do proprietário de recuperar a área.

Art. 11 A área de imóvel rural criada como RPPN poderá sobrepor, total ou parcialmente, à Reserva Legal ou às Áreas de Preservação Permanente previstas em normas legais.

Art. 12 A RPPN poderá ser criada dentro dos limites de Área de Proteção Ambiental (APA) sem necessidade de redefinição dos limites da APA.

Art. 13 Depois de averbada, a RPPN só poderá ser extinta ou ter seus limites alterados na forma prevista no art. 22 da Lei no 9.985, de 18 de julho de 2000.

Art. 14 Poderão criar RPPN as empresas e fundações públicas que possuam propriedades com atributos que justifiquem sua conservação.

Seção IV
DOCUMENTAÇÃO NECESSÁRIA PARA A CRIAÇÃO

Art. 15 O proprietário interessado em ter seu imóvel, rural ou urbano, integral ou parcialmente, reconhecido como RPPN deverá encaminhar requerimento ao órgão competente, solicitando a criação da RPPN, acompanhado dos seguintes documentos:
I – certidão atualizada de inscrição da propriedade no Cartório de Registro de Imóveis;
II - certidão de ônus reais e ações reais e pessoais reipersecutórias sobre o imóvel;
III – documento de identificação pessoal do proprietário; do cônjuge ou convivente; do procurador, se for o caso, e dos membros ou representantes quando pessoa jurídica;
IV – memorial descritivo dos limites do imóvel e da área proposta como RPPN, quando parcial, georreferenciado, indicando a base cartográfica utilizada e as coordenadas dos vértices definidores dos limites, assinado por profissional habilitado, com a devida Anotação de Responsabilidade Técnica e seu comprovante de pagamento.

§ 1° O requerimento relativo a propriedade de pessoa física deverá conter a assinatura do proprietário, do cônjuge ou convivente, se houver, e no caso de pessoa jurídica deverá ser assinado pelos seus membros ou representantes com poder de disposição de imóveis, conforme seu ato constitutivo e alterações posteriores.

§ 2° Cabe ao proprietário do imóvel apresentar, quando solicitado, a complementação do conteúdo documental visando à análise de situações especiais.

Seção V

PROCEDIMENTO PARA A CRIAÇÃO DA RPPN

Art. 16 O Órgão responsável pela criação da RPPN, quando requisitado, adotará o seguinte procedimento:

I - verificar a legitimidade e a adequação jurídica e técnica do requerimento frente à documentação apresentada;

II - realizar vistoria técnica na área proposta como RPPN, emitindo parecer conclusivo quanto à existência ou não de interesse público na instituição da RPPN;

III - realizar consulta pública sobre a proposta de criação da RPPN;

IV - emitir o termo de compromisso de criação da RPPN para o interessado averbar à margem da inscrição do imóvel no Registro de Imóveis, após a realização e aprovação dos itens I, II e III;

V - publicar a portaria de criação da RPPN, após a averbação do termo de compromisso.

Art. 17 A partir da publicação da consulta pública, a área não poderá ser afetada para outros fins, até a conclusão da análise e definição de sua destinação, respeitado o prazo máximo de 90 (noventa dias) dias, prevalecendo o que ocorrer primeiro.

Seção VI

COMPETE AO PROPRIETÁRIO DA RPPN

Art. 18 Caberá ao proprietário da RPPN:

I – averbar o Termo de Compromisso, emitido pelo ICMBio, à margem da inscrição do imóvel no Registro de Imóveis;

II - assegurar a manutenção dos atributos ambientais da RPPN e sinalizar os seus limites, advertindo terceiros quanto a existência da área protegida e suas restrições legais;

III – em até cinco anos, elaborar e submeter à aprovação o Plano de Manejo da unidade de conservação, em consonância com o previsto no art. 27 da Lei Federal nº 9.985, de 2000;

IV – implementar as ações do Plano de Manejo;

V – encaminhar, sempre que solicitado pelo órgão ambiental responsável por sua criação, relatório da situação da RPPN e das atividades desenvolvidas.

Seção VII

COMPETE AO ICMBIO

Art. 19 Caberá, ao ICMBio:

I - realizar avaliação técnica e jurídica da proposta de criação da RPPN e solicitar as complementações quando necessárias;

II - justificar a criação ou não da RPPN;

III - criar a RPPN, reconhecendo a iniciativa voluntária do proprietário;

IV - definir critérios para elaboração de Plano de Manejo de RPPN;

V - aprovar o Plano de Manejo da unidade de conservação;

VI - manter atualizado o Cadastro Nacional de Unidades de Conservação (CNUC), conforme previsto no art. 50 da Lei no 9.985, de 2000;

VII - realizar vistorias na RPPN;

VIII - apoiar o proprietário de RPPN nas ações de fiscalização, proteção e repressão aos crimes ambientais;

IX - prestar ao proprietário, sempre que possível e oportuno, orientação técnica para elaboração do Plano de Manejo;

X - realizar monitoria do Plano de Manejo da RPPN;

XI - manifestar oficialmente, perante outras Instituições Públicas, os fatos ocorridos nas RPPNs, quando necessário, visando a proteção e manutenção da área.

Parágrafo único. O ICMBio poderá credenciar terceiros com a finalidade de monitorar as atividades realizadas na RPPN.

Seção VIII

DO PLANO DE MANEJO E GESTÃO DA RPPN

Art. 20 O Plano de Manejo da RPPN será analisado e aprovado pelo órgão ambiental responsável pela sua criação.

§ 1° Até que seja aprovado o Plano de Manejo, as atividades realizadas na RPPN devem se limitar àquelas destinadas a garantir sua proteção e a pesquisa científica, resguardado o direito do proprietário de continuar exercendo as atividades que já exercia antes da criação da RPPN desde que as atividades sejam compatíveis com os objetivos da categoria.

§ 2° Até que seja aprovado o Plano de Manejo, novas obras a serem realizadas na RPPN devem se limitar àquelas destinadas a garantir sua proteção e a pesquisa científica.

§ 3° A aprovação do Plano de Manejo da RPPN não exime o proprietário da obtenção de atos autorizativos dos demais órgãos competentes para a realização de obras e atividades.

Art. 21 As construções e infraestrutura existentes antes da criação da RPPN bem como aquelas necessárias à sua gestão, poderão ser mantidas ou instaladas, conforme dispuser o seu Plano de Manejo.

Parágrafo único. O estabelecimento de infraestruturas, após a criação da RPPN, deverá ser autorizada pelo ICMBio.

Art. 22 A pesquisa científica em RPPN deverá ser estimulada e dependerá de autorização prévia do proprietário.

§ 1º A realização de pesquisa científica independe da existência de Plano de Manejo.

§ 2º O Plano de Manejo deverá indicar as prioridades de pesquisa e, se envolver coleta, os pesquisadores deverão adotar os procedimentos exigidos na legislação pertinente.

Art. 23 A soltura ou reintrodução de espécies silvestres em RPPN somente será permitida mediante aprovação prévia do proprietário, estudos técnicos e projetos específicos aprovados pelo órgão ambiental competente.

Art. 24 O órgão ambiental competente organizará e manterá cadastro das RPPNs interessadas em soltura de animais silvestres, orientando os proprietários, gestores e funcionários de RPPN sobre os procedimentos e critérios a serem adotados.

Art. 25. Será permitida a instalação de viveiros de mudas de espécies nativas dos ecossistemas onde está inserida a RPPN quando vinculadas a projetos de educação ambiental ou de recuperação de áreas alteradas dentro do mesmo bioma da unidade de conservação.

Parágrafo único. Será permitida a coleta de sementes e outros propágulos no interior da RPPN para a atividade prevista no caput deste artigo.

CAPÍTULO II
Seção I
DO PROGRAMA NACIONAL DAS RESERVAS PARTICULARES DE PATRIMÔNIO NATURAL

Art. 26 Fica instituído o Programa Nacional das Reservas Particulares do Patrimônio Natural sobre a coordenação do ICMBio.

Parágrafo único. Compete ao ICMBio estruturar e organizar o Programa, garantindo orçamento, pessoal e equipamento específico para a consecução das atividades e ações do Programa.

Art. 27 O programa tem por objetivo o fortalecimento das RPPNs, independentemente de sua esfera de criação por meio das seguintes ações:

I – criação do Comitê Consultivo das RPPNs para apoiar as ações de implementação do Programa com participação da sociedade civil e entidades representativas das RPPNs;

II – fortalecimento das organizações associativas dos proprietários de RPPNs;

III – criação do Selo Boas Práticas Ambientais que poderá ser creditado às RPPNs que demonstrarem boas práticas de manejo e conservação dos recursos naturais, agregando valor aos produtos e serviços originários destas unidades;

IV – capacitação dos proprietários e gestores das RPPNs;

V – apoio técnico aos órgãos estaduais e municipais de meio ambiente no que se refere às RPPNs;

VI – alimentação e manutenção do Sistema Informatizado de Monitoramento de RPPN (SIMRPPN);

VII – estabelecimento de parcerias com entidades públicas e privadas;

VIII – captação de recursos visando o fortalecimento do Programa e a sustentabilidade, gestão, manejo, criação e proteção das RPPNs;

IX - divulgação nacional das RPPNs, seus objetivos e importância, por meio de campanhas sistemáticas e permanentes, que tenham o público alvo a sociedade e os órgãos públicos e privados;

X – realização de visitas e vistorias nas RPPNs, articulando ação conjunta com os demais órgãos públicos fiscalizadores do meio ambiente com vistas à otimização de resultados;
XI – integração de ações de apoio à proteção e fiscalização nas RPPNs, pelo IBAMA, Polícia Federal, Unidades de Conservação, Polícia Militar e órgãos estaduais e municipais de meio ambiente;
XII – intermediação junto as Prefeituras Municipais para ações de apoio às RPPNs, tais como, educação ambiental, ecoturismo, manutenção das estradas de acesso, aceiros na RPPN, destinação de recursos do ICMS Ecológico, entre outras;
XIII - comunicação oficial aos órgãos competentes com vistas à implantação de sinalização informativa sobre a existência da RPPN, nas estradas e rodovias, quando solicitado pelo proprietário;
XIV – atuação junto às instituições de concessão de créditos para priorizar as propriedades com RPPNs;
XV – atuação junto às instituições públicas e privadas para isenção de taxas ambientais em relação à propriedade onde estiver contida a RPPN;
XVI – promoção e incentivo ao desenvolvimento de atividades de ecoturismo e educação ambiental;
XVII – promoção de estudos e propor ajustes nas políticas públicas, em especial naquelas voltadas à conservação ambiental, educação ambiental, corredor de biodiversidade, recursos hídricos, servidão florestal e fixação de carbono, pagamento por serviços ecossistêmicos, dentre outras, visando fortalecer à implementação das RPPNs;
XVIII – adequação de normas federais ou a edição de norma específica que estabeleça as bases de apoio à conservação da natureza em RPPN, respeitada a legislação vigente;
XIX – atuação junto às instituições públicas e privadas para criação de programas, projetos e atividades de apoio à conservação da natureza em áreas particulares;
XX – prestação de assistência técnica e orientação aos proprietários e gestores de RPPN.

Seção II
DO APOIO E INCENTIVOS

Art. 28 A área criada como RPPN, em área rural, será excluída da área tributável do imóvel para fins de cálculo do Imposto sobre a Propriedade Territorial Rural (ITR), de acordo com a norma do art. 10 § 1º inciso II da Lei no 9.393, de 19 de dezembro de 1996.

Art. 29 A RPPN pode ser beneficiária de recursos da Lei nº 8.313, de 23 de dezembro de 1991, nos projetos de implementação, gestão e comunicação, afetos às finalidades da referida lei.

Art. 30 No caso de empreendimento com significativo impacto ambiental que afete diretamente à RPPN, o licenciamento ambiental fica condicionado à prévia autorização do ICMBio, informando previamente ao proprietário da RPPN.

Art. 31 Os recursos provenientes de compensação ambiental deverão ser empregados, conforme o disposto nos incisos I a IV, do parágrafo único, do Decreto nº 4.340, de 22 de agosto de 2002.

Parágrafo único. É vedada a destinação de recursos da compensação ambiental para RPPN criada após o início do processo de licenciamento do empreendimento.

Art. 32 A área de vegetação nativa excedente da reserva legal presente na RPPN poderá ser objeto da compensação de reserva legal, servidão ambiental ou cota de reserva ambiental de outro imóvel, conforme disposto na Lei nº 12.651, de 25 de maio de 2012.

Art. 33 Os projetos referentes à implantação e gestão de RPPN terão análise prioritária para concessão de recursos oriundos do Fundo Nacional do Meio Ambiente (FNMA) e de outros programas oficiais.

Art. 34 Os programas de crédito rural regulados pela administração pública, priorizarão os projetos que beneficiem propriedade que contiver RPPN no seu perímetro, desde que o seu tamanho seja superior a cinquenta por cento da área de reserva legal exigida por lei para a região onde se localiza, e com Plano de Manejo da RPPN aprovado.

Art. 35 No caso da RPPN estar inserida em mosaico de unidades de conservação, o seu representante legal tem o direito de integrar o conselho de mosaico, conforme previsto no art. 9º do Decreto nº 4.340, de 2002.

Art. 36 Ao proprietário de RPPN criada pelo órgão ambiental federal é facultado o uso da logomarca do Governo Federal e do ICMBio nas placas indicativas e no material de divulgação sobre a unidade de conservação.

Parágrafo único. O proprietário poderá utilizar o manual de sinalização instituído pelo ICMBio para realizar a sinalização de sua RPPN.

Art. 37 A RPPN será beneficiária do Programa de Conversão de Multas Ambientais, prevista no Decreto nº 9.179, de 23 de outubro de 2017.

Parágrafo único. As multas decorrentes de infrações ambientais, impostas pelo poder público, poderão ser convertidas em bens, serviços e benfeitorias em RPPN.

Art. 38 A RPPN responsável pela proteção de recursos hídricos que contribuam ou beneficiem sistemas de geração e distribuição de energia ou mananciais de abastecimento público, poderão ser beneficiárias da contribuição financeira dos órgãos ou empresas, públicas ou privadas, geradoras ou distribuidoras de energia ou responsável pelo abastecimento hídrico, nos termos dos artigos 47 e 48 da lei 9.985 de 18 de julho de 2000.

Art. 39 A RPPN deverá ter prioridade na concessão de recursos financeiros e/ou apoio técnico nos projetos ou programas oficiais voltados à conservação da natureza, biodiversidade, estoque e remoção de carbono e dos recursos hídricos, em especial nos programas de pagamento por serviços ambientais.

Parágrafo único. A RPPN deve ter maior peso nos critérios de pontuação para fins de recebimento dos benefícios dos projetos ou programas referidos no caput.

Art. 40 O município beneficiário do Programa Estadual do ICMS Ecológico poderá priorizar a manutenção da qualidade ambiental das RPPN e dos respectivos acessos que estão dentro de sua jurisdição.

Parágrafo único. O município deverá ouvir os proprietários de RPPNs com relação ao uso dos recursos do ICMS Ecológico destinado às unidades de conservação do município.

Art. 41 Os fundos e instituições públicas que tenham objetivos voltados à manutenção e proteção da biodiversidade poderão criar linha especificas destinadas à RPPN.

CAPÍTULO IV
DAS DISPOSIÇÕES FINAIS

Art. 42 Não será criada RPPN em área já integralmente concedida para lavra mineral, ou onde já incida decreto de utilidade pública, ou de interesse social incompatível com os seus objetivos.

§ 1º Caso a existência de concessão de lavra se sobreponha parcialmente ao pedido de reconhecimento da RPPN, os limites da RPPN proposta deverão ser retificados para que a área concedida para lavra mineral seja excluída do perímetro proposto para a RPPN.

§ 2º A RPPN poderá ser criada nas demais fases que antecedem à concessão de lavra mineral.

Art. 43 Revoga-se o Decreto 5.746, de 05 de abril de 2006.

Art. 44 Esta Lei entra em vigor na data de sua publicação.

Apoio:

Ministério do Meio Ambiente – MMA

Instituto Chico Mendes de Conservação da Biodiversidade – ICMBio

Diretoria de Criação e Manejo de Unidades de Conservação

RESUMO EXECUTIVO DA PROPOSTA DE CRIAÇÃO DO MOSAICO DE UNIDADES DE CONSERVAÇÃO DO PANTANAL NORTE

O presente documento tem por objetivo apresentar os principais elementos técnicos que nortearam a proposta de criação do Mosaico de unidades de conservação do Pantanal Norte, bem como os critérios utilizados para justificar as poligonais resultantes.

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Julho de 2018

Revisão – Reinaldo Lourival - PhD

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Créditos da imagem de capa: Rafael Hoogesteijn

INTRODUÇÃO

O Pantanal constitui como uma depressão geológica da bacia do Alto Paraguai com cerca de 180.000 km² e é considerada a maior área úmida tropical continental contígua do mundo, localizada na porção central da América do Sul, com seu território distribuído 80% no Brasil, 15% na Bolívia e 5% no Paraguai. (Swarts 2000). A vegetação do Pantanal é um mosaico influenciado pelos biomas Cerrado, Amazônia e Chaco, e é moldada de acordo com os pulsos de inundação anuais e plurianuais (Junk *et al*. 2006). O Pantanal é reconhecido mundialmente pela abundância de sua fauna (Mittermeier *et al*. 1990; Harris *et al*. 2005), sendo assim reconhecido como importante destino para o ecoturismo (Chardonnet *et al*. 2002). Deste modo, e por sua relevância para conservação da biodiversidade Neotropical, o Pantanal foi declarado Patrimônio Nacional pela Constituição Federal de 1988, Reserva da Biosfera Mundial e Patrimônio Natural da Humanidade pela UNESCO. Algumas áreas situadas dentro do Pantanal, incluindo o Parque Nacional do Pantanal Matogrossense, foram declaradas como "sítios do patrimônio mundial" e áreas úmidas de importância global no âmbito da Convenção Ramsar de Zonas Úmidas.

Em relação à diversidade biológica catalogada, a flora pantaneira possui aproximadamente 2.000 plantas identificadas (Pott *et al*. 2011). Já em relação à fauna, as aves se destacam, tendo sido catalogadas 582 espécies (Nunes 2011), incluindo espécies ameaçadas de extinção a nível nacional como a arara-azul-grande (*Anodorhynchus hyacinthinus*), jacu-de-barriga-castanha (*Penelope ochrogaster*) e a águia pescadora (*Pandion haliaetus*). O Pantanal possui 132 espécies de mamíferos (MMA 2018) e também pode ser considerado um importante refúgio para espécies ameaçadas de extinção a nível nacional como a onça-pintada (*Panthera onca*), jaguatirica (*Leopardus pardalis*), lobo-guará (*Chrysocyon brachyurus*), cachorro-vinagre (*Speothos venaticus*) ariranha (*Pteronura brasiliensis*), cervo-do-pantanal (*Blastocerus dichotomus*), veado-campeiro (*Ozotoceros bezoarticus*) e o tatu-canastra (*Priodontes maximus*). A região possui um número considerável de espécies de peixes (265) (Britski *et al*. 2007), aproximadamente 113 espécies de répteis e 41 de anfíbios (MMA 2018).

No Pantanal brasileiro, a principal atividade econômica é a pecuária extensiva que coexiste com a paisagem natural há aproximadamente 200 anos (Wilcox 1992). Sob

práticas de gestão tradicionais, esta atividade é considerada de baixo impacto sobre a biodiversidade, quando comparada a outras formas de uso da terra nos trópicos (Seidl *et al*. 2001). Apesar deste uso sustentável nos últimos dois séculos, o desmatamento para a introdução de pastagens exóticas nas áreas mais altas e o subseqüente aumento na intensidade de uso do solo constitui-se como ameaças recentes ao Pantanal (Seidl *et al*. 2001; Harris *et al*. 2005; Junk *et al*. 2006). O desmatamento já comprometeu grande parte dos planaltos de entorno do Pantanal (Roque *et al*. 2016) e, se não houver medidas de precaução para controlar a conversão de ambientes naturais, a vegetação nativa da planície do Pantanal estará ameaçada (Silva *et al*. 2011), já tendo sido convertidos na planície 17% e nos planaltos 65%. Aproximadamente 95% do Pantanal são constituídos de propriedades privadas e apenas 4,6% encontram-se protegidos por unidades de conservação (UC), dos quais 2,9% correspondem a unidades de conservação de proteção integral e 1,7% a UCs de uso sustentável, como Reservas Particulares do Patrimônio Natural (Harris *et al*. 2005; BRASIL, 2018). Diante deste cenário, a criação de novas unidades de conservação e ampliação das UCs já existentes, e a melhoria na representatividade dos habitats locais constituem em medidas efetivas para garantir a conservação da fauna e flora do Pantanal.

O objetivo deste relatório executivo é providenciar informações técnicas que embasem a criação de duas novas unidades de conservação no Pantanal e também a ampliação de outras duas unidades de conservação já existentes. O relatório irá prover argumentos técnicos que envolvem aspectos sociais e ambientais, enfatizando a importância da criação destas UCs. Para fins deste relatório executivo, será utilizado o termo "Mosaico de unidades de conservação do Pantanal Norte", pois as áreas propostas neste estudo são limítrofes, formando um grande corredor ecológico entre as unidades de conservação localizadas no norte do Pantanal, assim como contribuem para sua dinâmica hidrológica.

HISTÓRICO DE UNIDADES DE CONSERVAÇÃO NO PANTANAL NORTE

Há 40 anos já se discutia a criação de uma unidade de conservação na região norte do Pantanal. Naquela época o cineasta/ambientalista Sueco Arne Sucksdorff e o pesquisador George Schaller já subsidiavam o então Instituto Brasileiro de Desenvolvimento Florestal – IBDF com informações técnicas acerca da criação de um Parque Nacional. Em 1981 foram criados o Parque Nacional do Pantanal Matogrossense (PNPM) e a Estação Ecológica de Taiamã (EET). Contudo a criação do PNPM na confluência do rio Paraguai com o Rio Cuiabá não foi bem recebida por Sucksdorff, que alegou falhas na escolha da localização do parque, situado em uma área muito baixa e permanentemente alagada, não incorporando a diversidade de habitats característica do Pantanal. Porém, incluir toda diversidade de habitats do Pantanal em uma única unidade de conservação implicaria na criação de uma área muito grande e de difícil gestão. Parte desta demanda por incluir habitats mais diversos foi parcialmente solucionada na década de 90 através da organização não governamental (ONG) Ecotrópica, em parceria com a ONG The Nature and Conservancy. Assim, a Ecotrópica adquiriu três fazendas vizinhas ao PNPM (Acurizal, Penha e Dorochê) e as transformou em Reservas Particulares do Patrimônio Natural, garantindo assim a proteção de áreas mais altas e com diferentes habitats. Na década seguinte, por iniciativa do estado de Mato Grosso, foram criadas o Parque Estadual Guirá (PEG) criado em 2002 e o Parque Estadual Encontro das Águas (PEEA) criado em 2004, formando um mosaico, todavia disjunto.

MOSAICO DE UNIDADES DE CONSERVAÇÃO DO PANTANAL NORTE

Estas quatro unidades de conservação, PNPM, EET, PEG e PEEA possuem em comum a conectividade fluvial. A Estação Ecológica Taiamã é uma ilha do Rio Paraguai, estando aproximadamente 120 quilômetros a montante do limite do Parque Nacional do Pantanal Matogrossente. O Parque Estadual Guirá é limítrofe na sua porção sul ao PNPM. O PNPM localiza-se exatamente na confluência do rio São Lourenço com o rio Paraguai (Fig.1b), formando estes rios, os limites naturais, de boa parte desta unidade de conservação. Partindo do PNPM e percorrendo aproximadamente 140 quilômetros a montante pelo rio São Lourenço, chega-se aos limites do Parque Estadual Encontro das Águas. Em terra firme estas unidades de conservação são conectadas por grandes propriedades privadas, onde ainda persiste a pecuária extensiva em um mosaico

de grandes áreas de campos nativos e áreas florestadas, formando uma paisagem heterogênea característica desta região do Pantanal.

Nesta região é proposta a criação de duas novas unidades de conservação em esfera federal: uma Reserva de Fauna e um Refúgio de Vida Silvestre. Além destas novas áreas, é proposto a ampliação da Estação Ecológica de Taiamã e Parque Nacional do Pantanal Matogrossense, em área hoje, já restrita quanto ao seu uso para a pesca. A criação e ampliação destas unidades de conservação formam assim um "Mosaico de unidades de conservação do Pantanal Norte" (Fig. 1) conectado tanto por água, pelos rios Paraguai e São Lourenço, como por terra englobando propriedades privadas. A criação da Reserva de Fauna e do Refúgio de Vida Silvestre e ampliação do PNPM e EET conectaria todas as unidades de conservação da região, criando um importante corredor ecológico, e reforçando este "hub-hidrológico". Corredores ecológicos podem desempenhar funções importantes para manutenção da biodiversidade, dentre elas: 1. Se uma população animal ou vegetal declina para um nível baixo em uma área, indivíduos de outra área podem imigrar e resgatar essa população da extinção local; 2. Uma população isolada tende a perder variabilidade genética. O corredor permite o fluxo gênico entre as populações interconectadas; 3. Um corredor permite a proteção de diversos tipos de habitats, resultando em uma maior biodiversidade e 4. Caso um habitat se tornar inadequado por razões diversas como um grande incêndio ou até mesmo, mudanças na estrutura da paisagem decorrentes das mudanças climáticas, as populações silvestres podem se mover pelo corredor em busca de um ambiente mais adequado para sua sobrevivência (Crooks & Sanjayan, 2006, Caro *et al*. 2009). A proposta de criação do Mosaico de unidades de conservação do Pantanal Norte é uma garantia da conectividade essencial para eficácia de um corredor ecológico.

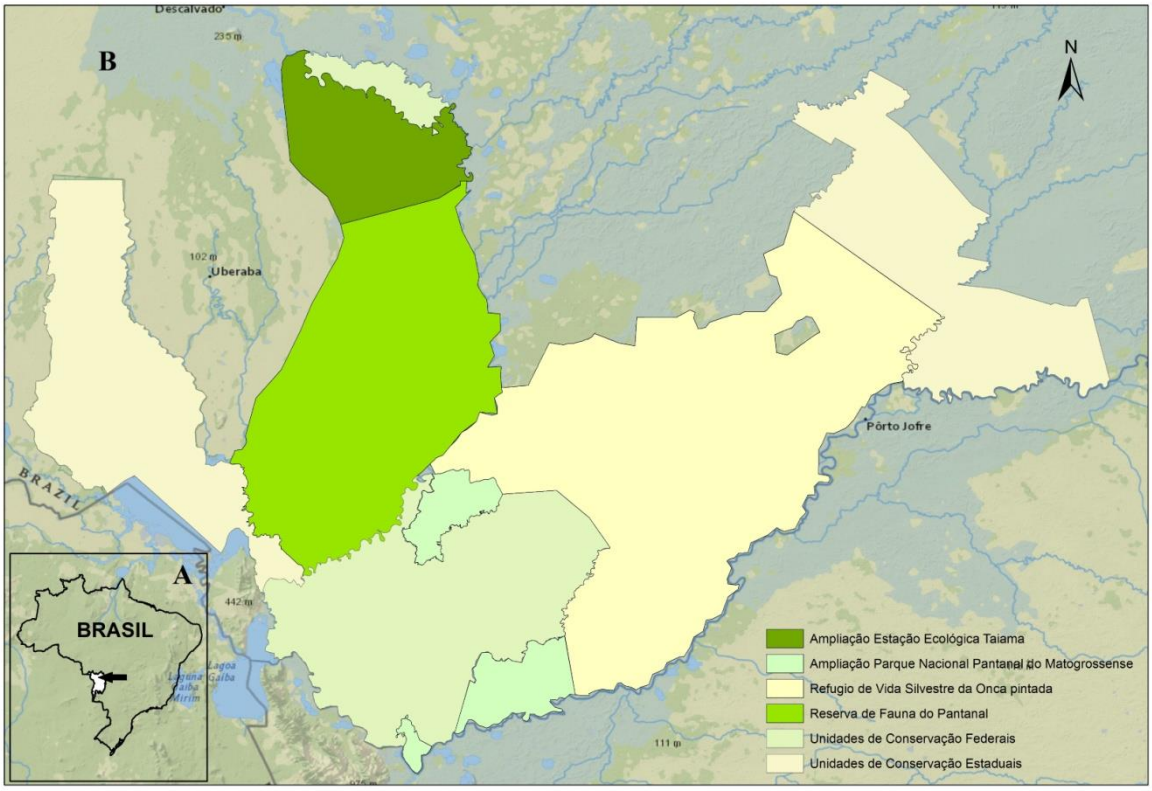

Figura 1. **A** – Mapa do Brasil indicando a localização do Bioma Pantanal em branco e seta preta indicando a região do Mosaico de unidades de conservação do Pantanal Norte; **B** – Mapa com os polígonos propostos pelo ICMBio para Ampliação da Estação Ecológica de Taiamã em verde escuro; Reserva de Fauna do Pantanal em verde; Refúgio de Vida Silvestre da Onça-pintada em amarelo; Ampliação do Parque Nacional do Pantanal Matogrossense em verde claro. Em amarelo claro são as unidades de conservação estadual.

Abaixo são descritos de acordo com o Sistema Nacional de Unidades de Conservação (MMA 2011) as quatro classes de unidades de conservação propostas para compor o Mosaico de unidades de conservação do Pantanal Norte:

RESERVA DE FAUNA DO PANTANAL

De acordo com o artigo 19 do Sistema Nacional de Unidades de Conservação (SNUC) a Reserva de Fauna "*... é uma área natural com populações animais de espécies nativas, terrestres ou aquáticas, residentes ou migratórias, adequadas para*

estudos técnico-científicos sobre o manejo econômico sustentável de recursos faunísticos." Os incisos abaixo caracterizam este tipo de unidade de conservação:

§ 1o A Reserva de Fauna é de posse e domínio públicos, sendo que as áreas particulares incluídas em seus limites devem ser desapropriadas de acordo com o que dispõe a lei.

§ 2o A visitação pública pode ser permitida, desde que compatível com o manejo da unidade e de acordo com as normas estabelecidas pelo órgão responsável por sua administração.

§ 3o É proibido o exercício da caça amadorística ou profissional.

§ 4o A comercialização dos produtos e subprodutos resultantes das pesquisas obedecerá ao disposto nas leis sobre fauna e regulamentos.

A proposta de Reserva de Fauna do Pantanal abrange 165.000 hectares entre a Estação Ecológica Taiamã e o Parque Nacional do Pantanal Matogrossense, incluindo terras devolutas e propriedades privadas localizadas ao longo das margens esquerda e direita do rio Paraguai.

REFÚGIO DE VIDA SILVESTRE DA ONÇA-PINTADA

De acordo com o artigo 13 do Sistema Nacional de Unidades de Conservação o Refúgio de Vida Silvestre "*... tem como objetivo proteger ambientes naturais onde se asseguram condições para a existência ou reprodução de espécies ou comunidades da flora local e da fauna residente ou migratória."* Os incisos abaixo caracterizam este tipo de unidade de conservação:

§ 1o O Refúgio de Vida Silvestre pode ser constituído por áreas particulares, desde que seja possível compatibilizar os objetivos da unidade com a utilização da terra e dos recursos naturais do local pelos proprietários.

§ 2o Havendo incompatibilidade entre os objetivos da área e as atividades privadas ou não havendo aquiescência do proprietário às condições propostas pelo órgão responsável pela administração da unidade para a coexistência do Refúgio de Vida

Silvestre com o uso da propriedade, a área deve ser desapropriada, de acordo com o que dispõe a lei.

§ 3o A visitação pública está sujeita às normas e restrições estabelecidas no Plano de Manejo da unidade, às normas estabelecidas pelo órgão responsável por sua administração, e àquelas previstas em regulamento.

§ 4o A pesquisa científica depende de autorização prévia do órgão responsável pela administração da unidade e está sujeita às condições e restrições por este estabelecidas, bem como àquelas previstas em regulamento.

A proposta de Refúgio de Vida Silvestre da Onça-pintada abrange 270.000 hectares entre o Parque Nacional do Pantanal Matogrossense e Parque Estadual Encontro das Águas, incluindo a Reserva Particular do Patrimônio Natural Dorochê e propriedades privadas.

AMPLIAÇÃO DO PARQUE NACIONAL DO PANTANAL MATOGROSSENSE

De acordo com o artigo 11 do Sistema Nacional de Unidades de Conservação o Parque Nacional "*...tem como objetivo básico a preservação de ecossistemas naturais de grande relevância ecológica e beleza cênica, possibilitando a realização de pesquisas científicas e o desenvolvimento de atividades de educação e interpretação ambiental, de recreação em contato com a natureza e de turismo ecológico*". Os incisos abaixo caracterizam este tipo de unidade de conservação:

§ 1o O Parque Nacional é de posse e domínio públicos, sendo que as áreas particulares incluídas em seus limites serão desapropriadas, de acordo com o que dispõe a lei.

§ 2o A visitação pública está sujeita às normas e restrições estabelecidas no Plano de Manejo da unidade, às normas estabelecidas pelo órgão responsável por sua administração, e àquelas previstas em regulamento.

§ 3o A pesquisa científica depende de autorização prévia do órgão responsável pela administração da unidade e está sujeita às condições e restrições por este estabelecidas, bem como àquelas previstas em regulamento.

§ 4o As unidades dessa categoria, quando criadas pelo Estado ou Município, serão denominadas, respectivamente, Parque Estadual e Parque Natural Municipal.

A proposta de ampliação do Parque Nacional do Pantanal Matogrossense abrange 33.000 hectares envolvendo três áreas distintas que englobam propriedades privadas limítrofes a esta unidade de conservação.

AMPLIAÇÃO DA ESTAÇÃO ECOLÓGICA DE TAIAMÃ

De acordo com o artigo 11 do Sistema Nacional de Unidades de Conservação a Estação Ecológica "*... tem como objetivo a preservação da natureza e a realização de pesquisas científicas*". Os incisos abaixo caracterizam este tipo de unidade de conservação:

§ 1o A Estação Ecológica é de posse e domínio públicos, sendo que as áreas particulares incluídas em seus limites serão desapropriadas, de acordo com o que dispõe a lei.

§ 2o É proibida a visitação pública, exceto quando com objetivo educacional, de acordo com o que dispuser o Plano de Manejo da unidade ou regulamento específico.

§ 3o A pesquisa científica depende de autorização prévia do órgão responsável pela administração da unidade e está sujeita às condições e restrições por este estabelecidas, bem como àquelas previstas em regulamento.

§ 4o Na Estação Ecológica só podem ser permitidas alterações dos ecossistemas no caso de:

I - medidas que visem a restauração de ecossistemas modificados;

II - manejo de espécies com o fim de preservar a diversidade biológica;

III - coleta de componentes dos ecossistemas com finalidades científicas;

IV - pesquisas científicas cujo impacto sobre o ambiente seja maior do que aquele causado pela simples observação ou pela coleta controlada de componentes dos ecossistemas, em uma área correspondente a no máximo três por cento da extensão total da unidade e até o limite de um mil e quinhentos hectares.

A proposta de ampliação da Estação Ecológica de Taiamã abrange 51.000 hectares englobando propriedades privadas limítrofes a esta unidade de conservação na porção sul.

FATORES SOCIOECONÔMICOS

Pecuária.

A porção norte do Pantanal teve como principal atividade econômica por aproximadamente 200 anos a pecuária extensiva (Wilcox 1992). Um exemplo do apogeu deste ciclo econômico é a Fazenda Jofre, que no início do século 20 possuía maquinário importado da Europa para produção de carne salgada para exportação (Fig. 2). Na década de 1960 o Pantanal Norte possuía um rebanho bovino superior ao número atual na mesma região. Um ciclo de grandes cheias, iniciado no ano de 1974 transformou vastas áreas outrora de pastagem em campos permanentemente inundados e formações arbustivo-arbóreas (Ex: Pomberais- *Combretum* sp. e Cambarazais- *Vochysia divergens*) inviabilizando a atividade de pecuária (Nunes da Cunha & Junk 2004) e provocando a sua desaceleração econômica nesta região do Pantanal (McManus *et al*. 2016). Atualmente a maioria das fazendas de pecuária da região que abrange o Mosaico de unidades de conservação do Pantanal Norte é utilizada somente no período de seca e início do período chuvoso do Pantanal, entre julho e dezembro. A taxa de lotação destas propriedades, mesmo no período de seca, raramente ultrapassa 0.3 cabeças por hectare (Tortato *et al*. Dados não publicados). Na área proposta para a Reserva de Fauna e área proposta para ampliação da EET à atividade de pecuária é inviável, devido limitações logísticas e o terreno permanecer boa parte do ano inundado. Na área proposta para ampliação do PNPM há também as mesmas limitações logísticas, com maior parte da área com uso limitado devido às intensas inundações e o uso para fins de pecuária pode ser considerado ocasional. Na área proposta para criação do Refúgio de Vida Silvestre há fazendas de pecuária, contudo estão subutilizadas em relação ao seu potencial econômico, inclusive com algumas propriedades a venda (e.g. Fazenda Jofre, Fazenda Campina Grande).

Figura 2. A - Ruínas da antiga fábrica de carne salgada (saladeiro) na Fazenda Jofre, localizada as margens do Rio São Lourenço. B - Detalhe do maquinário produzido na Suíça em 1924 e ainda existente nas ruínas.

Pesca.

A atividade de pesca representa uma importante atividade econômica na região do Mosaico de unidades de conservação do Pantanal Norte. Nesta região, pescadores profissionais dos municípios de Cáceres, Poconé e Barão de Melgaço no estado de Mato Grosso e também Corumbá no Mato Grosso do Sul exploram os rios Paraguai, Cuiabá, Piquiri e São Lourenço (Fig. 3). Um exemplo que dimensiona a pesca profissional é a Colônia Z11 do município de Poconé que conta com aproximadamente 600 pescadores profissionais cadastrados (http://www.mt.gov.br/-/9198883-representantes-do-setor-de-pesca-participam-de-dialogo-na-sema). Diversas pousadas, pesqueiros e barcos-hotel exploram a pesca amadora nesta região do Pantanal. Há carência de dados acerca da quantidade de turistas de pesca que visitam o Pantanal de Mato Grosso, mas a título de comparação, no ano de 2009, mais de 15.000 turistas de pesca visitaram o Pantanal de Mato Grosso do Sul (Albuquerque *et al*. 2011). Esta atividade econômica fornece emprego e renda para comunidade ribeirinha, que atua tanto como empregados de hotéis, como na coleta de iscas vivas para venda aos pescadores. A área utilizada para pesca profissional e amadora só é restringida em unidades de conservação como o Parque Estadual Encontro das Águas, Parque Nacional do Pantanal Matogrossense e

Estação Ecológica de Taiamã. A intensidade de uso destas atividades é limitada por questões logísticas, sendo mais concentrada nos arredores do Porto Jofre, próximo ao PEEA para pescadores oriundos de Poconé e Barão de Melgaço, na área permitida próxima a confluência entre os rios São Lourenço e Paraguai próxima ao PNPM para pescadores oriundos de Poconé e Corumbá, no rio Paraguai a montante dos limites do PNPM por pescadores oriundos de Corumbá e na porção do rio Paraguai entre a EET e o município de Cáceres para pescadores oriundos deste mesmo município. Comunidades tradicionais como a tribo indígena Guatós, nas proximidades do PNPM exploram a atividade de pesca de subsistência e comercial de forma sustentável, não sendo prejudicados pela criação e implementação destas unidades de conservação.

Figura 3. Barco de pesca profissional navegando no Rio São Lourenço, próximo a comunidade de Porto Jofre (Créditos: Daniela Tonon).

Ecoturismo.

O ecoturismo é uma atividade mais recente, se comparada ao turismo de pesca, mas que vem crescendo significativamente em algumas regiões do Pantanal, incluindo a região do Mosaico de unidades de conservação do Pantanal Norte. No município de Poconé, a construção da Rodovia Transpantaneira no fim da década de 1970 impulsionou o desenvolvimento do ecoturismo pantaneiro. Os primeiros guias de ecoturismo iniciaram suas atividades na década de 1980 trazendo pequenos grupos em

busca, principalmente, de aves e contemplação da paisagem. Esses guias utilizavam a infraestrutura já existente para o turismo de pesca amadora para acomodação dos visitantes. As primeiras pousadas nesta rodovia foram construídas em meados da década de 1980. Atualmente, a Transpantaneira possui perto de 20 opções de hospedagem voltadas ao turismo de observação de fauna e contemplação da natureza. Esta região é considerada um *hotspot* de visitação mundial em áreas selvagens (Levins *et al.* 2016, Tortato & Izzo 2016) recebendo milhares de turistas todos os anos (Tortato & Izzo 2017).

Nas margens do rio Cuiabá, porção final da Transpantaneira, na localidade de Porto Jofre, até início dos anos 2000 havia principalmente hotéis voltados ao turismo de pesca amadora. Contudo, nos últimos 15 anos iniciou-se um turismo para a observação de onças-pintadas. Essa atividade é sazonal, ocorrendo somente nos meses de seca do Pantanal, entre junho e novembro. Os turistas se deslocam em barcos de alumínio com motor de popa pelos rios e corixos da região observando a fauna nas barrancas e praias (Tortato e Izzo 2017). Uma informação que quantifica a intensidade desta atividade é que durante os meses de agosto e setembro de 2012 houve um fluxo de 10 turistas por hora durante o dia (06:00AM-06:00PM) na foz do rio Piquiri com o rio Cuiabá (Fernando Tortato, Dados não publicados). Durante o período de seca, os turistas estrangeiros representam mais de 80% dos hóspedes das principais pousadas e hotéis desta localidade. No Hotel Pantanal Norte, que oferece o maior número de leitos no Porto Jofre, há uma mudança no perfil dos turistas de acordo com o período do ano: de março a junho predominantemente turistas de pesca, e de julho a novembro, turistas que buscam observar a fauna, principalmente à onça-pintada (Fig. 4) (Tortato e Hoogesteijn 2014, Hoogesteijn *et al*. 2016, Tortato e Izzo 2017). A atividade de observação de onças-pintadas na região do Porto Jofre representou uma receita de 6.8 milhões de dólares em sete pousadas de ecoturismo no ano de 2015, sendo uma atividade considerada em expansão na região (Tortato *et al*. 2017, Tortato & Izzo, 2017).

Figura 4. Grupo de turistas estrangeiros fotografando uma onça-pintada as margens do Rio São Lourenço, Pantanal.

As propostas de ampliação da Estação Ecológica de Taiamã e o Parque Nacional do Pantanal Matogrossense incorporam somente regiões remotas, com baixo uso humano e grande valor biológico, não comprometendo a as atividades econômicas desenvolvidas na região norte do Pantanal. Os resultados destas ampliações podem ser considerados positivos, principalmente para pesca amadora e profissional, por proteger sítios reprodutivos de peixes de interesse econômico do Pantanal, como pacus (*Piaractus mesopotamicus*) e pintados (*Pseudoplatystoma corruscan*), garantindo assim a viabilidade do estoque pesqueiro da região, pelo fenômeno conhecido como efeito de *spillover* ou extravasamento. O ecoturismo também pode ser diretamente beneficiado, principalmente com a ampliação do Parque Nacional do Pantanal Matogrossense, aumentando as potenciais áreas de visitação desta unidade de conservação. A proposta de criação da Reserva de Fauna entre a Estação Ecológica Taiamã e o Parque Nacional do Pantanal Matogrossense não restringe o uso sustentável da pesca, fortalecendo a proteção do estoque pesqueiro do Pantanal Norte. A criação desta unidade de conservação não compromete a atividade de pecuária da região, pois esta delimitada principalmente em áreas permanentemente alagadas do Pantanal. A área proposta para o Refúgio de Vida Silvestre inclui em seus limites a atividade de pecuária extensiva, que é permitida por esta categoria de UC. Considerando a intensidade de uso humano na

região, o polígono proposto para esta unidade de conservação provocará pouca ou nenhuma limitação econômica para pecuária extensiva e pesca amadora e profissional. Para o ecoturismo, a sua criação é positiva, pois aumentará a divulgação da região a nível nacional e internacional. Por estar sob jurisdição federal, o governo poderá destinar recursos para o controle do fogo, mantendo permanentemente brigadistas de incêndio nesta unidade de conservação nos períodos mais críticos da estação seca. A criação deste Refúgio de Vida Silvestre garante também a conservação em longo prazo de espécies carismáticas, como por exemplo, a onça-pintada, arara-azul e ariranha, reforçando o potencial do ecoturismo para região norte do Pantanal. A porção final da rodovia Transpantaneira irá cortar esta unidade de conservação e servirá de entrada para milhares de turistas todos os anos desfrutarem desta área protegida.

FATORES AMBIENTAIS

A criação de unidades de conservação constitui atualmente uma das ações mais efetivas para a conservação de habitats e espécies ameaçadas de extinção (Margules e Pressey, 2000, Carranza *et al*. 2014). A proposta de criação do Mosaico de unidades de conservação do Pantanal Norte abrange totalmente ou parcialmente áreas reconhecidas como prioritárias para a conservação da biodiversidade em diversas avaliações técnicas, como os documentos "Cerrado e Pantanal - Áreas e Ações Prioritárias para Conservação da Biodiversidade" (MMA 2007), "Áreas prioritárias para conservação da biodiversidade no Cerrado e Pantanal" (WWF 2015), incluindo também avaliações específicas para grupos taxonômicos como as aves no documento "Áreas importantes para Conservação das aves - América - Brasil" (Develey & Goerck 2009).

A vegetação do Pantanal é moldada principalmente pelas suas inundações sazonais que produzem variabilidade espacial marcante em abundância e diversidade de espécies (Hamilton 1999). Influenciado por rios que drenam a bacia do Alto Paraguai, o Pantanal sofre a influência direta dos biomas da Amazônia, Cerrado e Mata Atlântica, além do Chaco. Devido a esta dinâmica natural de seca e cheia do Pantanal, a vegetação do Pantanal está em constante sucessão ecológica. Com isso, propostas de Unidades de conservação para o Pantanal devem considerar cenários futuros, onde as fitofisionomias podem ser diferentes do contexto atual (Lourival *et al*. 2011). A região proposta para o Mosaico de unidades de conservação do Pantanal Norte inclui um gradiente altimétrico,

considerando diferentes fitofisionomias que permitem a manutenção da heterogeneidade de habitats característica do Pantanal.

A complexa rede de rios, corixos e baías inseridas dentro do Mosaico de unidades de conservação do Pantanal Norte constituem um verdadeiro berçário para fauna de peixes do Pantanal (Lima 1987). O Parque Nacional do Pantanal, por exemplo, possui 182 espécies de peixes (Polaz *et al*. 2014), representando 70% de toda ictiofauna existente no Pantanal (Britski *et al*. 2007). Para a Estação Ecológica de Taiamã são listadas 143 espécies de peixes (ICMBio, 2017). Baginski *et al*. (2007) avaliou a dimensão espacial e temporal da diversidade de peixes em lagoas marginais ao rio Cuiabá. Estes autores concluem que a criação de unidades de conservação que abrangem um grande número de lagoas com diferentes formas e tamanhos conservaria um maior contingente da diversidade regional de peixes, pois a maioria das espécies de pequeno porte apresenta distribuição restrita a poucas lagoas (Baginski *et al*. 2007). As ampliações da EET, PNPM e criação da Reserva de Fauna e o Refúgio de Vida Silvestre englobam todos os diferentes habitats aquáticos existentes no Pantanal Norte, garantindo assim a conservação da ictiofauna regional.

Em relação à avifauna, a Estação Ecológica de Taiamã possui 237 espécies registradas (ICMBio, 2017) e o Parque Nacional do Pantanal Matogrossense / áreas de entorno possui 251 espécies registradas (Ibama, 2003). Estas duas áreas protegidas protegem assim aproximadamente metade das espécies de aves já registradas para o Pantanal (Nunes 2011). Maior parte destas unidades de conservação localiza-se em áreas baixas, susceptíveis a inundações, com isso, estas UCs garantem a conservação da avifauna migratórias associadas à ambientes aquáticos (Nunes & Tomas, 2004). Contudo, espécies associadas à ambientes secos do Pantanal são raras nestas duas UCs. A ampliação da EET e PNPM além da criação da Reserva de Fauna e o Refúgio de Vida Silvestre inserem novas fitofisionomias do Pantanal, aumentando a heterogeneidade de habitats, e por conseqüência agregando novas espécies ao Mosaico de unidades de conservação do Pantanal Norte. Considerando a avifauna da área proposta para o Refúgio de Vida Silvestre, em geral as aves utilizam diferentes fitofisionomias disponíveis na paisagem, sendo que ambientes florestados apresentam maior riqueza e maior estabilidade de habitat, seguidos por ambientes mais abertos de Cerrado e apresentando menor riqueza e menor estabilidade os campos inundáveis e ambientes aquáticos (Figueira *et al*. 2006). Com isso, a inserção de ambientes florestados é uma

ação necessária para manutenção da riqueza de aves do Mosaico de unidades de conservação do Pantanal Norte.

ESTUDOS DE CASO:

Apresentamos aqui dois estudos de caso avaliando a importância do Mosaico de Unidades de Conservação para duas espécies da fauna ameaçadas de extinção, o Jacu-de-Barriga-Castanha (*Penelope ochrogaster*) e a Onça-pintada (*Panthera onca*):

JACU-DE-BARRIGA-CASTANHA (*Penelope ochrogaster*)

Figura 5. Foto de um indivíduo adulto de jacu-de-barriga-castanha (*Penelope ochrogaster*). Foto de Fábio Olmos.

Cracídeos são endêmicos dos Neotrópicos, e são representados por 56 espécies, dos quais 22 estão ameaçadas de extinção devido à perda de habitat e a caça intensiva (del Hoyo *et al*. 2016). O jacu-de-barriga-castanha (*Penelope ochrogaster*) (Fig. 5) é uma das espécies ameaçada de extinção (Silveira *et al*. 2008) e endêmica do Brasil. Essa espécie ocorre em três populações disjuntas, uma às margens do Rio São Francisco em Minas Gerais, uma na Ilha do Bananal em Tocantins e uma outra na região norte do Pantanal (Olmos 1998, Olmos, 2003, Silveira *et al*. 2008).

No Pantanal, *P.ochrogaster* foi considerada rara (Cintra & Yamashita, 1990), contudo, em estudos mais recentes, foi constatado um aumento da população na Reserva Particular do Patrimônio Natural (RPPN) SESC Pantanal na porção norte do Pantanal, onde florestas de cambará (*Vochysia divergens* – Vochysiaceae) tem se expandido (Antas, 2002). Além da RPPN SESC Pantanal, há registros de *P.ochorgaster* ao longo de toda Estrada Parque Transpantaneira, Parque Estadual Encontro das Águas e RPPN Poleiro Grande (Olmos 1998, Kaestner 2003, Nunes *et al*. 2006). Estudos realizados durante o Plano de Manejo do Parque Nacional do Pantanal Matogrossense relataram a ausência de *P.ochrogaster* para região (Ibama 2003). Entre o Porto Jofre e a sede do PNPM foi avaliado a ocorrência de cracídeos nos quintais das casas de ribeirinhos. Constatou-se que a presença de *P.ochorgaster* fica menos freqüente a jusante do rio, sendo considerado raro nas proximidades do PNPM (Bonanomi *et al*. Dados não publicados). Entre os anos de 2009 e 2016 foram percorridas diferentes trilhas na região proposta para o Refúgio de Vida Silvestre, onde a taxa de encontro do Jacu-de-barriga-castanha era de um indivíduo a cada 8,7 km percorrido. Se considerarmos somente as trilhas em ambientes abertos, não houve nenhum registro desta espécie (Fernando Tortato, Dados não publicados). O Plano de Ação Nacional para a Conservação dos Galliformes Ameaçados de Extinção considera como medida importante para população de *P. ochrogaster* do Pantanal a proteção de áreas altas de floresta decidual, pois são estas áreas que vem sendo desmatadas para substituição por pastagens (Silveira *et al*. 2008). Considerando as informações discutidas, a ampliação do PNPM e criação do Refúgio de Vida Silvestre podem ser consideradas ações efetivas para manutenção e conservação de populações viáveis de *P. ochrogaster* na porção norte do Pantanal.

ONÇA-PINTADA (*Panthera onca*)

Figura 6. Macho adulto de onça-pintada (*Panthera onca*). Foto de Fernando Tortato.

Estudos científicos acerca da biologia, ecologia e conservação da onça-pintada (*Panthera onca*) (Fig. 6) tem no Pantanal o seu principal laboratório. No Pantanal que se iniciou a pesquisa com essa espécie, envolvendo diversos aspectos, desde a relação da onça-pintada com uma de suas principais presas, a capivara (*Hydrochoerus hydrochaeris*) (Schaller & Vasconcelos 1978), as primeiras informações sobre a sua área de vida (Schaller & Crawshaw 1980) e uso de habitat (Crawshaw & Quigley 1991). No ano de 1992 um plano para conservação para onça-pintada no Pantanal propôs a criação de áreas protegidas nas porções norte e sul deste bioma, onde se encontravam as maiores populações. Também foi proposto corredores ao longo dos principais rios para manter o fluxo gênico entre estas populações (Quigley & Crawshaw 1992). Em uma avaliação mais recente sobre o status de conservação desta espécie, foi considerado que as onças-pintadas ocorrem em aproximadamente 60% do Pantanal e novamente reforçou a importância da criação de corredores biológicos garantindo a conectividade entre as populações (Cavalcanti *et al*. 2012).

A região do Parque Nacional do Pantanal Matogrossense, Estação Ecológica de Taiamã e áreas inseridas na proposta de criação do Refúgio de Vida Silvestre contam com uma alta densidade populacional de onças-pintadas (Kantek & Onuma 2013; Devlin *et al*. Dados não publicados). Estimativas para região do PNPM estimam 8 indivíduos a cada 100km² (Devlin *et al*. Dados não publicados). Kantek & Onuma

(2013) concluem que apesar da alta densidade populacional encontrada na EET, a área desta unidade de conservação é insuficiente para garantir a manutenção de populações viáveis de onças-pintadas. Amostras de DNA de indivíduos capturados para fins científicos na Estação Ecológica de Taiamã, Parque Nacional do Pantanal Matogrossense e propriedades privadas próximas ao Porto Jofre concluíram que as onças-pintadas destas três áreas distintas podem ser consideradas uma mesma população genética (Kantek *et al*. 2016). A criação do Mosaico de Unidades de Conservação no Pantanal Norte cria um cenário muito favorável à manutenção desta população de onça-pintada em longo prazo no Pantanal e atinge as metas estabelecidas em planos de conservação desta espécie já propostos em estudos anteriores (Quigley & Crawshaw 1992; Cavalcanti *et al*. 2012; Paula *et al*. 2013).

A onça-pintada é considerada vulnerável de extinção no Pantanal (Morato *et al.* 2013). E a principal ameaça é a caça retaliatória provocada por eventuais ataques de onças no rebanho doméstico (Crawshaw 2002, Quigley & Crawshaw 1992). A presença da onça-pintada na propriedade é vista por maioria dos pecuaristas como uma ameaça ao rebanho (Zimmermann *et al*. 2005, Boulhosa & Azevedo 2014). Fatores socioeconômicos estão envolvidos neste conflito entre a proteção da onça-pintada e o prejuízo provocado por seus ataques no rebanho (Zimmermann *et al*. 2005, Marchini & MacDonald 2012). Contudo até mesmo a comunidade ribeirinha, que não possui rebanhos significativos tem uma percepção negativa em relação à onça-pintada (Porfirio *et al*. 2016). Uma das alternativas para minimizar esta ameaça é a exploração do ecoturismo, tendo a onça-pintada como atrativo, fazendo com que esta espécie gere mais receitas do que prejuízos (Tortato *et al*. 2017). Com isso, a ampliação do PNPM e criação do Refúgio de Vida Silvestre auxiliam no desenvolvimento do ecoturismo na região, criando oportunidades para as propriedades vizinhas e no caso do Refúgio de Vida Silvestre, propriedades inseridas nesta UC.

CONCLUSÕES

Este documento traz informações técnicas, da literatura e outras, baseadas principalmente na experiência prática do autor na região abordada. Estas informações justificam a criação do Mosaico de unidades de conservação do Pantanal Norte. Através das ampliações de unidades de conservação existentes bem como da criação de novas unidades de conservação, as propostas levam em consideração o uso do território,

tornando assim compatível a conservação da biodiversidade e manutenção das atividades econômicas sustentáveis desenvolvidas na região. Esta proposta pode ser considerada parte de um planejamento maior, que pode considerar no futuro a inclusão de novas unidades de conservação para o Pantanal, como uma Reserva de Desenvolvimento Sustentável para comunidade ribeirinha do rio Paraguai, um Monumento Natural abrangendo toda Serra do Amolar e sua impressionante beleza cênica e a proteção de áreas ainda pouco conhecidas, como as áreas florestadas limítrofes a Bolívia ao fundo da Serra do Amolar.

Há várias razões para se proteger o Pantanal. É um bioma considerado refúgio para diversas espécies ameaçadas da fauna brasileira. Sua complexidade hídrica bem preservada é essencial para manutenção de estoques pesqueiros. É considerado um dos principais destinos turísticos do Brasil. A criação de unidades de conservação, como discutido neste documento, constitui uma das ferramentas mais importantes para garantir que gerações futuras possam usufruir deste patrimônio brasileiro.

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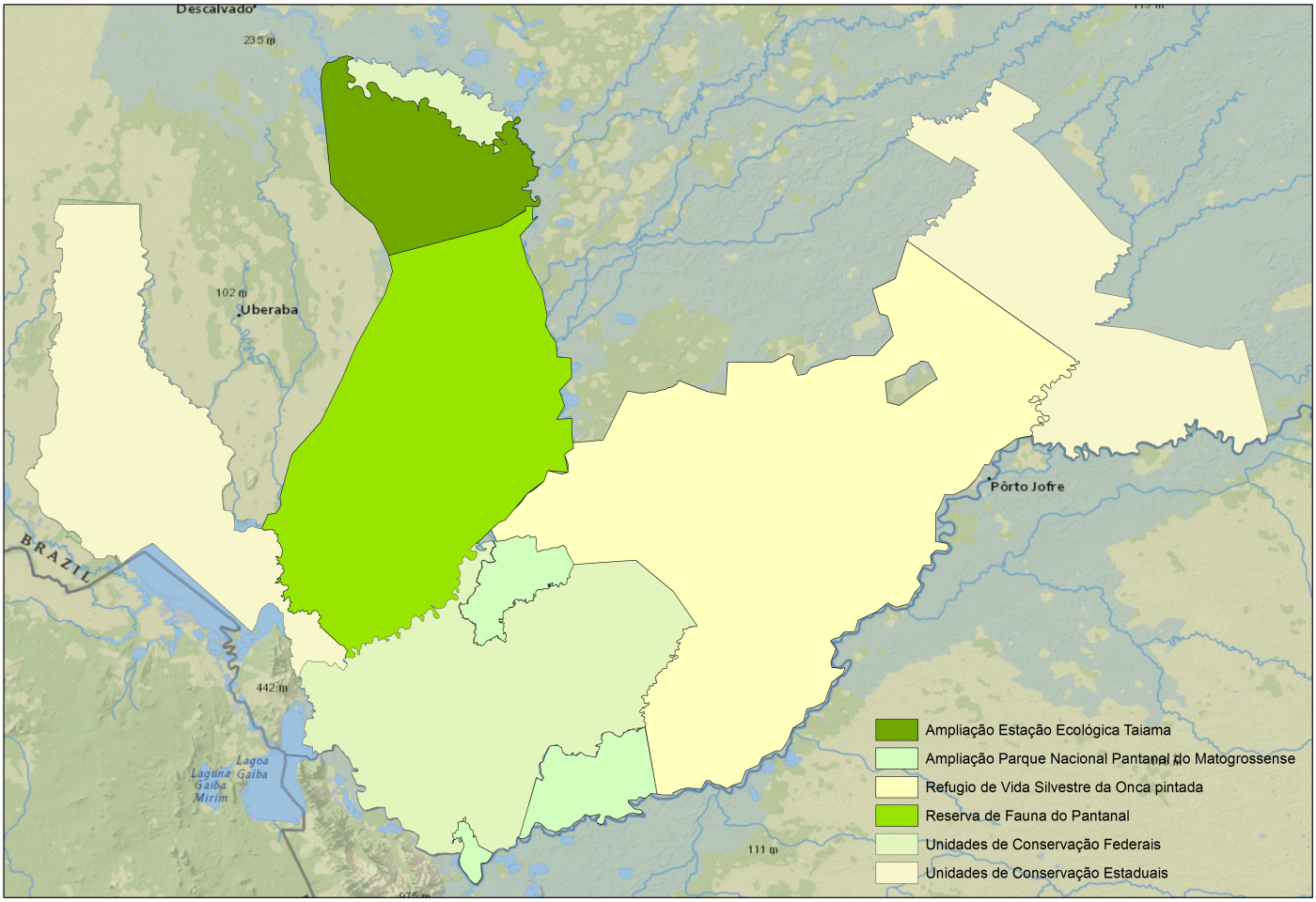
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Pôrto Jofre
BRAZIL
442 m
Lagoa
Laguna Gaiba
Gaiba
Mirim
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Ampliação Estação Ecológica Taiama
Ampliação Parque Nacional Pantanal do Matogrossense
Refugio de Vida Silvestre da Onca pintada
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NEWS AND NOTES

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En la actualidad, nos estamos enfocando en tres especies; de acuerdo a las sugerencias del Dr. Daniel Brooks y del Plan de Acción del Grupo de Especialistas en Crácidos. Estas especies son:

- Paují de Alagoas (*Mitu mitu*) Extinto en la naturaleza (EW)
- Pava de Trinidad (*Pipile pipile*) Críticamente en peligro (CR)
- Pavón (*Oreophasis derbianus*) En peligro de extinción (EN)

Otras especies que nosotros estaremos considerando son:
- Pava Aliblanca (*Penelope albipennis*) Críticamente en peligro (CR)
- Pava del Cauca (*Penelope perspicax*) En peligro de extinción (EN)
- Pavón Piquiazul (*Crax alberti*) Críticamente en peligro (CR)
- Pavón Piquirojo (*Crax blumenbachii*) En peligro (EN)

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No momento nós estamos procurando três espécies, com o aconselhamento do Dr. Daniel Brooks, e de acordo com o plano de ação do Grupo de Especialistas em Cracídeos. As espécies são:

- Mutum de Alagoas (*Mitu mitu*) Extinto na natureza (EW)
- *Pipile pipile* Criticamente ameaçada (CR)
- *Oreophasis derbianus* Ameaçado (EN)

Outras espécies que serão consideradas são:

- *Penelope albipennis* Criticamente ameaçado (CR)
- *Penelope perspicax* Ameaçado (EN)
- *Crax alberti* Criticamente ameaçado (CR)
- Mutum-do-Sudeste (*Crax blumenbachii*) Ameaçado (EN)

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At the present time, we are focusing on three species; from the advice of Dr. Daniel Brooks, as per the Cracid Specialist Group Action Plan, these are:

- Alagoas Curassow (*Mitu mitu*) EW
- Trinidad Piping Guan (*Pipile pipile*) CR
- Horned Guan (*Oreophasis derbianus*) EN

Other species that we will be considering are:

- White-winged Guan (*Penelope albipennis*) CR
- Cauca Guan (*Penelope perspicax*) EN
- Blue-billed Curassow (*Crax alberti*) CR
- Red-billed Curassow (*Crax blumenbachii*) EN

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ARTICULOS
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NOTAS SOBRE *Penelope ochrogaster* NA RESERVA RESERVA PARTICULAR DO PATRIMÔNIO NATURAL DO SESC-PANTANAL, BRASIL

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Penelope ochrogaster é uma espécie brasileira endêmica ocupando grande área do Brasil Central (Delacour e Amador 1973, Sick 1985). Listada como Ameaçada pela legislação brasileira (IBAMA 1989), é uma espécie citada como de alta prioridade de conservação em Brooks e Strahl (2000), e como ameaçada pela Birdlife (2000). A população do rio São Francisco apresenta poucos registros, e está listada como uma espécie ameaçada no estado de Minas Gerais (Azeredo, 1998). Caça e perda de habitat são os principais fatores que afetam negativamente esta espécie.

Dentro de sua distribuição geográfica, esta espécie apresenta três populações distintas: a do vale do rio São Francisco (Minas Gerais), a do vale do rio Araguaia, incluindo seus afluentes no rio das Mortes (Goiás e Mato Grosso), e as populações do Pantanal (Mato Grosso).

A população do São Francisco apresenta poucos registros, velhas peles de museus e uns poucos exemplares que foram caçados ilegalmente. Há notas esparsas e peles da população do rio Araguaia. Recentemente, observações de campo detectaram a espécie no interior do Parque Nacional do Araguaia (Yamashita 2001). Neste local, algumas notas sobre este jacú pouco conhecido existem para a população do Pantanal.

A RPPN (Reserva Particular do Patrimônio Natural) SESC – PANTANAL

Localizado entre os rios Cuiabá e São Lourenço no município de Barão do Melgaço, Mato Grosso, é uma unidade de conservação privada reconhecida pelo Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA). O SESC-Pantanal (Serviço Social do Comércio) foi estabelecido em 1997 (regulamento IBAMA 071/97 - N e 151/98 - N). Com cerca de 100.000 Ha, a reserva contém habitats sazonalmente alagados e habitats secos dentro da planície do Pantanal. Habitats de florestas incluem o cerradão, mata de galeria e floresta decídua, incluindo parte da maior floresta decídua do Pantanal, a floresta Bebe. A RPPN é uma zona nuclear da Reserva da Biosfera Pantanal e tem sido considerada para se tornar um local de proteção de aves áquatica sobre regulamentação da Convenção Ramsar.

PENELOPE OCHROGASTER NO PANTANAL

Este jacú tem sido registrado frequentemente no Pantanal no município de Poconé, Mato Grosso, desde que a rodovia Transpantaneira foi construída em meados dos anos 70 (Olmos 1996, pers. obs.). A rodovia Transpantaneira liga a cidade de Poconé à área de Campo Jôfre, chegando à borda do rio Cuiabá. Peles da região de Cuiabá foram usadas para descrever a espécie em 1870 (Naumburg 1930). Este jacú é considerado um residente raro de matas de galeria e floresta decídua do município de Poconé (Cintra e Yamashita 1990), mas foi registrada como sendo comuns em pelo menos algumas áreas (Olmos 1996). A espécie também foi coletada em áreas próximas ao rio Paraguay (Naumburg 1930).

Em julho e outubro de 1998, a avifauna da RPPN SESC-Pantanal foi inventoriada. Após 30 dias de trabalho de campo cobrindo toda a reserva, apenas dois exemplares da espécie foi registrado. Encontrados em um cambarazal, eles desapareceram rapida e silenciosamente assim que foram detectados pelo observador. O cambarazal é um habitat de foresta inundável sazonalmente, dominado pelo cambará *Vochysia divergens*. Todo o restante da reserva não apresenta jacús, e estes são os únicos encontrados nesta floresta.

Desde julho de 2001, um projeto com araras tem sido executado na região. Desde seu início, muitos jacus também foram observados. Por exemplo, em 30 de julho de 2001, das 6:00 às 6:30 hr, 30 jacús foram encontrados ao longo de um transecto de 12 km analisado com um veículo na floresta decídua Bebe. Pares e grupos contando até quatro jacús foram facilmente observados ao longo da rodovia. Além do cambarazal e da floresta decídua, *Penelope ochrogaster* tem sido encontrada em outros habitats florestais e semelhantes, incluindo matas de galeria, cerradão, capão e cordilheira de cerrado (uma área longa, estreita e seca).

Os jacús têm se alimentado no chão com invertebrados ou com folhas novas de liana. Em outubro e novembro, vôos territoriais foram observados, quando barulhos foram produzidos durante ataques. Este também é o período de reprodução para dois outros cracídeos, o mutum *Crax fasciolata* e o aracuã *Ortalis canicollis*. Em janeiro de 2002, pares de aracuãs foram vistos com filhotes, algo não observado com os jacús. Os jacús, quando assustados, produzem um chamado ásoeri e alto semelhante ao som de um trompete, similar ao canto de outro jacú, *P. jacucaca* (pers. obs.). Seu canto de alerta é mais áspero do que *P. superciliaris*, um possível vizinho em algumas partes de sua distribuição.

A caça é estritamente proibida e a reserva apresenta excelente sistema de vigilância. A vigilância é feita por barco e à cavalo, ao redor e dentro de toda a reserva. Além disso, campanhas educacionais motivam a população humana ao redor a proteger a reserva, assim como também cria um atmosfera geral muito positiva. O controle de fogo também é excelente, evitando grandes incêndios desde de 1999.

Contudo, a caça ainda ocorre, sendo praticada esporadicamente por pescadores amadores acampados ao redor da reserva, por alguns habitantes e índios da Reserva Indígena Perigara, ao sudoeste da RPPN. O jacú está entre as aves favoritas de caça, embora muitos caçadores prefiram grandes mamíferos. Sinais mais forte de que a caça é rara é dado pelo comportamento menos desconfiado exibidos pelos jacús.

A população de jacús apresentou um aumento em 2001 comparado a 1998. O aumento populacional não pode ser atribuído totalmente à fundação da reserva. Direta e indiretamente,a reserva tem ajudado para este aumento. Tornando-se uma área protegida contra fogo e caça, ela se torna atrativa para outros jacús residentes na região. No mais, o tamanho da reserva e a falta virtual de caça mudou o comportamento dos jacús, tornando-os menos desconfiados da presença humana. Eles podem ser vistos facilmente agora em diferentes partes da reserva e mesmo ao redor dela. Os jacús perderam a maior parte de seu medo da presença humana e se movem livremente nestas áreas.

Pesquisa sobre a biologia e ecologia de *Penelope ochrogaster* podem ser facilmente realizados na RPPN. A alta densidade populacional atual e o comportamento não desconfiado, assim como as instalações da reserva e controle contra a caça, são fatores positivos para o estabelecimentos de estudos na área. No mais, esta informação mal é necessária para o manejamento correto desta espécie ameaçada, tanto na reserva como em outro lugar. Também, a RPPN SESC-Pantanal contém a maior população natural desta espécie. Um programa de reintrodução poderia ser realizado num futuro próximo. Grupos pequenos capturados na RPPN poderiam ser translocados para outras áreas pequenas, permitingo a recuperação populacional em larga escala.

Em abril e agosto de 2001, uma avaliação ecológica rápida do Parque Nacional do Pantanal e RPPNs próximas foi realizada. A área estudada, localizada na foz do rio Cuiabá junto ao rio Paraguay, tem habitats de florestas similares aos da RPPN SESC, ou áreas onde este jacú foi coletado. De fato, tal lugar, como Descalvados (Naumburg 1930), está apenas a cerca 100 km ao norte do Parque Nacional. Trabalho de campo de 40 dias, cobrindo os habitats principais na porção oeste do parque e na região da Serra do Amolar foi realizado. Nenhum jacú foi encontrado (Antas et al. 2002), apesar da presença deles na fazenda Santa Isabel localizada bem próxima à área (Olmos 1996, pers. obs.). A fazenda Santa Isabel tem limita-se com o norte do Parque Nacional. Contudo, habitats usados pelos jacús podem ser encontrados ao nordeste e leste no Parque Nacional, assim como também em uma RPPN próxima. No futuro, se buscas de campo mostrarem que estas regiões não apresentam jacús. Um programa de reintrodução de *Penelope ochrogaster* deveria ser realizado com jacús da RPPN SESC-Pantanal.

NOTAS SOBRE LA PAVA VENTRIRUFA *Penelope Ochrogaster* EN LA RESERVA DO PATRIMÔNIO NATURAL DO SESC-PANTANAL, BRASIL

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Penelope ochrogaster es una especie endémica brasileña, con un rango que abarca una porción grande de Brasil Central (Delacour y Amador 1973, Sick 1985). Registrada como en peligro bajo la legislación brasileña (IBAMA 1989), la especie es considerada en Alta Prioridad de Conservación por Brooks y Strahl (2000), y considerada como En Peligro por Birdlife (2000). La población del río San Francisco tiene pocos registros recientes, y se enlista como En Peligro en el estado de Minas Gerais (Azeredo, 1998). Cacería y pérdida de habitat son los factores principales que afectan a esta especie.

Dentro de su rango geográfico, esta especie tiene tres poblaciones disyuntas: Valle del río San Francisco (estado de Minas Gerais), valle medio del río Araguaia, incluyendo su afluente en el Río Mortes (estado de Goiás y Mato Grosso), y las poblaciones de Pantanal (estado de Mato Grosso).

La población de San Francisco tiene pocos registros recientes, pieles viejas de museos y unos pocos casos de aves cazadas furtivamente. Hay también notas dispersas y pieles viejas de la población del río Araguaia. Sin embargo, recientes observaciones de campo la descubrieron dentro del Parque Nacional Araguaia (Yamashita 2001). Aquí se presentan algunas notas sobre esta pava pobremente conocida de la población de Pantanal.

EL RPPN SESC - PANTANAL

Localizado entre los ríos Cuiabá y São Lourenço en Barão condado de Melgaço, estado de Mato Grosso, la Reserva Particular do Patrimônio Natural (RPPN) es una unidad de conservación privada reconocida por la legislación brasileña a través del Instituto Brasileiro do Meio Ambiente y de los Recursos Naturais Renováveis. SESC-Pantanal (Serviço Social do Comércio) se estableció en 1997 (regulaciones de IBAMA 071/97 - N y 151/98 - N). Con casi 100,000 ha, la reserva contiene hábitats inundados estacionalmente y habitats secos dentro de las llanuras de Pantanal. Los hábitats del bosque incluyen Cerradão, bosques de galería y deciduos, incluyendo una de las porciones más grandes del bosque deciduo de tierras bajas en el bosque Pantanal-Bebe. El RPPN es una zona nucleo de la Reserva de la Biosfera de Pantanal y es considerada para convertirse en un sitio bajo la Convención de Ramsar para protección de humedales.

LA PAVA EN **EL PANTANAL**

Esta pava frecuentemente se ha registrado en el sector Pantanal del condado Poconé, estado de Mato Grosso, desde que se contruyó el camino Transpantaneira a mediados de 1970s (Olmos 1996, pers. obs.). El camino de Transpantaneira une la ciudad de Poconé con el área Campo Jôfre, terminando en la frontera del río Cuiabá. Se usaron pieles de la vecindad de Cuiabá para describir a la especies en 1870 (Naumburg 1930). Esta pava ha sido considerada una residente rara del bosque de galería y del bosque deciduo de Poconé (Cintra y Yamashita 1990), pero se ha registrado como común en algunas áreas (Olmos 1996). También se colectó en áreas cerca del mismo río Paraguay (Naumburg 1930).

En Julio y Octubre de 1998, se inventarió la avifauna de RPPN SESC-Pantanal. Después de 30 días de campo, cubriendo toda la reserva, solamente se registraron dos pavas. Estas se encontraron en el interior de un cambarazal y desaparecieron rápida y calladamente en cuanto nos descubrieron. El cambarazal es un bosque estacionalmente inundado, dominado por cambará *Vochysia divergens*. Todos los otros habitats de la reserva no presentaron pavas, y éstas fueron los únicos ejemplares en el bosque.

Desde Julio de 2001, se inició otro proyecto con Guacamayos en la reserva. Desde que empezó el proyecto con Guacamayos, muchos pavas se han descubierto. Por ejemplo, el 30 de Julio de 2001, de 6:00-6:30 hr, se encontraron 30 pavas a lo largo de un transecto de 12 km recorrido en vehículo, en una porción del bosque deciduo Bebe. Parejas y grupos de hasta cuatro pavas fueron fácilmente encontradas a lo largo del camino. Además del cambarazal y bosque deciduo, las pavas se han encontrado en otros bosques o habitats parecidos a bosques, incluyendo bosques de galería, el cerradão, capão (áreas secas pequeñas) y cordilheira (una área seca larga y estrecha) de cerrado.

Las pavas se han visto alimentándose en el suelo en busca de invertebrados, o en los árboles comiendo hojas jóvenes de lianas. En Octubre y Noviembre, se observaron luchas territoriales, donde se produjeron ruidos ásperos con los ataques. Éste también es el periodo de reproducción para otros dos crácidos en el sitio: *Crax fasciolata y Ortalis canicollis*. En Enero de 2002, las parejas de chachalacas ya tenían nuevos polluelos, algo aún no observado en las pavas. Las pavas, cuando alarmadas, tienen un llamado fuerte, áspero, similar al llamado de alerta de *P. jacucaca* (obs. pers.). Su llamado de alerta es más áspero que el de *P. superciliaris*, un posible vecino en algunas partes de su distribución.

La cacería furtiva se prohibe estrictamente y la reserva tiene un excelente sistema de vigilancia. La vigilancia se realiza usando vehículos, barcos y a lomo de caballo alrededor del perímetro y dentro de la reserva. Adicionalmente, las campañas educativas motivaron a la población humana circundante para proteger la reserva, así como crear una atmósfera positiva global. El sistema de control de fuego también es excelente, evitando cualquier tipo de fuego desde 1999.

Sin embargo, alguna cacería furtiva es todavía presente, realizada esporádicamente en los campamentos de pescadores aficionados cercanos, de algunos de los habitantes y de los indios Bororó que viven en la Reserva Indígena Perigara, justo al sudoeste del RPPN. La pava está entre las presas favoritas, aunque la mayoría de los cazadores furtivos prefieren cazar mamíferos grandes. La señal más fuerte de que la cacería furtiva es rara es la conducta cauta exhibida por las pavas.

La población de pavas ha aumentado en 2001 cuando se compara con 1998. La población de pavas en el momento en que la reserva fue establecida no podría ser el único factor responsable para los números actuales en tan poco tiempo. Directamente y indirectamente, la designación de la reserva probablemente explica este aumento de la población. Al convertirse en una área protegida contra fuego y cacería furtiva, la reserva se hizo atractiva para las restantes pavas que viven en la región, donde estas amenazas todavía están presentes. Adicionalmente, el tamaño de la reserva y la carencia virtual de presión de cacería cambiaron la conducta de las pavas, haciéndolas menos cautas a la presencia humana. Ellas pueden verse ahora fácilmente en partes diferentes de la reserva. Incluso es posible verlas cerca de las instalaciones de la

reserva. Las pavas perdieron el miedo a la presencia humana y se mueven libremente en tales lugares.

Investigaciones sobre la biología y ecología de la especie puede ser establecida rápidamente en el RPPN. La alta densidad de la población actual y conducta no cauta, así como las instalaciones de la reserva y el control sobre la cacería furtiva son factores positivos en tales estudios. Adicionalmente, el RPPN SESC-Pantanal alberga la población silvestre conocida más grande de este pava. Un programa de reintroducción podría lanzarse en el futuro cercano a partir de esta población. Grupos pequeños atrapados en el RPPN podrían ser translocados a otras áreas protegidas, habilitando la recuperación de la población a una escala mayor.

En abril y agosto de 2001, se realizó una Valoración Ecológica Rápida del Parque Nacional Pantanal y de los alrededores del RPPNs. El área de estudio, localizada en la boca del Río Cuiabá sobre Río Paraguay, tiene habitats similares al del RPPN de SESC, o áreas donde esta pava fue colectada. De hecho, uno de tales lugares, Descalvados (Naumburg 1930), está a unos 100 km al norte del Parque Nacional. El trabajo de campo ascendió a 40 días, cubriendo los principales hábitats en la porción occidental del parque, así como también en la región Serra do Amolar. Ninguna pava fue encontrada allí (Antas et al. 2002), a pesar de su presencia en las cercanías de la granja Santa Isabel (Olmos 1996, obs. pers.). Santa Isabel tiene límites con la parte norteña del Parque Nacional. Sin embargo, podrían encontrarse habitats usados por la pava en las porciones nororientales y orientales del Parque Nacional, así como en RPPN cerca de esta área. Si búsquedas de campo futuras demuestran que esas regiones no contienen pavas, un programa de reintroducción podría lanzarse translocando pavas de RPPN del SESC.

NOTES ON THE CHESTNUT-BELLIED GUAN *Penelope ochrogaster* AT THE RESERVA PARTICULAR DO PATRIMÔNIO NATURAL DO SESC-PANTANAL, BRASIL

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The Chestnut-bellied Guan *Penelope ochrogaster* is a Brazilian endemic, with a range encompassing a large portion of Central Brazil (Delacour and Amador 1973, Sick 1985). Listed as Endangered under the Brazilian legislation (IBAMA 1989), it is considered High Priority conservation status by Brooks and Strahl (2000), and Endangered by Birdlife (2000). The São Francisco river population has few recent records, and is listed as Endangered in the state of Minas Gerais (Azeredo, 1998). Hunting and loss of habitat are the main factors affecting this species.

Within its geographic range, this species has three disjunct populations: the São Francisco River valley (Minas Gerais state), middle Araguaia river valley, including its affluent at the Mortes River (Goiás and Mato Grosso states), and the Pantanal populations (Mato Grosso state).

The São Francisco population has few recent records, old museums skins and a few cases of poached birds. There are also sparse notes and old skins from the Araguaia River population. Recently however, field observations detected it inside Araguaia National Park (Yamashita 2001). Herein, some notes about this poorly known guan are presented from the Pantanal population.

THE RPPN SESC - PANTANAL

Located between the Cuiabá and São Lourenço Rivers in Barão do Melgaço county, Mato Grosso state, the Reserva Particular do Patrimônio Natural (RPPN) is a private conservation unit recognized by the Brazilian legislation through the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis. SESC-Pantanal (Serviço Social do Comércio) was established

in 1997 (IBAMA's regulations 071/97 – N and 151/98 – N). With almost 100,000 Ha, the reserve contains both seasonally flooded and dry habitats within Pantanal plains. Woodland habitats include Cerradão, gallery forest and decidous forest, including a portion of the largest lowland decidous forest in Pantanal – Bebe forest. The RPPN is a nuclear zone of the Pantanal's Biosphere Reserve and has been considered to become a site under the Ramsar Convention for wetlands protection.

THE CHESTNUT-BELLIED GUAN IN **THE PANTANAL**

This guan has been frequently recorded in the Pantanal sector of Poconé county, Mato Grosso state, since the Transpantaneira road was built in the middle 1970s (Olmos 1996, pers. obs.). The Transpantaneira road links Poconé city to the Campo Jôfre area, terminating at the Cuiabá River border. Skins from the vicinity of Cuiabá were used to describe the species in 1870 (Naumburg 1930). This guan has been considered a rare resident of the gallery forest and decidous forest of Poconé county (Cintra and Yamashita 1990), but was recorded as common in at least some areas (Olmos 1996). It was also collected in areas near the Paraguay river itself (Naumburg 1930).

In July and October 1998, the avifauna of RPPN SESC-Pantanal was inventoried. After 30 combined field days covering the whole reserve, only two Chestnut-bellied Guans were recorded. Found inside a cambarazal, they vanished quickly and quietly as soon as they were detected the observer. The cambarazal is a seasonnally flooded forest habitat, dominated by cambará *Vochysia divergens*. All of the reserve's other forest habitats did not contain guans, and these were the only guans in the forest.

Since July 2001, another project dealing with Macaws has taken place in the reserve. Since the Macaw project began, many Chestnut-bellied Guans have been detected. For example, on July 30 2001, from 6:00-6:30 hr, 30 guans were found along a 12 km long vehicle-driven transect in a portion of the Bebe decidous forest. Pairs and flocks containing up to four guans were easily found along the dirt road. Besides the cambarazal and decidous forest, the Chestnut-bellied Guan has been found in other forest or forest-like habitats, including gallery forests, cerradão, capão (small dry areas) and cordilheira (a long and narrow dry area) of cerrado.

The guans had been seen feeding on the ground searching for invertebrates, or in the trees eating young liana leaves. In October and November, territorial fights were observed, where harsh noises were produced with the attacks. This is also the breeding period onset for two other cracids at the site: the Bare-faced Curassow *Crax fasciolata* and Chaco Chachalaca *Ortalis canicollis*. In January 2002, the Chachalaca pairs had new chicks with them, something not yet observed for the guans. The guan, when frightened, has a loud, harsh trumpeting call, similar to the alert call of the White-browed Guan *P. jacucaca* (pers. obs.). Its alert call is harsher than the Rusty-margined Guan *P. superciliaris*, a possible neighbour in some parts of the range.

Poaching is strictly forbidden and the reserve has an excellent warden system. The wardens provide surveillance via vehicle, boat and horseback around the perimeter and inside the reserve. Additionally, educational campaigns motivated the surrounding human population to protect the reserve, as well as creating a positive atmosphere overall. The fire control system is also excellent, preventing any major fire since 1999.

However, some poaching is still present, coming sporadically from amateur fishermen camps nearby, some of the inhabitants and Bororó indians living in the Reserva Indígena Perigara, just southwest of the RPPN. The guan is among the favored game, although most of the poachers prefer hunting large mammals. The strongest sign that poaching is rare is the decreased wary behavior exhibited by the guans.

The guan population has increased in 2001 when compared with 1998. The population at the time the reserve was established could not be the only factor responsible for the current numbers

in such a short timespan. Directly and indirectly, the reserve design has likely accounted for this population increase. Becoming a protected area against fire and poaching made it attractive for remnant guans living in the region, where these threats are still present. Additionally, reserve size and virtual lack of hunting pressure changed the guans behavior, making them less wary of human presence. They now can be easily seen in different parts of the reserve. It is even possible to see them close to the reserve facilities. The guans lost most of their fear to human presence and move freely in such places.

Research on the species biology and ecology coud be readily established in the RPPN. The current high population density and unwary behavior, as well as the reserve's facilities and control over poaching are positive factors in such studies. Moreover, this information is badly needed for sound management of this Endangered species, both in the reserve and elsewhere. Additionally, the RPPN SESC-Pantanal harbors the largest known wild population of this guan. A reintroduction program could be launched in the near future from this population. Small groups trapped in the RPPN could be translocated to other protected areas, enabling population recovery at a larger scale.

In April and August 2001, a Rapid Ecological Assessment of the Pantanal National Park and surrounding RPPNs was made. The study area, located at the mouth of the Cuiabá River on the Paraguay River, has forest habitats similar to the SESC's RPPN, or areas where this guan was collected. In fact, one such place, Descalvados (Naumburg 1930), is some 100 km north of the National Park. Fieldwork there totaled 40 days, covering the major habitats in the western portion of the park, as well as the Serra do Amolar region. No guans were found there (Antas et al. 2002), in spite of its presence in the nearby Santa Isabel farm (Olmos 1996, pers. obs.). Santa Isabel has boundaries with the northern part of the National Park. However, habitats used by the guan could be found in the northeastern and eastern portions of the National Park, as well as in a RPPN near this area. If future field searches prove those regions do not contain guans, a reintroduction program could be launched translocating Chestnut-bellied Guans from SESC's RPPN.

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STATUS POBLACIONAL DE LA PAVA (*Penelope purpurascens*) EN BOLIVAR, COLOMBIA

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El presente trabajo tuvo como objetivo determinar las características poblacionales de *P. purpurascens* en áreas de bosque fragmentado en la Serranía de Pintura y el Santuario de fauna y flora "Los Colorados", departamento de Bolívar, con la finalidad de determinar el status poblacional y de conservación de esta especie en la zona, a pesar de las dificultades para acceder al hábitat de estas aves y a los problemas de orden público.

SANTUARIO DE FAUNA Y FLORA LOS COLORADOS

Localizado al oriente de la Serranía de San Jacinto, municipio de San Juan Nepomuceno (9°57'06" N y 75°04'01"W), Departamento de Bolívar. La temperatura media anual es 27.3° C y la precipitación media anual es de 1026 mm, con tendencia a distribución bimodal (IDEAM, 2000). El clima es cálido semiárido y cálido seco; el relieve es fuertemente quebrado a escarpado, con pendientes del 25 - 50 % y mayores del 50%. Se presentan varios tipos de vegetación en relación con su ubicación: vegetación riparia hallada en las partes bajas y cañadas, vegetación de ladera y vegetación secundaria en lugares sujetos a quema y tala. La presencia de algunas especies vegetales evidencian un buen estado del bosque, entre ellas figuran: Nazareno (*Peltogyne purpurea*), Ceiba *(Ceiba pentandra*), Guaymaro (*Brosimum alicastrum*), Ceiba blanca (*Hura crepitans*), Hobo blanco (*Spondias radkolferi*), Indio encuero (*Bursera simaruba*), Tamarindo de Mico (*Uribea tamarindoides*), Banco (*Gyrocarpus americana*) y Camajón (*Sterculia apelata*) entre otros (Inst. Alexander von Humboldt 1997). Aunque la reserva goza de protección legal, su cercanía con la cabecera municipal del municipio de San Juan Nepomuceno le ha acarreado graves problemas ambientales siendo la caza y el uso de leña los más importantes, además de la ocupación de tierras pertenecientes al Santuario por modificación de linderos (Ruiz **et al.**, 1997).

SERRANÍA DE PINTURA

Ubicada al suroccidente del Santuario de Fauna y Flora "Los Colorados", esta Serranía comprende una serie de cerros con una altitud máxima de 600 m, las partes menos onduladas y accesibles han sido taladas y destinadas a la ganadería y al cultivo (ñame, yuca, maíz y ají). El área de estudio comprendió un sector ubicado en la parte alta de la serranía de aproximadamente 400 hectáreas y dos en la parte media, de 100 y 150 ha aproximadamente. Los fragmentos de bosque se encuentran rodeados de pastos y cultivos. La región es humedad y la neblina es frecuente por las mañanas y las tardes. Los tipos de vegetación son: vegetación de laderas en buen estado de conservación, localizada en sitios con pendientes de 40 a 60%, y dosel continuo de aproximadamente 30 m, con árboles emergentes de más de 40 m, especialmente Zapatón (*Pterigota colombiana*). Otras especies observadas fueron Hobo (*Spondias sp*); Indio encuero (*Bursera simaruba*); Huaymaro (*Sorocea sp*); Ceibas *(Hura crepitans* y *Ceiba pentandra*). En las partes bajas se encuentra vegetación de áreas húmedas como son Heliconias y Platanillos (*Calathea sp* y *Heliconia spp.*) y algunos individuos aislados entre estos el Polvillo (*Tabebuia sp*) y Camajorú (*Sterculia apetala*). En los cursos de agua hay bosque de galería dominado por el Caracolí (*Anacardium excelsum*) y bosque de ladera.

METODOLOGÍA

A partir de reportes de avistamientos suministrados por los guarda parques y por el Biólogo Rafael Borja, sobre la observación de una Pava de Monte en el Santuario los Colorados en 1997, se inició su búsqueda entre los meses de octubre y noviembre del mismo año. Posteriormente visitamos el Santuario en abril, junio, julio, agosto y octubre de 1998 sin resultados positivos.

Campesinos reportaron la presencia de pavas de monte en un fragmento boscoso ubicado en la Serranía de Pintura (a dos horas de camino). En enero de 1998, verificamos visualmente la presencia de las pavas (tres individuos volando hacia un árbol en lo alto de la montaña). Entre marzo de 1999 y marzo del 2000 se realizaron salidas mensuales de 4 a 7 días de duración.

Durante la búsqueda de la especie en el Santuario "Los Colorados" se realizaron 28 transectos, utilizando un sistema de trochas preexistentes que sumaban más de 7 Km. de longitud. En la Serranía de Pintura se usaron dos senderos de 800 y 340 m y dos quebradas de 180 y 800 m de largo. En Serranía de Pintura realizamos 30 censos en un transecto de 0.32 km, 28 censos en un transecto de 0.8 km, 4 censos en un transecto de 0.12 km, y 4 censos en otro transecto de 0.8 km. En total 4 transectos de 2.04 km fueron censados 66 veces (35.9 km total). Los transectos se midieron en las dos zonas mediante el método de conteo de pasos.

Los transectos fueron recorridos entre las 0600 y 1000 horas y entre 1500 y 1800 horas, a una velocidad de un Km/h, realizando paradas cuando se presentaba un avistamiento. Al momento de la observación se tomaron los siguientes datos: número de individuos, distancia perpendicular de cada individuo al transecto, altura del individuo en la vegetación, distancia desde el punto de partida del transecto, altura de la vegetación y notas sobre comportamiento (social, alimentación ó reproducción). La información sobre alimentación se tomó por observación directa y posterior recolección de muestras botánicas.

Para el censo de la población se utilizó el método de longitud variable de King (Silva and Strahl 1991, Strahl and Silva 1998). Registramos una distancia L de una área A para estimar el tamaño de una población. Contamos el número pavas (n) y registramos la distancia perpendicular del individuo observado al transecto. La fórmula de este método es:

$$D = \frac{n}{2 * X * \sum L}$$

Donde:
D = Densidad estimada de la población
n = Número de aves observadas durante todos los transectos realizados.
X = Distancia perpendicular de los individuos observados al transecto. En este caso se tomó la distancia perpendicular media (Xp media), distancia perpendicular máxima (Xp max) y la distancia máxima real (Xp max real) (National Research Council 1981, Chapman **et al**. 1988), con el objeto de poder realizar comparaciones de las densidades a lo largo de los muestreos.
∑L = Suma de las longitudes de todos los transectos recorridos.

Entre marzo de 1999 y marzo del 2000 aplicamos encuestas por entrevista directa a 32 personas entre 15 y 70 años de edad, de los alrededores del Santuario (17) y la Serranía (15). La encuesta incluyó información concerniente al uso del bosque, la Pava de Monte y su frecuencia de aparición en la zona rural del Municipio de San Juan Nepomuceno.

DENSIDAD POBLACIONAL

Estimamos una densidad de 6.6-16.4 ind/km^2. Un grupo de tres individuos en los transectos 1 y 2, fueron constantes durante los muestreos. En el transecto 3, ubicado en la parte media de la montaña, cerca del transecto 1 y el 2, se registró otro grupo de tres individuos. En el transecto 4 un grupo de dos individuos, para un total de ocho individuos en el área de estudio. Estos datos fueron utilizados para comparaciones con los resultados de las densidades estimadas. Utilizando

X_p media se obtiene una sobrestimación del 107% en relación con los ocho individuos registrados mediante conteo directo.

La exactitud de los cálculos basados en transectos lineales depende de la validez de los supuestos en relación con la distancia de detección (distancia perpendicular) del organismo en cuestión y por lo tanto del área muestreada en cada recorrido (Benett and Defler 1998). Cuando el terreno es difícil la visibilidad del observador para estimar las distancias perpendiculares se ve afectada, así mismo la estimación de las distancias también depende de la visibilidad del hábitat censado y la detectabilidad intrínseca de los animales, esta última a su vez puede ser afectada por el tamaño de los grupos y dispersión de los mismos (Chapman **et al.** 1988). Estos factores no ejercieron mayor influencia en el Serrania.

TENDENCIAS EN EL USO DEL BOSQUE Y DE LA PAVA DE MONTE

Estos resultados se obtuvieron mediante una encuesta que incluyó a la totalidad de las fincas adyacentes al área de estudio, 15 personas en las cercanías de Los Colorados y 17 en la Serranía de Pintura. La principal actividad de los campesinos es la extracción de madera de forma ocasional, con el 53.3% y 94.1% en ámbas áreas, respectivamente. La caza de fauna silvestre fue mínima (6.7%, 5.9%, respectivamente), no obstante expresaron una alta aceptación de la carne de Pava de Monte como alimento (80%, 58.8%) y como mascota (20%, 29.4%).

Los últimos registros de la Pava en el Santuario datan de hace tres años (Borja, com pers., 1997, Inst. Alexander von Humboldt 1997, Ruiz **et al.** 1997) coincidiendo con lo expresado por los campesinos en las encuestas, quienes señalan un periodo de 1 a 3 años en el que dejaron de observarlas en esta reserva. Aquí, la pava es considerada poco común por el 93.3 % de los encuestados (común = 0%, rara = 6.7%), lo que nos sugiere una población reducida. En esta reserva no se obtuvieron registros visuales ni auditivos durante el muestreo (1997-2000), indicando su posible desaparición de esta zona. Su desaparición puede deberse a la intervención humana por largos período de tiempo. La cercanía del casco urbano de San Juan Nepomuceno facilitó el acceso de las personas al bosque, lo que ocasionó la conversión del santuario en zonas de pastoreo y cultivos. Estos cambios también favorecieron la caza de la fauna silvestre usando escopetas, trampas, perros, además de la extracción de madera con fines energéticos y de construcción, extrayendo individuos de mediano diámetro (10-30 DAP) (Inst. Alexander von Humboldt 1997, Ruiz **et al.** 1997). El Santuario Los Colorados es un fragmento relativamente aislado por barreras como la Troncal de Occidente y sabanas artificiales con actividad ganadera. Consecuentemente una presión permanente sobre la población de la Pava de Monte durante largo tiempo conllevaría a su extinción local. Esto parece haber ocurrido por la carencia de registros durante esta investigación.

En la Serranía de Pintura la Pava de Monte es considerada según la encuesta como una especie común (76.4%) y señalaron no haber observado disminución en el número de individuos, aunque también consideran que no han aumentado, manteniéndose un número similar de individuos desde hace tiempo. Esta afirmación se debe quizás a que existe un reclutamiento nulo o muy bajo en la población de *Penelope purpurascens*. Esta carencia de reclutamiento puede reflejar actividades del hombre, entre ellas el saqueo de nidos para el uso de las crías como mascotas, actividad considerada como costumbre entre los pobladores. En la Serranía de Pintura los fragmentos no están sometidos a un aislamiento total, aún existen corredores, en especial quebradas, que conectan algunos fragmentos. Sin embargo, la principal amenaza es la extensión de los fragamentos (de 100 a 300 Ha) la cual se reduce cada día más debido a la práctica de la quema para preparar tierras de cultivo, repercutiendo en las poblaciones de pavas. Muchas especies que requieren áreas grandes para mantener poblaciones viables desaparecerán conforme desaparece el bosque.

STATUS POPULACIONAL DE Penelope purpurascens EM BOLIVAR, COLÔMBIA

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RESUMO - No período de Outubro de 1997 a Março de 2000 foi realizado em estudo para se determinar o *status* populacional e os aspectos comportamentais de *Penelope purpurascens* no Santuario de Flora y Fauna los Colorados e nos fragmentos de floresta localizados na serranía de Pintura (Bolívar). Foram realizadas observações oportunistas, utilizando-se o método de longitude variável de king. Adicionalmente, foram feitas entrevistas com os moradores da região, com o objetivo de verificar a presença e a utilização deste jacu. Foram realizados 28 transecções no Santuario de Flora y Fauna los Colorados, e nesta localidade não se registrou avistamentos ou outra evidencia da presença dos jacus; as transecções abertas na Serrania de Pintura resultaram num total de 7,3 ind/km^2, utilizando como estimatica Xp máxima. Acredita-se que *P. purpurascens* se encontra confinada em pequenos fragmentos de mata e não se registrou mudanças em seu comportamento. Concluise que *P. purpurascens* era amplamente distribuída nas áreas estudadas (seguindo a encosta); atualmente está extinta ou desaparecida do Santuario los Colorados e comum, embora restrita, aos fragmentos de mata na Serrania de Pintura.

POPULATION STATUS OF THE CRESTED GUAN (*Penelope purpurascens*) IN BOLIVAR, COLOMBIA

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The objectives herein are to determine population trends of the Crested Guan (*Penelope purpurascens*) in areas of fragmented forest in the Serranía de Pintura and the “Los Colorados” flora and fauna Sanctuary, Departament of Bolívar, Colombia. Additionally we discuss population status and conservation of this species in the region in light of accessibility to the habitat where these birds live, and in relation to human use.

“LOS COLORADOS” FLORA AND FAUNA SANCTUARY

This site is located east of the Serranía de San Jacinto, near San Juan Nepomuceno (9°57’06” N, 75°04’01”W), Dept. Bolívar. Climatically this region has a mean annual temperature of 27.3° C, and a mean annual precipitation of 1026 mm, with a tendency towards a bimodal distribution (IDEAM 2000). This climate is typical of a semi-arid and dry region. The escarpment is strongly broken at 25-50% slopes, but at least 50% in general. The interior of the reserve varies in vegetation type depending on location, but includes riparian vegetation in lower swampy areas, hillside vegetation and secondary vegetation in areas subjected to burns. The reserve contains species indicating the forest is in good health, including: *Peltogyne purpurea*, *Ceiba pentandra*, *Brosimum alicastrum, Hura crepitans*, *Spondias radkolferi*, *Bursera simaruba*, *Uribea tamarindoides*, *Gyrocarpus Americana,* and *Sterculia apelata* among others (Inst. Alexander von Humboldt 1997). Although the Sanctuary has legal protection, it is close to the town of San Juan Nepomuceno and suffers some environmental threats such as hunting, timbering, and habitat modification (Ruiz **et al.** 1997).

SERRANÍA DE PINTURA

Located southwest of “Los Colorados”, the Serrania comprises a series of hills with a maximum altitude of 600 m asl. Some parts have been destroyed for cattle ranching and agriculture (yucca,

corn and pepper). The study site comprised one parcel in the higher part of the serranía (~400 ha), and two parcels in the middle (100 and 150 ha). The forest fragments are separated by grasses and cultivation. This region is characterized by humidity, and fog is frequent in the morning and evening. Habitats in this area include: hillside vegetation located along 40-60% slopes, and continuous canopy that reaches 30 m with emergent trees exceeding 40 m, especially *Pterigota colombiana*. Other species include: *Spondias, Bursera simaruba, Sorocea, Hura crepitans* and *Ceiba pentandra*. Vegetation typical of humid areas is present in lower parts, such *Calathea* and *Heliconia,* and some small islands between these of *Tabebuia* and *Sterculia apetala*. Along the watercourses, gallery forest is dominated by species such as *Anacardium excelsum* and hillside forest.

METHODS

After receiving reports that guans occurred in the Sanctuary from Park Guards and Biologist Rafael Borja we initiated searches there in October and November 1997 but did not encounter any birds. We continued to visit the Sanctuary in April, June, July, August and October 1998, still without encounters.

Rural people reported guans occurring in fragmented forest in the Serrania, southwest of the Sanctuary (2 hr by road). In January 1998, we verified presence of the guans (three individuals observed in the higher region). Between March 1999–March 2000 we sampled from 4–7 days in duration.

During searches for guans in the Sanctuary we ran 28 transects utilizing a pre-existing trail system that totaled 7 km in length. In the Serrania we ran transects along trails of 800 and 340 m in length, and two creeks of 180 and 800 m in length. At the Serrania we ran 30 cencuses along 0.32 km transect, 28 along a 0.8 km transect, 4 along a 0.12 km transect, and 4 along another 0.8 km transect. In total, 2.04 km of 4 transects were cencused 66 times (35.9 km total). The transects in both regions were measured by counting steps.

The transects were run 0600-1000 hr and 1500-1800 hr, at a speed of 1 km/hr, with stops made for each sighting. At the moment we observed the guans, we collected the following data: number of individuals, perpendicular distance of each individual in relation to the transect, height of each individual in the vegetation, distance from the transect starting point, vegetation height, and behavioral observations (social, dietary or reproduction).

For the population cencus we utilized the variable length method of King (Silva and Strahl 1991, Strahl and Silva 1998). We recorded a distance L from an area A to estimate the population size. We counted the number of guans (n) and recorded the perpendicular distance of the individual from the transect. The formula for this method is:

$$D = \frac{n}{2 * X * \sum L}$$

where:
D = Estimated population density
n = Number of birds observed during all transect runs
X = Perpendicular distance of the individuals observed in relation to the transect. In this case we used mean perpendicular distance (Xp mean), maximum perpendicular distance (Xp max) and maximum real (Xp max real) (National Research Council 1981, Chapman et al. 1988), with the objective of comparing densities for each sample.
∑L = Sum of the lengths of all transects recorded.

Between the months of March 1999 and March 2000 we interviewed 32 people ranging 15-70 yr, both at the Sanctuary (17) and the Serrania (15). The interview included information on forest use, the guan, and frecuenccy of its appearance in the rural portion of San Juan Nepomuceno.

POPULATION DENSITY

We estimated the density at 6.6-16.4 ind/km^2. There were three individuals occupying tranects 1 and 2, and these were constant throughout sampling. At transect 3, located in the middle part of the mountain and close to transects 1 and 2, we recorded another group of three individuals. At transect 4 there was a group of two individuals, for a total of 8 individuals in the study area. These data were used for comparisons with the results of estimated density. Using mean X_p we obtained an overestimate of 107% in relation to the 8 individuals registered through direct counts.

The precision of calculations based on linear transects depends on the perpendicular distance of the organism in question and also on how it was measured (Benett and Defler 1998). When the terrain is visibly difficult for estimating perpendicular distances, this affects the estimate. Distance estimates can also hampered by visibility of the habitat cencused and the intrinsic detectability of the animals, especially in relation to group size and dispersal (Chapman **et al** 1988), but these were not likely factors at the Serrania site.

FOREST USE AND GUAN UTILIZATION BY HUMANS

For this portion of the study people were surveyed, including on the property adjacent to the study area; 15 people were surveyed near the Sanctuary, and the 17 in the Serrania. The main activity which the people partake in is timber extraction, with 53.3% and 94.1% in the two areas, respectively. Hunting of wild fauna was minimal (6.7%, 5.9%), despite the primary utilization of guans being for food (80%, 58.8%) and pets (20%, 29.4%).

The last records of guans in the Sanctuary date from three years ago (Borja pers. comm. 1997, Inst. Alexander von Humboldt 1997, Ruiz et al. 1997), concordant with the information from the people surveyed - a period of 1-3 years since they last observed guans at this reserve. The guan is considered hardly common at the Sanctuary by 93.3 % of the interviewees (compared with common = 0%, and rare = 6.7%), suggesting a reduced population. We did not record any visual or auditory records of guans at the Sanctuary during the sampling regimes (1997-2000), indicating their possible disappearance from this area. The disappearance of the guans from the Sanctuary is likely due to human alteration of forest over a long period of time. The close proximity of the town of San Juan Nepomuceno facilitates easy access of people to the forest; this consequently led to conversion of the Sanctuary to pastoral and cultivated zones, as well as hunting wildlife with guns, traps and dogs, and timber extraction, both for fuel and construction, with trees having a mean DBH of 10-30 (Inst. Alexander von Humboldt 1997, Ruiz **et al** 1997). The Sanctuary is a relatively isolated fragment with barriers of artificial savannahs with cattle ranching. Therefore permanent long-term pressure on the guan population would result in local extinction of the species. This is likely what happened, as evidenced by the lack of records during this investigation.

In the Serrania the Guan is considered a common species according to the surveys we conducted (76.4%), and appears not to be diminishing in number, although numbers have not increased either, and appear to be stable over time. Perhaps this affirms very low or no recruitment in the guan population. The lack of an increase in the population may reflect activities of man, such as poaching nests to take the chicks for pets, which is a custom for people in this region. In the Serrania the fragments are not completely isolated, as corridors connect some fragments. However, the main threat is 100-300 Ha being reduced each time burning takes place to prepare land for cultivation, resulting in decreased guan populations. Multiple species requiring large areas to maintain viable populations will disappear as the forest disappears.

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PREMIOS
FINANCIAMENTOS
GRANTS

American Bird Conservancy (ABC) anuncia el fondo William Belton con una gran proporción de becas en apoyo a proyectos en América Latina y la región Caribeña. Propuestas deben ser enviadas a la oficina en Washington antes del 15 de Septiembre y las correspondientes decisiones serán anunciadas en Diciembre.

A American Bird Conservancy (ABC) anuncia o fundo William Belton, com um grande número de bolsas destinadas a apoiar projetos na América Latina e no Caribe. As propostas devem ser recebidas no escritório de Washington antes do dia 15 de Setembro, e as decisões serão anunciadas aos proponentes em Dezembro

The American Bird Conservancy (ABC) announces the William Belton Fund, with a high proportion of grants going to support projects in Latin America and the Caribbean. Proposals must be received in the Washington office before 15 September, and decisions will be announced to applicants in December.

American Bird Conservancy www.abcbirds.org

Anheuser-Busch y el National Fish and Wildlife Foundation han establecido un programa de becas denominado programa de becas Budweiser Conservation. Ellos proveerán 10 becas hasta de $10,000 dólares para estudiantes de licenciatura y graduados que estudien fauna silvestre y sus hábitats. Fecha límite 2 de Febrero.

A Anheuser-Busch e o National Fish and Wildlife Foundation criaram um programa competitivo de bolsas entitulado “The Budweiser Conservation Scolarship Program”. Este programa proverá 10 bolsas de US$ 10.000 para estudantes graduandos e graduados que estudam a vida selvagem e o seu hábitat. A data limite para o envio das propostas é 02 de fevereiro.

Anheuser-Busch and the National Fish and Wildlife Foundation have established a competitive scholarship program entitled the Budweiser Conservation Scholarship Program. They will provide 10 scholarships of up to $10,000 to undergraduate and graduate students studying wildlife and their habitat. Deadline is 2 February.

National Fish and Wildlife Foundation www.nfwf.org

Birdlife International (BL) , Fauna y Flora International (FFI) y British Petroleum Co. (BP) se unirán en el BP Conservation Program con el fin de apoyar y motivar equipos de estudiantes que organicen proyectos de investigación. Los premios son de £7000 para los mejores proyectos, £5000 para otros cinco proyectos, £3000 para 12 proyectos en marcha, y un gran premio “Follow up” cuyo valor es entre £10 000 y £20 000 para la mejor propuetas para continuar con trabajos previamente sometido por un previo ganador. Todos los proyectos que apliquen al programa para un premio deben: tener un componente conservacionista de importancia internacional, involucrar a la gente local en el sitio de estudio, tener anuencia del gobierno local, ser encabezado (y contener una mayoría) por estudiantes.

BirdLife International (BL), Fauna and Flora International (FFI), e a British Petroleum Co. (BP) se uniram no BP Conservation Program para apoiar e encorajar grupos de estudantes a organizar projetos de pesquisa. Os prêmios são de £7000 para o melhor projeto, £5000 para os outros cinco projetos, £3000 para os 12 projetos que ficaram em segundo lugar, e o grande prêmio 'Follow-Up', cujo valor fica entre £10,000-£20,000 são apresentadas as melhores propostas para os trabalhos apresentados pelos vencedores dos anos anteriores. Todos os projetos a serem apresentados para o programa e para receber o prêmio devem: ser reconhecidos como importantes para a conservação, envolver pessoas do local de estudo, ter a anuência do governo local, ser liderado por (e conter, na sua maioria, estudantes).

BirdLife International (BL), Fauna and Flora International (FFI), and the British Petroleum Co. (BP) come together in the BP Conservation Program to assist and encourage teams of students eager to organize research projects. The awards are £7000 to the best project, £5000 to 5 other projects, £3000 to 12 runner-up projects, and the top 'Follow-Up' Awards between £10,000-£20,000 are presented to the best proposals for follow-up work submitted by a previous year's winner. All projects applying to the Programme for an Award must: address a recognised conservation issue of international importance, involve people local to the study site, have clearance from the host government, be led by (and contain a majority of) students.

Marianne Dunn, BP Conservation Programme, BirdLife International, Wellbrook Ct., Girton Rd., Cambridge CB3 0NA, UK - http://www.bp.com/conservation

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Club 300 es una asociación Sueca sin fines de lucro que ofrece becas en el rango de $3000 a $8000 dólares para la protección de las aves. Las contribuciones de ese Club provienen directamente de los observadores de aves Suecos. Las aplicaciones son aceptadas anualmente y becas son también anuales. Envíe 4 copias de su aplicación por correo antes de las fechas límite 1 de enero y 1 de julio de cada año. No existe un formato específico requerido para las propuestas, pero se debe expresar apropiadamente los puntos de investigación del proyecto.

Club 300 é uma associação sueca sem fins lucrativos que provê bolsas entre US$ 3.000 e $ 8.000,00, para proteção das aves, com contribuições vindo diretamente dos observadores de aves suecos. Propostas são aceitas anualmente, e as bolsas liberadas para o ano da submissão. Envie quatro cópias da sua proposta, pelo correio, antes das datas-limite de de 01 de janeiro e 01 de julho de cada ano. Não se requere um formato específico para as propostas, mas elas devem expressar corretamente os pontos de vista do projeto apresentado.

Club 300 is a non-profit Swedish association that awards grants in the range of US$3,000 - $8,000 for the protection of birds, with contributions coming directly from Swedish birdwatchers. Applications are accepted on an annual basis, and grants awarded for that year. Submit 4 copies of the application by post before the deadlines of 1 January and 1 July of each year. There is no specific project proposal format required, as long as it properly expresses the viewpoints of the project.

Mikael Rosen, The Club 300 Foundation for Bird Protection, Department of Animal Ecology, Ecology Building, 223 62 LUND, Sweden, Tel: +46 (0) 706 059 772, Email: birdprotection@club300.se

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El Sophie Danforth Conservation Biology Fund, establecido por el Roger William Park Zoo y por Rhode Island Zoological Society in 1989, apoya programas de conservación que protejan a la fauna silvestre y sus hábitats. Estudios de campo y otros proyectos que demuestren un enfoque multidisciplinario para la conservación de la biodiversidad y los ecosistemas, y proyectos que involucren colaboraciones binacionales reciben prioridad para los fondos mayores. Son tambien sujetos de apoyo, programas de educación ambiental, desarrollo de técnicas que puedan ser usados en ambientes naturales, y programas de reproducción en cautiverio que impliquen un enfoque integral para la conservación.

O Sophie Danforth Conservation Biology Fund, instituído pelo Roger William Park Zoo e o Rhode Island Zoological Society em 1989, apóia programas de conservação que protegem a vida selvagem e os hábitats ameaçados ao redor do mundo. Trabalhos de campo e outros projetos que demonstrarem uma abordagem multi-disciplinar para a conservação da biodiversidade e dos ecossistemas e projetos que envolvam a colaboração de pessoas do país onde se desenvolve o projeto receberão a mais alta prioridade para financiamento. Programas de educação ambiental, desenvolvimento de técnicas que possam ser usadas no ambiente natural e programas de reprodução em cativeiro que possuam uma abordagem conservacionista também são apropriados.

The Sophie Danforth Conservation Biology Fund, established by the Roger Williams Park Zoo and the Rhode Island Zoological Society in 1989, supports conservation programs that protect

threatened wildlife and habitats worldwide. Field studies and other projects that demonstrate a multi-disciplinary approach to biodiversity and ecosystem conservation and projects that involve in-country collaborators receive the highest funding priority. Environmental education programs, development of techniques that can be used in a natural environment, and captive propagation programs that stress an integrative approach to conservation are also appropriate.

Stacia Martin, SDCBF, Roger Williams Park Zoo, 1000 Elmwood Ave., Providence, Rhode Island 02907, USA, Fax: (401) 941-3988, E-mail: SMartin@rwpzoo.org

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El prémio anual Joseph Grinnell será presentado por la Sociedad Ornitológica Cooper. Dos premios de hasta $1000 se otorgarán en la memoria de Joseph Grinnell, para apoyar la investigación básica en cualquier aspecto de la biología de aves. Proyectos sobre conservación y biología de aves deben de ser dirigidos al Comité de Premios Mewaldt-King, de la Sociedad Ornithológica Cooper. Estudiantes no podran presentar dos propuestas a ambos comités en el mismo año. Sólo estudiantes graduados o ya aceptados en programas de maestría o doctorado serán elegibles para este prémio. Solo se recibirán facsímiles y sumisiones electrónicas de personas interesadas en esta becas y que residan fuera de los Estados Unidos.

O prêmio anual Joseph Grinnell Student Research Awards será concedido pela Cooper Ornithological Society. Até dois prêmios de US$ 1.000,00 serão entregues, em honra da memória de Joseph Grinnell, para apoiar pesquisa básica em qualquer aspecto da biologia das aves. Projetos enfocando aspectos conservacionistas devem ser enviados ao comitê Mewaldt-King Research Awards, da Cooper Ornithological Society. Estudantes não podem submeter propostas a ambos os comitês no mesmo ano. Apenas estudantes de pós-graduação são elegíveis para o prêmio. Inscrições por fax ou e-mail serão aceitas apenas para pessoas residentes fora dos EUA.

The Joseph Grinnell Student Research Awards will be presented by the Cooper Ornithological Society. Up to two $1000 awards are designated, in the memory of Joseph Grinnell, to support basic research in any aspect of avian biology. Projects that deal with conservation issues in avian biology should be directed to the Mewaldt-King Research Awards Committee of the Cooper Ornithological Society. Students may not submit a proposal to both award committees in the same year. Only graduate students accepted to or enrolled in a Master's or Doctoral program are eligible for the award. Faxes and electronic submissions will only be accepted from those applying outside the United States.

Dr. John Faaborg, Chair, Mewaldt-King Award Committee, Division of Biological Sciences, 110 Tucker Hall, University of Missouri-Columbia, Columbia, MO 65211-7400, faaborgj@missouri.edu, http://www.cooper.org/awards.htm

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Idea Wild es una ONG no lucrativa que apoya proyectos de conservacion en America Latina y el Caribe mediante la donacion de equipo. Para obtener su apoyo se debe enviar una propuesta (preferentemente en ingles) indicando por que se necesita el equipo para el proyecto, una descripcion completa del equipo incluyendo numero de telefono y fax de la compania que lo comercia, asi como el numero de catalogo y el precio al publico.

Idea Wild é uma organização não-governamental que apóia projetos de conservação na América Latina e no Caribe, mediante a doação de equipamento. Para obter este apoio deve-se enviar uma proposta (de preferência em inglês), indicando a necessidade de determinado equipamento

para o projeto, uma descrição completa do equipamento, incluindo número de telefone e fax da empresa que o comercializa, assim como o número de catálogo e o preço final do produto.

Idea Wild is a non-profit organization that provides equipment for conservation projects in Latin America and the Caribbean. To obtain support from Idea Wild write a proposal (preferably in English) indicating why the equipment is needed for the project, a full description of the equipment, including phone and fax number of the company that distributes the equipment, as well as the catalogue number and list price.

Idea Wild, Biodiversity Research Assistance Organization, 420 Riddle Drive, Fort Collins, CO 80521, USA - ideawild@lamar.colostate.edu - www.feist.com/~ideawild

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La International Foundation for Science (IFS) proporciona apoyo a jóvenes científicos de países en vías de desarrollo a través del otorgamiento de becas de investigación y servicios adicionales tales como becas para el viaje y ayuda adquisitiva. La beca de investigación se otorga hasta por un monto de $12,000 dólares para un periodo de uno a tres años y puede renovarse dos veces. La beca es para la compra de equipo, viáticos y literatura. Los solicitantes deben ser ciudadanos de, y llevar a cabo la investigación en un país en vías de desarrollo. Ellos también deben trabajar en una universidad o una institución de investigación nacionales en un país en vías de desarrollo (Argentina y Uruguay no califican para este apoyo), así como también tener una edad menor a 40 años al inicio de su carrera de investigación. Candidatos deben poseer un alto grado académico que debe ser por lo menos Maestría o equivalente. El IFS apoya proyectos relacionados con el manejo, uso y conservación de los recursos naturales.

A International Foundation for Science (IFS) proporciona apoio para jovens cientistas de países em desenvolvimento através do fornecimento de bolsas de pesquisas e outros serviços, como ajuda de custos para viagem e auxílio para compra de material. As bolsas devem ter um valor máximo de $12,000 dólares para um período de um a três anos, podendo ser renovada por duas vezes. Esta bolsa pode ser utilizada para compra de equipamentos, gastos com material e literatura. Os interessados em submeter os projetos devem ser de, e conduzir as suas pesquisas em um país em desenvolvimento. Eles devem também trabalhar em uma universidade ou centro nacional de pesquisas em um país em desenvolvimento (Argentina e Uruguai não estão qualificados para receber este apoio), bem como possuir idade inferior a 40 anos no início da sua carreira de pesquisador. Os candidatos devem possuir um alto grau acadêmico, que deve ser de Mestrado ou equivalente. O IFS apóia projetos que tratam sobre o manejo, uso e conservação de recursos naturais.

The International Foundation for Science (IFS) provides support to young scientists of merit in developing countries by awarding research grants and providing grantees with additional services such as travel grants and purchasing assistance. Research grants are awarded up to a maximum value of $ 12,000 USD for a period of one to three years and may be renewed twice. They are intended for the purchase of equipment, expendable supplies, and literature. Applicants must be citizens of, and carry out the research in, a developing country. They should also work at a university or national research institution in a developing country (Argentina and Uruguay do not qualify for support), as well as being under the age of 40 and at the start of their research career. Candidates must possess a higher academic degree, which should be at least an MSc or equivalent. The IFS supports projects dealing with the management, use, and conservation of biological resources.

IFS, Grev Turegatan 19, S-114 38 Stockholm, Sweden, Fax: +46-8-54581801, Email: info@ifs.se, www.ifs.se

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El Lincoln Park Zoo Scott Neotropic Fund financia proyectos de investigación en biología de la conservación en América Latina y el Caribe. Los fondos son para apoyar principalmente a estudiantes graduados y a otros investigadores jóvenes, y se otorgan entre 5- 15 proyectos cada año. Los premios a otorgarse raramente sobrepasan los US$7500, y la mayoría de premios están en el rango de $3000-$6000. La fecha límite para presentar las propuestas al fondo Scott Neotropic es el 1 de Septiembre

O Lincoln Park Zoo Scott Neotropic Fund apoia pesquisas de campo em biologia da conservação na América Latina e Caribe. O fundo enfatiza o apoio a estudantes de pós-graduação e jovens pesquisadores, patrocinando de 5 a 15 projetos por ano. Os patrocínios raramente excedem US$ 7.500,00, e a maior parte está entre US$ 3.000-6.000,00. A data limite para envio de propostas é 01 de setembro.

The Lincoln Park Zoo Scott Neotropic fund supports field research in conservation biology in Latin America and the Caribbean. The fund emphasizes the support of graduate students and other young researchers, supporting 5 - 15 projects each year. The fund awards are seldom greater than US$7500, and most awards fall in the range of $3000-$6000. The current deadline for receipt of Scott Neotropic proposals is September 1.

Lincoln Park Zoo, SNF/AA Funds, c/o Director of Conservation and Science, Lincoln Park Zoo, Chicago, IL 60614, USA. steveed@ix.netcom.com. www.lpzoo.com

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James Lynch Conservation Biology espera apoyar a un investigador que se involucre en asuntos de conservación en Centroamérica, particularmente (pero no exclusivamente) estudiantes graduados locales. El premio de $ 5000 es por competencia, basado en la importancia y viabilidad del trabajo propuesto. La fecha límite de aplicación es el 15 de junio. Los solicitantes deben someter una propuesta y presupuesto (no más de 8 páginas en total), reasumen y 2 cartas de recomendación.

O James Lynch Conservation Biology Fund espera apoiar um pesquisador que deseja trabalhar em assuntos de conservação na América Central, especialmente (mas não exclusivamente), estudantes de graduação locais. O premio de $5,000 dólares é competitivo, e é baseado na relevância e na viabilidade do trabalho proposto. A data final para submissão é 15 de Junho. Os interessados devem submeter uma proposta e um orçamento (que deve ter no máximo 8 páginas), resume e duas cartas de recomendação.

The James Lynch Conservation Biology Fund hopes to support an aspiring researcher examining conservation issues in Central America, particularly (but not exclusively) native graduate students. The $5000 award is competitive, based on the relevance and feasibility of the proposed work. The submission deadline is June 15. Applicants must submit a proposal and budget (no more than 8 pages total), resume, and 2 letters of recommendation.

The James Lynch Conservation Biology Fund, c/o Linda McCann, Smithsonian Environmental Research Center, Box 28, Edgewater, Maryland 21037, USA. Email: mccann@serc.si.edu

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El Fondo Miami Metrozoo Conservation & Research ofrece pequeñas becas para proyectos que promuevan la conservación de la vida silvestre y los ecosistemas naturales. La becas bianuales no exceden los $ 5,000 dólares. Fecha límite de aplicación 1° de marzo.

O Fundo de Conservação e Pesquisa do Zoológico de Miami providenciará pequenas verbas a projetos de conservação da vida silvestre e ecossitemas naturais. A verbas bianuais não excedem 5.000 dólares. Prazo final para requerimento é 1º de Março.

Miami Metrozoo Conservation & Research Fund awards small grants to projects promoting conservation of wildlife and natural ecosystems. The biannual grants are usually do not exceed $5000. Deadline for application submission is 1 March.

Phyllis Tamburello, Zoological Society of Florida – 305-255-5551

Becas de investigación en el Bosque humedo tropical son disponibles para investigadores que realizen trabajo en le sur este Peruano, uno de los bosque tropicales con una de las diversidades biologicas mas altas del mundo. La investigación se conducirá en el Centro de Investigaciones de Tambopata (TRC) y albergue Posada Amazonas, dos establecimientos manejados por Rainforest Expeditions. Científicos interesados en cualquier aspecto de la biología tropical son particularmente alentados a postular por estas becas pero se dará preferencia los proyectos que enfoquen vertebrados grandes o los impactos de ecotourism. TRC esta rodeado por extensiones grandes de bosque protegido que incluye bosque rivereño of de varzea, bosque de altura y rodales de bambú. Pozada Amazonas se ecuentra más cerca al pueblo fronterizo de Puerto Maldonado y está en una reserva establecida en 1988 por la comunidad nativa de Infierno or el grupo Ese' eja. Con el permiso de la comunidad de infierno se puede llevar a cabo estudios en los diferentes ecosystemas los cuales estan o han estado sujetos a differente impacto y presentan vegatacion en diferente estado de sucesion. Las becas proporcionan en forma gratuita casa, comida, y transporte a y de Puerto Maldonado. Facilidades similares tambien son otorgadas a asistentes de campo pero a estos se cobra un pago diario de $15 por día. Rainforest Expediciones pueden ayudar a localizar a ayudantes de campo peruanos si esto es requerído. Para postular por estas becas enviar su curriculum y una propuesta de estudio que no exceda de trees hojas.

Bolsas estão disponíveis para pesquisadores que trabalham no sudested do Peru, em uma das florestas mais ricas do mundo. As bolsas patrocinam projetos de pesquisa conduzidos em Tambopata Research Center (TRC) e Posada Amazonas Lodge (PAL), dois estabelecimentos gerenciados pela Rainforest Expeditions. Cientistas interessados em qualquer aspectos da biologia tropical são convidados a enviar seus projetos, mas a preferência é dada para estudos de grandes vertebrados ou sobre os impactos do ecoturismo. TRC é circundada por uma grande extensão de floresta protegida, incluindo várzea, terra firma e mata de bambu. PAL é próxima do povoado de Puerto Maldonado, e é uma reserva estabelecida em 1988 pela comunidade nativa de Infierno, ou grupo Ese'ja. Com a permissão da comunidade, estudos podem ser realizados em diferentes hábitats, que estão sujeitos a diferentes impactos e estágios sucessionais. As bolsas proporcionam, gratuitamente, alojamento, alimentação e transporte até Puerto Maldonado. Estas facilidades também podem ser proporcionadas aos ajudantes de campo, mas cobra-se uma diária de US$ 15,00. Rainforest Expeditions podem contatar ajudantes de campo peruanos, se necessário. Para concorrer a estas bolsas, enviar *curriculum* e uma proposta de estudo que não ultrapasse três páginas.

Rainforest Research Grants are available for researchers working in southeastern Peru in some of the world's richest lowland tropical forests. Grants support research conducted at Tambopata Research Center (TRC) and Posada Amazonas Lodge (PAL), two facilities operated by

Rainforest Expeditions. Scientists interested in any aspect of tropical biology are encouraged to apply, but preference is given to studies focusing on large vertebrates or the impacts of ecotourism. TRC is surrounded by large expanses of protected forest including floodplain, terra firme and bamboo forest. PAL is closer to the frontier town of Puerto Maldonado and is on a reserve extablished in 1988 by the Ese' eja native community of Infierno. With permission of the community studies can be carried out on land with different habitats, impact regimes and successional states. The grants provide free room and board, and free transportation from Puerto Maldonado. Room and board is available to assistants at a rate of $15 per day and Rainforest Expeditions can help locate Peruvian Assistants if needed. To apply, send a resume and 3 or less page study proposal.

Donald Brightsmith, Duke University Dept. of Zoology – dbj4@duke.edu

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Rolex otorga becas de investigación para proyectos de investigación innovadores (no importa la nacionalidad) en áreas que incluyan exploración, descubrimiento y medio ambiente. Los premios constan de cinco becas de US $75,000 y un reloj Rolex de oro.

Prêmio Rolex para projetos inovadores (qualquer nacionalidade), em áreas que incluem exploração, descoberta e o meio-ambiente. São oferecidos cinco prêmios principais no valor de US$ 75.000 e um relógio de pulso Rolex de ouro.

Rolex awards grants for innovative projects (any nationality) in areas that include exploration, discovery, and the environment. Awards consist of five top prizes of US$75,000 and a Rolex gold watch.

The Secretariat, The Rolex Awards for Enterprise, PO Box 1311, 1211 Geneva 26, Switzerland, or visit http://www.rolexawards.com.

La Royal Society for the Protection of Birds (RSBP) tiene disponible una limitada suma de dinero para pequeñas becas. Estas becas que no deben exceder los $ 1,500 dólares, son específicas para la investigación y prospección de las aves más raras del mundo. La prospección o investigación deben enfocarse sobre especies de los siguientes grupos: especies que no ocurren en áreas conservadas, especies reconocidas como "Críticas" o con "Datos Deficientes" en el libro "Treatened Birds of the World". Prioridad será canalizada hacia los socios de Birdlife u otros trabajando en sus propios países, o en países vecinos los cuales no tienen un socio. Las propuestas deben ser enviadas integralmente con una justificación, descripción clara de las metas y métodos del proyecto, y una indicación de cómo el proyecto ayudará a la conservación de las especies.

A Royal Society for the Protection of Birds (RSPB) tem disponível uma limitada quantia em dinheiro para pequenas bolsas. Estas bolsas, que não devem exceder $1,500 dólares são específicas para pesquisas ou estudos com as aves mais ameaçadas do mundo. O projeto de pesquisa deve enfocar em espécies agrupadas nos seguintes grupos: espécies que não ocorram em áreas conservadas ou aquelas listadas como "Crítica" ou "Data Deficient" no livro "Threatened Birds of the World". Prioridade sera dada aos trabalhos realizados pelos parceiros da BirdLife, ou outros trabalhando em seu próprio país ou em países vizinhos que não são parceiros da BirdLife. As propostas devem ser submetidas integralmente com a sua justificativa, uma clara descrição dos objetivos e métodos do projeto e uma indicação de como o trabalho irá auxiliar na conservação das espécies.

The Royal Society for the Protection of Birds (RSPB), has available a limited sum of money to award as small grants. These grants, not to exceed US$1500, are specifically for research or surveys of the world's rarest birds. The survey or research project must focus on species falling into one of the following groups: species with no currently known occupied sites, or species listed as "Critical" or "Data Deficient" in "Threatened Birds of the World". Priority will be given to work carried out by BirdLife Partners, or others working in their own countries, or in neighboring countries which do not have a Partner. Full proposals should be submitted with full justification, a clear description of the aims and methods of the project, and an indication of how the work will aid the conservation of the species.

Dr Paul Donald, RSPB, The Lodge Sandy, Bedfordshire SG19 2DL,UK. Tel: ++44-1767-680551, Fax: ++44-1767-682118.

El premio de investigación Pamela y Alexander F. Skutch de la Association of Field Ornithologists apoya estudios sobre la historia natural de las aves, especialmente las relaciones sociales y reproducción de especies poco conocidas del Neotropico Continental, incluyendo Trinidad y Tobado que causen un mínimo de disturbio a las aves. La beca otorgada por el fondo debe ser adecuada para el estudio y evitar la busqueda de fondos adicionales. El investigador puede ser un ornitólogo amateur o profesional de cualquier nacionalidad. Es deseable que el o ella tenga previa experiencia de la región y de las aves (y si posible, la localidad) donde el o ella estudiarán. Un premio hasta de $ 10,000 dólares estará disponible anualmente. Los interesados deben enviar, antes del 15 de Febrero, una forma de aplicacióna completa (más detalle con Elissa Landre), un resúmen de una página, una carta de recomendación, y una propuesta de investigación (máximo tres páginas a doble espacio).

O prêmio de pesquisa Pamela and Alexander F. Skutch, da Association of Field Ornithologists apoiam o estudo da história natural das aves, especialmente as relações sociais e a reprodução, de aves pouco conhecidas na porção continental da região Neotropical, incluindo Trinidad e Tobago, que causem um mínimo de perturbação às aves. A premiação com as bolsas pelo Fundo deve ser adequada para que o projeto evite procurar por outras fontes de financiamento. O pesquisador deve ser um ornitólogo amador ou profissional de qualquer nacionalidade. É desejável que ele ou ela tenha uma experiência prévia com a região e suas aves (e, se possível, com a localidade) onde ele ou ela irão pesquisar. Uma bolsa de cerca de $10,000 dólares será disponibilizada anualmente. Os interessados devem submeter, até 15 de Fevereiro, o formulário completo (mais detalhes com Elissa Landre), um resumo de uma página, uma carta de referencia e uma proposta de pesquisa (com, no máximo, três páginas em espaço simples).

The Pamela and Alexander F. Skutch Research Award from the Association of Field Ornithologists supports the study of avian life histories, especially social relations and reproduction, of little known birds of the Continental Neotropics including Trinidad and Tobago, with a minimum of disturbance. The award of grants from the Fund should be adequate for the intended study to avoid the need to seek additional funding elsewhere. The grantee may be an amateur or professional ornithologist of any nationality. It is highly desirable that he or she has some previous experience of the region and birds (and if possible, the locality) where he or she will study. The award of grants from the Fund should be adequate for the intended study to avoid the need to seek additional funding elsewhere. The grantee may be an amateur or professional ornithologist of any nationality. It is highly desirable that he or she has some previous experience of the region and birds (and if possible, the locality) where he or she will study. One award of up to $10,000 will be awarded annually. Applicants must submit, by February 15, a completed application form (see below), a one-page resume, one letter of reference, and a research proposal (maximum 3 single-spaced pages).

Elissa Landre, Director, Broadmoor Wildlife Sanctuary, Massachusetts Audubon Society, 280 Eliot St., Natick, MA 01760 Phone: (508) 655-2296 x7301. elandre@massaudubon.org

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WCS (Wildlife Conservation Society) ofrece pequeñas becas á individuos que propongan proyectos de investigación de campo en temas como la conservación de hábitats y fauna amenazada y en peligro. El Programa de becas de la WCA es coordinado a través del programa Latinoamericano de la WCS. Las becas no deben exceder los $20,000. La fecha límite para la presentación de propuestas es el 1 de enero y julio 1 de cada año. Organizaciones no son elegible para financiamiento. Aplicaciones pueden ser obtenidas de la internet usando un formato PDF en: http://www.wcs.org/science/ conservationbio/rfp.pdf

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World Nature Association, PO Box 673, Silver Spring, MD 20918-0673, EEUU, Fax: (301) 593-2522

OPORTUNIDADES PARA DE INVESTIGACION
OPORTUNIDADES DE PESQUISA
RESEARCH OPPORTUNTIES

Localizada en Península de Osa, en la Provincia de Puntarenas, Costa Rica, la Reserva biológica del Marenco ofrece oportunidades para la conducción de investigación, cursos y excursiones relacionado con fauna y flora eotropical. Ecelentes oportunidades para investigación en aves migratorias y residentes en diferent habitats tales como bosque de litoral, bosque seco achaparrado, ríos, mangles, etc. Un limitado apoyo logístico es disponible.

Localizada na Península de Osa, Província de Puntarenas, Costa Rica, a Reserva Biológica Marenco oferece oportunidades para a realização de pesquisas, cursos ou excursões voltadas à fauna e flora neotropicais. Há excelentes oportunidades para pesquisa sobre aves residentes e migratórias em diferentes habitats, incluindo a zona costeira, floresta, capoeira, rios, manguezais, etc. Suporte logístico limitado disponível.

Located on the Osa Peninsula, Puntarenas Province, Costa Rica, the Marenco Biological Reserve offers opportunities to conduct research, courses or excursions related to Neotropical fauna and flora. Excellent opportunities for avian research and observation in different habitats, including coastline, forest, scrub, rivers, mangroves, etc. Limited logistical support available.

Lucia de la Ossa and Pablo Riba, Resident Biologists. Fax: (506) 771-1834. marenco@sol.racsa.co.cr

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Ubicada a aproximadamente 2 horas al NO de Quito en la cara oeste de los Andes, Maquipucuna Reserva invita a visitantes pora el desarrollo de acitividades de ecotourismo e investigación. Un numero aproximado de 320 especie del aves han sido registrados en el area de 4500 ha que constituyen la reserva, (80% de esta es bosque montano muy pristino entre los 1200 - 2800 m asl rodeado por 14,000 ha de zona de amortiguamiento adyacente a el ecosystema del Chocó el cual es considerado entre los 10 ecosystemas con mayor diversidad biologica del mundo.

Localizada a cerca de 2 horas NW de Quito na vertente oeste dos Andes, a reserva Maquipucuna convida visitantes interessados em ecoturismo e pesquisa. Há pelo menos 320 espécies de aves na reserva de 4500 ha (80% floresta nebular não perturbada a 1200-2800 m), circundados por uma zona tampão protegida, adjacente ao bioma do Chocó (uma das 10 áreas com maior biodiversidade).

Located approx. 2 hr NW of Quito on the W Andean slope, Maquipucuna Reserve invites visitors for ecotourism and research. There are at least 320 bird species in this 4500 ha reserve (80% undisturbed cloud forest, 1200 - 2800 m asl), surrounded by 14,000 ha buffered protected forest, adjacent to Chocó biome (top 10 biodiversity hotspots).

Abigail Rome, Fundación Maquipucuna. Fax: 593-2-50720. abi@maqui.ecx.ec

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Localizada en el sur este del Perú, en el departamento de Madre de Dios, la Associación para la Conservación de la Selva Sur ofrece sitios para la investigación biológica el bosque humedo tropical y bosque montano. Facilidades para la investigación y us sistema de trochas estan disponibles para los investigadores. Nuevos sitios para la investigación están siendo desarrollados en los lagos de herradura y bosques montanos.

Located in SE Peru, the Dept. Madre de Dios, Associacion para la Conservacion de la Selva Sur offers sites in both foothills and mature lowland floodplain rainforest. Research facilities and a gridded trail system are currently available. Sites are being developed along a lowland oxbow lake and in montane cloud forest along the eastern Andean escarpment.

Associacion para la Conservacion de la Selva Sur. acss+@amauta.rcp.net.pe

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El Parque Estatal de Ilhabela, localizado en el litoral norte de Sao Paulo, Brasi, alberga una población aislada y aún no estudiada de *Pipile jacutinga*, además de aproximadamente 200 especies de aves. Apoyo logístico limitado disponible.

O Parque Estadual de Ilhabela, localizado no litoral norte de São Paulo, Brasil, abriga uma população insular de Jacutingas *Pipile jacutinga* ainda não estudada, além de mais de 200 outras espécies de aves. Apoio logístico limitado disponível.

Ilhabela State Park, on the north coast of Sao Paulo state, Brasil, holds a still unstudied island population of Jacutingas *Pipile jacutinga* in addition to over 200 bird species. Limited logistical support (lodging and transportaton) available.

Cristiane Leonel, Diretora do PEIB. Fax: +55 (124) 722660

El Centro de Investigaciones Iracambi de Mata Altántica, en el estado de Minas Gerais, Brasil, proporciona un laboratorio vivo para investigadores visitantes que deseen investigar problemas en ecologia del bosque tropical. Además de sus actividades de investigación, el Centro actúa como un punto focal en programas de manejo forestal con las comunidades locales, en los cuales investigación relevantes del Centro y de otros lugares es aplicada en políticas y prácticas de manejo sustentable. Este trabajo es llevado a cabo por Amigos de Iracambi, una organización no gubernamental.

O Centro Iracambi de Pesquisas da Mata Atlântica, no estado de Minas Gerais, Brasil, proporciona um laboratório vivo para pesquisadores visitantes que desejam pesquisar os problemas da ecologia da floresta tropical. Em adição a estas atividades de pesquisa, o centro atua como um ponto focal para o manejo florestal com as comunidades locais, nas quais as relevantes pesquisas, do Centro e de outros locais, são aplicadas na prática e nas políticas de desenvolvimento sustentável. Este trabalho é conduzido pela Amigos de Iracambi, uma organização não-governamental registrada.

The Iracambi Atlantic Rainforest Research Center, in the state of Minas Gerais, Brazil provides a living laboratory on a commercial basis for visiting researchers who wish to do research on problems of tropical forest ecology. In addition to its research activities, the Center acts as a focal point for a forest land management program with local communities, in which relevant research from the Center and elsewhere is applied in the development of sustainable land management practices and policies. This work is carried out by Amigos de Iracambi, a registered civil association (NGO).

Robin Le Breton, research@iracambi.com

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Research

Levels and drivers of fishers' compliance with marine protected areas

Adrian Arias[1], *Joshua E. Cinner*[1], *Rhondda E. Jones*[2,3] *and Robert L. Pressey*[1]

ABSTRACT. Effective conservation depends largely on people's compliance with regulations. We investigate compliance through the lens of fishers' compliance with marine protected areas (MPAs). MPAs are widely used tools for marine conservation and fisheries management. Studies show that compliance alone is a strong predictor of fish biomass within MPAs. Hence, fishers' compliance is critical for MPA effectiveness. However, there are few empirical studies showing what factors influence fishers' compliance with MPAs. Without such information, conservation planners and managers have limited opportunities to provide effective interventions. By studying 12 MPAs in a developing country (Costa Rica), we demonstrate the role that different variables have on fishers' compliance with MPAs. Particularly, we found that compliance levels perceived by resource users were higher in MPAs (1) with multiple livelihoods, (2) where government efforts against illegal fishing were effective, (3) where fishing was allowed but regulated, (4) where people were more involved in decisions, and (5) that were smaller. We also provide a novel and practical measure of compliance: a compound variable formed by the number illegal fishers and their illegal fishing effort. Our study underlines the centrality of people's behavior in nature conservation and the importance of grounding decision making on the social and institutional realities of each location.

Key Words: *Costa Rica; illegal fishing; livelihoods; marine reserve; poaching; poverty*

INTRODUCTION

Nature conservation is fundamentally about managing people. Consequently, the effectiveness of conservation interventions depends on people's compliance with regulations. However, noncompliance with environmental regulations is pervasive, as illustrated by the following examples. In the worldwide timber trade, roughly 20% to 50% of all timber is of illegal origin (INTERPOL and The World Bank 2010). Meanwhile, in the world's industrial fisheries, estimates of nearly 20% of reported catch being illegal are probably conservative (Agnew et al. 2009). At least 23,000 elephants were poached in 2013, with wide-ranging consequences including the decimation of elephant populations, large-scale corruption, and funding of militias (Vira and Ewing 2014). Poaching has ultimately militarized the struggle between poachers and rangers with deadly consequences: more than half of the world's ranger deaths can be attributed to poachers (IUCN 2014). Noncompliance with environmental regulations threatens not only the environment, but also social and economic prosperity.

Compliance with fisheries regulations has been recognized as a vital topic to be addressed to achieve marine conservation goals. Therefore, in this study, we consider compliance though the lens of illegal fishing in marine protected areas (MPAs), which are increasingly used for conservation and fisheries management. International commitments to marine conservation aim to effectively conserve 10% of the world's coastal and marine areas (CBD 2010), although Devillers et al. (2015) and others have criticized broadly based percentage targets. Regardless of extent and location, however, the effectiveness of MPAs relies largely on users' compliance, particularly that of fishers, because fishing can profoundly degrade global marine ecosystems and biodiversity (Pauly et al. 2002). The mere presence of an MPA does not guarantee fishers' compliance, and its effectiveness can be eroded by illegal fishing. Indeed, ecological performance of MPAs has been clearly linked to compliance (Pollnac et al. 2010, Bergseth et al. 2013).

Despite the crucial importance of compliance for effective MPA management, little empirical research has attempted to investigate compliance with MPAs. Studies in other contexts have examined compliance, for example in hunting (Muth and Bowe 1998, Lindsey et al. 2013) and fisheries (Raakjær et al. 2003, King and Sutinen 2010, Sundström 2012). Although these studies provide useful information that could be applied to MPAs, their transferability is limited because of the different contexts. Further, although some studies have focused on measuring or understanding fishers' compliance in MPAs (Wood 2004, Peterson and Stead 2011, Read et al. 2011, Arias and Sutton 2013, Arias et al. 2014), the current literature and evidence base on compliance levels and, importantly, the factors that influence fishers' compliance with MPAs remain limited (Peterson and Stead 2011, Bergseth et al. 2013). The theoretical concepts underpinning compliance have been recently reviewed in the broader context of nature conservation (Arias 2015), but compliance with MPAs is linked to complex social and institutional interactions (e.g., rules, socio-demographics, and enforcement) that are context dependent.

Illegal fishing, either inside or outside MPAs, is a very broad topic, encompassing, for example, gear types, target species, regulations, and socioeconomic characteristics of regions where illegal fishing takes place (Arias 2015). This heterogeneity implies that we should not expect to find simple, generalizable solutions to noncompliance. Successful management interventions are typically characterized by responses that are adequate for the local socioeconomic and institutional realities (Waylen et al. 2010). It can be expected, therefore, that global progress in minimizing illegal fishing can be achieved through the multiplication of well-designed and locally relevant interventions that consider contextual factors (Petrossian 2015). Compliance management should be informed by a thorough understanding of factors that influence compliance in specific settings. Managers can then foster positive factors (e.g., high perceived legitimacy for institutions) and mitigate negative ones (e.g., weak social barriers against undesired behaviors).

[1]Australian Research Council Centre of Excellence for Coral Reef Studies, James Cook University, [2]College of Marine and Environmental Sciences, James Cook University, [3]Australian Institute of Tropical Health and Medicine, James Cook University

Table 1. Marine protected areas (MPAs) included in the study and key characteristics. Caletas-Arío and Camaronal were considered as one MPA, as explained in the Methods.

Managing institution	Coast	Name	Fishing permitted	Year created	Area (km^2)	Clear geographic boundaries [‡]
SINAC	Caribbean	Cahuita	Yes [†]	1970	233.0	No
SINAC	Pacific	Santa Rosa	No	1971	464.0	No
SINAC	Pacific	Manuel Antonio	No	1972	420.2	No
SINAC	Pacific	Cabo Blanco	No	1982	16.3	No
SINAC	Pacific	Ostional	Yes	1983	80.6	No
SINAC	Caribbean	Gandoca-Manzanillo	Yes	1985	49.8	No
SINAC	Pacific	Marino Ballena	No	1990	52.3	No
SINAC	Pacific	Caletas-Arío	Yes	2006	198.5	No
SINAC	Pacific	Camaronal	Yes	2009	160.3	No
INCOPESCA	Pacific	Palito-Montero	Yes	2009	6.3	Yes
INCOPESCA	Pacific	Golfo Dulce	Yes	2010	750.0	No
INCOPESCA	Pacific	Isla Caballo	Yes	2012	1.3	No

[†] Legally, fishing is not allowed in Cahuita (Asamblea Legislativa 2005); however, SINAC allows local fishermen to fish in certain areas within the Park, although gillnets are not allowed.
[‡] Boundaries that are easy to locate accurately, and are undisputed by the community.

INCOPESCA indicates Instituto Costarricense de Pesca y Acuicultura; SINAC, Sistema Nacional de Áreas de Conservación.

Here, we use MPAs in Costa Rica as a case study to analyze factors influencing fishers' compliance. MPAs in Costa Rica are affected by illegal fishing (Salas et al. 2012), which we define here either as fishing done in MPAs where fishing is not permitted, or breaking fishing regulations where fishing is permitted, e.g., using gillnets where they are not allowed (Table 1). Apart from Cocos Island National Park (Arias et al. 2014), there are no scientific studies focusing on illegal fishing in Costa Rican MPAs. We investigated illegal fishing within 12 MPAs in Costa Rica (Table 1) to answer two research questions. First, what are the levels of fishers' compliance in each MPA? Second, what is influencing fishers' compliance levels? These two questions are key for understanding and managing compliance (Arias 2015). Our broad goal is to help direct and tailor management efforts that increase conservation effectiveness. The methods used here could also be applied to other areas, where our results could help contextualize compliance.

MPAs in Costa Rica

Costa Rica has 31 MPAs, only 2 of which are offshore. Three MPAs are in the Caribbean and the rest are in the Pacific. All MPAs are managed by the state. The Ministry of Environment manages 23 MPAs through the National System of Conservation Areas (Sistema Nacional de Áreas de Conservación, or SINAC), and the fisheries authority (Instituto Costarricense de Pesca y Acuicultura, or INCOPESCA) manages the remaining 8 MPAs. MPAs managed by SINAC are patrolled by the Coast Guard and SINAC, and MPAs managed by INCOPESCA are patrolled by the Coast Guard. INCOPESCA has no patrolling mandates but can sanction noncompliance administratively. However, INCOPESCA's fisheries management, including sanctioning processes, is weak. For example, audits done by the Comptroller General found that INCOPESCA has not implemented bag and size limits, temporary and spatial closures are not science based, and the fishery database is outdated (CGR 2012, 2014). INCOPESCA's mismanagement has contributed to the impoverished state of fisheries and fishing communities in Costa Rica, sparking multiple calls for intervention and restructuring (Frente por Nuestros Mares 2013, Comisión Presidencial para la Gobernanza Marina 2012).

SINAC's approach has historically been top-down and includes no-take management categories, leading to MPAs that can disenfranchise fishers (Solis et al. 2012). Since the mid-1990s, SINAC opted to establish MPAs that would allow fishing and created new, more permissive management categories in 2008 (Salas et al. 2012). Similarly, in 2008, INCOPESCA created a type of MPA called a "responsible fishing area." Responsible fishing areas aim for fisheries sustainability and involve a bottom-up approach by which fishing communities propose an area and a management plan to INCOPESCA. Compared with traditional top-down approaches, responsible fishing areas have been generally well received by several artisanal fishing communities (Fargier et al. 2014). Recent marine conservation efforts in Costa Rica, both from SINAC and INCOPESCA, aim to involve stakeholders in decision making. However, still lacking is a strong governance system that allows balanced participation and adequate conservation (Comisión Presidencial para la Gobernanza Marina 2012, Solis et al. 2012, Jimenez-Ramón 2015). The country lacks clear policies that integrate sustainable use, conservation, navigation and ports, and safety at sea (Comisión Presidencial para la Gobernanza Marina 2012). The weak legal and governance system can foster noncompliance, for instance through inadequate legislation and enforcement (Arias et al. 2014), or low perceived legitimacy of management institutions (Levi et al. 2012).

METHODS

Study sites

We studied 12 coastal MPAs in Costa Rica, which at the time of sampling represented 46% of Costa Rica's coastal MPAs, each with different characteristics (Table 1 and Appendix 1). MPAs were chosen purposely to provide a varied sample in terms of size, year created, location, and whether fishing was allowed or not. These characteristics have been described in the literature as factors likely influencing compliance with MPAs (Andrade and Rhodes 2012).

Although Table 1 lists 12 MPAs, the Caletas-Arío and Camaronal MPAs were merged in the analyses because of (1) geographic proximity (Appendix 1); (2) lack of clear boundaries (Table 1);

(3) same regulations and similar size and age (Table 1); and (4) two artisanal fishing communities being located between them, with interviews revealing that fishers from the two communities fished both areas. For analysis purposes we averaged the age and size of these two MPAs.

Questionnaires and key informant interviews

Data collection was through questionnaires and key informant interviews, from February to April 2014. The survey was designed to collect information to address each research question; Table 2 summarizes the data and their purpose. Questionnaires were mostly quantitative, and respondents were artisanal fishermen and tourism operators, including those involved in sport fishing. These two stakeholder groups were selected because they spend considerable time on the water, giving them a good idea of the reality of each location. The questionnaires were conducted in communities adjacent to MPAs. We selected questionnaire respondents using snowball sampling, and convenience sampling at beaches, fish landing sites, marinas, and tourism companies. Key informant interviews were semistructured and were used to validate the information received from the questionnaires. Key informants included government staff (Coast Guard, INCOPESCA, and SINAC), managers of tour companies, community leaders, leaders of fishing associations, and researchers. Most key informants were contacted by telephone or email to arrange meetings. All interviews were conducted in person and in Spanish by AA, a Costa Rican.

Table 2. Individual and marine protected area (MPA) variables used to explain compliance, with corresponding research question (s) for each variable.

Level Variables	Metric	Research question
Individual level		
Number of people who fish illegally	Six-point scale	1-2
Frequency of illegal fishing	Six-point scale	1-2
Seen someone fish illegally in the MPA	Yes or no	1
Personally know someone who knowingly fished illegally in the MPA	Yes or no	1
Involvement in decision making	Not involved, passively involved, very involved	2
Support for MPA	Rated from 0 to 100	2
Effectiveness of government efforts against illegal fishing	Rated from 0 to 100	2
Fisherman or not	Yes or no	2
MPA level		
Size	Km^2	2
Type	Take or no take	2
Tourism levels	Number of hotel rooms in districts adjacent to MPA[†]	2

[†]Caballo was not considered part of a district because it is located approximately 8 kilometers from the coastline, and it is a small fishing community with no tourism industry.

Noncompliance is a sensitive behavior; therefore compliance studies are prone to response and nonresponse bias. Response bias arises when people give inaccurate answers; nonresponse bias occurs when people refuse to participate in surveys. We used several techniques to reduce these biases (see Arias 2015 for a review). First, when approaching potential interviewees, the interviewer identified himself as a student. Students can be considered neutral parties when compared with, for instance, government employees, and respondents can feel more comfortable when talking about sensitive behaviors with a neutral or impartial party (Roggenbuck 1992). Second, potential interviewees were told clearly that the questionnaire was anonymous. Anonymity reduces the "threat" of being accused of noncompliance. Third, the questionnaire started with nonsensitive questions and gradually increased their sensitivity. This allowed respondents to become accustomed to the interviewer and the interviewing process, rather than facing potentially confronting questions at the outset. Fourth, we used indirect questioning. Indirect questioning refers to the compliance behavior of others and not to that of the respondent; we therefore refer to it as "perceived compliance." This technique has been used for several decades and has been shown to reduce bias (e.g., the bias arising from answering in a way that that will be viewed favorably by the interviewer), allowing respondents to mask their own attitudes and behaviors through impersonality (Fisher 1993). Recent compliance studies in conservation contexts indicate the utility of perceived compliance (Arias and Sutton 2013, Cross et al. 2013), coinciding with findings from fields such as marketing (Jo et al. 1997). Additionally, studies have found correlations between perceived compliance and ecological health (Pollnac et al. 2010). Perceived compliance therefore appears to be an adequate proxy for actual compliance. Actual compliance can only be established by direct observation, making it infeasible in most cases. In this study we measured perceived compliance with fishery regulations in MPAs. By using these four techniques, it is likely that we reduced response and nonresponse biases.

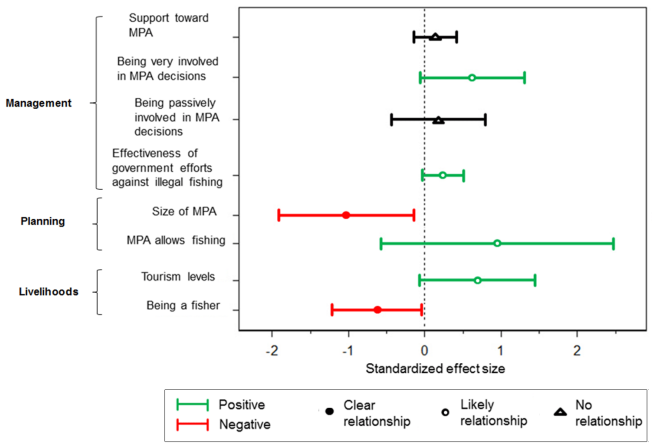
Compliance levels

Our first objective was to identify perceived compliance levels in each MPA. We used a composite measure of perceived compliance based on the number of illegal fishers and the frequency of illegal fishing. Including frequency is key because it provides a measure of illegal fishing effort (Arias 2015, Arias and Sutton 2013). For instance, the impact that five fishers have on an MPA would be very different if they fished every day versus only once a month. Preliminary analysis indicated that the number of illegal fishers and the frequency of illegal fishing were positively correlated (r_s (93) = .47, p = 0); hence, in areas where the number of illegal fishers was low, the frequency of illegal fishing also tended to be low, and vice versa. Because both variables measure compliance and they were moderately correlated, the values for each variable were converted to z-scores and summed to create the composite score for perceived compliance across interviewees for each MPA. A z-score is a score's relationship to the mean in a group of scores, given in standard deviations. Hence, a z-score for an individual MPA can be positive, negative, or zero, indicating whether it is above, below, or equal to, respectively, the MPA population mean. We elicited two additional metrics of perceived compliance by asking participants two proxy questions: (1) if they personally knew somebody who had knowingly fished illegally in the MPA and (2) if they had seen someone fishing illegally in the MPA within the last year. In Australia, Arias and Sutton (2013) found that fishermen who personally knew someone who intentionally fished illegally were more likely to have fished illegally themselves. We performed Mann-Whitney tests to assess if the compliance levels perceived by those who replied yes were different from the levels perceived by those who replied no to each of these two questions.

Factors influencing compliance

We used a linear mixed-effect model to quantify the influence on perceived compliance of three MPA- and eight individual-level predictor variables (Table 2 and Appendix 2). We used MPA as a grouping variable (random effect) to account for potential nonindependence of respondents within an MPA. Because there is evidence suggesting that respondents project their own beliefs and evaluations through indirect questioning (Fisher 1993), we hypothesized that individual-level variables (e.g., support of MPA, Table 2) can be related to the compliance levels perceived by respondents. We did not hypothesize or find a theoretical basis for examining interactions between predictor variables. Predictor variables were standardized using z-scores; this allowed direct evaluation, on the same scale, of their relative effects on perceived compliance levels. The variables included in the model were grouped into three categories: management, planning, and livelihoods (Fig. 1).

Fig. 1. Relationship between marine protected area (MPA) and individual variables and perceived levels of compliance. Circles and triangles represent the estimated effect of each variable. Bars represent 95% confidence intervals. Positive estimates are shown in green, negative are in red, and no effect is black. Filled red circles indicate a clear negative relationship to compliance; open green circles represent likely positive relationships to compliance (≥80% of the confidence intervals in a positive direction).



Tourism data were provided by the Costa Rican Tourism Institute in 2015. Data analyses were performed using SPSS version 20 (IBM, Armonk, New York, USA; http://www.ibm.com/) and S-PLUS version 8 (TIBCO Software, Palo Alto, California, USA; http://www.tibco.com/). Normality of modeled residuals was analyzed using Q-Q plots.

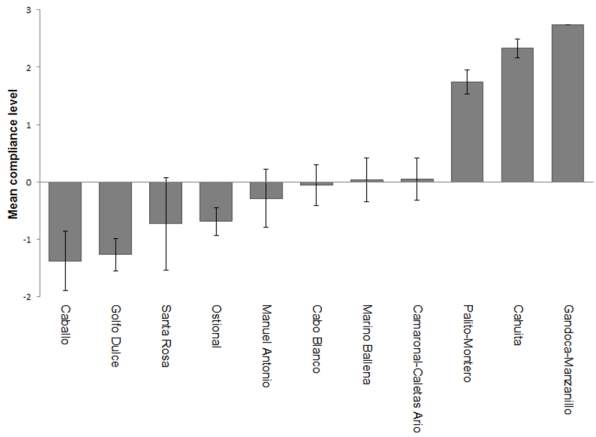
RESULTS

We collected a total of 99 questionnaires and 41 key informant interviews (Appendix 3). The response rate was 95% for the questionnaires and 100% for key informant interviews. All questionnaire respondents were male, mostly between 30 and 49 years old. Among the respondents, 63 relied exclusively on fishing (hereafter: fishermen), all of whom were associated with Pacific MPAs; 13 relied exclusively on tourism; and 23 had multiple livelihoods including fishing or tourism.

What were the levels of compliance in each MPA?

There was a high variability in perceived compliance levels between MPAs (Fig. 2). Levels of perceived compliance in Palito-Montero, Cahuita, and Gandoca-Manzanillo were above average (Fig. 2). The absolute number of illegal fishers was low to very low in Palito-Montero, Cahuita, and Gandoca-Manzanillo, and medium in all MPAs except for Caballo, where it was high. Illegal fishing occurred nearly every day in all MPAs except Palito-Montero, Cahuita, and Gandoca-Manzanillo. Qualitative key informant interviews did not diverge from the information received from the quantitative questionnaires and helped as validation.

Fig. 2. Mean perceived compliance level per marine protected area (MPA). Numbers on the y-axis indicate mean z-scores per MPA. Z-scores are standard deviations above or below the MPA population mean indicated by zero on the y-axis and representing the mean z-score across MPAs. Error bars indicate standard errors of the mean for each MPA, or variation between responses of interviewees for each MPA.



Sixteen percent of respondents said that they had not seen anyone fishing illegally within their corresponding MPA during the last year; 47% of these respondents were from Palito-Montero, Cahuita, and Gandoca-Manzanillo. Eighty-four percent of respondents mentioned that they had seen someone fishing illegally within the MPA during the last year, and 85% personally knew someone who intentionally fished illegally within the MPA. The compliance levels perceived by those who reported seeing someone fish illegally within the MPA during the last year were significantly lower than the compliance levels perceived by those who did not (mean = –0.2 and 1.3, respectively; U = 299.5, p = 0.002). The compliance levels perceived by those who reported personally knowing someone who fished illegally within the MPA were not significantly different from the compliance levels perceived by those who did not (mean = –0.08 and 0.17, respectively; U = 499.5, p = 0.44).

What was influencing compliance levels?

Key informants

The key informant interviews provided important insights into perceived compliance with MPAs. Key informants mentioned that poverty and the lack of livelihood alternatives were serious problems causing some of the illegal fishing. They also reported

a paucity of resources to patrol and adequately manage the MPAs. For instance, only Santa Rosa had a functioning patrol system operated by the park; the other areas either had no boats or the boats were inoperable (e.g., damaged, lack of funds, no qualified staff to operate them). Key informants mentioned that the Coast Guard had multiple duties and that illegal fishing was not a high priority compared with search and rescue and combatting drug trafficking. Lastly, there was a general belief that artisanal fishermen and government institutions interacted sparsely, and that this lack of communication should be corrected.

Linear mixed-effects model

The linear mixed-effects model (Fig. 1) revealed two predictor variables that had clear negative relationships with perceived compliance: size of the MPA and being a fisher. Additionally, four other variables indicated a likely positive relationship with perceived compliance: (1) tourism levels, (2) effectiveness of government efforts to combat illegal fishing, (3) MPAs that allowed some fishing, and (4) strong involvement in decision making. Support for MPAs and passive involvement in decision making (e.g., attending meetings but not participating in them) had no discernible relationship with perceived compliance. See Appendix 4 for additional figures.

DISCUSSION

Illegal fishing is a problem for many MPAs globally (Mora et al. 2006, Pollnac et al. 2010), and we found it present, at varying levels, in all of the MPAs that we assessed. Nearly all respondents had seen illegal fishing occurring inside MPAs and personally knew someone who intentionally fished illegally within an MPA. These responses provide a measure of descriptive social norms, i.e., what others do (Cialdini et al. 1991), suggesting that illegal fishing is common. Only three MPAs, Palito-Montero, Cahuita, and Gandoca-Manzanillo, had markedly high levels of perceived compliance (Fig. 2). Illegal fishing is of concern not only because of its likely negative environmental effects, but also because noncompliance can have a domino effect. If fishers believe that others are fishing illegally and perhaps are catching more fish (Appendix 2, Table A2.1), they are less likely to comply themselves, so compliance levels would continually decline (Cialdini et al. 1991, Arias 2015). For example, a participant from Cabo Blanco stated that most people used to respect the MPA, but government enforcement stopped and some free riders started fishing illegally. Illegal fishing then became so widespread that there was no noticeable difference between fishing inside versus outside of this small MPA.

It is often assumed that MPA compliance is associated solely with enforcement efforts. Enforcement is typically necessary, but not sufficient, to ensure compliance (Arias 2015). We found that government efforts against illegal fishing, normally considered as enforcement, can have a positive effect on perceived compliance; however, other variables were also related to perceived compliance (Fig. 1). Levels of perceived compliance were related to a range of socioeconomic and institutional conditions, some that are reasonably easy to influence and others that are more difficult to influence.

The compliance drivers easiest to influence include those associated with management, i.e., participation, support, and enforcement. Conservation is mostly about managing people, and approaches that are inclusive of stakeholders tend to be more successful than those that exclude stakeholders (Jentoft 2000, Schultz et al. 2011). A meta-analysis of 55 studies identified participation as a critical factor influencing compliance with protected areas (Andrade and Rhodes 2012). However, our results suggest that only the higher levels of involvement with MPA decisions were positively related to compliance. Simply supporting an MPA, or being weakly involved in decisions, seems insufficient to positively influence compliance (Fig. 1). In fact, some studies mention that participation can have negative outcomes, such as dilution of scientific input and "elite capture," a situation in which only some participate and displace others (Schultz et al. 2011). We did not collect information to further describe the participation processes and therefore cannot determine if some aspects of participation were eroding compliance in our study sites. It has been suggested that elite capture of participation applies in Golfo Dulce (Solis et al. 2012), and this might negatively affect compliance. Management interventions should be adaptive, aiming for high levels of participation that foster positive outcomes such as empowerment, legitimacy, and ultimately, increased compliance. Some of these positive outcomes can also be stimulated earlier through an MPA's planning process.

The compliance drivers associated with planning, such as size of the MPA and whether or not fishing is allowed, can be easy to plan for in advance, but can be difficult to change in existing MPAs, particularly when these changes require adjustments to laws that can take years to come into effect. Planning considerations such as MPA size, spacing, and location can also influence the achievement of ecological objectives (Green et al. 2014). However, there are critical trade-offs in planning between achieving compliance and achieving ecological objectives. Our results suggest that larger MPAs and those that were no-take had lower levels of perceived compliance (Fig. 1). Ecological considerations for planning MPAs commonly suggest that large, no-take MPAs are preferable to smaller ones because they can, for instance, encompass more habitats and highly mobile species, and offer higher levels of protection (Edgar et al. 2014, Green et al. 2014). However, larger MPAs can be harder to manage, and excluding fishing from coastal MPAs in developing countries is likely to create friction with fishing communities (Ban et al. 2011); hence, compliance and resultant ecological health are likely to weaken. Embedded in social-ecological systems in developing countries, smaller MPAs that allow regulated fishing tend to be more tractable. We believe that Costa Rica's moves to include permissive MPA management categories (e.g., responsible fishing areas) and increase stakeholder participation were steps in the right direction. However, further steps are required to significantly strengthen conservation planning, marine governance, and socioeconomic conditions in coastal areas.

We found two compliance drivers related to livelihoods, which are notoriously difficult to change in fishing communities (Hill et al. 2012, Cinner 2014). We found that relying solely on fishing had a clear negative relationship with perceived compliance, and increased levels of tourism had a likely positive relationship with perceived fishers' compliance (Fig. 1). We believe that tourism levels can serve as a proxy for livelihood options, at least in this study's context. Costa Rica has a strong nature-based tourism market; most tourists engage in ecotourism and nautical tourism, such as beach going, snorkeling, diving, and sport fishing (ICT 2015). High levels of tourism can generate more direct and indirect jobs. Protected areas are associated with reduced poverty

in Costa Rica (Andam et al. 2010), mainly through tourism (Ferraro and Hanauer 2014). Increased tourism can offer a wide diversity of livelihood alternatives, presenting fishermen with options for relying less on catch and hence, for some people, potentially reducing the motivations to fish illegally. Nevertheless, the economic activity around sites with high levels of tourism could also act as an incentive for some fishermen to stay in the fishery or fish more (Daw et al. 2012), e.g., to meet increased local demand for seafood. Therefore, the causal mechanisms through which tourism and associated livelihoods influence fishers' compliance are unclear. Although fishers' compliance with MPAs could potentially improve through more livelihood alternatives, we believe that this can be a challenging strategy that should be approached cautiously, and with objectives other than compliance with MPAs, e.g., poverty alleviation.

We identified steps toward informing and directing interventions to enhance conservation through increased compliance. At the time of sampling, we assessed perceived compliance with fisheries regulations in ~50% of Costa Rica's coastal MPAs. However, because our selection of MPAs was nonrandom, the ability to draw inferences outside our sample is limited. We provided a novel and improved way of measuring compliance: a compound variable formed by the number of people fishing illegally and a measure of their effort. Future studies could make further advances in two ways. First, more needs to be known about the mechanisms through which factors such as management, planning, and livelihoods influence compliance. Such studies would benefit from small geographical scales and large sample sizes. Second, conducting in-depth research in high-compliance sites would provide insights into key drivers of compliance. High compliance is the target behavior; therefore, areas with markedly high compliance (or "bright spots") can provide useful information on the factors that strengthen fishers' compliance. In the case of MPAs in Costa Rica, Cahuita, Gandoca-Manzanillo, and Palito-Montero seem to be bright spots (Fig. 2).

CONCLUSION

We found considerable levels of illegal fishing in multiple Costa Rican MPAs. However, there were sites with comparatively high levels of perceived compliance. Our study builds on previous research (Peterson and Stead 2011, Andrade and Rhodes 2012, Karper and Lopes 2014), adding information on the links between compliance, livelihoods, and participation in management of MPAs. However, the mechanisms through which participation and livelihoods affect compliance remain unclear, indicating an important area for future research. Our results suggest that MPA design can play an important role in fishers' compliance (Ban et al. 2011, Arias et al. 2014) and that enforcement is not a requirement for high compliance. Nevertheless, enforcement can help uphold compliance levels, especially in areas where there is a high dependence on fishing (e.g., Palito-Montero). Governments and conservation practitioners have a suite of tools to increase compliance. We identified several of these tools, along with some of the implications of using them. We emphasize, however, that adequate compliance interventions must be tailored to their particular contexts: There are no blanket solutions.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/issues/responses.php/7999

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Appendix 1. Interactive map of study sites - Requires Google Earth to open

Please click here to download file 'appendix1.kmz'.

Appendix 2. Additional methods, results, and discussion.

METHODS

MPAs were either long-established (24-35 years) or recent (less than 10 years). All recent MPAs allowed fishing (Table 1), so the effect of age group on compliance levels could only be tested in MPAs that allowed fishing, and preliminary analysis revealed no effect. Hence MPA age (Table 1) was excluded from the linear mixed-effect model.

To obtain additional information on factors influencing compliance we asked participants what they thought was driving compliance and noncompliance, ranking these responses according to the number of mentions.

RESULTS

Table A2.1 summarizes the salient factors that respondents thought influenced compliance (i.e., why fishermen follow MPA rules) and noncompliance (i.e., why fishermen break MPA rules).

Table A2.1. Three highest-ranked factors considered by respondents to influence compliance and noncompliance. n= number of mentions by respondents.

Rank	Compliance	Noncompliance
1	Afraid of sanctions (n=57)	Better/easier fishing in protected area (n=49)
2	Complying brings benefits (individual, communal, or environmental) (n=52)	Financial hardship (n=23)
3	Complying is the right thing to do (n=16)	Unlikely to get sanctioned (n=21)

DISCUSSION

The factors influencing compliance that were identified by respondents revealed that there is some degree of purposeful, voluntary compliance (Table A2.1). Voluntary compliance is preferable to coerced compliance because it can: 1) indicate that natural resource users are assertive about the benefits of regulating use of natural resources, 2) provide a buffer when costly enforcement is suspended, and 3) confirm effective governance and management (Arias, 2015). Some respondents believed that compliance involves environmental, personal, or communal benefits (Table A2.1). The fact that most respondents believed that fishing illegally in MPAs could be better or easier than fishing outside of them (Table A2.1), suggests that MPAs, despite varying amounts of illegal fishing, could contain higher fish biomass than the non-protected areas. Even though voluntary compliance is preferred, a degree of enforcement is typically necessary (Arias, 2015; Braithwaite & Braithwaite, 2001; Tyler, 2003) to maintain deterrence and compliance (Table A2.1). We therefore consider that if the deficit of enforcement efforts detected in most of these sites were to continue, or deteriorate further, fishers who might be complying voluntarily could defect in the face of flagrant noncompliance. This is supported by our results, which suggest

that effective government efforts to combat illegal fishing can relate positively to perceived compliance (Figure 1). Furthermore, patrol efforts (either formal or informal) tend to be more effective in smaller areas (Ban et al., 2011), and this might explain why perceived compliance was lower in larger MPAs (Figure 1).

We were also interested in knowing what respondents thought was influencing noncompliance. Respondents cited poverty and better fishing in MPAs as the main reasons for noncompliance (Table A2.1). Coastal communities in Costa Rica are predominantly poor (Morales-Aguilar, 2013). Scarcity of food or income could induce some people to fish illegally in MPAs, mostly if they believe that there are more fish in them than outside (Table A2.1). It is worth noting that, in Cahuita and Gandoca-Manzanillo, both in the Caribbean, people do not rely entirely on fishing, and fishing in Costa Rica's Caribbean is much less productive than the Pacific (FAO, 2011). This low dependence on fishing can help explain the higher compliance in these two Caribbean sites. In contrast, the communities adjacent to MPAs with low perceived compliance (e.g., Caballo, Golfo Dulce, and Santa Rosa) rely substantially on fishing (Marín-Cabrera, 2012; Solis et al., 2012). This is particularly true at the small island of Caballo, where fishing is the only livelihood. These facts support the results of our model, which shows that fishers perceive lower levels of compliance than non-fishers (Figure 1). It is likely that compliance levels were negatively affected by a high dependence on declining fisheries, and a lack of livelihood options. Similar conclusions have been drawn by previous studies. Peterson and Stead (2011) suggested that the main causes for noncompliance with MPAs in Rodriguez, an island in the Western Indian Ocean, were lack of food and limited livelihood opportunities. Similarly, Karper and Lopes (2014) found that artisanal fishermen that depended more on fisheries had stronger intentions to break rules in a Brazilian MPA. Thus, declining or collapsed fisheries can give rise to illegal fishing and other types of noncompliance, and a high dependence on fisheries exacerbates the problem (Brashares et al., 2014; Gettleman, 2015).

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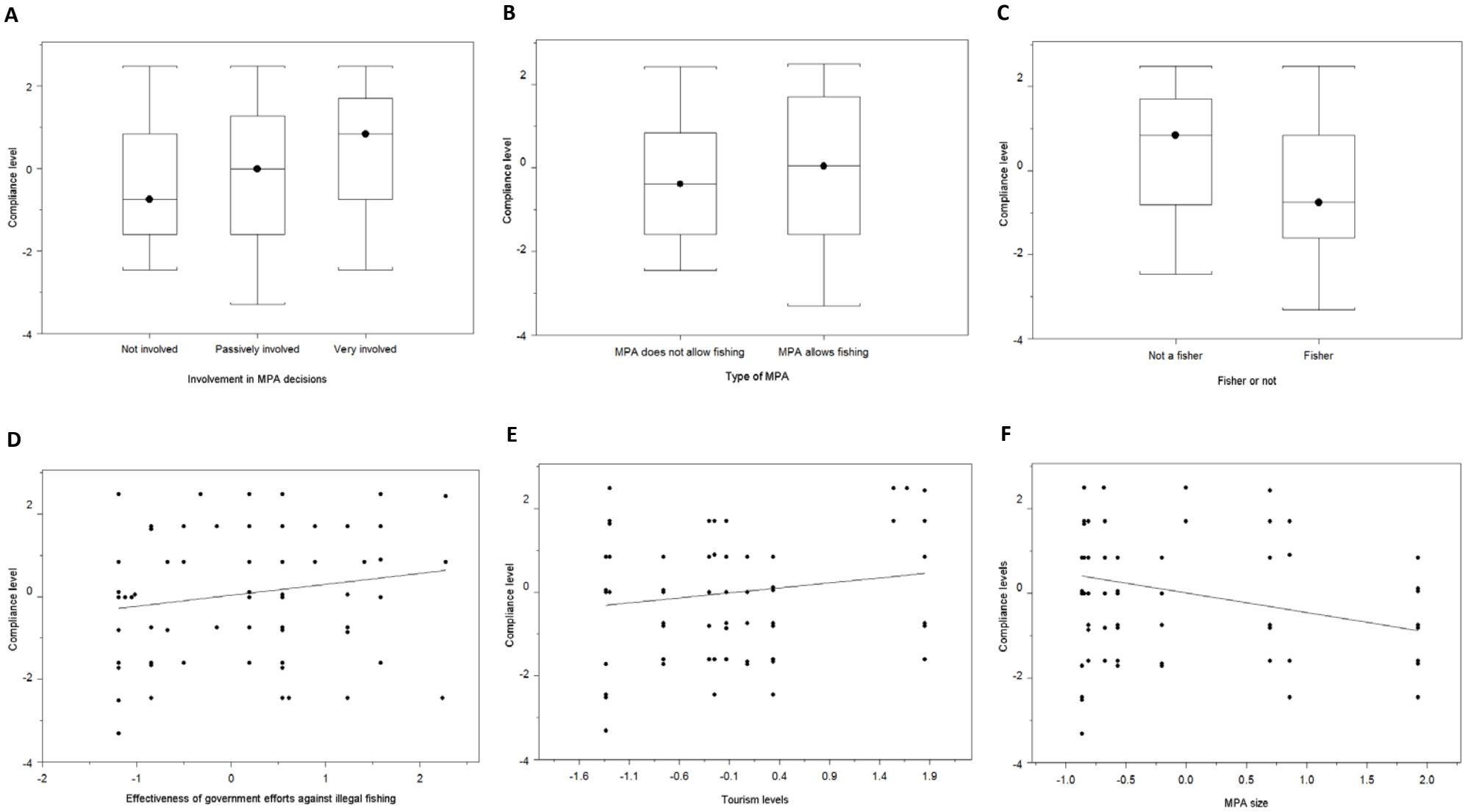
Appendix 3. Number of questionnaires and key informant interviews per MPA.

Marine Protected Area	Questionnaires	Key informant interviews	Total
Santa Rosa	5	9	14
Ostional	11	4	15
Camaronal-Caletas Arío	9	3	12
Cabo Blanco	11	2	13
Palito-Montero	11	2	13
Caballo	8	1	9
Manuel Antonio	9	5	14
Marino Ballena	9	5	14
Golfo Dulce	16	5	21
Cahuita	7	3	10
Gandoca-Manzanillo	3	2	5
Total	99	41	140

Appendix 4. Bivariate relationships between compliance and involvement in MPA decisions (A), type of MPA (B), being a fisher or not (C), effectiveness of government efforts against illegal fishing (D), tourism levels (E), MPA size (F), and support towards MPA (G). Values on Y-axis of panels A-G and X-axis of panels D-G are z-scores (see Methods section). Note that these figures do not show the marginal relationship between variables shown in Figure 1 (model output).



A dimensão espacial e temporal da diversidade de peixes da zona litoral vegetada de lagoas marginais da planície de inundação do rio Cuiabá, Pantanal, Brasil

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Abstract

Baginski, L.J., Florentino, A.C., Fernandes, I.M., Penha, J.M.P. & Mateus, L.A.F. **The spatial and temporal dimension of fish diversity of the vegetated littoral zone of marginal lagoons of the Cuiabá river floodplain, Pantanal, Brazil.** *Biota Neotrop*. Sep/Dez 2007 vol. 7, no. 3 http://www.biotaneotropica.org.br/v7n3/pt/abstract?article+bn04007032007. ISSN 1676-0603.

The present work has evaluated the spatial and temporal distribution of fish species richness of the vegetated littoral zone of 15 marginal lagoons in the floodplain of the Cuiabá River, Pantanal. The lagoons were sampled in three periods along of the dry season (June, September and December of 2005), through nine sieve throws distributed systematically at a minimum distance of five meters from each other. We caught 12,784 individuals belonging to seven orders, 21 families and 98 species of fish. Most of the captured species were rare and presented restricted geographical distribution. Drought intensification did not affect the spatial species distribution and the loss of species as dry season proceeded was proportional in the different orders. The total abundance of individuals as well as the richness varied with time. Rarefaction curves indicated that the reduction in richness was an artifact of the reduction in the abundance of individuals. When we compared the estimated richness under a same abundance level we did not find difference among the richness of species in the beginning and at the end of the dry season. Richness estimators indicated that to distribute the samples in the time was an appropriate strategy to reduce the problem of the false absences and to improve the efficiency of the sampling. Thus, our results suggest that for the design of reserves in the Pantanal, areas with a large number of lagoons of different forms and sizes would conserve the regional fish diversity, as the distribution of most small size species is restricted to a few lagoons.

Keywords: *effect of dry season, abundance distribution, spatial distribution, local extinction.*

Resumo

Baginski, L.J., Florentino, A.C., Fernandes, I.M., Penha, J.M.P. & Mateus, L.A.F. **A dimensão espacial e temporal da diversidade de peixes da zona litoral vegetada de lagoas marginais da planície de inundação do rio Cuiabá, Pantanal, Brasil.** Biota Neotrop. Sep/Dez 2007 vol. 7, no. 3 http://www.biotaneotropica.org.br/v7n3/pt/abstract?article+bn04007032007. ISSN 1676-0603.

O presente trabalho avaliou a distribuição espacial e temporal da riqueza de espécies de peixes da zona litoral vegetada de 15 lagoas marginais da planície de inundação do Rio Cuiabá, Pantanal. As lagoas foram amostradas em três períodos ao longo da sessão seca (junho, setembro e dezembro de 2005), por meio de nove lances de peneira, distribuídos sistematicamente a uma distância mínima de cinco metros um do outro. Capturamos 12.784 indivíduos pertencentes a sete ordens, 21 famílias e 98 espécies. A maioria das espécies capturadas foi rara e apresentou distribuição geográfica restrita. A intensificação da seca não afetou a distribuição espacial das espécies e a perda de espécies nas diferentes ordens, ao longo da seca, foi proporcional. Tanto a abundância total de indivíduos quanto a riqueza variou no tempo. As curvas de rarefação indicaram que a redução na riqueza foi um artefato da redução na abundância de indivíduos. Quando comparamos as riquezas estimadas sob um mesmo nível de abundância não encontramos diferença entre a riqueza de espécies no início e no final da seca. Os estimadores de riqueza de espécies indicaram que distribuir as amostras no tempo foi uma estratégia adequada para reduzir o problema das falsas ausências e melhorar a eficiência da amostragem. Assim, nossos resultados sugerem que para o delineamento de reservas no Pantanal, áreas com um grande número de lagoas com diferentes formas e tamanhos conservaria um maior contingente da diversidade regional de peixes, pois a maioria das espécies de pequeno porte apresenta distribuição restrita a poucas lagoas.

Palavras-chave: *efeito da seca, distribuição de abundâncias, distribuição espacial, extinção local.*

Introdução

Uma meta comum em estudos de ecologia de comunidades é encontrar padrões de distribuição e abundância das espécies e determinar os fatores responsáveis pelos padrões (Begon et al. 2006). Em geral, estes fatores são somente subconjuntos dos possíveis determinantes da organização da comunidade (Hinch & Collins 1991). Dentre os padrões mais abordados em ecologia de comunidades estão aqueles relacionados com a diversidade de espécies (número, identidade e as características das mesmas), bem como aqueles relativos às variações temporais nas abundâncias (Hoeinghaus et al. 2003, Miranda & Mazzoni 2003, Webster 2003, Lugendo et al. 2007).

Mudanças em comunidades naturais ocorrem no espaço e no tempo. Por exemplo, locais com altas taxas de mudança temporal acumulam mais espécies em um determinado período de tempo que locais com mudanças restritas (Chalcraft et al. 2004). Um entendimento detalhado da diversidade pode ser alcançado através de estudos que particionam a diversidade ao longo das dimensões de diferentes habitats, com tamanhos de amostras muito maiores, permitindo assim, medir a diversidade em diferentes subconjuntos da comunidade (DeVries et al. 1997).

O Pantanal, uma das maiores áreas alagáveis do mundo, ainda carece de estudos que avaliem a diversidade a estrutura e a dinâmica das comunidades de peixes. Entretanto, destacam-se os trabalhos de Súarez et al. (2001, 2004) no Pantanal da Nhecolândia, que avaliaram os padrões de composição e diversidade nas comunidades de peixes em lagoas sazonalmente isoladas. Os autores sugerem que, algumas características ambientais (p. ex., profundidade da lagoa, cobertura de macrófitas, distância da lagoa ao rio e tempo de isolamento da lagoa) estão entre os principais determinantes da distribuição das espécies, e que a intensidade das cheias é de grande importância, por afetar a colonização das lagoas e sua diversidade.

Este trabalho teve como objetivo avaliar o efeito da variação espacial e temporal do ambiente, durante o período da seca, na riqueza de espécies e distribuição de abundâncias nas assembléias de peixes da zona litoral vegetada de lagoas marginais da planície de inundação do rio Cuiabá, assim como avaliar a eficiência amostral do delineamento utilizado.

Material e Métodos

1. Área de estudo

As coletas foram realizadas em lagoas da planície de inundação do rio Cuiabá, localizadas dentro da Reserva Particular do Patrimônio Natural SESC Pantanal (RPPN SESC Pantanal) e seu entorno, situada entre as coordenadas 16° 30' a 16° 44' S e 56° 20' a 56° 30' W (Figura 1).

O rio Cuiabá pertence à porção norte do Pantanal Matogrossense. O rio recebe esse nome após a confluência dos rios Manso e Cuiabazinho e corre em direção ao sul, até a desembocadura com o rio Paraguai. Como quase todos os rios da região, trata-se de um rio de meandros, que associado à sua baixa declividade, propicia inundações anuais (Hamilton et al. 1996), as quais geralmente ocorrem de dezembro a março. Ao longo de suas margens encontra-se um complexo de lagoas de diferentes tipos, formadas pelas depressões naturais ou por mudanças naturais do curso do rio.

2. Amostragem

Foram amostradas 15 lagoas, sendo oito localizadas no interior da RPPN-SESC Pantanal e sete no entorno da reserva. Em cada lagoa foram realizadas três coletas nos meses de junho, setembro e dezembro de 2005, período de águas baixas na região. As amostras foram

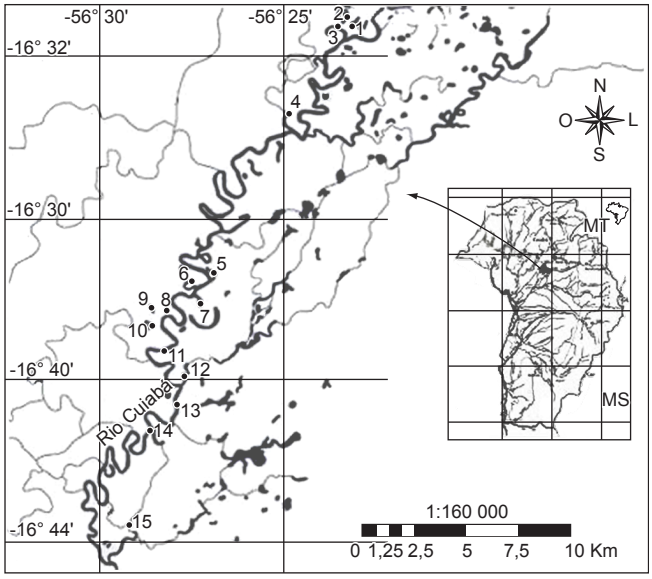

Figura 1. Localização das lagoas amostradas na bacia do rio Cuiabá, Pantanal, Brasil. As lagoas da margem esquerda do rio estão localizadas dentro da reserva RPPN SESC-Pantanal e as da margem direita fora da reserva.

Figure 1. Local of sampled lagoons on Cuiabá river basin, Pantanal, Brazil. The lagoons located on the left margin of the river are inside the RPPN SESC-Pantanal reserve and the ones located on the right margin are outside the reserve.

distribuídas no tempo, a fim de se avaliar as alterações na riqueza de espécies provocadas pela seca.

As amostras foram realizadas na zona litoral vegetada das lagoas, dominada por macrófitas flutuantes, especialmente *Eichhornia azurea*, *Eichhornia crassipes* e *Salvinia* sp.. Em cada lagoa foram aplicados nove lances de peneira, distribuídos sistematicamente a uma distância mínima de cinco metros um do outro. A peneira utilizada tinha um saco em forma de funil, com 1 m^2 de boca e profundidade de 1 m, confeccionada com tela de nylon de 1,5 mm de abertura de malha. Apesar da seletividade da peneira – ineficiente para as espécies de grande porte, esta é eficiente para a coleta de peixes de pequeno porte, que são as formas predominantes nas zonas litorais vegetadas.

Os peixes coletados foram fixados em formol 10% e preservados em álcool 70%. Posteriormente, os mesmos foram identificados com auxílio de literatura especializada (Britski et al. 1999, Reis et al. 2003) e a confirmação feita por especialistas do Museu de Zoologia da USP (MZUSP). Exemplares testemunhos se encontram depositados no Laboratório de Ecologia e Manejo de Recursos Pesqueiros/UFMT.

3. Análise de dados

Com o objetivo de comparar a distribuição de abundância das espécies ("Whittaker plots") na comunidade de peixes, as abundâncias das espécies (n) foram transformadas utilizando $\log_{10}(n+1)$ (Magurran 2004). A distribuição de abundância das espécies foi plotada utilizando Log na base 2 e comparada com os modelos de distribuição das abundâncias de espécies (Distribuição Log normal e Série logarítimica) (Magurran 1988b). Os modelos foram ajustados utilizando o programa estatístico BIO-DAP (Magurran 1988a).

Para comparar a freqüência de ocorrência das espécies nas lagoas e a distribuição de freqüência de espécies nas diferentes ordens, entre o início (junho) e o final (dezembro) da sessão seca, foi utilizado o teste não paramétrico de Kolmogorov-Smirnov (D_{max}). Em cada lagoa (unidades amostrais) foi obtido o número de espécies por ordem

(variável dependente) que foi comparado em diferentes momentos no tempo (variável independente).

Para avaliar possíveis diferenças na riqueza de espécies entre o início e o final da sessão de seca foi utilizada a técnica de rarefação (Sanders 1968). Essa técnica estima a riqueza de espécies esperada para cada subamostra de indivíduos de uma dada amostra, e é especialmente útil para comparar amostras de tamanhos diferentes (Gotelli & Graves 1996).

Com a finalidade de avaliar a eficiência de amostragem, comparamos o número de espécies registrados nas campanhas com o número de espécies esperado para a área, obtidos com os estimadores Chao 2 e Jackknife de segunda ordem, no programa EstimateS (Colwell 2005).

Resultados

Foram capturados 12.784 indivíduos pertencentes a sete ordens, 21 famílias e 98 espécies de peixes. A ordem com maior número de espécies foi Characiformes, com 53 espécies, seguida por Siluriformes (21 espécies), Perciformes (13 espécies), Gymnotiformes (7 espécies) e as demais somando quatro espécies.

A distribuição de abundâncias das espécies na comunidade mostrou que poucas espécies foram muito abundantes, algumas com abundâncias intermediárias e a maioria com baixa abundância (Figura 2), sendo que 73,5% das espécies apresentaram abundância inferior a 100 indivíduos e 39,7% das espécies foram representadas por 10 ou menos indivíduos. Por outro lado, a espécie mais abundante, *Serrapinnus calliurrus* representou 22,9% da amostra (2.798 indivíduos). Apesar das abundâncias apresentarem distribuição caracteristicamente lognormal, estas foram igualmente bem descritos pela série logarítmica (lognormal, $x^2 = 12,17$; df = 9; $p > 0,20$; série logarítimica, $x^2 = 15,53$; gl = 11; $p > 0,1$) (Figura 3).

Embora algumas espécies (*Gymnocorymbus ternetzi*, *Moenkhausia sanctaefilomenae*, e *Corydoras hastatus*) sejam exploradas com fins ornamentais e outras (*Synbranchus marmoratus* e *Gymnotus* cf. *carapo*) utilizadas como iscas vivas, nenhuma das 98 espécies capturadas é citada na lista vermelha da The Word Conservation Union (IUCN) como espécie ameaçada de extinção.

Nos três períodos de coleta, os maiores indivíduos capturados, que não ultrapassaram 40 cm de comprimento total, pertenciam às ordens Gymnotiformes e Synbrachiformes. Todos os demais indivíduos capturados apresentaram tamanho corporal pequeno, sendo principalmente espécies sedentárias ou migradoras de curta distância.

A maioria das espécies apresentou distribuição geográfica restrita e a intensificação do período de seca não afetou a distribuição das espécies. Em junho 52% (42/80) das espécies tinham ocorrência restrita a quatro lagoas (25% do total amostrado). Em dezembro este percentual aumentou para 60% (41/68). Entretanto, esta variação de 8% em relação ao início da seca (Figura 4) não foi estatisticamente significativa ($D_{max} = 0,333$ e $p = 0,341$).

A intensificação da seca não afetou a distribuição de freqüência de espécies nas diferentes ordens ($D_{max} = 0,143$ e $p = 1$) (Figura 5). Entre as campanhas de junho e dezembro todas as ordens, à exceção de Lepidosireniformes e Synbranchiformes, perderam aproximadamente a mesma proporção de espécies.

Tanto a abundância total de indivíduos quanto a riqueza variaram no tempo (Tabela 1). No mês de junho foram coletadas 81,6% do total das espécies, no mês de setembro 75,5% e no de dezembro 69,4%. Cerca de 50% das espécies foram comuns aos três períodos de coleta (Figura 6). Por outro lado, 22,4% das espécies ocorreram em apenas um período de coleta, sendo que 10,2% foram coletadas somente no mês de junho, 7,1% foram exclusivas ao mês de setembro e 5,1% ao mês de dezembro (Tabela 1).

As curvas de rarefação indicaram que a redução na riqueza foi um artefato da redução na abundância. Quando comparamos as riquezas estimadas sob um mesmo nível de abundância não encontramos diferença na riqueza de espécies entre o início e o final da seca (Figura 7).

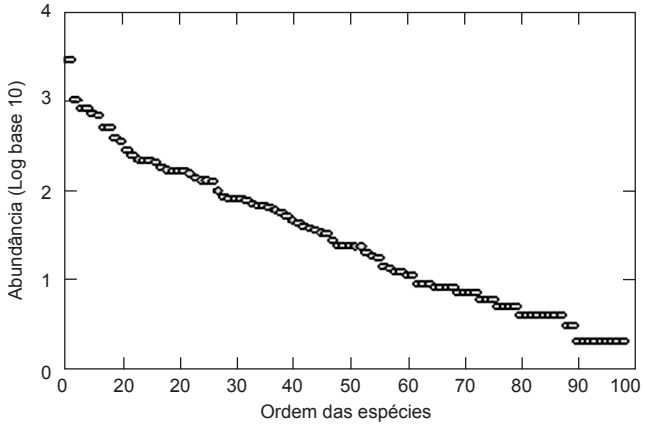

Figura 2. Distribuição de abundâncias da comunidade de peixes da zona litoral vegetada de 15 lagoas marginais do rio Cuiabá, Pantanal, Brasil. Os dados são a soma dos três períodos de amostragens (junho, setembro e dezembro de 2005).

Figure 2. Fish species rank of the vegetated littoral zone for 15 floodplain lagoons in the Cuiabá River Basin, Pantanal, Brazil. The data are the sum of the three periods sampled (June, September, and December of 2005).

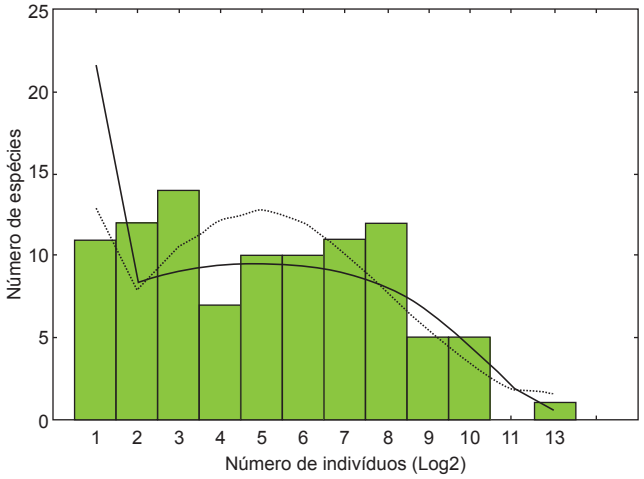

Figura 3. Distribuição das abundâncias de espécies para os meses de junho, setembro e dezembro de 2005, capturadas na zona litoral vegetada de 15 lagoas marginais do rio Cuiabá, Pantanal, Brasil. Os dados são a soma dos três períodos de amostragens junho, setembro e dezembro de 2005. Parâmetros para distribuição lognormal (curva pontilhada) utilizando o método de Pielou (1975), são a média = 1,379 a variância = 0,719 e o número de espécie estimada e de 102,6. Para a distribuição log-series (curva contínua) os parâmetros são alfa = 14,441 e x = 0,998. A distribuição log-normal ($x^2 = 12,17$ gl = 9 e $p > 0,20$) apresentou melhor ajuste do que o log-series ($x^2 = 15,53$ gl = 11 e $p > 0,1$).

Figure 3. Fish abundance distribution of the vegetated littoral zone for 15 floodplain lagoons of the Cuiabá River Basin, Pantanal, Brazil. The data are the sum of the three period sampled (June, September, and December of 2005). Lognormal distribution parameters (point line) estimated with Pielou (1975) method are: mean = 1.379, variance = 0.719, and species number = 02.6. For log-series (normal line) the parameters are: alfa = 14.441, and x = 0.998. Both models adjusted the data; lognormal ($x^2 = 12.17$, df = 9, and $p > 0.20$), and log-series ($x^2 = 15.53$, df = 11, and $p > 0.1$).

Tabela 1. Distribuição da riqueza de espécies, e abundância individual da zona litoral vegetada de peixes para 15 lagoas da bacia do rio Cuiabá, Pantanal, Brasil.

Table 1. Species richness distribution, and individual abundance of the vegetated littoral zone fishes for 15 floodplain lagoons of the Cuiabá River Basin, Pantanal, Brazil.

	Junho	Setembro	Dezembro	Total
Riqueza	80	74	68	98
Riqueza acumulada	80	93	98	98
Riqueza de espécies exclusivas	10	7	5	22
Abundância total (número)	5.591	5.105	2.088	12.784

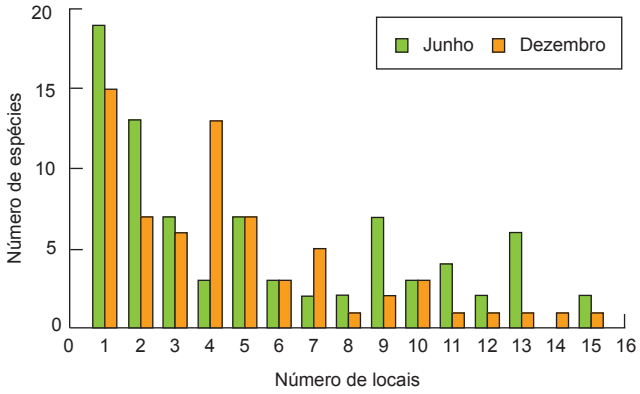

Figura 4. Distribuição de ocorrência das espécies de peixes na zona litoral vegetada da bacia do rio Cuiabá, Pantanal, Brasil. As coletas dos dados iniciaram em junho e encerraram em dezembro.

Figure 4. Distribution of fish species occurrence by lagoon for vegetated littoral zone in the Cuiabá River Basin, Pantanal, Brazil. Data collection started in June and ended in December.

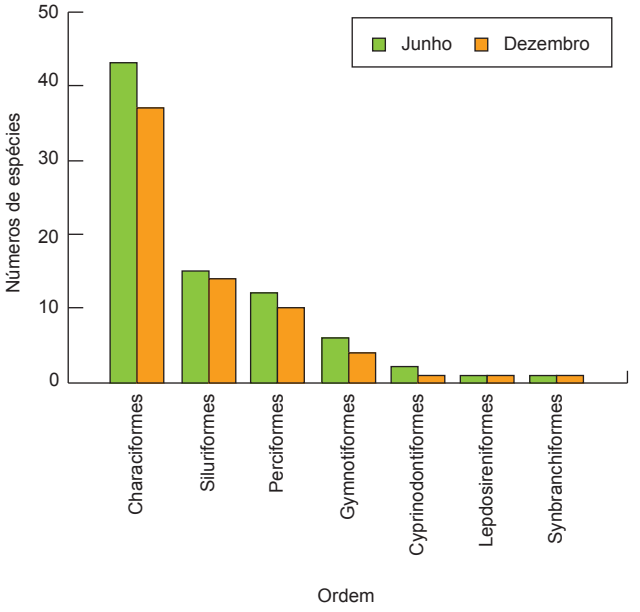

Figura 5. Distribuição da riqueza de espécies agrupadas por ordens taxonômicas na zona litoral vegetada para 15 lagoas da bacia do rio Cuiabá, Pantanal, Brasil. Coletas de dados iniciaram em junho e encerraram em dezembro.

Figure 5. Distribution of fish species richness grouped by taxonomic orders for vegetated littoral zone for 15 floodplain lagoons of the Cuiabá River Basin, Pantanal, Brazil. Data collection started in June and ended in December.

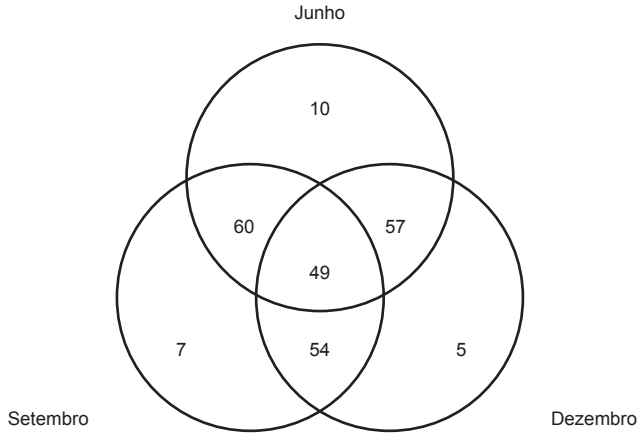

Figura 6. Distribuição da riqueza de espécies de peixes no espaço e no tempo na zona litoral vegetada para 15 lagoas da bacia do rio Cuiabá, Pantanal, Brasil.

Figure 6. Spatio-temporal fish species richness distribution within the vegetated littoral zone for 15 floodplain lagoons in the Cuiabá River Basin, Pantanal, Brazil.

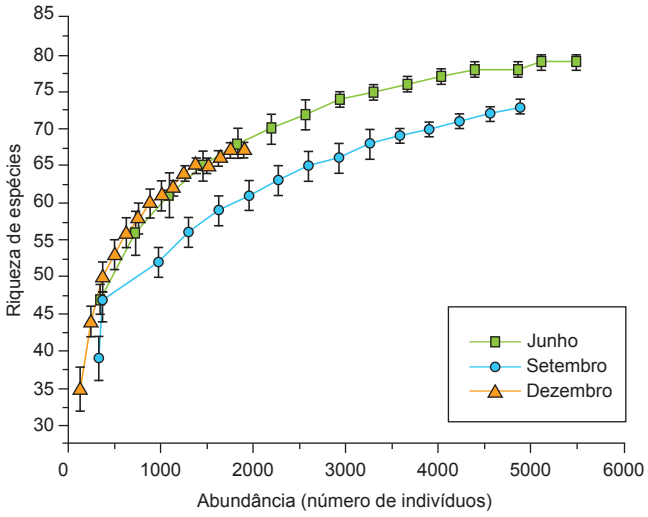

Figura 7. Curvas de rarefação da riqueza de espécies de peixes da zona litoral vegetada para 15 lagoas marginais da bacia do rio Cuiabá, Pantanal, Brasil.

Figure 7. Rarefaction curves of species richness of the vegetated littoral zone fishes for 15 floodplain lagoons in the Cuiabá River Basin, Pantanal, Brazil.

Os estimadores de riqueza de espécies indicaram que distribuir as amostras no tempo foi uma estratégia adequada para reduzir o problema das falsas ausências e melhorar a eficiência da amostragem. Os dados estimados pelo Jackknife de 2ª ordem sugerem que no

mês de junho foram amostradas cerca de 77,7% do total de espécies esperado (Jackknife 2 = 103 espécies; Chao 2 = 91, dp = 9,99). A eficiência da amostragem foi menor em setembro (70,5% do total esperado de espécies; Jackknife 2 = 105 espécies; Chao 2 = 100 espécies, dp = 16,76) e melhorou um pouco em dezembro (77,3% do total esperado de espécies; Jackknife 2 = 88 espécies; Chao 2 = 79, dp = 8,46). Entretanto, quando se agrupou as amostras, a eficiência da amostragem melhorou em cerca de 12,5% e foram registradas 84,5% do total de espécies estimado para a área (Jackknife 2 = 116 espécies; Chao 2 = 105, dp = 5,81).

Discussão

A ictiofauna da América do Sul é caracterizada pela dominância de Characiformes sobre Siluriformes (Lowe-McConnell 1999). Essa dominância é evidente tanto em lagoas da porção sul do Pantanal (Súarez et al. 2001, Súarez et al. 2004) quanto na porção norte (presente estudo).

Os resultados deste estudo demonstram que as assembléias estudadas apresentam predominância de espécies com abundâncias moderada e rara, e distribuição espacial restrita. Esse padrão pode resultar da variação entre as espécies na capacidade de dispersão, ou alternativamente, da seleção de habitat e interações populacionais. Possivelmente, as espécies com distribuição espacial mais ampla são abundantes e não apresentam limitação para a dispersão, devido às estratégias adaptativas que as capacitam a explorar ambientes sazonais. Por outro lado, espécies com distribuição espacial restrita devem apresentar limitação de dispersão, sem estratégias adaptativas evidentes para a exploração de ambientes sazonais (Granado-Lorencio et al. 2005).

O padrão de distribuição das espécies entre as lagoas deste estudo, assim como no trabalho de Súarez et al. (2001) – indicando baixa similaridade entre elas – demonstram que, na escala estudada, a diversidade de peixes de lagoas do Pantanal é determinada, principalmente, pela diversidade beta (diversidade entre locais). Assim, para se conservar o conjunto da fauna de peixes de uma das sub-regiões é preferível selecionar um conjunto de lagoas com características variadas (Súarez et al. 2001).

A distribuição de espécies entre as ordens não se alterou ao longo da seca. Esse resultado difere do encontrado por Rodríguez & Lewis (1997), em lagoas do rio Orinoco, na Venezuela, e por Tejerina-Garro et al. (1998), em lagoas do rio Araguaia, que observaram um aumento na proporção de Siluriformes em relação a Characiformes com o avanço da seca, devido, principalmente, à redução na transparência da água. Essa diferença pode ser decorrente da diferença nos delineamentos amostrais adotados. Diferentemente dos estudos de Rodríguez & Lewis (1997) e Tejerina-Garro et al. (1998), que amostraram toda a lagoa, nós amostramos peixes apenas na zona litoral vegetada. Além disso, utilizamos apenas um apetrecho de pesca, e com características mais apropriadas à amostragem de peixes de pequeno porte. Alternativamente, nossos resultados podem indicar maior estabilidade nas assembléias da zona litoral vegetada. Nos ambientes pouco profundos das lagoas, as melhores condições de oxigenação da superfície, aliadas à maior disponibilidade tanto de abrigos contra os predadores, quanto de alimentos, fornecido pelas macrófitas (formação de refúgios ecológicos), deve conferir vantagens às formas capazes de melhor explorá-las. Os pequenos Characiformes, como *Serrapinnus calliurus*, que predominaram nas amostragens parecem se enquadrar nessa categoria (Rodríguez & Lewis 1997, Veríssimo 1999, Súarez et al. 2004).

Ao longo do período de seca houve redução na riqueza geral e na abundância de indivíduos. As curvas de rarefação indicam que essa redução da riqueza pode estar associada com a menor abundância nos meses de setembro e dezembro. A menor abundância de indivíduos no mês de dezembro, final da estação seca, quando comparada ao mês de junho, início da estação seca, pode estar relacionada a duas razões principais, que atuam em conjunto. A primeira é de ordem demográfica: para a maioria das espécies de peixes da planície de inundação, o recrutamento é um evento discreto no tempo, em geral concentrado nos meses de cheia (Lowe-McConnell 1999), enquanto que a mortalidade é um evento contínuo e, portanto, dominante na fase de seca. A segunda está relacionada à diminuição do nível da água nas lagoas, que intensifica as interações bióticas (competição e predação), excluindo as espécies menos competitivas ou susceptíveis a forte pressão de predação, diminuindo assim a riqueza de espécies no final do período de seca (Hoeinghaus et al. 2003). De fato, Súarez et al. (2004) mostraram que a variação na riqueza é negativamente relacionada com a variação no tempo de isolamento e distância do rio principal, mas positivamente relacionada com a profundidade das lagoas.

Embora Brown (1986) afirme que as espécies que ocorrem no Pantanal têm ampla distribuição regional, apenas metade das espécies foram comuns aos três períodos de coleta e 22 espécies ocorreram em apenas uma lagoa. Isso mostra que as espécies de peixes de pequeno porte que habitam as áreas vegetadas de lagoas marginais do Pantanal, além de não possuírem ampla distribuição espacial, não apresentam ampla distribuição temporal. Provavelmente, isso ocorre devido às estratégias ecológicas distintas que cada espécie possui, e que as permitem manter populações viáveis em um sistema instável como o Pantanal. Conseqüentemente, o conjunto de resultados que encontramos nos leva a sugerir que, na situação de necessidade de delineamento de reservas no Pantanal, a escolha de áreas contendo um grande número de lagoas com tamanhos e formas variadas, é uma opção que permite a conservação da diversidade regional de peixes, pois a maioria das espécies de pequeno porte apresenta distribuição restrita a poucas lagoas.

Agradecimentos

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Perceptions of ranchers towards livestock predation by large felids in the Brazilian Pantanal

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Abstract

Context. Human–wildlife competition is a worldwide problem. In the Brazilian Pantanal, the competition is between livestock and large cats, such as the jaguar (*Panthera onca*) and the puma (*Puma concolor*). Only a few studies have been conducted in the region and have indicated low levels of cattle predation. In addition to the paucity of information on livestock predation levels, information on the local ranchers' understanding of cattle predation is limited.

Aims. To investigate local people's perceptions of large cats and husbandry practices in order to understand some of the causes and extent of jaguar–livestock interaction in the Brazilian Pantanal.

Methods. We present comprehensive surveys of the local people's perceptions towards large cats using a 5-point Likert scale evaluated using non-parametric tests in order to reach a better understanding of the causes of jaguar–livestock interaction and its extent in the Brazilian Pantanal.

Key results. In general, total mortality rate due to cat predation was $2.7 \pm 4.9\%$ of total cattle holdings. However, jaguars were reported as a real menace to cattle and cattle predation by large cats was a real concern for ranch operations. The majority of ranchers who implemented cattle management accept the risk of losing cattle to predation by large cats, but only a minority of respondents reported that they would rather live without jaguars.

Conclusions. The majority of the ranches surveyed had limited husbandry practices and the intensity of cattle management did influence respondents' perceptions of predation by large cats.

Implications. We suggest that the focus of conservation actions be on cattle management aimed at minimising other sources of income loss caused by poor husbandry practices.

Additional keywords: cattle management, human–wildlife interaction, large felids, local perception, predation.

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Introduction

Human–wildlife competition is a worldwide problem, especially when wild mammalian carnivores and humans compete over food resources and space (Treves and Karanth 2003). When domesticated ungulates became an available source of food (Frank and Woodroffe 2001), they became prey to wild carnivore species that specialise in preying on ungulates (Graham *et al*. 2005). Unlike wild herbivores, domestic ungulates are exceptionally vulnerable to predation (Frank and Woodroffe 2001). In many parts of the world, habitat loss and fragmentation and expansion of human populations have forced wild carnivores into close contact with domestic ungulates, exacerbating the competition between humans and large carnivores (Woodroffe 2000; Conover 2002). Moreover, large carnivores may inevitably use domestic animals maintained by humans in landscapes in which they occur in higher density than wild prey species (Schaller 1983).

Human–wildlife competition is mostly characterised by large carnivores attacking livestock, for instance, tigers (*Panthera tigris*), leopards (*Panthera pardus*) and snow leopards (*Panthera uncia*) in Asia; lions (*Panthera leo*), leopards, hyenas (*Crocuta crocuta*) and cheetahs (*Acynonyx jubatus*) in Africa; jaguars (*Panthera onca*) and pumas (*Puma concolor*) in all the Americas; and bears and wolves in North America and Europe (Dickman 2010). Interactions are more frequent when people live in, or close to, protected areas (Woodroffe and Ginsberg 1998; Conforti and Azevedo 2003; Wang and Macdonald 2006), when wild prey have been eradicated and replaced by livestock or when husbandry practices are poor (Polisar *et al*. 2003; Patterson *et al*. 2004). Moreover,

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livestock depredation can represent significant economic losses to ranchers (Patterson *et al*. 2004; Hemson *et al*. 2009) and lead ranchers to persecute and eliminate predators in retaliation or as a preventative measure against recurrent predation (Conforti and Azevedo 2003; Mishra *et al*. 2003; Inskip and Zimmermann 2009). In Latin America, cattle ranchers claim that large carnivores, such as jaguars and pumas, have a significant impact on their cattle herds, even though many studies have concluded that livestock predation rates by large felids are usually low (Hoogesteijn *et al*. 1993; Mazzolli *et al*. 2002; Azevedo and Murray 2007*a*; Palmeira *et al*. 2008; Loveridge *et al*. 2010).

The Pantanal region in Brazil has high levels of biodiversity and it is an important refuge for many threatened or endangered species, for instance, hyacinth macaw (*Anodorhynchus hyacinthinus*), marsh deer (*Blastocerus dichotomus*), tapir (*Tapirus terrestris*), giant otter (*Pteronura brasiliensis*) and jaguar (Alho *et al*. 2011). Approximately 250 years of cattle herding in the Pantanal has made cattle an integral part of the landscape, which consists of a system of almost exclusively private properties (Seidl *et al*. 2001). Beef cattle ranching is the mainstay of the region's economy (Rosa *et al*. 2007) with ~80% of all ranches in the Brazilian Pantanal managing cattle on an extensive basis (Seidl *et al*. 2001). Generally, this type of cattle ranching cannot be considered damaging to the environment, because the unpredictability of large floods in the region limits the size of the herds and maintains an ecologically sustainable industry (Seidl *et al*. 2001). However, poor cattle husbandry practices may have an important effect on levels of jaguar and puma predation on livestock; specifically, increasing rates of predation towards more vulnerable cattle (Polisar *et al*. 2003).

Livestock predation by large cats is one of the main contributors to human–wildlife competition in the Pantanal (Schaller and Crawshaw 1980; Quigley and Crawshaw 1992; Azevedo and Murray 2007*b*; Cavalcanti and Gese 2010). Although the few studies conducted in the region on the impact of jaguars on livestock have indicated low levels of cattle predation (Azevedo and Murray 2007*b*), large felids, mostly jaguars, continue to be persecuted and eliminated by local ranchers in response to putative predation events (Cavalcanti *et al*. 2010). In addition to the paucity of data on livestock predation in the Pantanal, information on the local ranchers' understanding of cattle predation is also limited (Azevedo and Murray 2007*a*). Therefore, comprehensive surveys of local perceptions towards cattle–large felid interactions may help in implementing sustainable conservation programs in the region. In the Pantanal region, programs to provide husbandry assistance to ranchers have been implemented since 1975 by Embrapa Pantanal (Brazilian Agricultural Research Corporation), but only one compensation program provided by a non-governmental organisation has been put in place to reimburse for cattle losses due to predation (Harris *et al*. 2005). Nonetheless, no research has addressed how this compensation program may have contributed to the conservation of large felids or affected local people's perceptions.

Historically, jaguars have been traditionally hunted in the Pantanal due to the presumed impact caused by livestock predation and also due to the trade on skins until the late 1970s (Swank and Teer 1989; Quigley and Crawshaw 1992). Since then, a steady decline in cattle ranching in the Pantanal region has been observed, mainly due to market conditions and also because of a major flood of the Paraguay river that caused an estimated loss of ~3.5 million cattle (~28% of all cattle raised in the region) (Mittermeier *et al*. 1990). In addition, the average size of properties has decreased and ranches became smaller and more numerous (Abreu *et al*. 2010), which may exert higher pressure on the landscape. Concurrently, the trade of jaguar skins throughout the world declined by the beginning of the 1980s. Although the combined effect of those major changes on jaguar population numbers in the Pantanal has not been measured, we speculate that local people believe jaguar numbers have increased in the Pantanal region.

In the present study, we investigated local people's perceptions towards large cats in order to understand the causes and extent of jaguar–livestock interaction in the Brazilian Pantanal. In particular, we investigated factors related to the conservation of large cats' on ranches in the Pantanal, including the community's perception of the presence of jaguars and pumas, cattle productivity and management, levels of livestock predation, history of predation events, the status of the prey base and hunting pressure upon wildlife. If large cats play an important role as livestock predators, higher rates of predation in ranches without husbandry practices such as presence of maternity paddocks, occurrence of breeding programs and occurrence of pasture rotation, should be observed and influence local people's attitudes towards large cats.

Materials and methods

Study area

The Brazilian Pantanal is one of the world's largest floodplains (Alho *et al*. 1988) and covers ~138 507 km^2. It is located on the borders of Brazil, Bolivia and Paraguay. Low mountains and plateaus surround the basin, with 48 865 km^2 (35.4%) of its area located in the Brazilian State of Mato Grosso (Northern region) and 88 318 km^2 (64.6%) in the Brazilian State of Mato Grosso do Sul (Southern region). The Pantanal is characterised by an annual regime of flooding and low land relief, with the landscape being comprised of wetland habitats, seasonally inundated grasslands and woodlands, and non-flooding forests.

The Pantanal is one of the best-preserved regions of Brazil mainly because of low levels of forest fragmentation, introduction of exotic pastures and human density. Even though, paradoxically, a system of almost exclusively private properties (95%) has dominated cattle ranching for more than two centuries (Seidl *et al*. 2001). It is also one of the least-known regions of the globe, where scientific information is scarce. Large ranches were first established in the higher areas, both surrounding and within the Pantanal. The expansion of these ranches throughout the basin was completed only in the twentieth century. Nowadays, beef cattle ranching is the main economic activity of the region, with ~4 million head of cattle (Rosa *et al*. 2007).

Data collection

The Pantanal is divided into 11 sub-regions (Silva and Abdon 1998). The ranches were selected based on the historical occurrence of jaguars in the Pantanal according to Schaller (1979), and on the feasibility of accessing ranches by car or boat. Our survey covered the following sub-regions: Aquidauana,

Miranda, Abobral, Nhecolândia, Nabileque, Paiaguás, Barão de Melgaço and Poconé. We surveyed ranches located along and far from highways of the Pantanal region (Fig. 1). Interviews focussed on landowners or ranch managers, who were usually long-term residents and were conducted during meetings in local rural associations or on the ranches. Respondents were informed that the interviewers were not government employees involved in law enforcement or land demarcation.

Survey

We personally carried out the interviews for the survey between September 2005 and January 2008, which was based on questionnaires used throughout the country by other researchers and government institutions (Pitman *et al*. 2002; Conforti and Azevedo 2003; Marchini 2003; Zimmermann *et al*. 2005; Michalski *et al*. 2006). We recorded socioeconomic and demographic variables, such as the age, gender and time of residence of respondents, ranch size, number of cattle and cattle density. Data on cattle productivity was gathered on cattle stocking rate per hectare of pasture (the number of cattle that can be put into one hectare of pasture per year), the age of cows at first birth, inter-calving period (period between successive calves) and cattle birth and discard rates (ages at which cows give birth and are discarded because of lower fecundity). Likewise, data on management was gathered on presence of maternity paddocks, occurrence of breeding programs and occurrence of pasture rotation. In addition, we designed a structured survey based on two sections: the first constituted by 13 closed-ended questions to gather general data regarding predation of livestock by large cats (e.g. occurrence of large cats, perceived number of cattle predated, history of predation events, status of the prey base, occurrence of hunting upon wildlife, and involvement in tourism), and the second based on 19 statements to record potential determinants of perceptions by local people. Responses of closed-ended questions were measured on a bivariate scale (Yes/No) and of statements on a 5-point Likert scale: strongly agree (1), agree (2), neutral (3), disagree (4), strongly disagree (5).

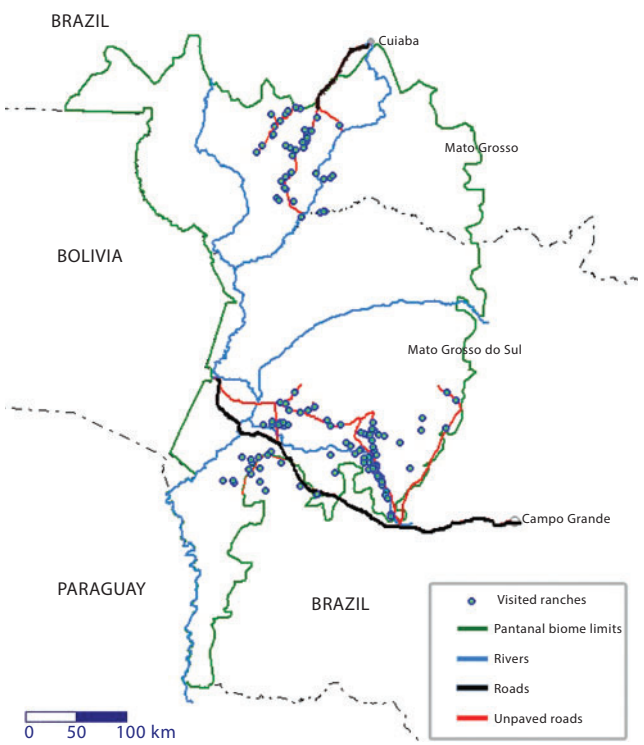

Fig. 1. Location map of the study area marked with sampling ranches located throughout the visited area encompassed by the Pantanal region of the Mato Grosso and Mato Grosso do Sul States in Brazil.

Data analysis

Descriptive statistics were used to illustrate proportions and overall patterns in the factual data. Responses regarding characteristics of ranches and respondents were reported as mean ± standard deviations. All questions regarding respondents' perceptions were reported as percentages, 95% confidence intervals and number of respondents.

Relationships between continuous variables (respondent age, gender, time of residence, ranch size, number of cattle, cattle-density, age of cows at first birth, intercalving period, discard rate, presence of maternity paddock, breeding programs, pasture rotation and perceived proportion of cattle lost to jaguars), were analysed using Pearson correlation coefficient. Relationships among responses derived from closed-ended questions were examined using chi-square tests. We also used two-sample *t*-tests to analyse relationships of those responses with continuous variables, such as number of cattle and perceived proportion of cattle lost to large cats. Data was log10 transformed to better approximate a normal distribution.

We conducted principal components analysis (PCA) with an oblimin rotation on 19 statements representing respondent's attitudes towards large cats to identify underlying processes in attitudinal data. We used only factors having an eigenvalue of more than 1 in our analysis. We used Cronbach's α to provide a reliability estimate of the internal consistency of the subsets of variables identified in the PCA. The Kaiser–Meyer–Olkin and the Bartlett's test of sphericity were used to check for the adequacy of PCA for our data (Kaiser 1970). Statistical analyses were performed using SPSS software (SPSS, Inc., Chicago, IL).

Results

Characteristics of sample and ranches

In total, 110 ranches were visited and 95 respondents completed the survey. Ranches located in the Northern ($n = 35$) and Southern ($n = 60$) regions of the Pantanal were surveyed. Out of the 95 respondents, 93 were male and 2 female. The mean age of respondents was 41.9 ± 12.1 years old (±s.d., $n = 63$; range = 26 to 74). Almost half of the respondents (49%, $n = 47$) had lived on their ranches for less than 10 years, 16% ($n = 15$) between 10 and 19 years and 35% ($n = 33$) for more than 20 years.

The survey covered 91 ranches where cattle were raised exclusively for beef, three ranches also worked with dairy cattle, one ranch worked exclusively with tourism, two ranches had no cattle, and one ranch raised only buffalo (*Bubalus bubalis*) (total number of ranches = 95). The total surveyed area corresponded to 1 074 821.81 ha, which represents 7.76% of the total area of the Brazilian Pantanal.

The majority of ranches were <5000 ha in size (50.5%, $n = 47$). Native pastures comprised 436 237.25 ha of the area surveyed (40.14%) and the total area occupied by pastures with non-native vegetation was 179 704.05 ha (16.5%). Of the ranches, 39% ($n = 35$ out of 91) had fewer than 1000 head of cattle, 44.7% ($n = 41$ out of 91) had 1000 to 5000 head of cattle, and 15.9% ($n = 15$ out of 91) had >5000 head of cattle. When asked whether the ranch had another source of income in addition to cattle ranching, the minority (26.3%; CI = 17.5–35.1%, $n = 95$) reported other sources such as tourism ($n = 14$) (Table 1). There was a positive relationship between ranch size and number of cattle (log) and a negative relationship with cattle density (log) ($r = 0.713$, $P < 0.001$; $r = –0183$, $P < 0.1$ respectively). Ranches not involved in tourism activities had significantly more cattle than other ranches ($t_{89} = –2.392$, $P < 0.05$). General characteristics of ranches are reported in Table 1.

Management and productivity

Of the respondents who answered questions regarding management and productivity, 79 implemented some type of cattle management on their ranches at the time of our survey. The majority of surveyed ranches performed some type of pasture rotation to avoid overgrazing (54.3%, $n = 92$). On 42 ranches (45.6%, $n = 92$), no type of pasture rotation was reported. The majority of ranches (56.5%, $n = 92$) did not keep a maternity paddock to restrict cow movements and did not have a cattle breeding program (57.5%, $n = 50$). There was a positive relationship between age of cows at first birth and inter-calving period ($r = 0.811$, $P < 0.001$). Most respondents (85.7%, $n = 91$) reported cattle were in good overall health. Among the factors causing cattle mortality before weaning, predation by large cats was the most cited (60%, $n = 75$). In total, 81 respondents reported snake bite ($n = 45$) and jaguars ($n = 36$) as factors that caused cattle mortality after weaning. General characteristics of management and levels of productivity are reported in Table 1.

Livestock predation by large cats

The majority of respondents (94.5%) confirmed the presence of jaguars (CI = 91.2–99.7%, $n = 86$) and pumas (96.7%, CI = 94.7–98.6%, $n = 889$) on their ranches. Predation by jaguars was reported by 83.0% of respondents (CI = 75.0–90.0%, $n = 88$) and predation by pumas by 85.4% (CI = 77.6–92.5, $n = 89$). Most of the respondents ($n = 39$) stated that the jaguar population had increased in the last five years before the survey (51.3%; CI = 42.9–59.7), but could not report on the status of the puma population. The majority of respondents, 78.9% (CI = 70.5–87.3%, $n = 90$), reported losses in the two years before the survey, but only 33.3% (CI = 23.4–42.6%, $n = 90$) employed any methods to prevent cattle predation by large cats. Most respondents (77.3%; CI = 67.9–86.7%, $n = 75$) believed economic compensation programs should have been implemented in the Pantanal and were willing (89.5%; CI = 83.0–96.0%, $n = 86$) to receive help to solve predation problems. Few respondents (4.0%; CI = 0.0–7.9%, $n = 91$) reported receiving compensation for their losses towards large cats predation (Table 2).

Responses regarding large cat predation did not depend on responses towards population sizes of the prey base for large cats in the region (caiman, white-lipped peccaries, collared peccaries, marsh deer, armadillos and giant anteaters; all x^2 with $P > 0.168$). Few respondents (28.6%; CI = 19.4–37.8%, $n = 91$) reported that game hunting occurred within their ranches. A similar trend was observed when asked about preventive measures for jaguar attacks (persecution with hounds, poisoning, hunting, electric fences, others) on their properties. Only 33.3% (CI = 23.4–42.6%, $n = 90$) of the respondents reported using one or more of these preventive measures (Table 2). However, we found no

Table 1. Characteristics of the ranches regarding management and productivity of cattle

Ranches activities	*n*	Ranches characteristics	Mean (±s.d.)	*n*
Cattle	95	Ranch size (hectares) (range = 344 to 135 000)	11 628.5 ± 20 044.5	92
Tourism	14	Size of pastures (hectares)	7255.4 ± 13 772.4	84
Renting land	5	Number of cattle head (range = 15 to 46 600)	3424 ± 6796	91
Sport fishing	4	Cattle stocking rate per hectare of pasture[a]	0.58 ± 0.38	82
Beekeeping	1	Cattle stocking rate per hectare total area[b]	0.36 ± 0.25	94
Caiman ranching	1	Age of cows at first calving (months)	36.6 ± 6.4	83
Cheese-making	1	Inter-calving period (months)[c]	14.8 ± 4.8	79
Agriculture	1	Cattle birth rate[d]	62.6 ± 17.6	71
		Annual discard rate[e]	17.4 ± 15%	61
		Cattle mortality rate[f]	4.8 ± 4.5%	71
		Total perceived predation rate caused by large cats[g]	2.7 ± 4.9%	77
		Calf mortality rate before weaning[h]	9.9% ± 12.8	70
		Mortality rate after weaning[i]	3.4% ± 5.9	72

[a] and [b]The number of cattle that can be put into one hectare or in the total area of pasture per year;
[c]Period in between successive calves;
[d]Ages at which cows give birth;
[e]Ages at which cows are discarded because of lower fecundity;
[f]Number of deaths of cattle per year;
[g]Number of cattle predated by large cats per year according to the perception of ranchers;
[h] and [i]Number of deaths of calves before and after weaning per year.

Table 2. Distribution of responses of the 13 closed-ended questions aimed to gather general information on predation of livestock by large cats
Responses are reported as bivariate scale

Questions	Yes	No	No answer	Total
Do you see jaguars within your property?	86	4	1	91
Do you see pumas within your property?	88	1	2	91
Does the property have another income source besides cattle?	19	72	0	91
Did you have any problems with livestock predation by large cats in the last 24 months?	71	19	1	91
Did you confirm the presence of jaguars on this ranch in the last 12 months?	89	2	0	91
Do you see more jaguar than 5 years ago?	39	15	15	69
Do you believe the number of attacks by big cats have increase in the last five years?	63	25	3	91
Do you try to prevent big cats attacks on cattle?	30	60	0	90
Do you believe killing jaguars would prevent attacks on cattle?	52	14	25	91
Have you ever received any compensation for cattle taken?	4	87	0	91
Do you believe a compensation scheme should be implemented?	58	17	16	91
Would you like to receive help to solve the predation problem?	77	09	0	86
Is there any type of hunting of wild species within this ranch?	26	65	0	91
Did you have any problems with livestock predation by jaguars in your property?	73	15	3	91
Did you have any problems with livestock predation by pumas in your property?	76	13	2	91
Did you have any problems with livestock predation by jaguars and pumas in your property?	62	28	1	91

dependence between respondents' answers regarding the jaguar population size in the last five years before the survey and the use of preventative measures against jaguar attacks ($x^2 = 0.908$, d.f. = 2, $P = 0.635$).

We found that significantly more cattle losses to predation were reported by those who believed to see more jaguars around their ranches in the last five years before our survey ($t_{49} = 2.00$, $P < 0.05$). Similarly, those who claimed more problems of predation by large cats and who believed the number of attacks by big cats increased in the last five years before our survey, reported more losses of cattle due to predation by large cats ($t_{74} = 3.95$, <0.001; $t_{70} = 2,79$, $P < 0.005$, respectively).

We found no dependence between levels of ranch productivity and respondents' answers regarding predation by large cats ($x^2 = 2.441$, d.f. = 2, $P = 0.295$) and evolution of predation during the last five years before the survey ($x^2 = 2.798$, d.f. = 4, $P = 0.592$). However, we found dependence between intensity of cattle management and respondents' answers about large cat predation ($x^2 = 6.37$, d.f. = 2, $P = 0.041$). Out of 79 respondents who implemented some type of cattle management on their ranches, the majority of those ($n = 60$) did agree with the possibility of occurrence of predation in their cattle ranching operations.

When asked whether jaguars could be a menace to people, 34.1% ($n = 31$) agreed or strongly agree that jaguars can cause harm or present danger to people. However, the majority of respondents, 67.0% ($n = 61$), agreed or strongly agree jaguars could be a menace to cattle, and 76.9% ($n = 70$) agreed or strongly agree that cattle predation by large cats (jaguars and pumas) was a real concern for their ranch operations. Although respondents agreed that jaguars were a menace to their cattle, only 28.6% ($n = 26$) reported they would rather live without jaguars in the Pantanal (Table 3). There was a negative relationship between log (proportion of cattle lost to predation) and log (cattle density) ($r = –0.203$, $P < 0.1$). No other management or productivity variable was found to be correlated with the proportion of cattle lost to predation by large cats (all $P > 0.1$).

Factors influencing perceptions towards large cats

PCA data suggested the retention of six factors that accounted together for 61.7% of total variance of the general attitude of respondents (Table 4). The items were included in the component in which they had the highest loading. The Kaiser–Meyer–Olkin measure of sampling adequacy was 0.680. The Bartlett's test of sphericity was significant ($x^2 = 422.79$, $P < 0.001$) indicating that data were appropriate for PCA. The first factor included four items and had an internal consistency of 0.676 (Cronbach's α), showing that these four items were a moderate measure of lifestyle impacts on respondents in the Pantanal region. Items included in factor 1 appeared to relate to possible menaces on ranchers' lifestyles. The second factor contained four items and seemed to be related to the need of ranchers for assistance. The internal consistency of these four items was 0.579, suggesting that they were a reasonable measure of issues that could help improve ranching operations in the Pantanal. The third factor, profile of ranchers towards conservation, contained five items and had an internal consistency of 0.690, showing that these five items were a moderate measure of the profile of ranchers in the Pantanal region. The fourth, fifth and sixth factors (environmental engagement, Pantanal's protection and out ranch help) had low internal consistencies (Cronbach's $\alpha = 0.470$, 0.421 and 0.495 respectively) indicating unsatisfactory unidimensionality and that the items were not as well related. These factors were therefore dropped in further analyses of the data (Table 4).

Discussion

Among conservation issues, the control of wild predators that prey on livestock has received a great deal of attention, particularly in the last two decades (Woodroffe 2000). The focus of most conservation studies has been on the analysis of the quantity, quality and importance of ecological factors that may affect predators' preference for livestock over wildlife and the impact of livestock predation upon local economies (Graham *et al*. 2005; Sangay and Vernes 2008; Inskip and

Table 3. Distribution of the responses of the survey (%) given in the general attitudes towards large cats

Attitudinal Items	1. Strongly agree	2. Agree (%)	3. Neutral (%)	4. Disagree (%)	5. Strongly disagree (%)
Jaguars are a menace to your cattle	12	49	11	18	1
Jaguars are a menace to people	6	25	7	47	6
I would be happy if there was no more jaguars around	3	23	5	51	9
Jaguars need to be protected	9	58	6	18	0
At this ranch we can't tolerate jaguars and pumas attacking the cattle	5	17	6	58	4
Jaguars and pumas attacking cattle is an acceptable risk in cattle business	4	66	6	15	0
It is necessary to find a solution for livestock predation	20	56	2	13	0
Livestock predation should be solved by local, state or federal authorities	14	53	7	17	0
Livestock predation should be solved at each ranch without external help	0	21	3	64	3
I would like to receive help to solve the problem of predation	16	58	6	9	0
I benefit directly from tourism activities	3	21	4	63	0
Tourism in the Pantanal is a menace to my personal life and to Pantanal culture and traditions	4	14	4	58	11
The Pantanal needs more progress and development	13	58	1	18	1
Nature in the Pantanal is a national asset	27	59	1	3	0
Nature in the Pantanal is properly protected	3	25	10	50	3
I am concerned with the future of nature in the Pantanal	16	71	0	4	0
I am fully aware of the problems regarding conservation of the Pantanal	8	80	1	2	0
The Pantanal needs more National Parks and wildlife reservations	1	41	8	38	3
Current laws are sufficient to protect wildlife and flora of the Pantanal	1	44	10	33	3

Table 4. Results of the principal component analysis (PCA): three factors were extracted and used in the analyses
The other three factors were dropped in further analyses of data. Only those loadings >0.40 are shown in the table

Factor Attitudinal items	1 Menace to way of life	2 Need for help	3 Ranchers' profile
Jaguars are a menace to your cattle	**0.59**	**0.524**	
Jaguars are a menace to people	**0.68**		
I would be happy if there were no more jaguars around	**0.43**		**0.50**
Jaguars need to be protected			**–0.49**
At this ranch we can't tolerate jaguars and pumas attacking the cattle			
Jaguars and pumas attacking cattle is an acceptable risk in cattle business			
It is necessary to find a solution for livestock predation		**0.55**	
Livestock predation should be solved by local, state or federal authorities			
Livestock predation should be solved at each ranch without external help			**0.64**
I would like to receive help to solve the problem of predation		**0.75**	
I benefit directly from tourism activities			
Tourism in the Pantanal is a menace to my personal life and to Pantanal culture and traditions	**0.727**		
The Pantanal needs more progress and development			
Nature in the Pantanal is a national asset		**0.598**	
Nature in the Pantanal is properly protected			**0.46**
I am concerned with the future of nature in the Pantanal			
I am fully aware of the problems regarding conservation of the Pantanal			
The Pantanal needs more National Parks and wildlife reservations			
Current laws are sufficient to protect wildlife and flora of the Pantanal			**0.86**
Eigenvalue	3.90	2.53	1.67
% of variance explained by each component	20.55	13.31	8.78
Cumulative % of variance explained	20.55	33.87	42.65
Cronbach's α	0.676	0.579	0.690

Zimmermann 2009). Although ecological factors are important, the attitudes of local people towards wildlife competition are also vital and have often been neglected in conservation planning. In the Pantanal region, the perception of livestock depredation is widespread and has a long history of occurrence (Schaller and Crawshaw 1980). In order to gather a more complete picture of the interaction and how it was perceived, our survey covered ranches representing the Northern and Southern portions of the Pantanal region, even in most remote places, a broader range than previously reported in another study of local people's perceptions

towards predation of livestock in the Pantanal (Zimmermann *et al*. 2005).

Our results indicate that the great majority of respondents (95.5%) confirmed the presence of jaguars and pumas on their ranches. Considering that most of them believed that jaguars are a menace to cattle and a real concern to their ranch operations, we expected that respondents would report high levels of cattle depredation on their ranches. Indeed, the majority of respondents reported having lost cattle to predation by large cats within the last two years before our survey. To measure the impact of jaguar and puma predation upon the local economy, it might be possible to quantify the percentage of cattle loss by predation. However, it is difficult to collect this data because little concern was indicated by respondents in recording the number of attacks by predators. Moreover, their lack of expertise in identifying carcasses of cattle killed by predators precluded any attempt to gather information on these losses. Consequently, rather than focussing on the percentage of losses, we focussed on understanding how respondents perceived the impacts of the competition between humans and wild carnivores.

Livestock predation by large cats

Our results show that the majority of respondents believed that the jaguar population has increased over the last five years, a perception that has been previously recorded for the Pantanal region (Cavalcanti *et al*. 2010). This perception coincides with the current trend of increasing deforestation, human population, and mean size of agricultural properties, and decreasing amounts of land in pastures with native vegetation (Seidl *et al*. 2001; Alho *et al*. 2011). Therefore, local people have begun to occupy former forested areas and come into closer contact with jaguars, which may have contributed to the popular belief that the population of jaguars has increased over the last five years before the survey. Furthermore, our results show that when local people perceived an increase in the jaguar population, there was an increase in preventive measures against predation. However, contrary to our prediction, we found no dependency between respondents' awareness of the size of the jaguar population and the use of control measures against jaguar predation. These results may either represent a lack of consistency regarding the belief that jaguar population has increased, or respondents may perceive that the population increase is not great enough to implement preventive measures against predation.

Factors influencing perceptions towards large cats

Our results on the perceptions of local people towards large cats defined three major components. The first component, menace to way of life, had the highest loadings on tourism and jaguars. Although few respondents believed that jaguars are a menace to people, certain tourism activities may contribute to an increase in negative attitudes towards jaguars, and may cause the elimination of individuals neither associated with attacks on humans or livestock. Indeed, in addition to the lack of consistency towards the belief of a jaguar population increase, tourism activities have increased in the Pantanal, which may have led to a higher rate of human encounters with wildlife, causing predators to become more accustomed to local people. Although tourism can generate profits for local people, it has been conducted unsustainably in the Pantanal, particularly fishing and wildlife safaris (Alho and Sabino 2011). While tourism activities may boost positive attitudes towards wildlife (Hemson *et al*. 2009), they have not contributed to the understanding of large predators and can neither be considered acceptance of their presence nor a solution for minimising livestock predation problems in the Pantanal (Cavalcanti *et al*. 2010). For instance, in the region of Taiamã Ecological Station (Upper Paraguay River), located in Cáceres County in the State of Mato Grosso, package tours to approach and observe jaguars in the wild have been offered. In order to guarantee sightings, jaguars have been attracted with bait (e.g. fish). Because of this practice, jaguars in the region have become more accustomed to human presence. Coincidently, two unprovoked jaguar attacks on humans (one fatal) have occurred in this region in the last three years (Neto *et al*. 2011).

Cattle ranching activities in the Pantanal have traditionally operated in areas where jaguars occur. The consumption of cattle by jaguars is neither recent nor sporadic throughout the Pantanal, as cattle are an important prey source. Cattle depredation has long been reported in the region and it is a common source of loss for the local economy (Schaller and Vasconcelos 1978; Schaller and Crawshaw 1980). However, data regarding livestock predation rates indicate that predation by jaguars is not the major source of cattle loss ranchers at the region (e.g. 0.25% to 0.84% of total livestock holdings; Dalponte 2002; Azevedo and Murray 2007*b*). Although these predation rates represent only isolated portions of the vast Pantanal area, they may explain, in part, why our results indicate that few respondents implemented any preventive methods against jaguar predation on livestock. Contrasting with the low rates of recorded predation, the respondents believed that compensation programs provided by the federal government should be implemented to reimburse local ranchers for losses due to livestock depredation by large carnivores. Although compensation has been used as a major measure to reduce human–wildlife competition in several countries, when not implemented specifically to improve livestock care, it can be ineffective at minimising cattle losses to predation (Madhusudan 2003; Bulte and Rondeau 2005; Zabel and Holm-Müller 2008; Loveridge *et al*. 2010). In addition, our results show that the majority (89.5%) of respondents were willing to receive any type of help from governmental or non-governmental organisations in order to minimise losses. Indeed, the second component of our perception analysis, need for help, had the highest loadings on items such as 'I would like to receive help to solve the problem of predation, and it is necessary to find a solution to livestock predation'. This contrasts with the results from a previous survey for a group of ranchers from the Northern Pantanal who were not willing to receive any type of extra income from the government (Zimmermann *et al*. 2005). Our results may reflect a different economic trend in the Pantanal. Our surveys were conducted a decade later, cattle ranching has become more competitive in Brazil, cattle prices and taxes have increased at the same time that land splitting has lowered the profits of cattle ranching in the region (Cavalcanti *et al*. 2010).

Elimination of jaguars in retaliation for livestock predation is still a common and widespread practice in the Pantanal (Schaller and Crawshaw 1980; Almeida 1990; Cavalcanti *et al*. 2010). Our results show that 33% of the respondents stated that they deal with

predation problems by eliminating the predator, not protecting their cattle. Indeed our results of the perceptions of local people indicated that the third component, ranchers' profile, had the highest loadings on items 'Livestock predation should be solved at each ranch without external help, and I would be happy if there were no more jaguars around'. Trying to solve predation problems on their own is still a common response from agro-pastoralists towards wild predators (Mishra *et al*. 2003; Graham *et al*. 2005; Bagchi and Mishra 2006; Hemson *et al*. 2009). This retaliatory response, particularly in the Pantanal, constitutes an illegal hunting tradition (Cavalcanti *et al*. 2010). This tradition, in part, explains why our results show that only a minority of the local people would rather live without the presence of jaguars, a positive attitude that has also been reported for a group of ranchers from the northern part of the Pantanal, in which jaguars were considered important animals to the equilibrium of the environment (Zimmermann *et al*. 2005).

Low prey availability has been reported as a key factor in predation of livestock by large felids (Polisar *et al*. 2003; Patterson *et al*. 2004; Bagchi and Mishra 2006; Inskip and Zimmermann 2009). Our results show that respondents did not perceive any dependence between large cat predation and population size of prey species for large cats in the region. Although some wild prey for jaguars, such as capybaras and caimans (Azevedo and Murray 2007*a*), are very abundant in the Pantanal, their population sizes vary seasonally due to variations in food abundance and available space caused by the annual flooding (Alho *et al*. 1988). When food abundance is high, jaguars seem to be influenced by a territorial system and cattle becomes an alternative prey (Azevedo and Murray 2007*a*, 2007*b*). Therefore, the seasonal variation in prey population sizes may result in different livestock predation levels (Cavalcanti and Gese 2010), which is not perceived by local ranchers in the region.

Game hunting may also affect jaguar predation rates on livestock (Polisar *et al*. 2003; Hoogesteijn and Hoogesteijn 2008). Jaguars feed mostly on large and medium-sized prey species (Azevedo 2008). Poaching in the Pantanal may also cause variations in the abundance of large wild prey species. Indeed, some respondents reported that illegal game hunting was still common at their ranches (28.7%), and this may have contributed to increase jaguar predation rates on livestock. However, there is no data to support this assumption. The commercial or recreational hunting of wildlife for pelt and skin trade, once very common in the region, is no longer active, and poaching is no longer common in the Pantanal. In spite of that, hunting of the feral pig (*Sus scrofa*) occurs in the Pantanal. Instead of contributing to increase predation levels by reducing the jaguars' prey base, feral pigs provide an alternative species for local ranchers and employees to hunt, providing meat and lard to isolated ranches and keeping alive local tradition of game hunting (Desbiez *et al*. 2011).

Theoretically, ranches with higher levels of productivity and management would be better prepared to deal with depredation problems (Hoogesteijn *et al*. 1993; Azevedo and Murray 2007*b*). However, our results show that the majority of the ranches surveyed practiced limited husbandry practices. Except for the fact that more than half of the ranches performed some type of pasture rotation, the majority of the ranches lacked a breeding program (57.5%), had low (0.58 ± 0.38 cattle head) cattle stocking rate per hectare and had cows calving for the first time at an advanced age (>36 months); these ranches also presented high rates of livestock discard (>17% of total holdings), predation by large cats before weaning and lacked maternity paddocks for restricting cow movements. This may result from the fact that livestock is raised extensively throughout the Pantanal (Seidl *et al*. 2001; Zimmermann *et al*. 2005). Therefore, management efforts may not be perceived as necessary because a certain number of cattle are expendable. Indeed, we found no dependency between levels of productivity and respondents' answers regarding large cats' predation and evolution of predation during the last five years before the survey.

Although levels of productivity did not influence respondents attitude towards predation and only a few respondents who were more tolerant towards predation by large cats implemented cattle management practices, we found that, in support to our prediction, intensity of cattle management did influence ranchers' responses regarding predation by large cats. These respondents did not seem to care about the risk of losing their own cattle to large cats. The majority of ranchers that implemented cattle management agreed that losing cattle to predation by large cats was a real risk to their ranching operations. This type of attitude is not dissimilar to that recorded for other large cats (Loveridge *et al*. 2010), for instance pumas (Thornton and Quinn 2009) or tigers, when opportunities such as poaching are available to offset loss by predation (Johnson *et al*. 2006).

Conservation recommendations

Human–wildlife competition in the Brazilian Pantanal is a complex process that has yet to be thoroughly clarified and understood. Killing jaguars is an accepted long-term tradition based on the attitudes of landowners mostly associated with perceived impact of jaguars on livestock (Cavalcanti *et al*. 2010). Regardless of the paucity of data on this matter, our study highlighted some particularities for the region that may be vital in solving or minimising the consequences of the competition. Contrary to a previous study (Zimmermann *et al*. 2005), we believe that preventive methods against predation will be difficult to implement in the Pantanal, since cattle ranching is extensive in the region, cattle herds are huge and ranches are composed of large tracts of natural landscape. Our results show that ranchers did not care about, and are not interested in, implementing preventive methods against predation. Therefore, we suggest that the focus of conservation actions should be on cattle management aimed at minimising other sources of income loss caused by poor husbandry practices (e.g. cattle stocking rate per hectare of pasture, the age of cows at first birth, inter-calving period and cattle birth and discard rates). By improving husbandry practices, ranchers may benefit from higher productivity levels, higher cattle quality and therefore increased beef prices. Few attempts have been made to improve husbandry practices in the Pantanal region, such as the increasing number of smaller allotments for pasture rotation, decreasing cows' first calving age to less than three years and establishing maternity paddocks away from forested areas. These practices together with tourism activities have shown to be effective in minimising cattle loss and therefore alleviate the economic impact of predation on livestock (Cavalcanti *et al*.

2010). Moreover, such practices have also contributed to keep livestock predation rates at a lower level (Azevedo and Murray 2007*b*), which highly affected rancher's attitudes and may alleviate negative perception towards the presence of large felids in the Pantanal region.

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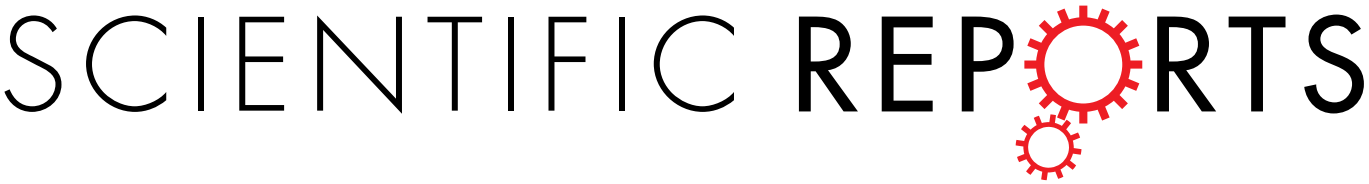

OPEN

Community-based management induces rapid recovery of a high-value tropical freshwater fishery

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Tropical wetlands are highly threatened socio-ecological systems, where local communities rely heavily on aquatic animal protein, such as fish, to meet food security. Here, we quantify how a 'win-win' community-based resource management program induced stock recovery of the world's largest scaled freshwater fish (*Arapaima gigas*), providing both food and income. We analyzed stock assessment data over eight years and examined the effects of protected areas, community-based management, and landscape and limnological variables across 83 oxbow lakes monitored along a ~500-km section of the Juruá River of Western Brazilian Amazonia. Patterns of community management explained 71.8% of the variation in arapaima population sizes. Annual population counts showed that protected lakes on average contained 304.8 (±332.5) arapaimas, compared to only 9.2 (±9.8) in open-access lakes. Protected lakes have become analogous to a high-interest savings account, ensuring an average annual revenue of US$10,601 per community and US$1046.6 per household, greatly improving socioeconomic welfare. Arapaima management is a superb window of opportunity in harmonizing the co-delivery of sustainable resource management and poverty alleviation. We show that arapaima management deserves greater attention from policy makers across Amazonian countries, and highlight the need to include local stakeholders in conservation planning of Amazonian floodplains.

Although freshwater ecosystems comprise only 0.8% of Earth's surface[1], they host one third of all vertebrate species worldwide[2], and have always played a critical role in societal development throughout human history. Currently, freshwater environments and wetlands are top global scale conservation priorities, because they are rapidly becoming the most threatened ecosystems, particularly in the tropics, with rates of species loss substantially higher than those of terrestrial environments[3].

Many of these overexploited and increasingly degraded freshwater environments can be described as socio-ecological systems (SES), where social norms, ecological relationships and biophysical interactions are dynamic, complex and reciprocal[4]. Human settlements, for example, are heavily dependent on freshwater resources such as fish, and the top-down structure of entire fish communities is often governed by the intensity of human overexploitation[5]. Conservation and management of fish stocks are therefore essential to the economic stability and social wellbeing of floodplain dwellers. Conservation of freshwater ecosystems is widely considered an intractable problem affected at different spatial scales, and is inextricably related to the often extolled but rarely reconciled major challenges for humanity in the new millennium: biodiversity conservation, improved quality of life, and poverty alleviation[6].

Establishing the framework for sustainable resource use in locally co-managed SESs is often a herculean task. This challenge is particularly difficult partly because resource populations are affected by both biotic and abiotic factors, in addition to the landscape dynamics of human exploitation pressure. For example, marine fisheries respond to large-scale spatial patterns, such as latitude, elevation, annual precipitation, and ecosystem primary productivity[7]. At smaller scales, several other important variables can govern freshwater resource availability including landscape and habitat heterogeneity[8], water chemistry, and plankton productivity[9].

Setting aside and implementing well-managed protected areas is but one way of achieving sustainable resource use[10]. For example, effectively established marine protected areas have resulted in significant seascape-scale increases in fishery yields[11]. Moreover, there are contentious discussions that remain unresolved about the role of

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sustainable-use protected areas in realistically reducing poverty and promoting other social benefits, mainly in developing countries[12]. The rationale behind the thorny issue of reconciling biodiversity conservation with local socioeconomic needs can be mainly justified at two levels. First, implementation and maintenance of existing protected areas, particularly large tropical reserves, are rarely effective due to scarce financial and human resources, and inherent surveillance difficulties in enforcing reserve regulations against a myriad of increasing external threats[13]. Therefore, formal alliances with reserve residents can decentralize resource management, strengthen full-time surveillance systems, and reduce overall conservation costs[14]. Secondly, protected areas can enhance income opportunities, creating direct social and economic benefits for local people[15]. For both of these reasons, legally occupied sustainable-use reserves now exceed people-free strictly-protected reserves in terms of both numbers and total area throughout the tropics[16].

There are good examples of local communities that have been effectively empowered to manage their own resources. These approaches are often referred to as Community-Based Management (hereafter, CBM), whereby local people with a vested interest in sustainable-use activities undergo an empowering process to gain management control of their local natural resources[17]. This has been independently demonstrated to work in different resource management systems, for example to strengthen the sustainability of coral reef fisheries[18], convert commercial hunters into conservationists in Afrotropical forests[19] and improve conservation outcomes in Himalayan forests[14]. However, well-grounded examples of positive ecological outcomes from CBM schemes have been rarely demonstrated[20].

A rare noteworthy example of community empowerment of artisanal fisheries management has been occurring in lowland Amazonia[21]. With growing market demand and technological innovation, large-scale commercial fishing pressure on Amazonian fish stocks has been escalating since the early 1960s[22]. This fueled the emergence of community-based management initiatives, whereby fisherfolk began to restrict access by large commercial fishing boats into lakes near their communities[23]. These initiatives, whenever they can be formalized, have been variously referred to as 'Fishing Accords' between subsistence and commercial fishing interests and have had a strong effect on local fisheries management. In 1993, government agencies legally sanctioned these local agreements as a formal fisheries management tool, which has since become a powerful strategy to prevent overexploitation of important fish species[24]. Since 1999, such fishing accords, based on a strong social organization movement, paved the way to the development of a promising community-based management system focused on the exploitation of arapaima or *pirarucú* (*Arapaima gigas*, Arapaimidae), a target species of marked importance in Amazonian history and prehistory.

Arapaima spp. represents an apex predator in Amazonian fish communities and Earth's largest scaled freshwater fish, reaching >3.0 m and >220 kg (Supplementary Information, Fig. S1). The alpha taxonomy of this monotypic genus is poorly understood, and some new Amazonian species may yet be described[25]. Adult arapaima exhibit high levels of parental care, protecting its fry at all times, which contributes to its relatively low fecundity[26]. Fry-guarding adults produce a mucous secretion, which flows through the water creating a safety net that maintains a more cohesive family unit, and reducing natural predation on young[27]. Due to its high ecological, economic and cultural value, large body size, late maturity, and small brood sizes, Arapaima *spp.* is highly vulnerable to overexploitation, and has been driven to local extinction at many localities[28]. Surprisingly, however, *A. gigas* is currently listed as 'data deficient' in the most recent IUCN Red List of Threatened Species.

Here, we provide a quantitative assessment of how CBM can promote the recovery and conservation of arapaima, one of the most important tropical freshwater fisheries, while generating both significant income and economic food security for local livelihoods across Amazonian floodplains. We examine the effects of different spatial scales of protection (protected lakes within and outside protected areas), community management regime, distance to nearest markets, and limnological and landscape-scale variables associated with 83 monitored lakes spread across a ~600-km section of the Juruá River of western Brazilian Amazonia. We further identify the patterns of local perception on arapaima population growth as witnessed across 41 semi-subsistence communities surveyed over the last 10 years. Finally, we discuss CBM initiatives as a powerful tool for Amazonian floodplain conservation in decentralizing responsible decision-making over natural resources, while serving the interests of both biodiversity conservation and local livelihoods.

Methods

Study Landscape and Social Context. This study was carried out at 80 floodplain lakes inside and outside (upriver and downriver) of two large contiguous sustainable-use reserves along the middle section of the Juruá River, the second-largest white-water tributary of the Amazon River (Fig. 1). The ~14,000-km^2 study landscape contains two main forest types: 17.7% of seasonally-flooded (*várzea*) forest along the wide floodplain and 82.3% of upland (*terra firme*) forest which is rarely if ever inundated[29]. The wet and dry seasons coincide with periods of high (January–June) and low floodplain water levels (August–November), with a prolonged flood pulse often exceeding 10 m in amplitude[30].

We note the unusually high level of socio-political organization of the local communities occupying this region. Over much of the last century, natural latex exploitation by rubber tappers was the dominant economic activity in central-western Brazilian Amazonia. However, as government subsidies dwindled, rubber extractivists gradually succumbed to extreme rural poverty. This created a serious need for social self-organization fueling local demands for sustainable-use forest reserves, where traditional extractive lifestyles were granted communal territory rights, thereby preventing more predatory forms of land use[31].

In this context, the federally-managed 253,227-hectare Médio Juruá Extractive Reserve (RESEX Médio Juruá) was created in 1997. Located on the west bank of the river (5°33′54″S, 67°42′47″W; Fig. 1), this reserve is legally occupied by some 2000 people distributed across 23 villages. This was followed by the creation of the state-managed 632,949-hectare Uacari Sustainable Development Reserve (RDS de Uacari) (5°43′58″S, 67°46′53″W) where ~1200 people live in 32 villages. In addition to those 45 local communities, we also monitored 14

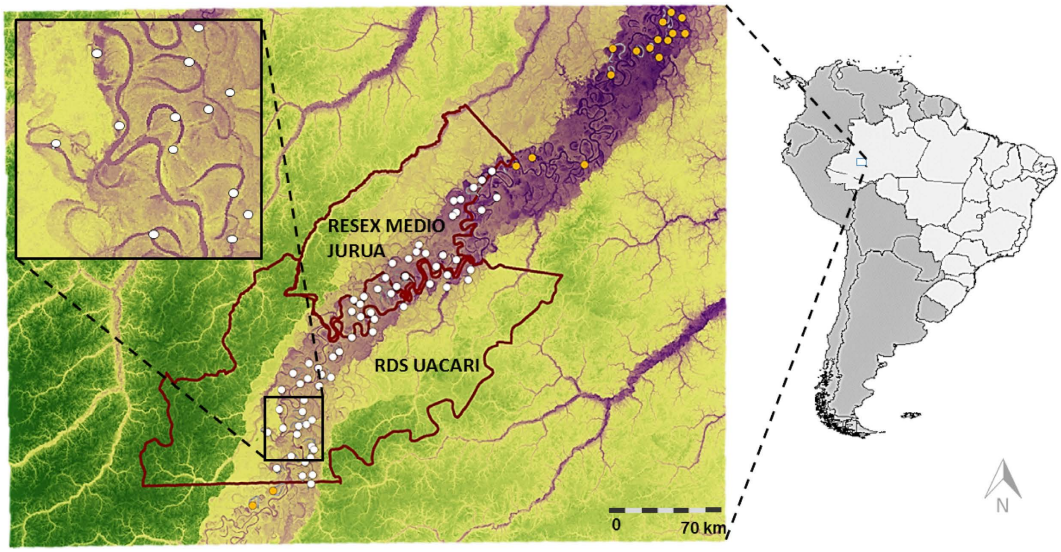

Figure 1. Distribution of 87 floodplain lakes sampled across a ~600-km segment of the Juruá River of western Brazilian Amazonia. White and orange circles indicate lakes inside and outside protected areas, respectively. Dark-red lines show the boundaries of two contiguous sustainable-use forest reserves, which amount to a combined area of 886,176 ha. This map was generated in ArcGIS 10.3 (http://www.esri.com).

communities outside these protected areas. The local economy is sustained by fisheries, slash-and-burn cassava agriculture, and non-timber forest products such as oil seeds and palm fruits.

'Fishing Accords'. To ensure food and economic security for rural communities, *Fishing Accords* in the mid Juruá region were negotiated between local communities at the two focal reserves, communities outside those reserves, and the Fishermen Cooperative of Carauari, the nearest town. However, this is the first attempt to evaluate the effectiveness of these fishing agreements.

These agreements established three categories of lake resource access during the dry season, when lakes become discrete geographic features in the landscape: (1) **Open-access lakes** contain free-for-all resource pools and remain available for any fishing interests, including commercial fishing boats; (2) **Subsistence-use lakes** are designed to supply local subsistence needs and restrict access to only subsistence artisanal fishermen from the resident community responsible for guarding that lake; and (3) **Protected lakes** are managed by local communities primarily as stock recovery and arapaima management sites, and exclude both commercial and subsistence fishing boats. A floating wooden guard post is usually erected at the main strategic entrance of the lake, thereby serving as a full-time armed vigilance unit managed by the resident community (Fig. 2). During the arapaima management season, some of protected lakes are harvested by the resident community for only a brief dry-season period of up to 5 days per year, according to a previously set proportional harvest quota based on the number of adult and juvenile arapaima censused at that lake in the previous year.

Annual arapaima counts along the mid Juruá started at several lakes in 2005, whereas lake management was implemented in 2010 by a partnership between local communities, local associations and government agencies. Arapaima counts take place during the low-water season at each monitored lake every year, and the census data are forwarded to IBAMA (Brazilian Natural Resources Agency), which then authorizes a lake-specific harvest quota of up to 30% of all adults (>1.5 m in length) counted, depending on the fish processing requirements of the resident community and other extenuating factors.

Arapaima counts. *Arapaima spp.* is an air-breathing fish that is highly adapted to hypoxic and anoxic environments[27], thereby frequently coming to the surface to breathe air, which facilitates direct sightings and counts (supplementary video S1). This census method is highly effective, was developed and repeatedly field-tested in Central Amazonian floodplains, with the specific objective of quantitatively surveying arapaima populations (see ref. 32 for further details). This census method produces population size estimates that are strongly correlated with those from mark-recapture abundance estimates[32]. Along the Juruá, this technique involved the collaborative participation of up to 20 previously trained and highly experienced arapaima fishermen per lake, who could detect air-breathing arapaima on the lake surface through both visual and acoustic cues. During systematic censuses of each lake, each fisherman working collectively sequentially covered a non-overlapping lake area ranging from 0.2 to 2.0 ha, depending on local constraints such as macrophyte coverage and lake area, to avoid double-counts.

During census periods, each observer remained silent on the lake margins and counted all arapaima detected within each census area over multiple 20-min periods (coinciding with the mean observed air-breathing interval at which they become visible), which were synchronized across observers. These counts could distinguish two main size classes: juveniles (1.0–1.5 m in length) and adults (>1.5 m in length). In very large lakes, counts were conducted over more than one census session often taking the whole day, until the entire census had been

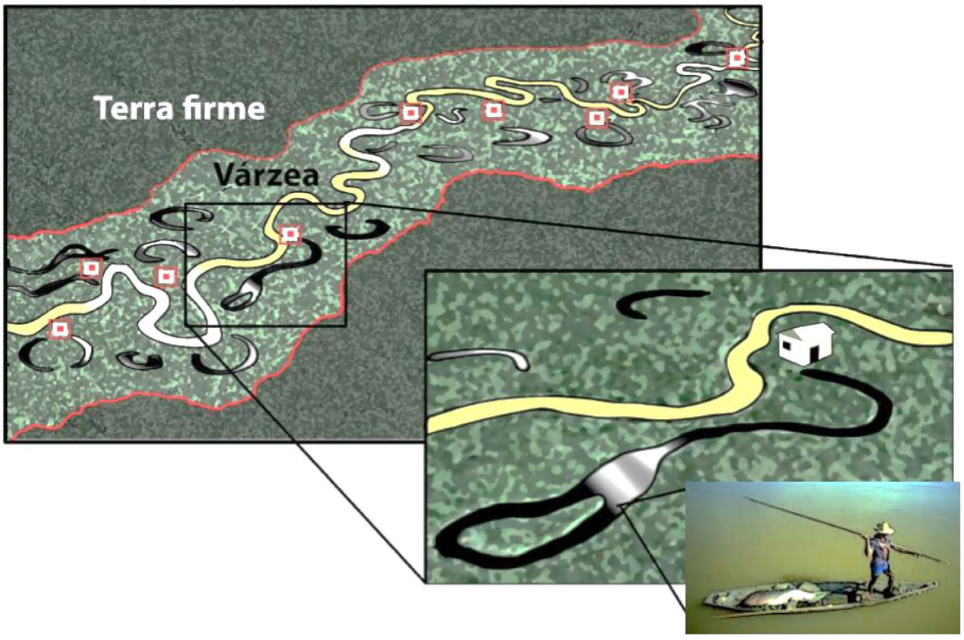

Figure 2. Section of the Rio Juruá floodplain showing the upland (terra firme) forest (dark green area) and floodplain várzea forest (light green area), containing oxbow lakes and levees . Community-based full-time surveillance scheme protecting lakes during the dry season is made possible by a wooden floating house placed at a strategic access point at the mouth of the lake (red squares). Different families in each resident community, who are often armed with a shotgun, take turns guarding the lake against underhand poachers. Intermediate inset figure shows details of a protected lake; small inset figure shows a harpoon fisherman in a dugout canoe harvesting arapaimas.

completed. To preclude any detectability problems due to background noise, arapaima counts were restricted to favourable weather conditions, which excluded rainy days and strong winds.

Arapaima revenues. For each lake and each family household, we estimated the total revenue derived from sales of legally harvested arapaima for local communities of the Juruá region. This was based on ~6200 adult arapaima counted in 2015 at 26 protected lakes. In doing so, we assumed (i) the maximum legally permitted offtake of 30% of the recently censused adult population (Sept–Oct 2015) at managed lakes; (ii) the average dressed weight of butchered and clean carcasses ready to be commercialized (71.3 kg per adult); (iii) the mean market price in the nearest local town (R$ 5.5 ≈ US$2.08 per kg), which is a conservative estimate of market value but more realistically reflects transaction prices actually paid to floodplain dwellers; and (iv) a mean monetary exchange rate of US$1 = R$2.64 (December 2014). We include both subsistence and open-access lakes in these calculations for comparison, but in practice, arapaima catches from these lakes can be consumed locally or bartered, but cannot be sold to external traders.

Datasets and Variables. To understand the determinants of arapaima population sizes within oxbow lakes, we examined systematic arapaima census data obtained at 83 lakes located along a ~500-km fluvial distance along the Rio Juruá (31 protected; 34 subsistence; and 18 open-access lakes; Fig. 1) that had been surveyed at least once during the dry season of 2013. We also had access to yearly dry-season arapaima count data (2005–2015) from most of these lakes, obtained by a collaborative institutional partnership, which yielded a total of 269 counts at 77 lakes (mean = 3.49 annual counts per lake).

For the full set of 83 lakes (Dataset 1), we obtained explanatory data on fisheries management history and a range of landscape variables extracted for each lake using ArcGIS (version 10.2). Predictors of arapaima stock sizes across those lakes included: *Protection area status*: if the lake was inside or outside any protected area; *Lake management category*: open-access, subsistence, or protected; *Lake area:* including both open-water and macrophyte cover; *Distance to nearest community*: the true nonlinear path distance on foot or boat used by local users, which was measured using a GPS; *Distance to nearest market:* expressed as the nonlinear fluvial travel distance from the lake entrance to the town of Carauari port; *Distance to the river channel*: the Euclidean distance between the lake entrance and the main Juruá river channel; *Connectivity:* presence of a perennial levee or secondary channel connecting the lake to any larger water body; and *Water geochemistry*: 'black' or 'white', defined as the locally perceived amount of suspended alluvial sediments in the lake water column.

Secondly, for a subset of 43 of the 83 lakes (Dataset 2), we quantified proxies of primary productivity of the lakes and obtained detailed limnological data based on both field and laboratory measurements of water samples collected during both the dry (low-water) and wet (high-water) seasons. These included: *Depth:* maximum lake depth; *Water transparency:* estimated using a Secchi disk; *Conductivity:* measured in μS/cm using a conductivity

meter; *Macrophyte cover:* initially mapped in the field and then independently measured using 5-m resolution RapidEye© images, which we purchased for the entire study area; *Phytoplancton biomass:* estimated based on both dry- and wet season water samples and chlorophyll-a measurements using high-performance liquid chromatography (HPLC); and *Total phosphorus and nitrogen*: determined using light absorbance at 882 nm. A more detailed description of these variables, measurements and hypotheses are presented in Supplementary Table S1.

Local perception surveys. We conducted 63 semi-structured interviews at 41 local extractive communities containing at least six households. A total of 26 and 15 of these communities were located inside and outside our two focal protected areas, respectively. Interviewees were selected if they were heads of households who were both highly experienced arapaima fishermen and had been continuous full-time residents at any given community for >10 years. During these interviews, we objectively asked about the overall perception of the local arapaima population status (i.e. increasing, decreasing, or stable) in terms of the perceived size of the present population within one or more lakes that had been frequently visited by local villagers during the dry season, against perceived background population trends over the last 10 years. The experienced fishermen have been chosen according the leadership indication, at least one per community.

We also conducted 28 interviews with self-declared formerly illegal arapaima fishers at 13 communities, 12 of which inside the reserves and one outside. These experienced fishers had since abandoned illegal fishing practices and are currently working with the arapaima management program. They also reported on perceived socio-economic changes since the onset of the management program. Essentially, we asked about major perceived changes in local livelihoods after the implementation of CBM. We also assessed the level of importance of any given response, in terms of its overall relative frequency across all interviews. Each interview lasted up to 15 min, and was facilitated by the overall experience of resident fishermen in terms of frequent observational exposure to arapaima populations at community lakes, and fishing effort over at least a decade using harpoons, gillnets, or both.

In this study, we adhere to the full set of legislative and ethical specifications to conduct the research within or outside Brazilian protected areas, including the way we handled local interviews and conducted arapaima surveys. Our methods were explicitly carried out in accordance with the formally approved legal guidelines and licensing requirements as stipulated by the Brazilian Ministry of Science and the Environment (SISBIO license number 45054). We can confirm that all sampling protocols were approved by Brazilian law; and that any data acquisition activities that may have involved people or third parties were conducted with their explicit and clear-headed consent, once they had been completely informed by native Portuguese speakers about the nature and objectives of the research. We further declare no conflicts of interest in reporting the results of this research work.

Data Analysis. To understand the local environmental and management determinants of arapaima population size, we examined Datasets 1 and 2, using the number of adult and juvenile arapaima estimated from systematic counts at each focal floodplain lake as response variables. Dataset 3 was then used to examine the variation in population size and annualized population growth rates from multiple counts within each lake.

First, we ran generalized linear models (GLMs) to examine the variation in recent (2013) counts within the full set of 83 lakes (dataset 1) as a function of all potential predictors. Second, we performed GLMs to examine the variation in arapaima population size within the subset of 43 lakes for which limnological data, including proxies of productivity, were available (dataset 2). Our patch metrics, lake management, and limnological fixed effects are listed above for these datasets. Although arapaima population sizes should scale to lake area, we opted to retain this variable as a fixed effect, rather than as an offset measure, because both census detectability and habitat suitability within lakes were likely highly variable. However, because ecological studies using count data are often affected by overdispersion, a quasi-poisson and negative binomial distribution are often used[33]. We used the latter because the variance-mean relationship provided a better fit.

Third, we used generalized linear mixed models (GLMMs) and a negative binomial error structure to examine variation in all 269 yearly arapaima counts (2005–2015) considering the same set of predictors, but nesting population counts within the 77 lakes surveyed at least twice (range = 2–8 yearly counts), with lake identity defined as a random factor. Fourth, we examine the variation in annualized population growth rates (G_N) within and across lakes by calculating percentage changes in population sizes between any two consecutive dry-season counts (including both adults and juveniles) within the same lake $\left(G_N = \frac{\frac{(Yr_1 - Yr_2)}{Yr_1} \cdot 100}{N_{yrs}} \right)$, which did not necessarily take place in consecutive years. This yielded 186 positive or negative G_N estimates (% yr^{-1}) across 71 lakes exploited by 26 local communities.

We first selected the most parsimonious random intercept structure by identifying the model with the lowest Akaike Information Criterion corrected for small sample size (AICc) with all fixed effects added[34]. ΔAICc is calculated as the difference between the AICc of each model and the lowest AICc, with ΔAICc <2 interpreted as substantial support that the model belongs to the set of best models. Akaike weights give the probability that a model is the best model, given the data and the set of candidate models[35]. Models were fit with lmer in the *lme4* package and every model combination examined with the *MuMIn* package[36] within the R platform (R Development Core Team 2015). When comparing models that varied in their random effects but not fixed effects, models were fit using restricted maximum likelihood (REML). Finally, we calculated the hierarchical partitioning of each explanatory variable.

Because arapaimas exhibit seasonal movements during the flood pulse (JVCS and CAP, unpubl. data), it is possible that population sizes could be homogenized through source-sink dynamics across lakes near one another regardless of their prevailing local management history. We therefore examined the spatial structure of the data across all 83 lakes (yielding 3,160 pairwise Euclidian distances between any two lakes; mean = 73.6 ± 55.6 km; range = 1.3–223.3 km) to investigate the degree to which lakes could be considered as spatially independent.

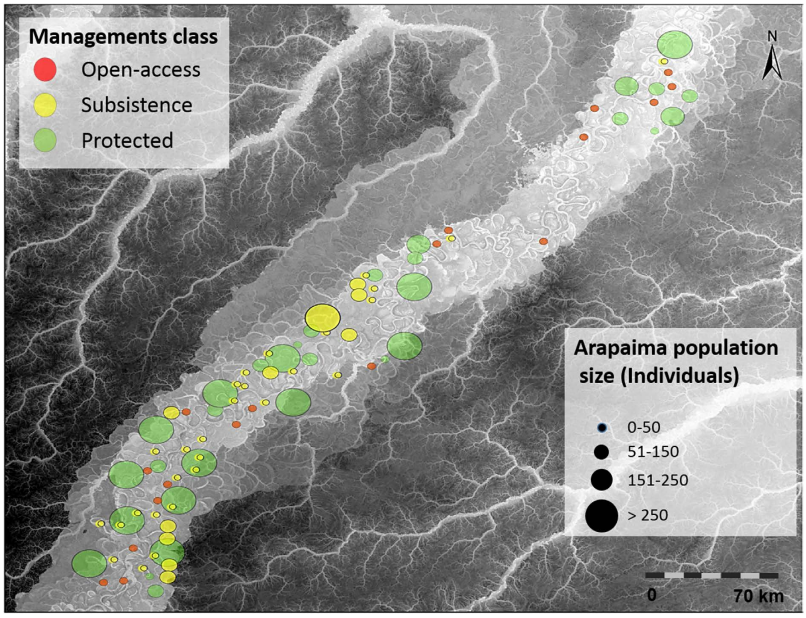

Figure 3. Spatial distribution of protected (green circles), subsistence (yellow circles) and open-access lakes (red circles) along a ~500-km section of the Rio Juruá, Western Brazilian Amazon. Symbol sizes are scaled according to the 2013 arapaima annual population counts. Background elevation map of the study region shows a colour gradient from higher (dark grey) to lower terrain (light grey), with várzea floodplains and oxbow lakes shown in very light grey. This map was generated in ArcGIS 10.3 (http://www.esri.com).

However, there were no differences in model fits between whether or not we included the geospatial structure of the data (expressed as the x, y centroids of lake localities) as additional terms in spatial autoregressive models explaining arapaima stock sizes within lakes based on key environmental and management predictors (χ^2 likelihood ratio test, $P = 0.15$). In addition, stock sizes in open-access lakes were unrelated to physical distances to the nearest protected lake ($R^2 < 0.001$, $P = 0.966$). We therefore decided to interpret, rather than formally incorporate, large-scale spatial effects in any subsequent analyses.

Results

Population responses to community management. There was a dramatic positive response of local arapaima populations to community-based lake management regime (Figs 3 and 4). Lake protection status, as enforced by local communities, explained 71.2% of the variation in population sizes in dataset 1 and 66.8% in dataset 2. Population size estimates were significantly different between the three lake management classes ($p < 0.001$), and averaged over three orders of magnitude from 304.8 (±332.46, $N = 31$) individuals in protected lakes to 34.1 (±24.4, $N = 34$) and 9.2 (±9.8, $N = 18$) individuals in subsistence and open-access lakes, respectively (Supplementary Fig. S2). This becomes even more striking considering that open-access lakes were much larger (222.5 ± 172.1 ha, $N = 18$) than protected lakes (126.5 ± 117.4 ha, $N = 31$), resulting in a mean arapaima population density 131-fold higher in the latter (open-access lakes: 0.002 ind. ha^{-1}; protected lakes: 0.294 ind. ha^{-1}). Whether or not a lake was formally within or outside protected areas was not a significant predictor of arapaima stock sizes (Supplementary Fig. S2).

Lake management class also induced marked differences in the relative abundance of both adults and juveniles (ANOVA, $F_{75,2} = 14.6$, $P < 0.001$). In protected lakes, there were no numerical differences between these age classes, with adults representing an average ratio of 53.4% (±3.7%) of all individuals (162.9 ± 170.3 adults vs. 141.9 ± 171.6 juveniles). In contrast, subsistence lakes were proportionally dominated by juveniles (71.6 ± 3.3%), with mean counts of 9.4 (±10.7) adults and 24.7 (±19.23) juveniles (Supplementary Fig. S3), almost certainly because the persistent year-round harvesting in those lakes selectively targeted adults, whereas live captures of juveniles (<1.5 m in length) were always released.

Positive growth rates were widespread in arapaima populations in both protected and subsistence lakes following the onset of community-based management (Supplementary Fig. S4). Annualized population growth rates across lakes of different management categories (subjected to at least two annual counts) were negative for seven open-access lakes (median = −7.1%, $N = 21$ G_N estimates), but invariably positive for all 41 subsistence (22.7%, N = 125) and 29 protected lakes (34.6%, N = 123). In exceptional cases, arapaima stocks from one year to the next grew five to eight-fold in subsistence lakes, and five to 16-fold in protected lakes. Comparing the first and last years of management at each lake, population sizes increased by 213.3% in protected lakes (mean interval = 5.4 ± 2.5 yrs, $N = 29$) and 193.5% in subsistence lakes (3.9 ± 2.0 yrs, $N = 41$), but declined or remained at persistently low numbers at open-access lakes. For example, the very small $Year_1$ populations recorded at open-access lakes (range 0–24 ind.), which were surveyed over three consecutive years (2013–2015), declined even further or remained unchanged (median change = −11.1%), except for two lakes (Lago Santo Antônio and

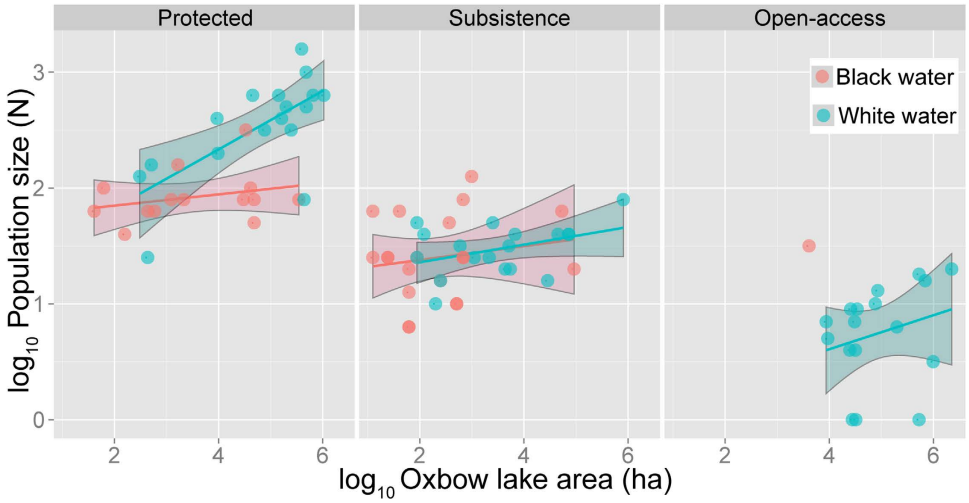

Figure 4. Arapaima population size as a function of floodplain lake area for protected, subsistence and open-access lakes. These relationships were broken down into two main categories of lake water geochemistry, black- and white-water lakes. Intercepts (but not slopes) are significantly different across lake management classes. Slopes are significantly different between black- and white-water protected lakes, with population sizes expanding with lake area much faster in the latter.

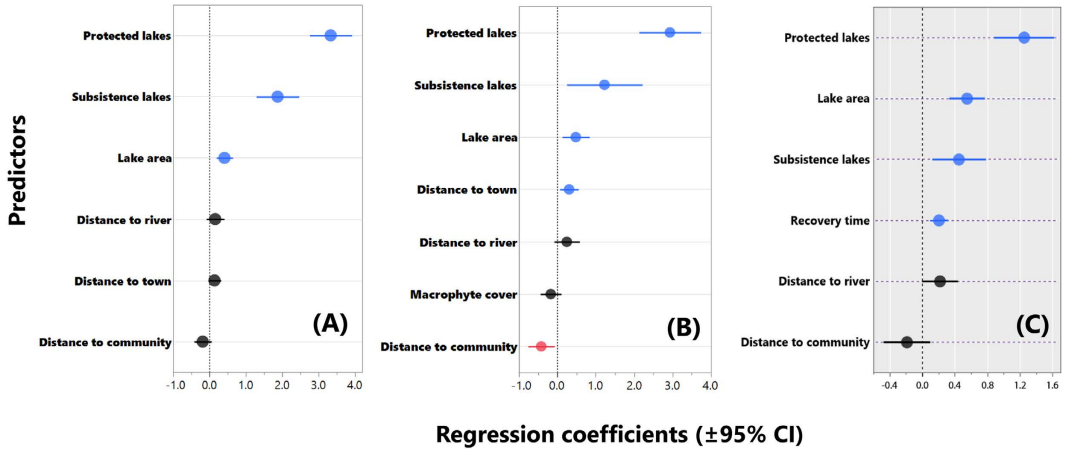

Figure 5. Coefficient estimates (±95% confidence intervals) showing the magnitude and direction of effects of different local and landscape scale variables on arapaima stock sizes and population growth rates within floodplain lakes of Western Brazilian Amazonia. Arapaima stock sizes were modelled with (**A**) generalized linear models (GLMs) using a set of 83 lakes censused in the dry-season of 2013; (**B**) GLMs for a subset of 43 lakes where detailed limnological and lake productivity variables were also quantified; and (**C**) generalized linear mixed models (GLMMs) for a subset of 77 lakes for which 269 annual counts (2005–2015) were available. 'Time' in panel C interaction terms refers to recovery time or the number of years since the onset of sustainable management at any given lake. Explanatory variables were standardized prior to analyses.

Lago Baliera) whose initially small stocks more than trebled, perhaps showing some signs of source-sink demographic subsidies from neighbouring protected and subsistence lakes.

Local management, landscape and limnological effects. Whether we considered (i) all 83 lakes where at least a single arapaima count was available for the same dry season (2013), (ii) the 77 lakes subjected to at least two annual counts, or (iii) the smaller subset of 43 lakes for which limnological data were available, community-enforced mode of lake access always explained the most amount of variance in stock sizes and population growth rates (Fig. 5A–C), with protected lakes always containing the largest or fastest growing populations, followed by subsistence lakes. As expected, although lake area was a significant positive predictor of stock sizes, its effect was consistently smaller than that of lake management class. Recovery time (years) was a significant positive predictor of stock sizes for those lakes counted over more than one year, with high growth rates for protected lakes showing no evidence of slowing down (Supplementary Fig. S4). Nonlinear walking distance to the nearest local community had a significant negative effect on population growth rates (Fig. 5B and Supplementary Fig. S5),

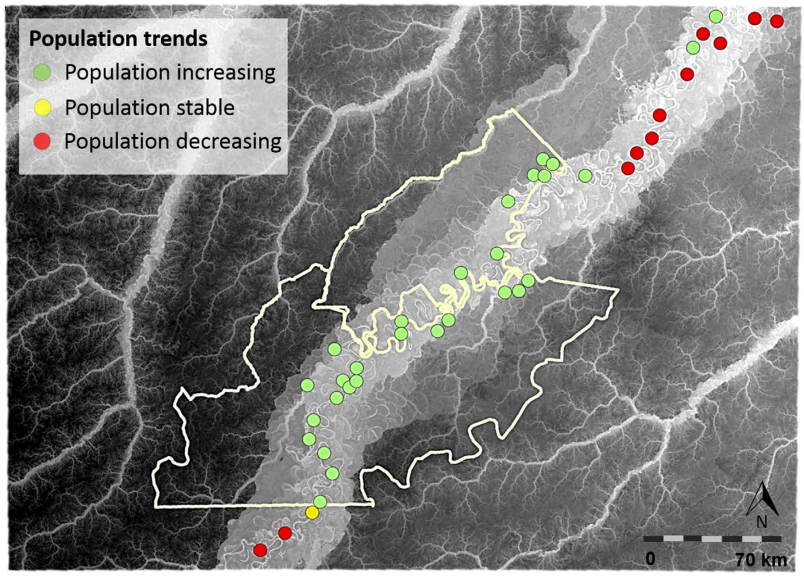

Figure 6. Local perceptions on arapaima population trajectories based on semi-structured interviews with experienced arapaima fishermen. Red and green circles indicate communities (and community lakes) for which local informants reported either a decline or an increase in arapaima population sizes over the last decade, respectively. Yellow circles indicate stable populations that have not appreciably changed over time. Yellow lines represent the boundaries of the two contiguous sustainable-use forest reserves, which may or may not contain lakes referred to during interviews. This map was generated in ArcGIS 10.3 (http://www.esri.com).

presumably because protection measures were inherently more effective at lakes in close proximity to a village, provided residents remained vigilant to enforce widely agreed community rules in light of Fishing Accords. None of the limnological variables were important predictors of population descriptors, except for the proportion of macrophyte cover which was negatively correlated with stock sizes ($r = -0.41$). Further model details can be seen in Supplementary Table S2).

Local perception of stock recovery. Perception surveys with experienced fishermen confirmed the increasingly evident notion that local arapaima populations have been growing inside but not outside protected areas. However, at two communities well outside the protected areas, there was unanimous consensus that arapaima stocks were also increasing since a community management scheme was established (Fig. 6). This again lends support to the idea that lake management in itself overrides the wider effects of protected area status in determining arapaima population trajectories. Socioeconomic benefits accrued from population recovery, as listed by formerly illegal fishermen, were in order of importance: generation of local income, strengthening of cultural values, growing "pride" in the community, and a more equitable distribution of profits from fisheries (Supplementary Table S3).

Arapaima revenues. The bulk of local income benefits accrued from fisheries management was restricted to protected lakes, with subsistence and open-access lakes flat-lined at virtually zero commercial value (Fig. 7). Protected lakes could derive total fishing revenues from arapaima stocks averaging US$10,601 [95% CI: US$5,393, US$15,808] every year, provided that full compliance with management rules takes place and total allowable catches (TACs) are harvested. However, some exceptionally large white-water lakes could yield as much as US$52,093 yr^{-1} if the officially sanctioned TAC had been sold. This translates into mean annual revenues per community household of US$1,046.6 [95% CI, US$497, US$1,596], considering the 14.4 ± 8.5 families per community (range = 4–30) that were engaged in arapaima management activities. These family revenues were positively correlated with the number of years since the onset of the CBM program ($r = 0.791$, $P < 0.001$). Arapaima population growth (and potential revenues) scaled strongly to lake area in white-water lakes, but not in black-water lakes, which appear to be intrinsically less productive in terms of carrying capacity and stock recovery (Fig. 7). White-water lakes on average yielded significantly higher mean revenues (US$1,662.2 ± 350.6) than black-water lakes (US$449.4 ± 395.2; $P = 0.025$).

Finally, we used a predictive model to estimate the average recovery time to achieve a stock size of 1000 adult arapaimas per lake, which could generate a reasonable annual income (≈US$44,491) for the resident community managing that lake. We used as predictors the size of the lake, the distances to the nearest local community and to the main river channel, and the nearest market town. This shows that achieving a stock size of 1000 individuals would take a mean recovery time of only 7.5 to 8.0 years from the onset of the CBM program for white-water and black-water lakes, respectively, and at most 14 years considering the upper 95% CI of our estimates (Supplementary Fig. S6).

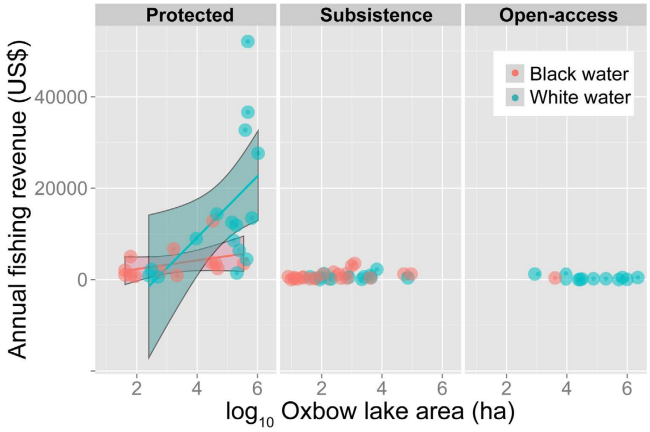

Figure 7. Gross fishing revenues per local community across three classes of lake resource protection through community-based management, which were further broken down into two main lake types in terms of water geochemistry. Slopes for protected lakes are significantly different between black- and white-water lakes, with arapaima populations in increasingly larger lakes accruing much higher revenues.

Discussion

Even some of the most severely underfunded protected areas can be powerful instruments of tropical biodiversity conservation[37]. However, most tropical protected areas are designed on the basis of known terrestrial ecology guidelines, even if they contain extensive freshwater ecosystems. In Amazonia, the overwhelming majority of protected areas are designed to protect forest biodiversity, whereas increasingly threatened freshwater biotas remain highly neglected[38]. This emphasizes the need to rethink how best to protect freshwater ecosystems, but this is hindered by severe political resistance to create new, or expand existing, protected areas[39]. In fact, protected area policy will likely succumb to serious setbacks in many tropical countries, where existing reserves are being downgraded, downsized or degazetted[40]. Given this unfavourable scenario and government suspension of spawning season closures[41], decentralization of conservation policies and alliances with highly engaged local stakeholders can become powerful tools[14].

Recovery of arapaima fisheries has been suggested within some Amazonian protected areas[21,42]. Although our study reinforces these findings, we further show that CBM initiatives, in which floodplain lakes are the management unit of interest, can impart even stronger positive outcomes for conservation, even if implemented outside the boundaries of formally protected areas. Local stewardship, direct *in situ* surveillance, full-time presence, and management of high-value fish stocks were the most important factors in boosting arapaima population sizes across a wide range of lakes. Proximity to the nearest community was a key proxy of effective protection, largely because community management rules and *de facto* exclusion of competing resource users cannot be easily enforced in more remote lakes. Moreover, arapaima represents an umbrella species in floodplain lakes, so that protecting their stocks brings about collateral benefits to other important taxonomic groups, such as freshwater turtles[43] and caimans (JVCS and CAP, unpubl. data).

Although arapaima populations in subsistence lakes are not fully protected, these lakes are in theory closed to commercial fishing boats. This resulted in a much reduced and more size-selective offtake, with live catches of smaller individuals released back into the lakes. This explains both the intermediate arapaima population size compared to either open-access or protected lakes, and the high number of juveniles. In fact, subsistence lakes likely serve a critical role in juvenile recruitment, and ensure largely exclusive access to highly-selective artisanal fisheries targeting large populations of smaller-bodied detritivore and frugivore fish, which provide the mainstay of animal protein for Amazonian floodplain dwellers[21].

Although protected area context has been shown to be imperative to ensure arapaima stock recovery elsewhere[21,42], and remains an important overarching scale of protection, we argue that the Juruá sustainable-use reserves were not only important in protecting harvest-sensitive stocks, but also provided more favourable conditions for successful CBM establishment. Community-level socio-political organization and local compliance are critical determinants of successful resource management[44], and these community traits were conspicuously missing in villages outside protected areas.

Beyond the protected area and CMB effects on arapaima populations, understanding the environmental factors that govern resource distribution and abundance is critical to the establishment of resource use guidelines[45]. First, all other things being equal, larger lakes should be expected to contain larger arapaima populations, and should be prioritized for management (cf. 45). Distances to the nearest town and to the main river channel could also important predictors of stock sizes. The mid Juruá town of Carauari serves as a convergence point for an operational fleet of over 800 variable-sized fishing boats, which largely supply chilled fish to a few wholesale middlemen who monopolize the regional fish trade. Therefore, harvesting pressure on fish stocks is substantially higher near the town than at distant sites up- or down-river, for which travel costs are higher, as well documented in other CBM schemes[46]. The floodplain distance effect can be explained simply in terms of physical access, because more remote (and often older) floodplain lakes far from the meandering main channel are rarely visited by commercial fishing boats.

Considering the subset of 43 lakes where detailed limnological variables were quantified, macrophyte cover was an important yet ambiguous predictor of arapaima population size. The habitat heterogeneity created by macrophytes positively affects aquatic species richness[47] — providing shelter, refuge and foraging sites for many species[48]— but hinders physical access to gillnet and harpoon fishermen. The macrophyte zone also provides a critical food supply for juvenile arapaima[49], so we expected the coverage of macrophytes and number of arapaima to covary positively. Surprisingly, however, our data show an inverse relationship, possibly due to a sampling artifact. High levels of macrophyte cover impair counts of arapaima whose detectability is associated with surfacing in open-water[32], thereby super-inflating sampling imprecision. In this study, arapaima population sizes were most likely underestimated in lakes dominated by large areas of macrophytes.

Water geochemistry also played important roles in arapaima population size as proxies of primary productivity. Although this effect size was weak, more productive white-water lakes with high phytoplankton biomass likely supported larger numbers of arapaima. In sum, arapaima populations within dry-season lakes responded strongly to both human exploitation and some biophysical variables. Therefore, we can identify both top-down and bottom-up factors affecting populations of an Amazonian harvest-sensitive large-bodied fish, so that large white-water lakes, particularly those near local communities should be prioritized for local co-management initiatives both *within* and *outside* protected areas.

Arapaima population growth trajectories in protected lakes were a function of time. This is consistent with the results from Mamirauá Sustainable Development Reserve, Brazil, where the arapaima population increased nine-fold in eight years[21]. We cannot yet estimate the maximum carrying capacity of these lakes, but all protected subpopulations were still growing, partly fueled by the annual input of alluvial nutrients brought in by the rising floodwaters, which likely enhances the resilience of exploited animal populations[48]. An example worth highlighting is the Marari Grande lake (Supplementary Table S4), which had been entirely unprotected and available for professional fisheries until 2008. Experienced fishers from the nearest community reported that this lake had long been depleted, and that arapaimas had been locally extirpated. After only 7 years of protection this lake yielded the largest arapaima population in our study landscape (~2,020 individuals). Like elsewhere in Amazonia[22,24], much of this depletion process was driven by less selective large-scale commercial fishing boats, which come from far afield to harvest arapaima and other high-value fish from unprotected lakes. The rapid reversal in this situation resulted from a local initiative to guard the Marari Grande and other protected lakes, which suddenly enforced the exclusion of professional fishing boats from those lakes.

Throughout our study landscape, experienced fisherfolk have reported that arapaima stocks gradually dwindled to very low numbers during the heyday of commercial fishing boats of the 1980s, to the point of perceived local extinction from most lakes in the region. However, this predicament was only reversed with the onset of negotiated fishing closures in both protected and subsistence lakes. This becomes clear when we assessed stock sizes in open-access lakes, which have been bearing the brunt of overfishing. These free-for-all lakes clearly fall under a 'tragedy of the commons' scenario[50], whereby scramble competition for valuable fish resources accelerate overexploitation. During the first years of exploiting an open-access lake, the benefits are disproportionately concentrated on the few commercial fishermen harvesting that lake, to the detriment of all local users. Over time, the pressure on harvest-sensitive resources became prohibitively high, so the population eventually collapsed. Fishing Accords are thus a concrete example of positive communal organization, defining boundaries, and establishing rules of governance that are instrumental in managing common-pool resources, thereby precluding resource collapse[51]. Moreover, such local initiatives can trigger rapid co-benefits in multi-species population recovery in previously depleted lakes, thus increasing the overall fisheries productivity of both those lakes and the neighbouring waterscape[22].

Although arapaima population growth is restricted to managed lakes, the map resulting from local perception surveys indicates that the recovery is widespread throughout the reserves (Fig. 6), whereas arapaima stocks are perceived to have bottomed out outside protected areas. This clear perception pattern is largely due to the absence of widely known protected lakes outside protected areas. However, in the few cases where grassroots management plans were self-established by communities outside protected areas, the arapaima population has been clearly showing an early growth trajectory. This can be seen at Lago Grande (Supplementary Table S4), a 294-ha lake outside the protected areas where the arapaima population increased from ~30 to over 1200 individuals in only 3 years of CBM lake protection.

Yet the degree to which population growth is due to internal recruitment or immigration remains poorly known. For example, it is inconceivable that a low-fecundity fish population can increase 3900% in only 3 years, such as in Lago Grande. Rapid stock recovery must therefore be due to both local reproduction and lateral migration during the high-water season[52], whereby protected lakes likely function as demographic sources. This is consistent with the long-range movements exhibited by arapaima during the flood pulse. For example, one of the juveniles we tracked at RDS Uacari using VHF radio-telemetry moved ~30 km in a few days (JVCS and CAP, unpubl. data). A better understanding of seasonal subpopulation movements during floodwaters is critical in designing a landscape-scale network of protected, semi-protected and unprotected lakes that maximizes fisheries productivity for all regional stakeholders.

Integrated development strategies that render biodiversity conservation truly compatible with poverty alleviation are still too rhetorical but often elusive[53]. Locally co-managed arapaima fisheries in Amazonian floodplains could become an important window of opportunity because this can generate income for thousands of families, apparently without significant wider opportunity costs, for example, in depressing fish catches for excluded commercial stakeholders. Indeed, we show that protected lakes have recently become something analogous to a high-interest savings account, ensuring an average value of nearly US$10,600, assuming the maximum allowable harvest quota of up to 30% of adults and an adequate level of communal organization and compliance. This rare cash-earning opportunity has also improved the socioeconomic welfare of local communities, enhancing education and health services. Moreover, resident communities managing protected lakes can count on an

unprecedented annual windfall payment every year, which enables often prohibitive private or communal investments, such as house refurbishment and purchase of expensive equipment. In addition to local income and social welfare, emergency funds can be generated from arapaima sales, which have covered costs of urgent travel and medical care at nearby urban centers or the state capital (Manaus) in case of serious illness or accidents. This form of immediate access to health care, often resulting in life-saving interventions, is unavailable from state health services. In sum, we show that arapaima CBM schemes can become a colossal welfare enhancement opportunity at relatively low costs. For example, covering all additional expenses for both counting the arapaima population at a large lake (>120 ha) each year, and enforcing anti-poaching vigilance at that lake costs only US$700 per year.

Socioeconomic benefits listed in our perception surveys with formerly illegal arapaima fishermen include local income, more equitable distribution of fisheries profits, and maintenance of cultural integrity. Prior to the management program, illegal arapaima sales were distributed throughout the annual calendar, rather than accrued as a lump sum following the collective dry-season offtake. This cash windfall contributes further administrative benefits in terms of village and household scale financial organization, enabling local managers to invest, for example, in community infrastructure. Fisheries CBM has also been instrumental in propagating traditional knowledge. Children often help during the fish offtake season, while simultaneously learning about arapaima ecology and capture techniques. Experienced fishermen also reported that CBM communities now show a stronger "sense of pride" flowing from the management program, which has been reinforced by positive media coverage disseminating this success story. All of these direct and collateral benefits have greatly strengthened local empowerment, providing positive feed-back on the emergence of the management program as a whole[54]. Finally, local income distribution within villages has become significantly more egalitarian following arapaima CBM because everyone can participate, whereas illegal catches were previously oligopolized by a few highly skilled fishermen.

In recent decades, the Brazilian government, local organizations, local communities, and conservation NGOs have attempted to develop participatory management strategies with a broad base of local uptake[55]. One of the most important features of arapaima CBM in this study is the robust social organization of both small and large communities, which ensures the dialogue, articulation and partnership among stakeholders at different institutional scales, ensuring that the lake protection system operates properly. The management structure is essentially communitarian, whereby the resident community coupled with other lake users define the rules of engagement and use of that environment, so that the spatial patterns of resource access are defined at both individual and collective levels. Moreover, CBM becomes more robust with the adhesion of additional partners because of higher financial benefits, stronger self-monitoring of management effectiveness, and greater collective vigilance in terms of formal or informal law compliance. We also note the strong participation of grassroots institutions, including reserve resident cooperatives and associations of rural producers, which were erected by community members themselves. This ensures that decision-making is in fact in the hands of local communities that were hitherto disenfranchised and had no political voice. This further empowers local resource-users to co-adapt and fine-tune management guidelines according to local culture, which is critical to the success of conservation interventions[56].

However, the long-term viability of Arapaima CBM will depend on a number of externalities. Legal trade of sustainably harvested fish requires producers to meet a number of sanitary preconditions stipulated by Brazilian health authorities. This demands minimum processing equipment and infrastructure, which most local communities do not yet have. These historically deprived communities have so far been isolated from public policies, so meeting even minimum certification standards will clearly require catalysis from government subsidies.

But perhaps the most important incidental challenge to be considered is the likely urban market saturation from many competing arapaima management initiatives at several Amazonian river basins, which would considerably increase supply but depress market prices. Moreover, illegal fishing also remains a significant competitive threat[57], because offtakes from unknown sources are delivered to consumers in large amounts at substantially lower cost. A third wildcard threat to sustainable arapaima management comes from aquaculture in that many Amazonian fish farms are now beginning to produce captive-bred arapaima for local and regional markets[58]. Understanding these market bottlenecks will be vital for the continuity of successful community-based wild fish management. In doing so, government agencies, NGOs and other stakeholders should consider the nuances of trade chains to enhance market conditions for novice CBM traders. Managing wild arapaima populations remains a highly promising conservation opportunity, but maintaining economically viable CBM in the long term will critically depend on solving these challenges.

Arapaima, a paradigm "fish of change". Local Fishing Accords are not new, as they have been established at several Amazonian sites for nearly four decades, although the outcomes have been elusive[59]. However, arapaima fisheries have profoundly changed the concept of local fishing agreements. This fishery and its associated value reinforces the justification of protecting lakes, and allocating much community time and endeavor to this end.

Undoubtedly, arapaima management is a rare window of opportunity to harmonize the often incompatible goals of sustainable resource management and poverty alleviation. All similar efforts across the Amazon are also showing positive results[21,42]. This is significant because these local communities rarely have any alternative cash-earning opportunities. Arapaima management can thus positively empower local communities, and fishing agreements can be instrumental in the sustainable management of aquatic resources in tropical floodplains, thereby serving as an excellent stratagem to recruit allies with full-time physical presence in protecting these threatened environments. Yet, there is not enough federal and state government investment in Brazil—in terms of information transfer, technical input and trade subsidies—to catalyze the initiation and consolidate similar CBM programs despite widespread popular demand. Finally, we emphasize that fishing agreements alone are not a panacea and cannot substitute the creation of large protected areas, because these also ensure the continuity of many complex ecological processes that sustain baseline resource productivity[60].

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Author Contributions

J.V.C.S. and C.A.P. designed the experiment; J.V.C.S., C.A.P. and partners collected the data. J.V.C.S. and C.A.P. analyzed the data and co-wrote the manuscript.

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Short communication

Realities of documenting wildlife corridors in tropical countries

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ABSTRACT

Connectivity is regarded as vital in conservation planning but the whereabouts of remaining wildlife corridors and dispersal areas in most tropical countries are poorly documented. With local experts, we compiled an annotated list of the most important wildlife corridors remaining on mainland Tanzania, information on the status of each corridor, wildlife using these corridors, and threats to them. We discovered that the concept of a wildlife corridor differs greatly between different people working in the same country, so we divided these into five working categories. The most common categories were those identified by known movements of animals between two protected areas, or simply proposed connections between important habitats. In Tanzania, the majority of documented corridors now seem to be in a critical condition, that is, they may have less than 5 years remaining before they disappear, judging by current rates of land use change. Five corridors are in extreme condition and could disappear within 2 years unless immediate action is taken. These pressing problems – and our experience in Tanzania – indicate that surveys of remaining wildlife corridors may need urgent documentation in other countries too and that collators should maintain loose definitions of corridors, accept data of variable quality and give information to authorities as soon as possible in order to maximize the chances of saving these conservation assets.

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1. Introduction

Terrestrial wildlife corridors are usually defined in two ways, either functionally as an area used by animals to pass from one 'habitat patch' to another; or structurally, as an area that connects two patches of suitable habitat by passing through a matrix of unsuitable habitat (Hilty et al., 2006). Wildlife corridors may be important for five reasons. (i) If an animal or plant population declines to a low level or becomes extinct in one area or habitat patch, individuals from another patch can immigrate and rescue that population from local extinction. (ii) If a small population is isolated, it can lose genetic variation over the long term and suffer from inbreeding. A corridor allows immigrants to import new genetic material into isolated populations. (iii) A corridor increases the area and diversity of habitats over and above the area of the two habitat patches that it connects. (iv) If the habitat of one area becomes unsuitable (e.g., because of climate change), organisms (both plants and animals) can move along corridors to reach more suitable habitat, and in a sense be 'rescued'. (v) Some protected areas do not encompass the range of ecosystem requirements needed by certain species. Migrating species, for example, move outside and/or between protected areas and may use corridors for this purpose (Dobson et al., 1999; Crooks and Sanjayan, 2006).

While conservation scientists recognize the importance of connectivity for wildlife (Beier and Noss, 1998), specific information on major nationally important wildlife corridors is often widely dispersed because knowledge resides with research scientists, protected area managers and local people who have little contact with each other. It is therefore very difficult for central government authorities to gain a comprehensive picture of wildlife corridors to formulate and prioritize policies (Sanderson et al., 2006).

In Tanzania, a megadiversity tropical country (Mittermeier et al., 2003), many protected areas are rapidly becoming isolated (Newmark, 2008). The reasons behind this include a growing human population and concomitant land use shifts towards agriculture, infrastructure, and settlement in previously unpopulated areas. Yet at the same time, people depend increasingly on protected areas for the ecosystem services that they provide (e.g., clean and abundant water for domestic, agricultural and industrial use, hydroelectricity) and are benefiting from revenue generated by protected area tourism. Since the opportunities for establishing, maintaining or managing corridors between protected areas are

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rapidly diminishing, and information on remaining wildlife corridors is being lost as historical animal movements are forgotten, we tried to document remaining corridors using expert opinion and grey literature. This exercise resembles Noss and Daly's (2006) "seat of the pants approach" which uses intuitive and opportunistic methods of assessment, based on subjective best guesses, existing knowledge or expert opinion. Specifically, we set out to compile a comprehensive list of all the remaining wildlife corridors in Tanzania to highlight the challenges and opportunities faced in connecting protected areas across the country (Jones et al., 2009). In so doing, we uncovered a number of salutary points that pertain to identifying corridors at a national scale, and which should therefore be of interest to others embarking on such large scale analyses.

2. Methods

We introduced the idea of collecting information on wildlife corridors to attendees of the December 2007 Tanzania Wildlife Research Institute Conference in Arusha, Tanzania. Email requests were also sent out opportunistically to government officers, university research scientists, NGO personnel and conservation area managers across the country for information on the location, status, use and threats to each corridor. We expanded our list of contacts (and corridors) as information accumulated. In the few situations in which we received no response we went to grey literature. On the basis of these reports, we subjectively classified corridors into *Extreme* denoting probably less than 2 years remaining; *Critical*, probably less than 5 years remaining; and *Moderate*, less than 20 years remaining.

3. Results

3.1. Types of wildlife corridor in Tanzania

We found that wildlife corridors are discussed in five different ways by wildlife managers, scientists and interested parties in Tanzania; these probably apply in other tropical countries too. We placed each corridor described from mainland Tanzania into one of these categories (Jones et al., 2009), and the criteria are elucidated below and in Table 1.

A. Unconfirmed corridors. These are the most poorly documented type of corridor. They consist of two sub-categories: (a) known historical migration routes of particular species, usually elephants *Loxodonta africana*, where it is unclear if these routes are still in use or (b) the shortest distance between two protected areas across which animals could travel. In contrast to the next two categories, current land use is not taken into account.

B. Uncultivated lands between protected areas without documentation on animal movement. These are usually patches of natural vegetation that lie between two protected areas, or sometimes a string of lightly protected forest reserves or wildlife management areas (see Caro et al., 2009) between larger protected areas. For almost all such corridors, it is not known whether any population actually uses them to move between the protected areas. Furthermore, habitat suitability and population sizes of species living in these corridors are unknown. Such corridors may, however, be essential in the future if habitat in one of the protected areas becomes modified and/or unsuitable, for example through climate change, oil exploration or mining. These areas may also be very important for wildlife already, e.g., forest-dwelling birds that will not cross open spaces (Newmark, 2006), but this is not yet documented.

C. Continuous or semi-continuous uncultivated land between protected areas with anecdotal information on animal movements. These consist of uncultivated patches or networks of one or more forest reserves that lie between two larger protected areas. Additionally one or more species are believed to move through them, although there are no systematic observations. In Tanzania, this type of corridor often focuses on elephant movements.

D. Known animal movement routes between two protected areas. Irrespective of habitat (and therefore in contrast to C), documented movements of large animals, usually elephants, across a habitat that connects two protected areas; the habitat may be legally protected, or agricultural land, or both. Information is obtained from transect surveys or by radio telemetry as reported in the conventional or grey literature, or by personal communication in the case of ongoing unpublished research.

E. Potential connectivity of important habitats. Formally proposed corridor areas linking fragmented or threatened habitat patches that contain endangered species as specified by an NGO or government agency. A lack of cultivation between patches, usually highland forest, is often a key factor in corridor identification (in contrast to A (b)). Management of such corridors may involve forest restoration projects.

3.2. Characteristics of wildlife corridors in Tanzania

We documented a total of thirty-one wildlife corridors (Table 2 and Fig. 1). Their location was somewhat biased towards places where research has been more concentrated, hence there were a number in the Eastern Arc Mountains and the northern savannas. We found that 16.1% were type A (unconfirmed), 3.2% were type B (land connection), 12.9% were type C (land connection plus movements), 41.9% were type D (known routes) and 25.8% were type E (proposed). Five were classified as in extreme condition, 18 as critical and eight as in moderate condition.

4. Discussion

This compilation of all the major wildlife corridors in a tropical country, Tanzania, highlights three issues. First, the concept of a wildlife corridor differs greatly between different people and it includes shortest routes, only remaining routes, routes based on expert knowledge of certain species, and observations of animal sign. This parallels Noss and Daly's (2006) discussion of the ways in which corridors are identified in the real world. They highlighted the following methods: (i) the most direct logical route between

Table 1
Requisite information to categorise types of corridors described in this study.

Type of corridor	Requires information on wildlife habitat	Requires anecdotal information on animal movements	Requires systematic information on animal movements	Formally proposed by agency
A. Unconfirmed		X		
B. Land connection	X			
C. Land connection plus movements	X	X		
D. Known routes		X	X	
E. Proposed	X			X

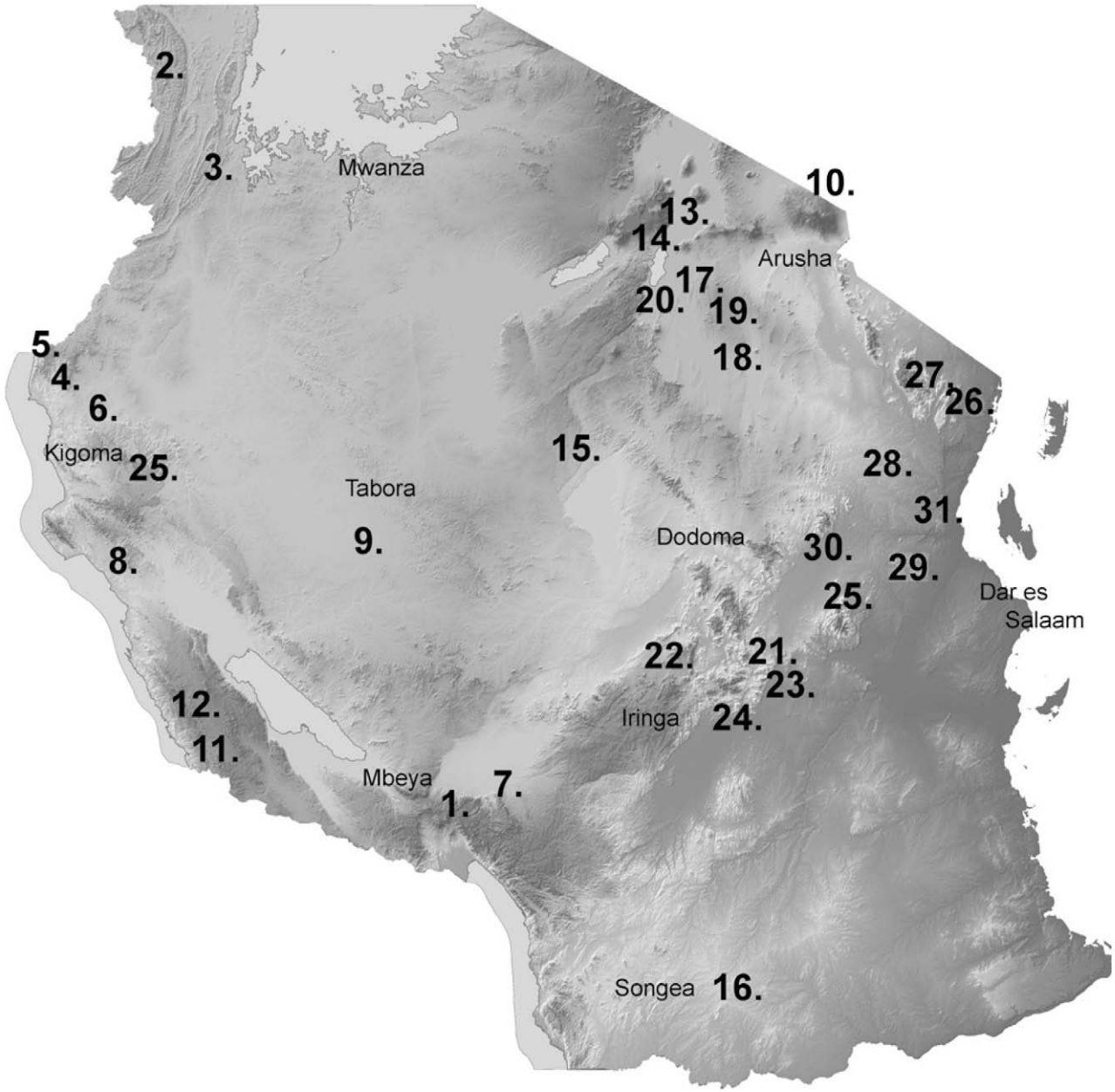

Fig. 1. Summary map of locations of wildlife corridors in mainland Tanzania.

core areas, (ii) the only remaining routes in highly modified landscapes, (iii) routes that incorporate sites of conservation interest, (iv) routes based on expert knowledge of particular species, and (v) combinations of expert-based approaches that incorporate several species' movements, conservation opportunities, landscape data, and consideration of ecological processes. Our categories lean heavily on their approaches (i) and (iv) but also include (ii), e.g., Manyara–Ngorongoro, and (v), e.g., several highland forest corridors. Our exercise also includes their empirical approaches that rely on animal presence, movements and signs, and occasionally radio telemetry but do not yet involve modeling techniques such as least-cost path analysis or routes based on spatially explicit population modeling. Such methods may, however, be employed as specific corridor management strategies are developed. Our main message is that using several locally relevant definitions of what constitutes a corridor is very helpful; for example, elephant movements were an important component in the Tanzanian context.

Second, we found that most corridors in Tanzania are in the category of known animal movement routes between two protected areas (type D), or are proposed connections of important habitats (type E); in Tanzania, the latter being dominated by proposals in the Eastern Arc and Southern Highlands chain of mountains. Aside from proposed corridors, most descriptions of connectivity in this relatively well-surveyed tropical country are based on known animal movement routes. These movements, however, derive from anecdotal observations rather than systematic monitoring of individually-known animals. Indeed, there are few instances where radio telemetry been used to follow species (such as elephants) between protected areas. Moreover, well established modeling and GIS methodologies used to establish connectivity in other areas of the world (e.g., Carroll, 2006) are only in their infancy in Tanzania. This may well be true in other tropical nations too, but we maintain that lack of systematic evidence about corridors does not matter when opportunities for habitat connectivity are being lost at such a fast pace.

Table 2
Summary table of important corridors in mainland Tanzania.[a]

Corridor	No.[b]	Region(s)	Type[c]	Urgency
Bujingijila (Mt. Rungwe-Livingstone)	1	Mbeya	E	Critical
Burigi-Akagera (Rwanda)	2	Kagera	B	Critical
Burigi-Moyowosi/Kigosi	3	Kagera, Shinyanga, Kigoma	C	Critical
Gombe-Kwitanga	4	Kigoma	E	Critical
Gombe-Mukungu-Rukamabasi	5	Kigoma	E	Critical
Greater Gombe Ecosystem-Masito-Ugalla	6	Kigoma	D	Moderate
Igando-Igawa	7	Iringa	D	Critical
Katavi-Mahale	8	Rukwa, Kigoma	C	Moderate
Katavi-Rungwa	9	Rukwa, Mbeya, Iringa	D	Critical
Kilimanjaro-Amboseli (Kenya) (Kitendeni)	10	Kilimanjaro, Arusha	E	Critical
Loazi-Kalambo	11	Rukwa	D	Extreme
Loazi-Lwafi	12	Rukwa	D	Moderate
Manyara Ranch-Lake Natron	13	Manyara	D	Extreme
Manyara–Ngorongoro (upper Kitete/Selela)	14	Arusha, Manyara	C	Critical
Muhezi-Swaga Swaga	15	Dodoma	D	Moderate
Selous-Niassa (Mozambique)	16	Ruvuma	D	Moderate
Tarangire-Makuyuni (Makuyuni)	17	Manyara	D	Moderate
Tarangire-Mkungunero/Kimotorok	18	Manyara	D	Critical
Tarangire-Simanjiro Plains	19	Manyara, Arusha	D	Critical
Tarangire-Manyara (Kwakuchinja)	20	Manyara	C	Critical
Udzungwa-Mikumi	21	Morogoro	D	Critical
Udzungwa-Ruaha	22	Iringa	D	Extreme
Udzungwa-Selous	23	Iringa, Morogoro	E	Critical
Uzungwa Scarp-Kilombero NR (Mngeta)	24	Iringa, Morogoro	E	Critical
Uluguru North–South	25	Morogoro	E	Critical
Usambaras, East (Derema)	26	Tanga	E	Critical
Usambaras, West	27	Tanga	A	Moderate
Wami Mbiki-Handeni/ Southern Masai Steppe	28	Morogoro, Tanga	A	Critical
Wami Mbiki-Jukumu/Gonabis/Northern Selous	29	Morogoro	A	Extreme
Wami Mbiki-Mikumi	30	Morogoro	A	Extreme
Wami Mbiki-Saadani	31	Morogoro	A	Extreme

[a] See Jones et al. (2009) for full bibliography.
[b] Numbers refer to Fig. 1.
[c] A, unconfirmed corridor; B, uncultivated lands between protected areas without documentation on animal movement; C, continuous or semi-continuous uncultivate land between protected areas with anecdotal information on animal movements; D, known animal movement routes between two protected areas; and E, potential connectivity of important habitats.

Our third finding pertains specifically to Tanzania. Alarmingly, we discovered that the majority of documented corridors in the country are in poor condition, and many are critical, meaning that they may have less than five years remaining (up to the year 2013) before they disappear, judging on current rates of habitat change. Annual human population growth rates in Tanzania are high and significantly higher in wards <5 km from protected areas (C. Packer, pers. comm.); and, compared to forest losses in eight other east and southern African nations (surface area of forest lost as proportion of total area of country) between 1990 and 2005, Tanzania matched Zimbabwe in suffering the worst losses (http://www/fao.org/forestry/32185/en/). Based on reports and authors' visits, five Tanzanian corridors are in an extreme condition and will disappear within an estimated two years without intervention. These are the Loazi–Lwafi corridor, the Ngorongoro–Manyara corridor, the Udzungwa-Selous corridor(s), the Wami Mbiki-Mikumi corridor, and the Wami Mbiki-Saadani corridor (Fig. 1). Most corridors are being destroyed by rapid agricultural expansion, increased bushmeat trade and road building, and poor governance. Unless action is taken to manage these activities in a way that considers both human and wildlife needs, human–wildlife conflict will increase and Tanzania's protected areas will become geographically and genetically isolated islands. This will have serious economic and environmental implications for the next generation of Tanzanians. Tanzanian authorities recognize these constraints and welcomed the Jones et al. (2009) report to the extent of sending a copy to the Office of the President.

Our general conclusions are that nationwide surveys of this sort should be conducted immediately in other tropical countries, regardless of the quality of information on corridors and the difficulties in collating data from a wide array of disparate and hard-to-contact sources. Second, it is important to maintain loose definitions of corridors in any such compilation, and to present data to central authorities rapidly given the current pace of land use change.

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LETTER

Protected Area Effectiveness in Reducing Conversion in a Rapidly Vanishing Ecosystem: The Brazilian Cerrado

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Keywords
Cerrado; conservation; effectiveness; habitat conversion; matching methods; protected areas.

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Abstract

Measuring how far protected areas (PAs) reduce threats to nature is essential for effective conservation. This is especially important where a high degree of threat is coupled with opportunities for increasing conservation investments, such as in the Brazilian Cerrado. We examined the effectiveness of strictly protected and multiple-use PAs as well as indigenous lands (ILs) in reducing conversion in Cerrado from 2002 to 2009 by using matching methods to sample protected and unprotected sites similarly exposed to pressures. We found that both types of PAs and ILs experienced lower habitat conversion during this period than did matched unprotected sites, whether results were analysed for individual PAs or for PA networks as a whole. Judging from their matched unprotected sites, strictly PAs had similar levels of baseline conversion to multiple-use PAs, but were more effective at reducing it. This may be expected as multiple-use PAs are under less restrictive land-use rules. ILs had a strong effect in reducing conversion, though baseline rates in matched areas were also high. Our results highlight the usefulness of PAs in the Cerrado and the value of research that differentiates among PA categories.

Introduction

Protected areas (PAs) are an important focus of global conservation efforts, so measuring their effectiveness is essential for conservation. To achieve this, quantifying the extent of PAs is important, but it must be complemented by evaluation of their effectiveness in reducing threats to wild nature (Chape *et al.* 2005). Such evaluation is especially urgent for ecosystems that are experiencing a great level of threat coupled with opportunities for increasing conservation investments. This is the case for the Brazilian Cerrado.

A global hotspot of biodiversity (Myers *et al.* 2000) that originally covered nearly 2 million km^2 of Brazil, the Cerrado biome is a mosaic of savannas, forests, and grasslands (Sano *et al.* 2010) with high species richness, in particular for birds (Silva 1995) and vascular plants (Ratter *et al.* 2003). Conversion rates accelerated over the past four decades as advances in farming technology enabled Cerrado to become Brazil's main agricultural frontier (Klink & Moreira 2002). By 2002, around 40% of the biome had been converted, mostly to cultivated pastures and agriculture (Sano *et al.* 2010). On the other hand, conservation investments appear to be growing, with a total grant of US$ 13 million approved by 2010 for the Sustainable Cerrado Initiative (Marinho & Aguillar 2010), and the release of the Action Plan for Preventing and Controlling Deforestation and Fire in Cerrado—the operational instrument for Brazil's target of reducing Cerrado's conversion rate by 40% by 2020 (MMA 2011).

One of the main strategies of the Action Plan is to improve and expand the PA network. However, little is known about its effectiveness and whether it varies across PA types. The PA system in the Cerrado is governed through the Sistema Nacional de Unidades de Conservação (SNUC) (MMA 2003), which classifies them

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as strictly protected areas (SPs), for categories that allow only the indirect use of natural resources, and multiple-use protected areas (MUs), for categories aiming to reconcile conservation with sustainable use. An additional designation that has been shown to contribute to conservation outcomes elsewhere in Brazil (Nepstad *et al.* 2006) is indigenous lands (ILs). In 2010 SPs covered roughly 3% of the biome and MUs 5%, whilst ILs covered 4% (MMA 2011). Despite this variation in PAs objectives in the Cerrado and elsewhere, studies that compare effectiveness across PA types are scarce (Nelson & Chomitz 2011; Nolte *et al.* 2013; Pfaff *et al.* 2013).

Recent improvements in measuring PA effectiveness through the use of matching methods provide an opportunity to address this gap. These involve comparing PAs with unprotected areas that have similar characteristics that could affect their exposure to pressures, such as soil quality and proximity to infrastructure (Joppa & Pfaff 2009). Failing to control for these characteristics can provide misleading results, as PAs are often located in areas where pressures are relatively low (Joppa & Pfaff 2009). Matching has increasingly been applied in conservation-related research (Costello *et al.* 2008; Morgan-Brown *et al.* 2010), with recent matching studies quantifying PA effectiveness in Costa Rica (Andam *et al.* 2008), Sumatra (Gaveau *et al.* 2009) and the Amazon (Nolte *et al.* 2013), as well as regionally and globally (Joppa & Pfaff 2011; Nelson & Chomitz 2011).

However, to date no such studies have examined PA effectiveness in the Cerrado, or in other savanna biomes. Here we apply matching methods to explore whether habitat conversion is lower inside Cerrado PAs than in comparable unprotected areas, and whether effectiveness levels vary among PA types.

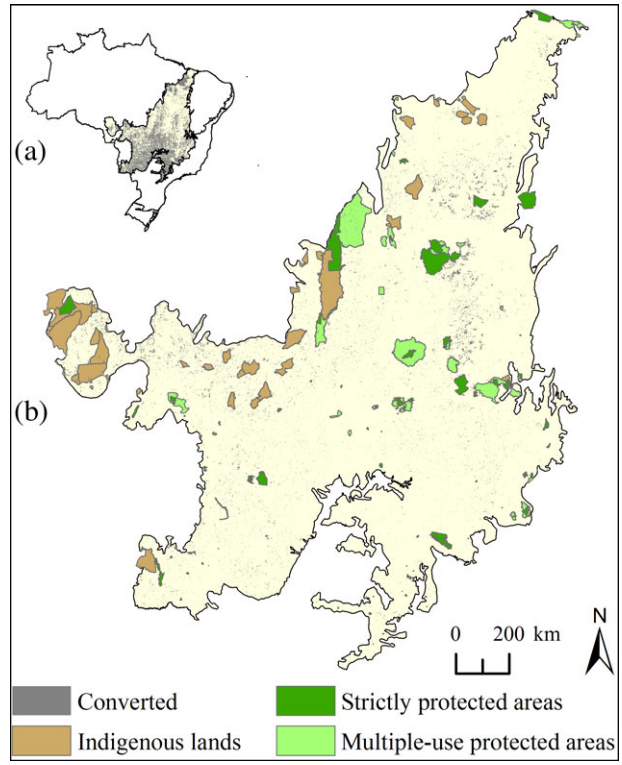

Figure 1 Spatial distribution of conversion and protection of the Cerrado biome. Top left (a) shows its location among other biomes in Brazil, and its conversion by 2002. The main map (b) shows conversion during the study period (2002–2009), and the location of protected areas sampled for this study (169).

Methods

The fact that conversion in Cerrado is not distributed homogeneously throughout the landscape (Figure 1) indicates that pressures are spatially varied. In order to measure PA effectiveness whilst controlling for this spatial variation, we used the study design detailed later.

Outcome variable

Our outcome was a binary score indicating whether a given area was converted between 2002 and 2009 according to conversion data from the Integrated Warning Deforestation System (SIAD) (LAPIG 2012). SIAD data are generated using MODIS satellite imagery, with a vegetation change threshold of 15% followed by visual inspection using higher resolution imagery (Landsat TM and CBERS CCD) to help separate conversion events from vegetation changes caused by seasonal droughts (Rocha *et al.* 2011). A validation study based on field inspections and using a threshold of 30% found that SIAD data had a 79% success rate in detecting conversion, with 21% misclassification due to the effects of seasonal droughts and fire (Ferreira *et al.* 2009).

Protected areas

We included all PA types in the Brazilian SNUC legislation (henceforth SNUC PAs) and ILs. We considered SNUC PAs separately from ILs, as they are governed by different legislation. SNUC PAs were subset into SPs and MUs, which comprise 5 and 7 SNUC categories, respectively, with varying levels of restrictions on land use and a wide range of management objectives. In the international classification (Dudley 2008), SPs and MUs correspond broadly to IUCN categories I–IV and V–VI, with ILs classed as a governance type that can span any IUCN category. We used PA boundaries data provided by the Brazilian database (MMA 2012), and downloaded from

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the SIAD database (LAPIG 2012). We were unable to include private reserves as they are not yet mapped.

Sampling design

In a Geographical Information System we created a grid of 250 × 250 m cells covering the officially recognized extent of the Cerrado (IBGE 2012) and a points layer corresponding to the center of each cell. In our sample we used only those points that intersected native vegetation remnants present in the 2002 land-cover data (Sano *et al.* 2010). These points were then identified as being in PAs, ILs, buffers, or control samples, as described later.

PA or IL sample

We included all points that intersected SNUC PAs (1,137,972) and ILs (1,202,068) designated before 2002. Points that fell in more than one SNUC PA type were assigned to the PA with the strictest protection, for example, a point shared by an SP and an MU was assessed as part of the former only. Where a point fell both within a SNUC PA and in an IL it was assigned to the SNUC PA. Finally, we excluded 49 points that fell in overlaps between PAs of the same category, as these could not be assigned to a single PA. Our sample included 107 SNUC PAs (62 SPs, 45 MUs) out of 116 designated by 2002, and 62 out of 67 ILs, leaving out those which had no remnants of native vegetation in 2002 or where such remnants did not intersect our sample points. Other studies using matching methods pooled all sample points within a PA network (Andam *et al.* 2008; Joppa & Pfaff 2011; Nelson & Chomitz 2011), with the result that larger PAs had more weight than smaller ones in the overall estimates. Here, we sampled (and generated a matched, unprotected control sample for) each PA individually, which allowed us to analyse not only the network effect, but also the average effect of individual PAs (by weighting each PA equally) as well as the variation in PA effectiveness across our sample.

Buffer sample

In order to test for displacement of conversion from inside PAs to their immediate surroundings (i.e., local scale leakage; Ewers & Rodrigues 2008) we sampled all points (1,471,059) within 10 km of our PA or IL sample, excluding any that fell inside other PAs or ILs.

Control sample

We sampled a random set (8,129,688) of those points at least 10 km away from any PA or IL. This gave us approximately 7 control points per PA or IL point, as well as 5 per buffer point, which was considered adequate for matching.

Matching variables

As our study included small PAs, we followed the recommended approach for small sample sizes (Brookhart *et al.* 2006) of focusing on matching variables potentially associated with the outcome in question, which is habitat conversion. Based on knowledge of Cerrado (Klink & Machado 2005) and previous studies (Andam *et al.* 2008; Joppa & Pfaff 2009; Nelson & Chomitz 2011), these variables were: measures of accessibility (distance to paved roads and nearest state or federal capital city (IBGE 2012), complemented by travel time to the nearest city with population $\geq$50,000 (Nelson 2008)); rainfall and agricultural suitability (based on features, such as soil fertility, slope, salinity, and risk of flooding) (IBGE 2012); vegetation type according to Sano *et al.* (2010) split into major formations—seasonal deciduous forest, seasonal semi-deciduous forest, dense ombrophilous forest, open ombrophilous forest, pioneer formations and steppe savanna—and cerrado physiognomies—florestado, arborizado, parque, and gramínio-lenhoso; and elevation (Reuter *et al.* 2007).

Matching methods

We used the Matchit package (Ho *et al.* 2007), in R environment ×64 2.14.0 (R Core Team 2012), which fits a logistic generalized linear model where the treatment assignment is the response variable, and the matching variables are the predictors. The predicted values from the model, termed propensity scores, range from 0 to 1 and represent the probability that a given site belongs to the treatment group based on the matching variables. These values are then used for matching treatment and control samples with similar propensity scores in order to improve balance between samples (Rosenbaum & Rubin 1983).

As our minimum matching criterion, we used a caliper of 0.25 standard deviations of the propensity scores, and exact matching for agricultural suitability and vegetation type. Due to the large volume of data, we considered each combination of vegetation type and agricultural suitability in isolation for the largest sets, since matching for these two variables had to be exact. Some combinations still included too large a dataset; in these cases, we used a random sample of 600,000 control points when the control pool alone was too extensive. When the number of treatment points was higher than 100,000 we used a subset of the data (600,000 points, 90,000 of which were treatment) to estimate the coefficients of the generalized

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linear model that defines the propensity scores, and then estimated the scores for the full dataset. We used a no-replacement policy (where each control site is matched to only one treatment) to increase independence in the control sample (Stuart 2010), and one control per treatment to improve the number of matches.

We were able to match 85.7% of the original SNUC PA sample to controls that suited the criteria, resulting in 975,661 matched pairs. For our IL sample, we matched 57.4% of the points, resulting in 690,425 pairs. We then grouped these pairs according to the PA or IL intersected by the treatment point, resulting in a final sample of 106 SNUC PAs (62 SPs, 44 MUs) and 62 ILs, as for one PA there were no successful matches. As the number of matched pairs per PA varied, we created a cohort of 88 SNUC PAs and 50 ILs that included only those with at least 50% successful matches and 20 matched pairs, and used this cohort to check the impact of sampling intensity on our results. For our buffer sample, we matched 95.0% of the points, resulting in 1,397,620 matched pairs.

Measures of the effect of PAs

Previous studies have quantified the effect of PAs in reducing threats in different ways (Andam *et al.* 2008; Gaveau *et al.* 2009; Joppa & Pfaff 2011; Nelson & Chomitz 2011); we therefore used a variety of metrics.

Absolute effect

This is the difference between conversion in a control sample and in its matched PA (so a positive value means that the PA experienced less conversion than its control sites). We calculated these metrics for each PA in order to estimate their individual average effect (where all PAs had the same weight in the overall results regardless of their size), in addition to their network effect (where the result for each PA was weighted by its total area of native vegetation). We compared the median absolute effect of each of our groups of PAs (all SNUC PAs combined, SPs and MUs subsets, and ILs) with zero, and with each other (SNUC PAs vs. ILs and SPs vs. MUs), using unpaired Wilcoxon tests. We performed the same comparisons for network-wide medians (area-weighted) by bootstrapping (10,000 samples).

Relative effect

This metric complements the information provided by the absolute effect metric by measuring how far baseline conversion rates have been changed by protection, thereby allowing for comparing results with those of regions or periods of time with different baselines. We calculated the relative effect of each PA as the difference between conversion in a control sample and in its matched PA, divided by conversion in the control sample. We compared the median relative effect of each of our groups of PAs (all SNUC PAs combined, SPs and MUs subsets, and ILs) with zero, and with each other (SNUC PAs vs. ILs and SPs vs. MUs), using unpaired Wilcoxon tests. We performed the same comparisons for network-wide medians (area-weighted) by bootstrapping (10,000 samples).

Pooled relative effect

Because previous papers have measured PA effectiveness by pooling data across an entire PA network (Andam *et al.* 2008; Gaveau *et al.* 2009; Nelson & Chomitz 2011), we also calculated the pooled relative effect for each of our groups of PAs. For each network (all SNUC PAs combined, subsets SPs and MUs, and ILs), we computed the mean conversion found in the pool of matched control locations and subtracted it by the mean conversion found in all matched locations within the network, and divided the result by the mean conversion found in the pool of matched controls. This metric differs from our previous network estimates as it pools all locations within a given group (protected and controls) rather than keeping the pairing information of which controls belong to which PA (which is preserved in the area-weighted median). To make the comparison with other studies (with differing baseline conversion rates) meaningful, we expressed their results as relative effects, using information in the papers and additional data sent by their authors.

Conversion in buffers versus control areas

We explored the possibility that any effects of PAs may be offset by displacement of conversion into surrounding areas (local leakage) by comparing conversion in a 10 km buffer around PAs or ILs with that in the buffer's matched control sample. Because many PAs in Cerrado are adjacent, there was great overlap between their 10 km buffers. Therefore, we used a pooled sample of points from all buffers instead of a discrete sample for each buffer.

Results

Absolute effect of PAs

From 2002 to 2009 SNUC PAs in Cerrado had a positive absolute effect overall (Figure 2a, Wilcoxon test, $V = 3844$, $N = 106$, $P < 0.001$), and so did each of their two major subsets—SPs ($V = 1431$, $N = 62$, $P < 0.001$) and MUs ($V = 607$, $N = 44$, $P < 0.001$). This effect was generally larger for SPs than for MUs (unpaired Wilcoxon

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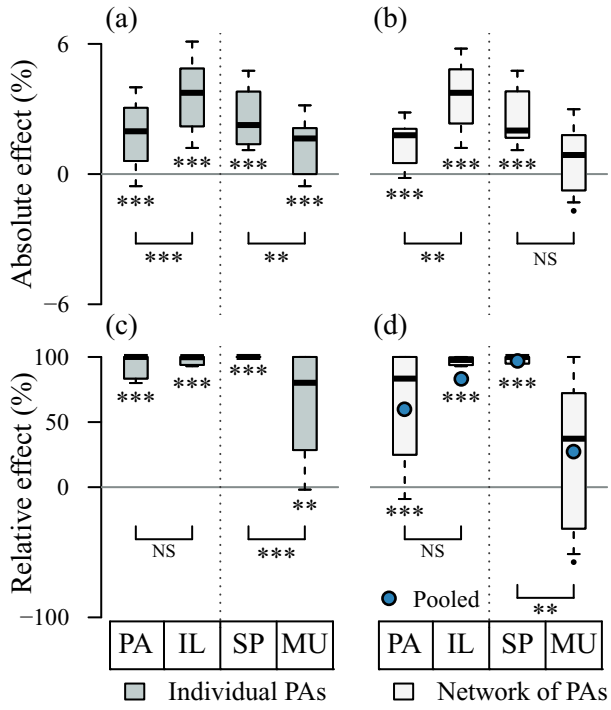

Figure 2 Absolute and relative effect of Cerrado protected areas (PAs) in avoiding conversion from 2002 to 2009. The absolute effect (a and b) is the difference between conversion in matched unprotected and protected sites, and the relative effect (*c* and *d*) is this difference divided by conversion in matched unprotected sites (i.e., the percentage of baseline conversion represented by the absolute effect). Results are shown both for individual PAs (a and c), and their network (b and d; where effects are weighted by PAs total area of native vegetation in 2002). PA: $N = 106$ and 91 (absolute and relative effect, respectively), indigenous land (IL): $N = 62$ and 59, strictly protected area (SP): $N = 62$ and 53, multiple-use protected area (MU): $N = 44$ and 38. NS = $P > 0.1$, $^{\bullet}P \leq 0.1$, $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$, boxes: interquartile range, whiskers: extreme values or 0.5 times the interquartile range, bars: medians. SP and MU are subsets of PA. Outliers are computed but not drawn.

test, $W = 1{,}822$, $N = 62$ and 44, $P = 0.003$), although conversion in control sites for the two categories was similar ($W = 1{,}352$, $N = 62$ and 44, $P = 0.941$). ILs also had a positive effect (Wilcoxon test, $V = 1{,}730$, $N = 62$, $P < 0.001$), which was larger than that for SNUC PAs (unpaired Wilcoxon test, $W = 2{,}023$, $N = 106$ and 62, $P < 0.001$). Conversion in IL control sites was also higher than in those for other PAs ($W = 1{,}962$, $N = 106$ and 62, $P < 0.001$).

When analysed at the network level (using area-weighted medians, Figure 2b), Cerrado SNUC PAs also had a positive absolute effect ($P < 0.001$, 95% CI [0.7, 2.99]), and so did SPs ($P < 0.001$, 95% CI [1.22, 3.85]). The network-wide effect of MUs showed a positive trend ($P = 0.082$, 95% CI [−0.06, 3.08]), due to the great contribution of large MUs with relatively high conversion. Overall, there was no difference between SPs and MUs in their network-wide absolute effect ($P = 0.203$, 95% CI [−0.15, 3.83]), or between conversion in their control sites ($P = 0.256$, 95% CI [−0.78, 1.31]). ILs also had a positive absolute network effect ($P < 0.001$, 95% CI [2.2, 4.87]), which was larger than that for SNUC PAs ($P = 0.001$, 95% CI [0.45, 3.71]). Conversion in their control sites was again higher than in those for other PAs ($P = 0.04$, 95% CI [0.02, 3.03]).

Relative effect of PAs

Examined individually, SNUC PAs in both categories and ILs had a positive relative effect (Figure 2c, Wilcoxon test, all SNUC PAs, $V = 3{,}865$, $N = 91$, $P < 0.001$; SPs, $V = 1{,}431$, $N = 53$, $P < 0.001$; MUs, $V = 591$, $N = 44$, $P = 0.001$; and ILs, $V = 1{,}745$, $N = 59$, $P < 0.001$). This effect was again lower for MUs than for SPs (unpaired Wilcoxon test, $W = 1{,}563$, $N = 53$ and 38, $P < 0.001$), but it was similar for SNUC PAs and ILs (unpaired Wilcoxon test, $W = 2{,}568.5$, $N = 91$ and 59, $P = 0.625$). Note that some sample sizes are reduced in these analyses as it is not possible to calculate the relative effect of PAs that have zero conversion in control sites.

At the network level (using area-weighted medians), SNUC PAs overall also had a positive relative effect ($P < 0.001$, 95% CI [84.62, 100.00], Figure 2d), and so did SPs ($P < 0.001$, 95% CI [99.95, 100.00]), and ILs ($P < 0.001$, 95% CI [93.78, 100.00]). The network-wide effect of MUs showed a positive trend ($P = 0.100$, 95% CI [−16.50, 100.00]), due to the contribution of large MUs with low effect, and it was lower than the network-wide effect of SPs ($P < 0.001$, 95% CI [19.2, 121.45]). The network-wide relative effects of ILs and SNUC PAs were similar ($P = 0.329$, 99% CI [−2.32, 66.65]).

When we checked the effect of sampling intensity on our results, we found that repeating all the analyses above (both for absolute and relative effects) using the cohort of 138 PAs and ILs with at least 50% of successful matches and 20 matched pairs did not produce significantly different results.

Pooled relative effect of PAs

The pooled relative network-wide effect estimates are illustrated in Figure 2d. These estimates differ somewhat from the network-wide area-weighted medians, as the latter preserves the information of which controls belong to which PA (whilst the pooled metric ignores such pairings). The pooled estimates of relative effectiveness of Cerrado SNUC PAs and ILs (Figure 3) were broadly similar to those seen in comparable studies for tropical forests. However, when SPs and MUs were split, SPs tended to

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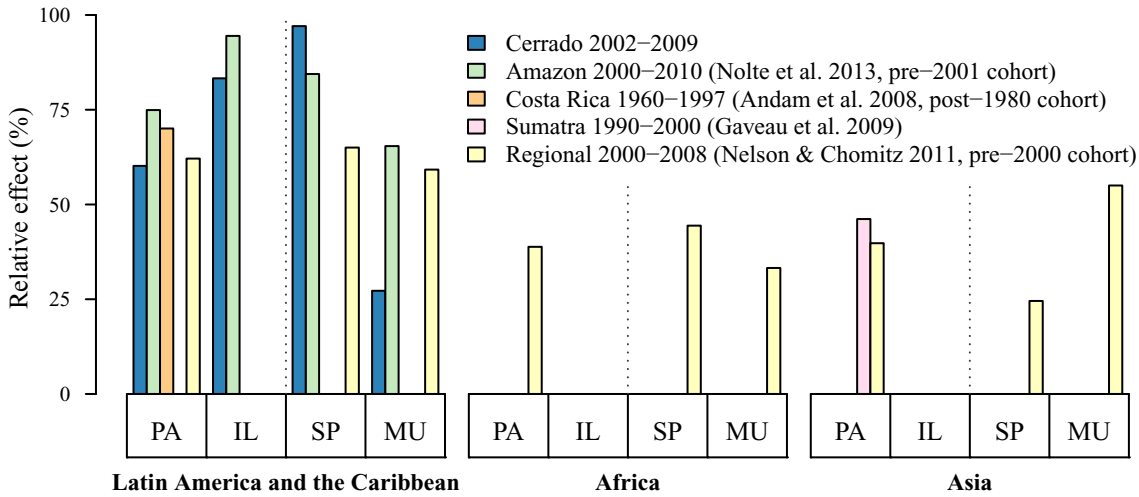

Figure 3 Relative effect of protected areas in Cerrado in comparison with other studies using matching methods, all of which focus on tropical forests. Relative effect is the difference in habitat loss (conversion in Cerrado, deforestation in the Amazon, Costa Rica, and Sumatra, and fire incidence in the regional study) in unprotected and protected sites, divided by that in unprotected sites. Estimates were produced using a sample of sites pooled from the combined range of a protected area network. PA: protected area, IL: indigenous land, SP: strictly protected area, MU: multiple-use protected area. SP and MU are subsets of PA. When other studies used more than one method, time period or data source, we provided the mean for their results and chose the PA cohorts that were most similar to the ones in our study. For the studies that showed results for SPs and MUs, we used the mean between the two as their overall result for PAs.

have larger effects than those reported in other regions, while the effects of MUs tended to be smaller.

Conversion in buffers vs. control areas

The 10 km buffers surrounding PAs did not appear to experience higher conversion than did their matched unprotected sites during the study period (3.0% vs. 3.5%), showing no evidence of local-scale leakage.

Discussion

Our findings are consistent with those of recent matching studies in tropical forests (Andam *et al.* 2008; Gaveau *et al.* 2009; Nelson & Chomitz 2011; Nolte *et al.* 2013; Pfaff *et al.* 2013) and a global analysis (Joppa & Pfaff 2011), all of which found lower deforestation inside PAs than outside. This is the first detailed evidence based on matching methods that PAs also reduce habitat conversion in a tropical savanna biome, and it supports the view that they play an important role in Cerrado conservation despite varying effectiveness across PAs.

Such variation is often a result of differences in their location, as this will influence the baseline threat to which they are compared (Pfaff *et al.* 2009). In general agreement with previous findings in the Amazon (Nelson & Chomitz 2011; Nepstad *et al.* 2006; Nolte *et al.* 2013), Cerrado ILs were located in areas with baseline levels of threat higher than those for SPs and MUs, which provided the scope for greater absolute effect in terms of avoided conversion. When comparing SPs and MUs, previous studies in Latin American tropical forests (Nelson & Chomitz 2011; Pfaff *et al.* 2013) found that PAs under greater land-use restrictions were located in less accessible lands with lower threat, and therefore had lower effects, although the opposite was found for PAs created since 2005 in the Amazon (Nolte *et al.* 2013).

In contrast, SPs in Cerrado were located in areas with baseline levels of threat similar to those for MUs, but were generally more effective. Since their baselines were similar, this may be expected as MUs are under less restrictive land-use rules (MMA 2003). This is particularly true in Cerrado, as most MUs are classed as environmental protected areas (locally termed APAs), which broadly allow more land-use change than other MU categories, and are commonly used for buffering stricter reserves such as National Parks (Rylands & Brandon 2005). Given their different objectives, it may be argued that such MUs should not be compared directly with other PAs in terms of their effectiveness in slowing conversion, but should be assessed using different scales more appropriate to their expected outcomes.

Looking at the relative effect reduces the influence of baseline differences and may highlight other factors that contribute to variation in PA effectiveness (such as aspects of management and enforcement, Bruner *et al.*

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2001; Vanclay 2001). Interestingly, Cerrado PAs were broadly similar in relative effectiveness to the overall average for forest PAs in Latin America, even though the estimates are based on different measures of habitat loss (deforestation, fire incidence, or conversion). Although MUs in the Cerrado have lower relative effectiveness than those in other regions in Latin America, the MU categories involved are different and may not be comparable (see earlier, and Nolte *et al.* 2013).

Based on our findings, conversion avoided by Cerrado PAs was not offset by increased conversion in their immediate surroundings. This apparent absence of local leakage is generally consistent with the findings of other studies using matching methods and a similar 10 km buffer area (Andam *et al.* 2008; Gaveau *et al.* 2009). However, various studies suggest that leakage can involve complex mechanisms with both positive and negative effects, varying with location and scale (as extensively reviewed in Pfaff & Robalino 2012); we were unable to address these issues in this study. Two other caveats should also be considered. First, we do not evaluate how far the extent, location, and connectivity of Cerrado PAs adequately represent the biome's important habitats (Silva *et al.* 2006) and threatened species (Nóbrega & De Marco 2011; Rodrigues *et al.* 2004). Also, we did not explore other threats such as habitat degradation (e.g., by frequent fires), fragmentation, or spread of invasive species—all of which are pervasive pressures in Cerrado (Klink & Machado 2005).

Despite these limitations, our results fill an important knowledge gap, particularly in the context of conservation efforts planned for Cerrado (MMA 2011). Further research incorporating a broader suite of threats would be an important additional step toward the evaluation of PA systems in Cerrado and beyond.

Acknowledgments

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The status of the jaguar in the Pantanal

The Pantanal is considered an important area for the conservation of jaguars *Panthera onca* in the long-term. In comparison to other biomes in Brazil, the Pantanal can be considered still relatively well preserved. According to a recent study, the original vegetation cover remains intact in 85% of the Pantanal plain. However, in the uplands of the Upper Paraguay watershed over 50% of the original vegetation has been altered. This situation is worrisome as this area harbors the headwaters of the rivers that are responsible for maintaining the wet and dry cycles of the Pantanal. As opposed to previously reported, only about 63% of the Pantanal biome is actually occupied by jaguars. Habitat fragmentation caused by human presence and intensification of land use is a threat to jaguars in the Pantanal. Other threats include high levels of retaliation from ranchers due to livestock depredation and the lack of enforcement by wildlife authorities, illegal hunting tourism activity, pasture management through the use of annual fires, and the mining industry. The first estimate of a jaguar population in Brazil was conducted in the southern Pantanal (6.5-7.0 jaguars/km^2), although the distribution of the species is heterogeneous, which precludes an accurate estimation of the current population size in this biome. Authorities should recognize the cost associated with grazing cattle in an area where jaguars exist in considerable numbers and regularly prey on cattle. A unique regional policy could address some of the problem, perhaps in the form of tax benefits, special lines of credit, or a regional increase in beef prices. It is important that environmental actions be implemented to increase market value of cattle raised in the region without changing the main characteristics of the Pantanal.

Assessment

Near Threatened – Due to loss of habitat, increased human presence and intensification of land use, as well as poaching of jaguars, this species is considered to be Near Threatened in the Pantanal biome.

Geographic range information

Extent of Occurrence EOO and Area of Occupancy AOO

The Brazilian Pantanal biome encompasses about 140,000 km^2. Results from the range-wide assessment developed by the Wildlife Conservation Society (WCS) in 1999 suggest that 91-100 % of the biome is occupied by jaguars (Sanderson et al. 2002, Marieb 2005). Their extent of occurrence encompasses about 125,000 km^2 (S. Cavalcanti, map adapted from a MMA Pantanal map and results from the Pantanal Landscape Species Workshop, organized by WCS in Corumbá, 2003).

An exercise by Brazilian researchers working in the Pantanal (Pantanal Landscape Species Workshop, 2003) suggests that only about 63 % or 88,200 km^2 of the Pantanal biome is actually occupied by jaguars (Fig. 1). The area of occupancy exclude most of the Taquari Alluvial Fan, parts of the Cáceres sub-region, portions of the Nabileque sub-region (south of Corumbá), and areas in the north-eastern and eastern border of the Pantanal.

Fragmentation

In general, and in comparison to other biomes in Brazil, the Pantanal can be considered still relatively well preserved (Fig. 2). The inaccessibility of much of its area restricts agricultural practices and deforestation on the plains (Fig. 3). Beef cattle ranching on the savannas with flooding native pastures is relatively less destructive of the environment than large scale agricultural fields.

Less than 20 years ago, the deforestation in the Pantanal was quantified as 5,438 km^2 or 3.9% of the Pantanal area (Silva et al. 1992). In 1993 Mourão et al. (2000) observed that much of the upland areas originally covered by forests or savanna woodlands had been cleared and replaced by pastures. Deforestation areas corresponded to 9,490 km^2 or 6.8% of the Pantanal. In 2000 Padovani et al. (2004) quantified the deforested area as 12,182 km^2 or almost 9% of the total Pantanal area.

According to Mourão et al. (2000), deforestation for pastures has started to spread from the east to the Taquari Alluvial Fan (Nhecolândia and Paiaguás sub regions) and along the courses of the Aquidauana and Miranda rivers. The spread of man-made pastures has been especially intense in the Cáceres sub region (area of Corixo Grande) and in the Taquari river watershed, mainly near the city of Coxim.

The most current information on the status of the vegetation cover in the Pantanal reveals that in the last 9 years (2001-2009) deforestation has accounted for an additional 6% of the area of the Pantanal. The data derives from a recent ongoing survey initiated in the middle of 2008 and carried out by 5 Non-Governmental Organizations (WWF-Brazil, SOS Mata Atlântica, Conservation International, Avina, and Ecoa) with the support of researchers from EMBRAPA Pantanal. According to the study the original vegetation cover remains intact in 85% of the Pantanal plain. However, in the uplands of the Upper Paraguay watershed over 50% of the original vegetation has been altered. This situation is worrisome as this area, adjacent to the plain, harbors the headwaters of the rivers that are responsible for maintaining the wet and dry cycles of the Pantanal (Harris et al. 2005).

In addition to deforestation and fires, human presence causes habitat fragmentation. Over the past several decades, ranches in the Pantanal have decreased in size as land has been subdivided among family members. This division has increased access to areas that were formerly remote and had little movement of vehicles and people. This trend is likely to continue, or even intensify, thereby increas-

Fig. 1. Extent of Occurrence EOO and Area of Occupancy AOO for the jaguar in the Brazilian Pantanal.

Fig. 2. Aerial photograph of a ranch in the northern Pantanal, in the district of Poconé, Mato Grosso, Brazil (Photo S. Cavalcanti).

ing access to prime jaguar habitat. This fragmentation of land decreases its profitability; to maintain economically viable operations, many ranchers opt to increase herd size. This intensification in grazing pressure increases the need for open pastures and introduced grasses which further modifies native habitats.

Ecology and population information

Population size

The few formal attempts to describe jaguar occurrence in the Pantanal have indicated that the jaguar has a heterogeneous distribution in the region (Quigley & Crawshaw 1992). The lack of information for most of the different subtypes of the Pantanal precludes an accurate estimation of the current population size in this biome. It is believed however that the Pantanal still holds a large population of jaguars (Soisalo & Cavalcanti 2006).

In one of the pioneering studies of jaguars in the late 1970's, Crawshaw & Quigley (1991) estimated a population of 3.2 jaguars/100 km^2 in the southern Pantanal. The authors noted however, their data was only speculative. More recently Soisalo & Cavalcanti (2006) published the first estimate of a jaguar population in Brazil based on camera-trap data in conjunction with GPS radio-telemetry data. Their data indicate that in the southern Pantanal, jaguars occur at a density of 6.5-6.7 jaguars/100 km^2. These results are consistent with the estimate of 7.0 jaguars/100 km^2 Azevedo & Murray (2007) reported for the same general area.

Fig. 3. Aerial image of a ranch in the southern Pantanal during the wet season, showing the area's inaccessibility (Photo S. Cavalcanti).

Population trends

Over the past several years there has been increased speculation on the numbers of jaguars in the Pantanal. Ranch owners and cowboys claim that jaguar numbers have increased (Marchini 2003). The suggestion that jaguar numbers are increasing is controversial among government officials, environmentalists and livestock producers throughout the country. There is little evidence whether the presumed increase in jaguar/livestock conflicts are related to increased numbers of these carnivores, increased number of cattle, increased contact due to habitat fragmentation, or increased attention from the media.

Until recently this controversy could not be evaluated due to a lack of baseline data on population numbers. Information on jaguar populations in the Pantanal have been published in the last few years (Soisalo & Cavalcanti 2006, Azevedo & Murray 2007). Although the data from these two studies are consistent at 6.5-7.0 jaguars/100 km^2, it would be unreasonable to assume a stable trend as the studies cover a short period of time. In order to evaluate the trend of the jaguar population in the Pantanal additional estimates from subsequent time periods are needed.

Subpopulations

Within the Pantanal there are no significant barriers that could potentially hinder jaguar dispersal. However, there are regions that are significantly affected by factors such as human presence, density of roads and towns, etc. These areas may hamper jaguar movement to a degree, although it is unclear whether they would separate individuals into subpopulations. Jaguars could possibly be divided into 2 subpopulations (Fig. 4) which would be reasonably connected by the lowland corridor along the Paraguay River. The southern population would be separated from the northern population by the area to the southeast of Corumbá near Fazenda Bodoquena and its surroundings, which has been severely deforested, but probably does not keep jaguars from moving between the two areas.

Extreme fluctuations

Given the diversity of prey species characteristic of the Pantanal and the ability of jaguars to readily switch prey (Cavalcanti & Gese

2010), it is unlikely that jaguar populations undergo severe fluctuations in the biome. Nevertheless, this statement may depend on the time scale being considered. In the late 1970's, jaguars were almost extinct over most of the Pantanal (Schaller 1979) and presently they appear to exist in considerable numbers (Soisalo & Cavalcanti 2006, Azevedo & Murray 2007).

Other life history information

Jaguars are challenging to study. Nevertheless, our knowledge on jaguars has increased since the first field studies in the mid 1980's as several studies have helped uncover different aspects of their ecology and life history (Crawshaw et al. 2004, Novack et al. 2005, Polisar et al. 2003, Scognamillo et al. 2003, Cullen et al. 2005, Palmeira et al. 2008, Harmsen et al. 2009).

The reproductive profiles of female jaguars indicate a lack of an established mating season, i.e., asynchrony, suggesting they associate with males throughout the year (Cavalcanti & Gese 2009). The breeding pattern suggests successful mating taking place at roughly two-year intervals and offspring becoming independent at an approximate age of 18-24 months. Male offspring tend to disperse further than females (Quigley & Crawshaw 2002), thus being the key element in colonizing new areas and in linking subpopulations with dispersal movements.

Cavalcanti & Gese (2009) suggest that the mating system in jaguars may be one of a polygynous and promiscuous nature; a male likely mates with several females and a female mates with several males.

Soisalo & Cavalcanti (2006) found a male: female ratio of 1.5:1 and 1.2:1 during 2003 and 2004, respectively. In a different study area, Azevedo & Murray (2007) reported a male:female ratio of 0.6:1. This might represent different methodological approaches adopted by the two studies or the presence of transient males on the former studied population.

Although there is still a lack of consistent information on jaguar dispersal, jaguars have been reported to disperse over 60 km in the Atlantic Forest (Iguaçu National Park, Crawshaw et al. 2004) and 30 km in the Pantanal (Quigley & Crawshaw 2002, S. Cavalcanti, unpubl. data).

The locations of female jaguars suggest a pattern of spatial avoidance among females during the wet season. Home range overlap among males is extensive both in the wet and in the dry seasons, suggesting that males do not maintain exclusive ranges. Overlap between males and females occurred both in the wet and dry seasons (Cavalcanti & Gese 2009).

Threats

One of the main threats to jaguars in the biome comes from high levels of retaliation from ranchers due to livestock depredation. Historically, jaguars have been killed in the Pantanal as a way to curtail livestock depredation by the large cats (Crawshaw & Quigley 1991, Lourival & Fonseca 1997) even though the amount of damage incurred by jaguars may be less significant than that incurred by other sources of mortality (such as droughts, malnutrition and diseases; Hoogesteijn et al. 1993).

Jaguar persecution goes beyond the economic aspect as it has also a cultural aspect (Cavalcanti et al. 2010). Jaguar hunts are viewed as an act of bravery and dexterity among cowboys, a way to increase their personal status within the community (Banducci Jr. 2007), and therefore remains a common practice in the Pantanal (B. Rondom, pers. comm., V. Correia, pers. comm).

Another serious threat comes from the lucrative illegal hunting tourism activity involving national and international hunters (Almeida 1990, Azevedo & Murray 2007, B. Fiori, pers. comm.).

Although jaguars are fully protected at the national level across most of its range (IUCN 2009), cultural traditions in the Pantanal coupled with the characteristics of the area and the lack of enforcement by wildlife authorities contribute to the regular illegal shooting of these cats. The illegal nature of this hunting makes it difficult to quantify and monitor its effect on the population. The shooting of jaguars remains a regular activity even in areas where landowners have banned the practice.

Fig. 4. Possible jaguar subpopulations within the Pantanal biome.

Increasing deforestation for the implementation of pastures of native and exotic grasses for grazing cattle is another threat that likely disrupts jaguar movements and habitat use (Fig. 5). As previously mentioned, deforestation is more severe in the southeast and north-west borders of the plain.

Pasture management through the use of annual fires, although controversial, also im-

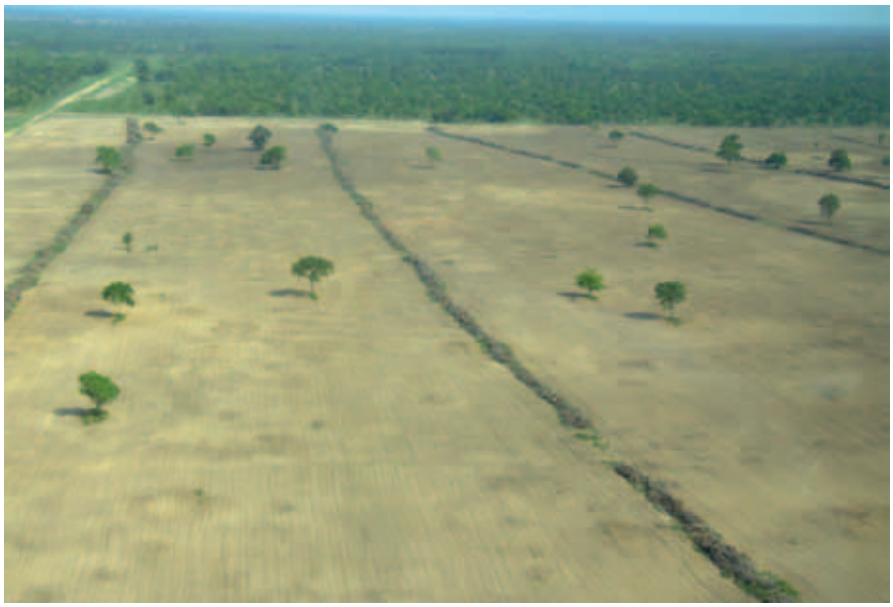

Fig. 5. Area in the southern Pantanal formerly covered by native trees deforested for the implementation of pastures for cattle grazing (Photo W. Tomas).

Fig. 6. Pasture management through the use of annual fires in the Pantanal (Photo S. Cavalcanti).

pacts important natural habitats and kills several prey species. It also probably changes jaguar density in some areas, by disrupting their movements and habitat use. These effects may be especially severe in dry years, when shrubs and trees are less resistant to fire (Fig. 6).

Charcoal production is a potential indirect threat for jaguars in that it may generate incentives for additional deforestation. Wood for charcoal production is usually obtained from sites that have been legally deforested for pasture implementation (Fig. 7). In that sense, it is a legal activity. However, given that wood selling for charcoal production enhances the economic viability of pasture implementation, it tends to be an incentive for the creation of additional pastures and consequent deforestation.

The mining industry is considered a great threat to the Pantanal environment and indirectly to jaguars, both in the north, where there is gold and diamond extraction, and in the south, where there is iron, manganese and limestone extraction (Fig. 8). The district of Poconé has presently fourteen large gold mines and two-hundred smaller excavation sites (PM Pocone 2010). This recent gold mining activity has created great environmental problems, including water and soil contamination with mercury, river sedimentation and changes in the banks of rivers and lakes.

Fig. 7. Furnaces for charcoal production installed in Pantanal ranches on areas that have been recently deforested. Not only they make pasture implementation economically more viable, but also help with the "cleaning" of recently cut areas (Photo W. Tomas).

Locations

The persecution of jaguars by ranch employees occurs throughout the Pantanal biome. It affects both male and female jaguars in all age classes as it is done both opportunistically and in a preventive manner, even before depredations occur. The practice of sport hunting is more localized, but because of its illegal nature, it is difficult to determine precisely where it happens and how much impact it poses to jaguars.

Increasing deforestation is most intensive near the borders of the Pantanal plain, but it happens throughout the biome as well. Considering the ongoing survey carried out by WWF-Brazil, SOS Mata Atlântica, Conservation International, Avina, and Ecoa, the current rate of deforestation in the Pantanal is about 0.67%/year or 6% over the last 9 years. Considering the total area of 140,000 km^2, the annual area being deforested in the plain is about 938 km^2/year, which is quite significant. Considering the non-overlapping home ranges of female jaguars, the total area deforested every year is almost the size of the area occupied by 20 jaguars. But this figure is likely an underestimate given that not all the 140,000 km^2 of the plain is covered by forests.

Another significant threat, the use of annual fires for management of pastures, happens throughout the biome and during drier years may affect even the lower areas of the Pantanal, where most of the jaguars are found. Charcoal production as a threat in the form of incentive for additional pasture implementation is particularly serious in the Miranda/Aquidauana regions, near the southern border of the plain.

Conservation measures

Authorities should recognize the cost associated with grazing cattle in an area where jaguars exist in considerable numbers (Soisalo & Cavalcanti 2006) and regularly prey on cattle. An unique regional policy could address some of the problem, perhaps in the form of tax benefits, special lines of credit, or a regional increase in beef prices. It is important that environmental actions be implemented to increase market value of cattle raised in the region without changing the main characteristics of the Pantanal. Certain

actions have already been tested or put into place, such as organic certified cattle ranching. With the objective of making business ventures economically viable while maintaining the region's environmental and social balance, local ranchers have participated in the organic certified cattle ranching (ABPO Organic Pantanal, http://assets.wwfbr.panda.org/downloads/organic pantanal.pdf, January 2010). Although the international protocols of meat production do not include actions for wildlife conservation, ABPO follows an internal protocol that establishes some environmental directives important from a conservation standpoint.

Embrapa Pantanal has been conducting a 7-year project with the main objective of establishing sustainability criteria/indicators that are specific for Pantanal ranches and include environmental issues. The focal point of the different criteria for ranch evaluation and decision making is biodiversity conservation. This could result in a certification or a stamp of approval program. The adoption of low impact production systems together with an added value to Pantanal meat products can be beneficial for jaguar conservation. This added value via a possible certification program could compensate, throughout the market system, the economic losses caused by jaguar depredation and the lower profitability from lower impact production systems. Embrapa Pantanal has been taking the necessary steps to increase the value of low impact systems, working with ABPO in the search for a strategy that could join both initiatives (organic cattle and sustainability). The institution also works toward a system that is applicable to other production systems, such as the traditional Pantanal ranches that are not part of the organic meat initiative.

Traditional ranchers should focus on increasing their production potential, curtailing losses due to rudimentary herd management and poor husbandry practices, which can be more significant than jaguar depredation (Hoogesteijn et al. 1993). Although predation on cattle in the Pantanal will likely always occur, the results from recent studies (Azevedo & Murray 2007, Cavalcanti & Gese 2010) illustrate the importance of maintaining native prey populations as a possible means of minimizing these conflicts.

The establishment of private reserves inside ranches is another important measure towards conservation of jaguars in the Pantanal. Private reserves act as a guarantee of maintenance of the original natural landscape without human modification. Benefiting from local and federal governments, local ranchers have converted part of their lands into private reserves, or RPPNs. Currently, more than 2,100 km^2 of land are set aside as private reserves in the Pantanal (Harris et al. 2005) and this figure is likely to increase. The recent purchase of large tracts of land by owners that are committed to conservation in the northern Pantanal has produced a mosaic of private ranches interspersed with state and federal parks to create an almost continuous corridor that adds up to roughly 300,000 km^2 encompassing the areas of SESC Pantanal, Mata do Bebe, Encontro das Águas and Guirá State Parks, Pantanal National Park, São Bento, Porto Jofre and Baía Vermelha Ranches, RPPNs Penha, Acurizal, Dorochê, Rumo a Oeste, and Novos Dourados. Such initiatives in strategic locations would definitely contribute to reduce the decline in jaguar distribution or population size.

Long-term ecological studies are also vital for the conservation of jaguars in the Pantanal. Some recent long-term studies have provided important information on jaguar's spatial organization, food habits, density estimates, genetics and predation impact on livestock in the Pantanal (Soisalo & Cavalcanti 2006, Azevedo & Murray 2007a, 2007b, Eizirik et al. 2008, Cavalcanti & Gese 2009, 2010). However, there is a lack of studies on demographic parameters such as age at first reproduction, litter size, age at dispersal, dispersal distances, population sizes, etc, human/predator conflicts and jaguar prey base availability which precludes implementation of management actions. This type of information can contribute to better management decisions that not only minimize cattle depredation by jaguars but that also contribute to increasing acceptance of jaguars by ranchers.

Fig. 8. Gold mining near the municipality of Poconé, in the state of Mato Grosso, Brazil (Photo R. Boulhosa).

Current research projects

1. *Jaguar Ecology in the Pantanal – The Northern Corridor*. Coordinator: Peter G. Crawshaw Jr. and Panthera. The objectives of the project include the foraging, spatial, and social ecology of jaguars, as well as examining demographic parameters of the studied population.

2. Indicators of Sustainability. Coordinator: Embrapa Pantanal – CPAP. This program encompasses 4 or 5 integrated projects, that have been developed since 2002 to implement a ranch evaluation/certification system for the Pantanal.

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HABITATS, ABUNDÂNCIA E OCORRÊNCIA DAS ESPÉCIES DE AVES DO PANTANAL DE POCONÉ, MATO GROSSO, BRASIL

RENATO CINTRA*
CARLOS YAMASHITA**

ABSTRACT

A list of 317 bird species (from 61 families) with their habitats, relative abundance and seasonality is presented for the Pantanal of Poconé (16°S 56°W e 18°S 58°W), Mato Grosso, Brazil.

Observations were made between 1982 and 1986.

Of the total number of species 231 (72.9%) were resident and 86 (27.1%) were seasonal in occurrence.

There were 60 (18.9%) species of wading and "aquatic" birds. Of these 58.3% are migrant birds (i.e enter and leave the area annually).

The families Tyrannidae and Fringillidae had the largest number of species. In twenty-two families only one species occurred. Eighteen families (29.5%) and 143 species (45.9%) were Passeriformes, and 43 (70.5%) families and 174 species (54.1%) were from non-passerine orders.

INTRODUÇÃO

As informações básicas para melhorar o conhecimento sobre a distribuição geográfica das espécies de aves são obtidas inicialmente através de observações de campo e listagem local das espécies.

Alguns estudos já foram realizados nas áreas e regiões vizinhas ao Pantanal (para a Chapada dos Guimarães, Allen 1891, Naumburg 1930, para a Amazônia, Pinto 1932, Pinto e Camargo 1952, Novaes 1976, Willis 1977, para o Planalto Central, Negrett 1981, Negrett *et al.*, 1984; e para o Chaco, Short 1975).

Entretanto poucos levantamentos foram feitos dentro do Pantanal propriamente, exceto alguns de curto período de observação. Além disso estes estudos, na maioria listas, foram realizados em Municípios de Pantanais do estado do Mato Grosso do Sul (na parte Central, Dubs 1983; em Corumbá e Nhecolandia, Weinberg 1984; em Nhecolandia, Cintra em elab.; em Miranda, Antas *et al.*, em elab.).

Apesar de existirem na literatura informações gerais para todo o continente sul americano (Schauensee 1970) e para o Brasil (Pinto 1938, 1944, Sick 1984) registros regionais ainda são insuficientes para muitas espécies. Uma destas regiões no Brasil é a Centro Oeste e especificamen-

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te o Pantanal Matogrossense. O Pantanal além de ser uma área localizada entre a Amazônia, o Planalto Central e o Chaco é uma via importante para aves migratórias (Antas, 1983) vindas do hemisfério norte e das partes norte e sul da América do Sul. Várias espécies migratórias, entre garças, biguás, colhereiros, gaivotas, maçaricos e andorinhas nidificam no Pantanal.

Ecológicamente o Pantanal apresenta diferenças em composição de habitats em cada um dos vários municípios que abrange. Por isso listas regionais precisam ser elaboradas para futuras comparações.

Brown (1984) ao analisar a zoogeografia das espécies de borboletas e aves do Pantanal Matogrossense apresenta uma síntese das observações de vários pesquisadores que moraram ou visitaram a região. Informações gerais sobre quais habitats existem nas áreas periféricas e dentro do Pantanal estão disponíveis no trabalho. Entretanto, especificamente os diferentes habitats onde as aves podem ser observadas não estão descriminados para cada espécie.

O objetivo deste artigo é apresentar uma lista preliminar das espécies de aves existentes no Pantanal de Poconé, em Mato Grosso. Informações adicionais sobre os habitats, ocorrência e abundância (dados qualitativos) são apresentados. Esta lista resultou somente das observações de campo dos autores. O primeiro autor morou durante dois anos e meio e o segundo autor três anos, no Pantanal de Poconé.

Métodos

As observações foram feitas entre 1982 e início de 1986 (Março no Município de Poconé entre 16°S 56°W e 18°S 58°W), em várias fazendas (Fazenda Baía de Pedras, Fazendinha, Fazenda São João, Fazenda Ipiranga, Fazenda Rio Alegre, Fazenda Santa Isabel, Fazenda Jofre, Fazenda Acurizal, Fazenda Malhada), e mais intensivamente em áreas 1) ao longo das Rodovias Transpantaneira de Poconé à Porto Jofre, 2) de Poconé a Porto Cercado, 3) no rio Cuiabá de Porto Jofre até o encontro com o rio Paraguay, 4) e nas áreas dentro do Parque Nacional do Pantanal (Fig. 1).

Nós utilizamos binóculos (8x30, 7x50) e luneta (x30) para observações de campo, e redes ornitológicas armadas em diferentes habitats para captura, marcação e medidas de aves.

Os pantaneiros não tem nomes para todas as espécies de aves do Pantanal. Portanto os nomes regionais adotados pelo povo pantaneiro estão com "MT" entre parênteses, os restantes são nomes comuns utilizados para outras regiões do Brasil.

Os termos "raro" e "comum" são subjetivos e não são resultantes de estudos de dinâmica de população de cada espécie. "Raro" significa que indivíduos da referida espécie foram observados poucas vezes e em pequeno número. "Comum" significa que indivíduos da espécie foram observados repetidas vezes, podendo ou não estar em grandes concentrações. O termo sazonal significa que indivíduos daquela espécie foram observados somente durante um período do ano. As épocas de ocorrência (iniciais de cada mês estão colocadas entre parenteses) são apresentadas em intervalos dos meses nos quais as espécies foram observadas. Infelizmente ainda não temos dados para todas as espécies, então colocamos somente (s) na tabela.

Como lista de referência elaborada por sistematas utilizamos o livro de Meyer de Schauensee (1970), mesmo contendo nomes desatualizados, para orientar a lista apresentada neste estudo.

Os nomes comuns utilizados para outras regiões do Brasil foram tirados dos livros de Sick (1984) e Frisch (1981).

Os habitats estão definidos. A seguir apresentamos um mapa com os pontos de observação de aves com a lista da localização de cada ponto dentro do município de Poconé.

Resultados

A tabela 1 mostra a lista das espécies de aves do Pantanal de Poconé. No total são 317 espécies de 60 famílias. Deste total 86 (27.1%) espécies são de ocorrência sazonal e as restantes 231 (72,9%) ocorrem durante todo o ano e portanto parecem ser residentes.

Entre as espécies aquícolas foram registradas 60 (18,9%) sendo que 35 destas (58.3%, e 11.0% do total para o Pantanal) são sazonais e parecem ser migratórias.

As famílias Tyrannidae e Fringilidae foram as que mostraram o maior número de espécies em relação ao total de espécies: vinte e duas famílias (36.6%) contêm apenas uma espécie. Dezoito famílias (29.5%) e 143 espécies (45.1%) foram da ordem Passeriformes, e 43 (70.5%) famílias e 174 espécies (54.9%) foram de 18 ordens de não passeriformes.

Principais áreas, com os respectivos habitats, onde as aves foram observadas:

1. Fazendinha, km 66 da Rodovia Cuiabá-Poconé - mata semidecídua, cerrado, cerradão, campos (não alagáveis), áreas cultivadas (plantações);
2. Fazenda Baía de Pedras - pantanal de cerrado, baías, cerrado, áreas cultivadas (pastagens);
3. Rio Bento Gomes, nas proximidades da estrada Poconé-Porto Cercado - rio e brejos;
4. Rio Cuiabá - praias do rio e áreas cultivadas (plantações e pastagens) próximo a Porto Cercado;
5. Rodovia Transpantaneira Poconé-Porto Jofre, km 14 - cerradão, campos e cerrado;
6. Posto de Fiscalização, km 17 - cerrado, corixos, áreas cultivadas (pastagens);
7. Rodovia Transpantaneira, km 19 - ilhas de mata semidecídua, campos alagáveis;
8. Rodovia Transpantaneira, km 30 - mata semidecídua, campos alagáveis, e áreas cultivadas (pastagens), até 2 km da rodovia.
9. Rodovia Transpantaneira, km 40 - matas semidecíduas e campos alagáveis, até 3 km saindo da rodovia;
10. Rodovia Transpantaneira, km 59 - corixos e áreas cultivadas (pastagens), até 6 km saindo da rodovia;
11. Rio Pixaim, km 61 - margens do rio, cerrado, e campos (não alagáveis), até 4 km saindo da rodovia;
12. Rio Cassange, km 79 - mata ciliar, brejos, campos alagáveis, até 5 km saindo da rodovia;
13. Rio Cassange, km 81 - mata ciliar, áreas cultivadas (pastagens), até 2 km saindo da estrada;
14. Rodovia Transpantaneira, km 95 - campos alagáveis, corixos e brejos, até 2 km saindo da estrada;
15. Fazenda Rio Alegre, entre os km 105 e 108 - brejos, baías, matas semidecíduas, e áreas cultivadas (pastagens), até 5 km saindo da rodovia;
16. Fazenda Santa Cruz, km 111 - mata semidecídua, até 7 km saindo da rodovia na trilha (interior da mata) para a sede da fazenda;
17. Base de pesquisas da Fauna do Pantanal (IBDF), km 111 - mata ciliar do Rio Alegre, mata semidecídua, baía grande de rio, campos alagáveis;
18. Fazenda Santa Isabel, ao lado de toda a estrada (13 km) saindo da rodovia até a sede - mata semidecídua, Baía do Barreirão, campos alagáveis;
19. Fazenda Jofre, km 115 - mata semidecídua e campos alagáveis, até 10 km saindo da rodovia para a direção oeste;
20. Fazenda Jofre, km 120 - campos alagáveis com matas de cambarás, até 3 km saindo da estrada para leste e oeste.
21. Fazenda Jofre, entre km 125 e km 140 - campos alagáveis, matas semidecíduas, corixos, até 5 km para cada lado da rodovia;
22. Fazenda Jofre, km 143 - matas semidecíduas e corixos, até 3 km de cada lado da rodovia;
23. Rio Cuiabá, Porto Jofre - mata semidecídua e ciliar, campos alagáveis, beira do rio, áreas cultivadas (pastagens) em um raio de até 3 km do porto;
24. Rio Cuiabá - manchas de mata ciliar, praias e áreas cultivadas (plantações), até 2 km das margens do rio;
25. Rio Cuiabá - mata ciliar, vegetação aquática sobre o rio, brejos, até 1 km das margens do rio;
26. Rio Cuiabá - brejos e mata ciliar, até 500 m das margens do rio;
27. Rio Cuiabá - baías e corixos, até 1 km da beira do rio

28. Parque Nacional do Pantanal (IBDF), no encontro do Rio Cuiabá com o Rio Paraguai - mata ciliar, encostas do Morro do Caracará, baía próxima,
29. Fazenda Acurizal, margens do rio Paraguai - cerrado e áreas cultivadas (pastagens), margens do rio.

Definições Fisionômicas dos Habitats

mc - Mata Ciliar

- Formação vegetal, composta principalmente de árvores altas, com trepadeiras e epífitas (bromélias e orquídeas) distribuída ao longo das margens de rios e corixos. Pode ser alagada durante inundações ou enchentes.

ms - Mata Semidecídua

- Formação vegetal, composta principalmente de árvores que perdem parcial ou totalmente as suas folhas durante a estação climática seca. No pantanal estão localizadas principalmente em áreas mais elevadas como as chamadas localmente "cordilheiras" e em áreas montanhosas, "morrarias".

e - Cerrado

- Formação vegetal com o estrato arbóreo apresentando altura cerca de 3 metros normalmente, contendo espécies com o tronco recortado e de casca grossa. Apresenta ainda os estratos arbustivo e herbáceo (principalmente gramíneas e ciperáceas).

r - Rio

- Corpos d'água lóticos (lineares) e sinuosos normalmente com mata nas margens. São perenes e contínuos mesmo durante a estação seca.

b - Baía

- Corpos d'água lênticos, normalmente circulares ou elípticos circundados por matas ou cerrado, que permanecem com água após a vazante do pantanal, represando assim grande quantidade de peixes. Não são muito profundas e chegam a apresentar um comprimento superior a 1 km.

j - Brejo

- Ambiente permanentemente alagado, de menores dimensões que as "Baías", com pouca profundidade e coberto em quase toda a sua extensão com plantas aquáticas na superfície e no fundo.

i - Campo Inundável

- Campos com estrato herbáceo, que durante a estação chuvosa alagam-se, podendo ter ilhas de arbustos e árvores (murunduns), ilhas de matas (capões), além de áreas elevadas não alagáveis formando pequenas praias.

x - Corixo

- Corpos d'água lóticos (lineares) e sinuosos como um rio, que durante a estação seca apresenta diversos trechos interrompidos. Interligam "baías" entre si e rios.

p - Pastagens

- Áreas alteradas em fazendas, para plantações de pastagens, fruticultura e agricultura em geral.

TABELA 1. Lista das Espécies de Aves do Pantanal de Poconé, MT.

Habitats — Abundância e Ocorrência

mc - mata ciliar; ms - mata semidecídua; e - cerrado; r - rio; b - baía; j - brejo; i - campo inundável; x - corixo; p - pastagens

c - comum; r - raro; s - sazonal; t - ocorre o ano inteiro

NOME COMUM	NOME EM INGLÊS	HABITAT	ABUNDÂNCIA E OCORRÊNCIA DURANTE O ANO
RHEIDAE			
Rhea americana Ema	Great Rhea	p, i	c (t)
TINAMIDAE			
Crypturellus undulatus Jaó (MT)	Undulated Tinamou	mc, ms	c (t)
Crypturellus parvirostris Inhambú-chororó	Small-billed Tinamou	mc, ms	c (t)
PODICIPEDIDAE			
Podiceps dominicus Mergulhãozinho	Least Grebe	r, b	r (t)
PHALACROCORACIDAE			
Phalacrocorax olivaceus Biguá (MT)	Neotropic Cormorant	r,b,x,i	c (t)
ANHINGIDAE			
Anhinga anhinga Anhinga (MT)	Anhinga	r,b,x,i	c (t)

Continua

	NOME COMUM	NOME EM INGLÊS	HABITAT	ABUNDÂNCIA E OCORRÊNCIA DURANTE O ANO
ARDEIDAE				
Ardea cocoi	Maguari (MT)	White-necked Heron	r,b,x,i	c (t)
Casmerodius albus	Garça-branca-grande (MT)	Great Egret	r,b,x,i	c (t)
Egretta thula	Garça-branca-pequena (MT)	Snowy Egret	r,b,x,i	c (s-Mai-Nov)
Florida caerulea	Garça-azul	Little Blue Heron	r,b,i	r (s)
Butorides striatus	Socozinho (MT)	Striated Heron	r,b,j,x	c (t)
Bubulcus ibis	Garça-vaqueira (MT)	Cattle Egret	p	c (s-Abr-Set)
Syrigma sibilatrix	Maria-faceira	Whistling Heron	p, j	c (s-Mai-Out)
Pilherodius pileatus	Garça-real	Capped Heron	j,x,b,i	r
Nycticorax nycticorax	Boca-d'água	Black-crowned Night-Heron	r,b,x	c (s-Abr-Dez)
Tigrisoma lineatum	Socó-boi (MT)	Rufescent Tiger-Heron	b,x,j,r	c (t)
Ixobrychus exilis	Socózinho (MT)	Least Bittern	x	r
COCHELEARIIDAE				
Cochlearius cochlearius	Arapapá	Boat-billed Heron	x, i	r (s-Mai-Out)
CICONIIDAE				
Mycteria americana	Cabeça-seca (MT)	Wood-Stork	r,b,x,i	c (s-Abr-Dez)
Euxenura maguari	Tabuiaiá (MT)	Maguari Stork	b,x,i	r (s-Abr-Dez)
Jabiru mycteria	Tuiuiu (MT)	Jabiru	r,b,x,i	c (s-Abr-Dez)
THRESKIORNITHIDAE				
Harpiprion caerulescens	Curicaca-cinza (MT)	Plumbeous Ibis	b,x,j,i	c (t)
Theristicus caudatus	Curicaca (MT)	Buff-necked Ibis	j, p, i	c (t)
Mesembrinibis cayennensis	Chapéu-velho (MT)	Green Ibis	r,b,j,i	c (s-Mai-Dez)
Phimosus infuscatus	Frango d'água (MT)	Bare-faced Ibis	b,x,j,i	c (s-Mai-Dez)
Plegadis chihi	Caraúna	White-faced Ibis	b, x, i	c (s-Abr-Dez)
Ajaia ajaja	Colhereiro (MT)	Roseate Spoonbill	r,b,x,i,j	c (s-Mai-Dez)

Continua

	NOME COMUM	NOME EM INGLÊS	HABITAT	ABUNDÂNCIA E OCORRÊNCIA DURANTE O ANO
ANHIMIDAE				
Chauna torquata	Tachã, anhuma (MT)	Southern Screamer	r,b,x,i	c (t)
ANATIDAE				
Dendrocygna viduata	Irerê (MT)	White-faced Whistling-Duck	b, i, p	c (t)
Dendrocygna autumnalis	Marreca-cabocla	Black-bellied Whistling-Duck	ms,b,i,p	c (t)
Dendrocygna bicolor	Sinházinha (MT)	Fulvous Whistling-Duck	b, i, p	r (s-Mai-Dez)
Amazonetta brasiliensis	Sinhá (MT)	Brazilian Duck	b,x,i,p	c (t)
Sarkidiornis melanotos	Pato-de-crista	Comb Duck	b, x, i	r (s)
Cairina moschata	Pato-do-mato	Muscovy Duck	ms,r,b,i,p	c (t)
CATHARTIDAE				
Sarcoramphus papa	Urubu-rei (MT)	King Vulture	ms	r (t)
Coragyps atratus	Ububu	Black Vulture	ms,mc,r,b,p	c (t)
Cathartes aura	Urubu-de-cabeça-vermelha (MT)	Turkey Vulture	ms,mc,r,p	c (t)
Cathartes burrovianus	Urubu-de-cabeça-amarela	Lesser Yellow-headed Vulture	ms, r, p	c (t)
ACCIPITRIDAE				
Elanus leucurus	Gavião-peneira	White-tailed Kite	mc	r
Gampsonyx swainsonii	Gaviãozinho (MT)	Pearl Kite	ms, mc	r (t)
Elanoides forficatus	Gavião-tesoura	Swallow-tailed Kite	ms, mc	r (s)
Leptodon cayanensis	Gavião-de-cabeça-cinza	Gray-headed Kite	ms, mc	r
Rostrhamus sociabilis	Gavião-caramujeiro (MT)	Snail Kite	r,b,x,j,i	c (s-Abr-Out)
Accipiter bicolor	Gavião-caçador-bicolor	Bicolored Hawk	mc, ms	r (t)
Accipiter striatus	Gavião-caçador	Sharp-shinned Hawk	mc, ms	r (t)

Continua

	NOME COMUM	NOME EM INGLÊS	HABITAT	ABUNDÂNCIA E OCORRÊNCIA DURANTE O ANO
Buteo albicaudatus	Corucuturi	White-tailed Hawk	mc, ms	r
Buteo albonotatus	Gavião-rabo-barrado	Zone-tailed Hawk	ms	r (t)
Buteo magnirostris	Gavião-carijó (MT)	Roadside Hawk	mc, ms, x	c (t)
Busarellus nigricollis	Gavião-belo (MT)	Black-collared Hawk	r,b,x,j,i	c (t)
Heterospizias meridionalis	Gavião-caboclo	Savanna Hawk	mc,ms,b,x,p	c (t)
Buteogallus urubitinga	Gavião-preto (MT)	Great Black Hawk	mc,ms,b,x	c (t)
Spizastur melanoleucus	Gavião-pato	Black and White Hawk-Eagle	mc, ms	r
Spizaetus ornatus	Gavião-de-penacho	Ornate Hawk-Eagle	mc, ms	r (t)
Geranospiza caerulescens	Gavião-mateiro (MT)	Crane Hawk	mc, ms, b,x	r (t)
PANDIONIDAE				
Pandion haliaetus	Águia-pescadora	Osprey	r, b, i	c (s)
FALCONIDAE				
Herpetotheres cachinnans	Acauã (MT)	Laughing Falcon	mc,ms,p	c (t)
Micrastur semitorquatus	Mancauã (MT)	Collared Forest-Falcon	mc, ms	r (t)
Milvago chimachima	Carrapateiro	Yellow-headed Caracara	mc,ms,p	c (t)
Polyborus plancus	Caracará	Crested Caracara	mc,ms,r,b,i	c (t)
Falco rufigularis	Falcão (MT)	Bat Falcon	mc,ms,p	r (t)
Falco femoralis	Falcão-de-coleira	Aplomado Falcon	mc,ms,p	r (t)
Falcon sparverius	Falcão-quiriquiri	American Kestrel	mc,ms,p	c (t)
CRACIDAE				
Penelope ochrogaster	Jacucaca (MT)	Chestnut-bellied Guan	mc, ms	r (t)
Penelope superciliaris	Jacugoela (MT)	Rusty-margined Guan	mc, ms	r (t)
Pipile pipile	Jacutinga (MT)	Blue-throated Piping Guan	mc, ms	c (t)
Ortalis canicollis	Arancuã (MT)	Chaco Chachalaca	mc, ms	c (t)
Crax fasciolata	Mutum (MT)	Bare-faced-Curassow	mc, ms	c

Continua

	NOME COMUM	NOME EM INGLÊS	HABITAT	ABUNDÂNCIA E OCORRÊNCIA DURANTE O ANO
ARAMIDAE				
Aramus guarauna	Carão (MT)	Limpkin	r,b,x,i,j	c (t)
RALLIDAE				
Aramides cajanea	Saracura (MT)	Gray-necked Wood-Rail	mc,ms,b,x,j	c (t)
Rallus nigricans	Saracura-preta (MT)	Blackish Rail	r,b,x,i,j	r (s)
Porzana albicollis	Saracura-sanã	Ash-throated Crake	b, x, j	r
Neocrex erythrops	Pinto dagua (MT)	Paint-billed Crake	b,x,j,i	r (s)
Porphyrula martinica	Frango-dagua-azul	Purple Gallinule	b,x,j,i	r (s-Jan-Jul)
Porphyrula flavirostris	Frango-dagua-pequeno	Azure Gallinule	b,x,j,i	r (s)
HELIORNITHIDAE				
Heliornis fulica	Picaparra	Sungrebe	mc,ms,b,x	r (t)
EURYPYGIDAE				
Eurypyga helias	Pavãozinho (MT)	Sunbittern	mc,ms,b,x,j	c (t)
CARIAMIDAE				
Cariama cristata	Seriema (MT)	Red-legged Seriema	i, p	r (t)
JACANIDAE				
Jacana jacana	Cafézinho (MT)	Wattled Jacana	r,b,x,i,j	c (t)
CHARADRIDAE				
Vanellus chilensis	Quero-quero (MT)	Southern Lapwing	r,b,x,i,p	c (t)
Hoploxypterus cayanus	Mexeriqueira	Pied Lapwing	r,b,x,i	c (s-Mar-Set)
Charadrius collaris	Maçarico-de-coleira	Collared Plover	r,b,x,i	c (s-Jan-Jul)

Continua

	NOME COMUM	NOME EM INGLÊS	HABITAT	ABUNDÂNCIA E OCORRÊNCIA DURANTE O ANO
SCOLOPACIDAE				
Tringa solitaria	Maçarico solitário	Solitary Sandpiper	r,b,x,i	c (s-Abr-Out)
Tringa flavipes	Maçarico (MT)	Lesser Yellowlegs	r,b,x,i	r (s-Abr-Out)
Actitis macularia	Maçarico-pintado	Spotted Sandpiper	r,b,x,i	r (s-Abr-Out)
Calidris canutus	Maçarico	Red Knot	i	r (s-Abr-Out)
Calidris minutilla	Maçarico	Least Sandpiper	r	r (s)
Calidris fuscicollis	Maç.-de-sobre-branco	White-rumped Sandpiper	r, i	r (s-Mar-Abr)
Calidris melanotos	Maçarico-de-colete	Pectoral Sandpiper	r,b,x,i	r (s-Mar-Jun)
Gallinago gallinago	Narceja (MT)	Common Snipe	b,x,i	c (t)
RECURVIROSTRIDAE				
Himantopus himantopus	Pernilongo	Common Stilt	b,x,i	c (s)
LARIDAE				
Phaetusa simplex	Gaivota (MT)	Large-billed Tern	r,b,x,i	c (s-Abr-Set)
Sterna superciliaris	Gaivotinha (MT)	Yellow-billed Tern	r,b,x,i	c (s-Abr-Out)
Sterna hirundo	Gaivota (MT)	Common Tern	i, r	r (s-Jul-Ago)
RYNCHOPIDAE				
Rynchops niger	Taiamã (MT)	Black Skimmer	r,b,x,i	r (s-Mai-Out)
COLUMBIDAE				
Columba picazuro	Asa-branca (MT)	Picazuro Pigeon	mc, ms, p	c (s-Mar-Dez)
Columba cayennensis	Pomba-pocaçu	Pale-vented Pigeon	mc, ms, p	c (t)
Geotrygon montana	Juriti-vermelha	Ruddy Quail-Dove	mc, ms	r (t)
Zenaida auriculata	Avoante	Eared Dove	ms, p	r (s-Abr-Set)
Scardafella squammata	Fogo-apagou	Scaled Dove	ms, p	r (t)
Leptotila verreauxi	Juriti (MT)	White-tipped Dove	mc, ms, p	c (t)
Leptotila rufaxilla	Juriti (MT)	Gray-fronted Dove	mc, ms	r (t)

Continua

	NOME COMUM	NOME EM INGLÊS	HABITAT	ABUNDÂNCIA E OCORRÊNCIA DURANTE O ANO
Claravis pretiosa	Rola-azul	Blue Ground-Dove	mc, ms, p	c (t)
Uropelia campestris	Rola-vaqueira (MT)	Long-tailed Ground-Dove	p	c (t)
Columbina talpacoti	Rolinha (MT)	Ruddy Ground-Dove	mc, ms, p	c (t)
Columbina picui	Rolinha (MT)	Picui Ground-Dove	mc, ms, p	c (t)
PSITTACIDAE				
Anodorhynchus hyacinthinus	Arara-azul (MT)	Hyacinthine Macaw	mc, ms	c (t)
Ara chloroptera	Arara-vermelha (MT)	Red-and-green Macaw	mc, ms	r
Ara ararauna	Arara (MT)	Blue-and-yellow Macaw	ms, mc	r
Ara nobilis	Ararã-nanica	Red-shouldered Macaw	ms, mc	r (t)
Ara auricollis	Ararinha (MT)	Golden-collared Macaw	mc, ms, p	c (t)
Aratinga acuticaudata	Jandaia-da-cabeça-azul	Blue-crowned Parakeet	mc,ms,e,p	c (s)
Aratinga leucophthalmus	Araua-í (MT)	White-eyed Parakeet	mc,ms,e,p	c (s-Nov-Mai)
Aratinga aurea	Nandaia (MT)	Peach-fronted Parakeet	mc,ms,e,p	c (t)
Nandayus nenday	Periquito-de-cabeça-preta	Black-hooded Parakeet	mc,ms,e,p	r (t)
Myiopsitta monachus	Periquito do papo branco (MT)	Monk Parakeet	e,p	c (t)
Brotogeris versicolurus	Periquito	Canary-winged Parakeet	mc,ms,e,p	c (t)
Amazona amazonica	Papagaio (MT)	Orange-winged Parrot	mc,ms,p	c (t)
Amazona aestiva	Papagaio (MT)	Turquoise-fronted Parrot	mc,ms,c,p	c (t)
Amazona xanthops	Papagaio (MT)	Yellow-faced Parrot	ms, mc	r (s)
Pionus maximiliani	Baitaca	Scaly-headed Parrot	mc,ms,e,p	c (t)
CUCULIDAE				
Piaya cayana	Alma-de-gato	Squirrel Cuckoo	mc, ms, p	c
Piaya minuta	Chincoã-pequeno	Little Cuckoo	mc, ms	r
Crotophaga major	Anú-coroca	Greater Ani	ms,mc, j	c (s-Nov-Abr)
Crotophaga ani	Anú-preto	Smooth-billed Ani	e, p	c
Guira guira	Anú-branco	Guira Cuckoo	ms, e, p	c
Tapera naevia	Sací	Striped Cuckoo	ms, e, p	r

Continua

	NOME COMUM	NOME EM INGLÊS	HABITAT	ABUNDÂNCIA E OCORRÊNCIA DURANTE O ANO
TYTONIDAE				
Tyto alba	Suindara	Barn Owl	mc,ms,e	r (t)
STRIGIDAE				
Otus choliba	Corujinha	Tropical Screech-Owl	ms,mc,e,p	r (t)
Bubo virginianus	João-curutu (MT)	Great Horned Owl	mc,ms,e,p	c (t)
Pulsatrix perspicillata	Murucututu (MT)	Spectacled Owl	mc,ms,e,p	r (t)
Glaucidium brasilianum	Caburé	Ferruginous Pygmy-Owl	mc,ms,e,p	c (t)
Speotyto cunicularia	Coruja-buraqueira	Burrowing Owl	e,p	c (t)
NYCTIBIIDAE				
Nyctibius grandis	Urutau	Great Potoo	mc,ms,e	r
Nyctibius griseus	Mãe-da-lua	Common Potoo	mc,ms,e,p	c (t)
CAPRIMULGIDAE				
Chordeiles pusillus	Bacurauzinho	Least Nighthawk	e,p	c (s-Mai-Set)
Nyctiprogne leucopyga	Bacurau-cauda-barrada	Band-tailed Nighthawk	ms,e,p	c (r-Mai-Out)
Podager nacunda	Curiangú (MT)	Nacunda Nighthawk	e,p	c (s-Abr-Out)
Nyctidromus albicollis	Mede-léguas (MT)	Pauraque	e,p	c (s-Abr-Out)
Caprimulgus parvulus	Bacurau-pequeno	Little Nightjar	e,p	c (s-Abr-Out)
Caprimulgus rufus	João-corta-pau (MT)	Rufous Nightjar	e,p	c (s-Abr-Out)
Hydropsalis brasiliana	Bacurau-tesoura	Scissor-tailed Nightjar	e,p	r (s-Mai-Out)
APODIDAE				
Chaetura andrei	Andorinhão-do-temporal	Ashy-tailed Swift	mc,ms,e	r (s-Dez-Abr)
TROCHILIDAE				
Glaucis hirsuta	Beija-flor (MT)	Rufous-breasted Hermit	mc,ms,e	c (s-Abr-Set)
Phaethornis pretrei	Beija-flor (MT)	Planalto Hermit	mc,ms,e	c (t)

Continua

	NOME COMUM	NOME EM INGLÊS	HABITAT	ABUNDÂNCIA E OCORRÊNCIA DURANTE O ANO
Phaethornis subochraceus	Beija-flor (MT)	Buff-bellied Hermit	mc, ms	c (t)
Phaethornis ruber	Beija-flor (MT)	Reddish Hermit	mc, ms,e	r (t)
Thalurania furcata	Beija-flor (MT)	Fork-tailed Woodnymph	mc,ms,e	c (s-Abr-Set)
Hylocharis sapphirina	Beija-flor (MT)	Rufous-throated Sapphire	mc, ms	r (s-Abr-Set)
Hylocharis chrysura	Beija-flor (MT)	Gilded Hummingbird	mc,ms,e	c
Polytmus guainumbi	Beija-flor (MT)	White-tailed Goldenthroat	mc, ms	c (s-Abr-Set)
Amazilia versicolor	Beija-flor (MT)	Versicolored Emerald	mc,ms,e	r
Amazilia fimbriata	Beija-flor (MT)	Glittering-throated Emerald	mc, ms	c (s-Abr-Set)
Heliomaster furcifer	Beija-flor (MT)	Blue-tufted Starthroat	e	r (t)
TROGONIDAE				
Trogon curucui	Surucuá-de-barriga-vermelha	Blue-crowned Trogon	mc, ms	c (t)
ALCEDINIDAE				
Ceryle torquata	Martim-pescador-grande	Ringed Kingfisher	r,b,x,j,i	c (t)
Chloroceryle amazona	Martim-pescador-verde	Amazon Kingfisher	r,b,x,j,i	c (t)
Chloroceryle americana	Martim-pescador (MT)	Green Kingfisher	r,b,x,j,i	c (t)
Chloroceryle inda	Martim-pescador (MT)	Green-and-rufous Kingfisher	r,b,x,j,i	r (t)
Chloroceryle aenea	Martinzinho (MT)	Pygmy Kingfisher	r,b,x,j,i	r (t)
MOMOTIDAE				
Momotus momota	Udú (MT)	Blue-crowned Motmot	mc, ms	r (t)
GALBULIDAE				
Galbula ruficauda	Bico-de-agulha (MT)	Rufous-tailed Jacamar	mc, ms	c (t)
BUCCONIDAE				
Nystalus maculatus	Bico-de-lata (MT)	Spot-backed Puffbird	ms, e	r (t)
Monasa nigrifrons	Chora-chuva (MT)	Black-fronted Nunbird	mc, ms	c (t)

Continua

	NOME COMUM	NOME EM INGLÊS	HABITAT	ABUNDÂNCIA E OCORRÊNCIA DURANTE O ANO
RAMPHASTIDAE				
Pteroglossus castanotis	Tucaninho (MT)	Chestnut-eared Aracari	mc, ms	c (t)
Ramphastos toco	Tucano (MT)	Toco Toucan	mc,ms,p	c (t)
PICIDAE				
Picumnus minutissimus	Picapauzinho (MT)	Arrowhead Piculet	mc,ms,e	r (t)
Colaptes campestris	Pica-pau-do-campo	Campo Flicker	e, p	c (t)
Chrysoptilus melanochloros	Pica-pau-dourado	Green-barred Woodpecker	mc,ms,e	r (t)
Piculus chrysochlorus	Pica-pau-dourado-escuro	Golden-green Woodpecker	mc,ms,e	r (t)
Celeus flavescens	Pica-pau-de-cabeça-amarela	Blond-crested Woodpecker	mc, ms	r (t)
Dryocopus lineatus	Pica-pau (MT)	Lineated Woodpecker	mc, ms	c (t)
Leuconerpes candidus	Pica-pau-branco	White Woodpecker	e, p	r (t)
Veniliornis passerinus	Picapauzinho (MT)	Little Woodpecker	mc,ms,e	c (t)
Phloeoceastes melanoleucos	Pica-pau (MT)	Crimson-crested Woodpecker	mc, ms	c (t)
DENDROCOLAPTIDAE				
Sittasomus griseicapillus	Arapaçu-verde	Olivaceus Woodcreeper	mc,ms,e	c (t)
Xiphocolaptes major	Pica-pau (MT)	Great Rufous Woodcreeper	mc,ms,e	r (t)
Dendrocolaptes platyrostris	Arapaçu-grande	Planalto Woodcreeper	mc,ms,e	r (t)
Xiphorhynchus picus	Pica-pau (MT)	Straight-billed Woodcreeper	mc, ms	r (t)
Xiphorhynchus guttatus	Pica-pau (MT)	Buff-throated Woodcreeper	mc, ms	c (t)
Lepidocolaptes angustirostris	Arapaçu-do-cerrado	Narrow-billed Woodcreeper	mc, c	r (t)
Campylorhamphus trochilirostris	Arapuçu-do-bico-torto	Red-billed Scythebill	mc,ms,e	c (t)
FURNARIIDAE				
Furnarius rufus	Amassa barro (MT)	Rufous Hornero	ms,mc,e,p	c (t)
Furnarius leucopus	Amassa barro do brejo (MT)	Pale-legged Hornero	mc, ms	c (t)
Schoeniophylax phryganophila	Bichoita	Chotoy Spinetail	e, i, p	r (t)
Synallaxis gujanensis	João-teneném-becuá	Plain-crowned Spinetail	mc, ms, p	c (t)

Continua

	NOME COMUM	NOME EM INGLÊS	HABITAT	ABUNDÂNCIA E OCORRÊNCIA DURANTE O ANO
Synallaxis frontalis	Petrim	Sooty-fronted Spinetail	e, i, p	r (t)
Synallaxis hypospodia	João-teneném	Cinereous-breasted Spinetail	e, p	r (t)
Certhiaxis cinnamomea	Curatié	Yellow-throated Spinetail	i	r (t)
Cranioleuca vulpina	Arredio-do-rio	Rusty-backed Spinetail	e, i	r (t)
Phacellodomus rufifrons	João-de pau	Rufous-fronted Thornbird	e, p	r (t)
Phacellodomus ruber	Graveteiro	Greater Thornbird	e, p	c (t)
Pseudoseisura cristata	Casaca-de-couro	Rufous Cacholote	ms,c,p	r (t)
Hylocryptus rectirostris	Fura-barreira	Chestnut-capped Foliage-gleaner	ms	r (t)
Xenops rutilans	Bico-virado-carijó	Streaked Xenops	ms, e	r (t)
FORMICARIIDAE				
Taraba major	Chocão-de-barriga-branca	Great Antshrike	mc, ms	c (t)
Thamnophilus doliatus	Nhanacocá (MT)	Barred Antshrike	ms	c (t)
Thamnophilus punctatus	Sanacocá (MT)	Slaty Antshrike	ms, e	r (t)
Dysithamus mentalis	Choca-olivacea	Plain Antvireo	mc, ms	r (t)
Myrmorchilus strigilatus	Formigueiro-pintalgado	Stripe-backed Antbird	mc, ms	r (t)
Herpsilochmus longirostris	Formigueiro-de-bico-longo	Large-billed Antwren	mc, ms	r (t)
Formicivora rufa	Papa-formigas-vermelha	Rusty-backed Antwren	mc,ms,j	c (t)
Cercomacra melanaria	Chororó-do Pantanal	Mato Grosso Antbird	mc, ms	c (t)
Conopophaga lineata	Chupa-dente	Rufous Gnateater	mc, ms	r (t)
COTINGIDAE				
Tityra cayana	Anambé-branco-de-rabo-preto	Black-tailed Tityra	mc, ms	c (t)
Tityra inquisitor	Anambé (MT)	Black-crowned Tityra	mc, ms	r (t)
Pachyramphus polychopterus	Caneleirinho-preto	White-winged Becard	mc, ms	r (t)
Pachyramphus viridis	Caneleirinho-verde	Green-backed Becard	mc, ms	r (t)
PIPRIDAE				
Antilophia galeata	Soldadinho	Helmeted Manakin	mc, ms	c (t)

Continua

	NOME COMUM	NOME EM INGLÊS	HABITAT	ABUNDÂNCIA E OCORRÊNCIA DURANTE O ANO
TYRANNIDAE				
Xolmis cinerea	Maria-branca	Gray Monjita	e, p	c (s-Out-Mar)
Xolmis velata	Noivinha-branca	White-rumped Monjita	e, i, p	r (s-Out-Mar)
Xolmis irupero	Noivinha	White Monjita	b,x,j,i	r (s-Out-Mar)
Fluvicola pica	Lavadeira (MT)	Pied Water-Tyrant	r,b,x,j,i	c (s-Ago-Mai)
Arundinicola leucocephala	Veinho (MT)	White-headed Marsh-Tyrant	r,b,x,j,i	c (s-Out-Mai)
Pyrocephalus rubinus	São-Joãozinho (MT)	Vermilion Flycatcher	r,b,x,i,e	r (s-Ago-Fev)
Satrapa icterophrys	Suiriri-pequeno	Yellow-browed Tyrant	mc, ms, e	r (s-Jul-Jan)
Machetornis rixosus	Bem-te-vi-do-gado	Cattle Tyrant	r,j,i,e,p	c (t)
Muscivora tyrannus	Tesoura	Fork-tailed Flycatcher	mc,ms,e,p	r (s-Ago-Mar)
Tyrannus melancholicus	Suiriri	Tropical Kingbird	mc,ms,e,p	c (t)
Legatus leucophaius	Bem-te-vi-pirata	Piratic Flycatcher	mc, ms	c (s-Out-Abr)
Megarhynchus pitangua	Bem-te-vi-bico-chato	Boat-billed Flycatcher	mc, ms	c (s-Jul-Fev)
Myiodynastes maculatus	Bem-te-vi-rajado	Streaked Flycatcher	mc, ms	c (s-Ago-Fev)
Myiozetetes cayanensis	Bem-te-vizinho-de-asa-ferrugínea	Rusty-margined Flycatcher	mc, ms	c (t)
Myiozetetes similis	Bem-te-vizinho-penacho-vermelho	Vermilion-crowned Flycatcher	ms, j, r	r (t)
Pitangus sulphuratus	Bem-te-vi (MT)	Great Kiskadee	mc,ms,b,j,e,p	c (t)
Pitangus lictor	Bentevizinho	Lesser Kiskadee	r, x, j	r (t)
Attila bolivianus	Tinguaçu-parda	Dull-capped Attila	mc, ms	r (t)
Casiornis rufa	Caneleiro	Rufous Casiornis	mc, ms	r (s-Jul-Jan)
Myiarchus ferox	Maria-cavaleira	Short-crested Flycatcher	mc, ms	c (t)
Myiarchus tyrannulus	Maria-cavaleira-de-rabo-enferrujado	Brown-crested Flycatcher	mc, ms	c (s-Jul-Fev)
Contopus cinereus	Papa-mosca-cinzento	Tropical Pewee	mc, ms	r (s-Out-Mar)
Empidonax euleri	Enferrujado	Euler's Flycatcher	mc, ms	r (s-Jul-Jan)
Cnemotriccus fuscatus	Papa-mosca-castanho	Fuscous Flycatcher	mc, ms	c (t)
Myiophobus fasciatus	Felipe	Bran-Colored Flycatcher	mc, ms	r (t)
Tolmomyias sulphurescens	Mosqueteiro-olivaceo	Yellow-olive Flycatcher	mc, ms	r (t)
Todirostrum cinereum	Ferreirinho	Common Tody-Flycatcher	mc, ms	c (t)
Todirostrum latirostre	Ferreirinho ferrugineo	Rusty-fronted Tody-Flycatcher	ms	c (t)

Continua

	NOME COMUM	NOME EM INGLÊS	HABITAT	ABUNDÂNCIA E OCORRÊNCIA DURANTE O ANO
Idioptilon striaticolle	Sebinho-rajado-amarelo	Stripe-necked Tody-Tyrant	mc, ms	r (t)
Idioptilon margaritaceiventer	Sebinho-de-olho-ouro	Pearl-vented Tody-Tyrant	mc, ms	c (t)
Euscarthmus meloryphus	Barulhento	Tawny-crowned Pygmy-Tyrant	ms	r (t)
Serpophaga subcristata	Alegrinho	White-crested Tyrannulet	mc, ms	c (s-Set-Fev)
Elaenia flavogaster	Guaracava-de-barriga-amarela	Yellow-bellied Elaenia	mc, ms, e	c (t)
Myiopagis gaimardii	Guaracava	Forest Elaenia	ms	r (t)
Myiopagis viridicata	Guaracava-de-orelhas	Greenish Elaenia	ms	r (t)
Phaeomyias murina	Papa-mosquito-murino	Mouse-colored Tyrannulet	mc, ms, e	r (t)
Camptostoma obsoletum	Risadinha	Southern Beardless Tyrannulet	mc, ms	c (t)
Leptopogon amaurocephalus	Cabeçudo	Sepia-capped Flycatcher	mc, ms	r (t)
HIRUNDINIDAE				
Tachycineta albiventer	Andorinha-do-rio	White-winged Swallow	r,b,x,j,i	c (t)
Tachycineta leucorrhoa	Andorinha (MT)	White-rumped Swallow	r,b,x,j,i	c (s-Jul-Jan)
Phaeoprogne tapera	Andorinha (MT)	Brown-chested Martin	r,b,x,j,i	c (s-Out-Jan)
Progne chalybea	Andorinha-grande	Gray-breasted Martin	r,b,x,j,i	c (t)
Progne subis	Andorinha-purpura	Purple Martin	b, x, i	c (s-Dez-Mar)
Stelgidopteryx ruficollis	Andorinha (MT)	Rough-winged Swallow	i, p	c (t)
Hirundo rustica	Andorinha (MT)	Barn Swallow	x, i	c (s-Jan-Mai)
CORVIDAE				
Cyanocorax cyanomelas	Gralha (MT)	Purplish Jay	ms, e	c (t)
Cyanocorax cristatellus	Gralha-do-campo	Curl-crested Jay	e	r (t)
TROGLODYTIDAE				
Campylorhynchus turdinus	João-corta-pau (MT)	Thrush-like Wren	mc, ms	c (t)
Thryothorus genibarbis	Garricha	Moustached Wren	mc, ms	c (t)
Thryothorus leucotis	Garricha-de-peito-castanho	Buff-breasted Wren	mc, ms	c (t)
Donacobius atricapillus	Capivareiro (MT)	Black-capped Mockingthrush	r,b,x,j	c (t)

Continua

	NOME COMUM	NOME EM INGLÊS	HABITAT	ABUNDÂNCIA E OCORRÊNCIA DURANTE O ANO
MIMIDAE				
Mimus saturninus	Sabiá (MT)	Chalk-browed Mockingbird	e, p	c (t)
TURDIDAE				
Turdus rufiventris	Sabiá-laranjeira	Rufous-bellied Thrush	mc, ms, p	c (t)
Turdus leucomelas	Sabiá-branco	Pale-breasted Thrush	mc, ms	r (t)
Turdus amaurochalinus	Sabiápoca	Creamy-bellied Thrush	mc, ms	c (s-Mai-Out)
SYLVIIDAE				
Polioptila dumicola	Balança-rabo-de-máscara	Masked Gnatcatcher	e, p	c (t)
MOTACILLIDAE				
Anthus lutescens	Caminheiro-zumbidor	Yellowish Pipit	x, i, p	c (s-Abr-Out)
VIREONIDAE				
Cyclarhis gujanensis	Pitiguari	Rufous-browed Peppershrike	mc, ms	c (t)
Vireo olivaceus	Juruviara	Red-eyed Vireo	mc, ms	c (s-Out-Abr)
Hylophilus pectoralis	Juruviara-de-peito-amarelo	Ashy-headed Greenlet	mc, ms	r (t)
ICTERIDAE				
Molothrus bonariensis	Chopim	Shiny Cowbird	i, p	c (s-Jan-Jun)
Molothrus badius	Asa-de-telha	Bay-winged Cowbird	i, p	c (t)
Psarocolius decumanus	Japu (MT)	Crested Oropendola	mc, ms, p	c (t)
Cacicus cela	Japuira (MT)	Yellow-rumped Cacique	mc, ms, p	c (t)
Cacicus solitarius	João-congo (MT)	Solitary black Cacique	mc, ms, j	c (t)
Cacicus haemorrhous	Guaxo	Red-rumped Cacique	mc, ms	r (t)
Gnorimopsar chopi	Pássaro-preto	Chopi Blackbird	e, p	c (t)
Agelaius cyanopus	Dorémi-preto	Unicolored Blackbird	r,b,x,j,i	c (t)
Icterus cayanensis	Encontro	Epaulet Oriole	mc, ms	c (t)

Continua

	NOME COMUM	NOME EM INGLÊS	HABITAT	ABUNDÂNCIA E OCORRÊNCIA DURANTE O ANO
Icterus icterus	João-pinto (MT)	Troupial	mc,ms,e,p	c
Amblyramphus holosericeus	Capitão	Scarlet-headed Blackbird	x, j	r (s)
Leistes superciliaris	Polícia-inglesa	White-browed Blackbird	x, j	r (t)
PARULIDAE				
Parula pitiayumi	Mariquita	Tropical Parula	mc, ms	c (t)
Basileuterus flaveolus	Mariquita amarelada	Flavescent Warbler	mc, ms	c (t)
Basileuterus hypoleucus	Mariquita-de-peito-branco	White-bellied Warbler	mc, ms	r (t)
Coereba flaveola	Cambacica	Bananaquit	x, j	c (t)
Conirostrum speciosum	Figuinha-de-rabo-castanho	Chestnut-vented Conebill	c	c (t)
THRAUPIDAE				
Euphonia chlorotica	Vi-vi	Purple-Throated Euphonia	ms, e	c (t)
Euphonia violacea	Gaturamo-verdadeiro	Violaceus Euphonia	ms, e	c (t)
Thraupis sayaca	Sanhaço (MT)	Sayaca Tanager	mc,ms,e,p	c (t)
Thraupis palmarum	Sanhaço do coqueiro	Palm Tanager	mc,ms,e,p	c (t)
Ramphocelus carbo	Pipira-vermelha	Silver-beaked Tanager	mc,ms,e,p	c (t)
Tachyphonus rufus	Pipira-preta	White-lined Tanager	ms, e, p	r (t)
Eucometis penicillata	Pipira-da-taoca	Gray-headed Tanager	mc, ms	c (t)
Nemosia pileata	Saíra-de-chapéu-preto	Hooded Tanager	mc, ms	r (t)
Thlypopsis sordida	Saíra-canária	Orange-headed Tanager	mc, e	r (t)
FRINGILLIDAE				
Saltator coerulescens	Sabiá-gonga	Grayish Saltator	mc,ms,x,i	c (t)
Saltator similis	Trinca-ferro-verdadeiro	Green-winged Saltator	mc, ms, x	r (t)
Saltator atricollis	Bico-de-pimenta	Black-throatad Saltador	ms, e	c (t)
Paroaria coronata	Galo-da-campina (MT)	Red-crested Cardinal	i, p	r (t)
Paroaria capitata	Cardeal (MT)	Yellow-billed Cardinal	i, p	c (t)
Pheucticus aureoventris	Bicudo-barriga-amarela	Black-backed Grosbeak	ms, p	r

Continua

	NOME COMUM	NOME EM INGLÊS	HABITAT	ABUNDÂNCIA E OCORRÊNCIA DURANTE O ANO
Volatinia jacarina	Tiziu	Blue-black Grassquit	e, i, p	c (s-Jan-Mai)
Sporophila plumbea	Patativa-Verdadeira	Plumbeous Seedeater	x,j,i,p	r (s-Jan-Mai)
Sporophila collaris	Coleiro-do-brejo	Rusty-collared Seedeater	r,b,x,j	c (s-Jan-Mai)
Sporophila lineola	Bigodinho	Lined Seedeater	x,j,i,p	c (s-Jan-Mai)
Sporophila caerulescens	Coleirinho	Double-collared Seedeater	x,j,i,p	c (s-Jan-Mai)
Sporophila leucoptera	Chorão	White-bellied Seedeater	x, j, i	c (s-Fev-Jun)
Sporophila bouvreuil	Caboclinho	Capped Seedeater	x,j,i,p	c (s-Fev-Mai)
Oryzoborus angolensis	Curió	Lesser Seed-Finch	mc, ms, e	c (t)
Sicalis flaveola	Canário-da-terra	Saffron Finch	ms, e, p	c (t)
Sicalis citrina	Canarinho (MT)	Stripe-tailed Yellow-Finch	i, p	c
Sicalis columbiana	Canário-do-amazonas	Orange-fronted Yellow-Finch	p	r
Coryphospingus cucullatus	Tico-tico-rei	Red-crested Finch	mc,ms,e,p	c (s-Mar-Out)
Arremon flavirostris	Tico-tico-da-mata	Saffron-billed Sparrow	mc	r (t)
Myospiza humeralis	T.-tico-de-bico-amarelo	Grassland Sparrow	e, p	c (t)
Emberizoides herbicola	Canário-do-campo-rabo-longo	Wedge-tailed Grass-Finch	e, p	c (t)
Zonotrichia capensis	Tico-Tico	Rufous-collared Sparrow	e, p	c (t)

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Áreas Importantes para a Conservação das Aves **AMÉRICAS**

BRASIL

Pedro F. Develey & Jaqueline M. Goerck

O Pato-mergulhão (*Mergus octosetaceus*) em crítico risco de extermínio provoca critérios do IBA em apenas cinco IBAs no Brasil. Têm uma população global de menos de 250 indivíduos e é ameaçada pela barragem e a poluição dos rios do Cerrado e da Mata Atlântica. Foto: Adriano Gambarini; www.rarebirdsyearbook.com

Resumo:

Área:	8,514,877 km^2
População (2006):	186,770,562
Capital:	Brasília
Altitude:	0–2994 m
Número de IBAs:	234
Área Total de IBA:	93,713,597 ha
Cobertura das IBA no país:	11%
Número total de espécies de aves:	1822
Aves globalmente ameaçadas:	122
Aves globalmente ameaçadas nas IBAs:	104
Endêmicas do país:	232

Introdução Geral

Com uma área de 8,5 milhões de quilômetros quadrados o Brasil é o maior país da América do Sul e o quinto maior no mundo. Está dividido em 26 estados e o Distrito Federal, agrupados em cinco macro-regiões: Norte, Nordeste, Sul, Sudeste e Centro-Oeste. Tal divisão considerou características político-administrativas, físicas, econômicas, populacionais e sociais. As cinco regiões diferem amplamente e possuem grande desigualdade social. As regiões sul e sudeste são as mais desenvolvidas economicamente com índices de desenvolvimento humano e social superiores aos das regiões Norte, Nordeste e Centro-Oeste. O sistema de governo é do tipo república presidencialista, com o presidente eleito pela população, de forma direta, a cada quatro anos. O presidente governa juntamente com o Parlamento bicameral formado pela Câmara Federal e pelo Senado.

A população brasileira é em sua maioria branca ou mestiça. De acordo com os últimos dados da FUNAI (Fundação Nacional do Índio) ainda vivem no Brasil 460 mil índios, sendo que, em alguns pontos da região norte, existem tribos ainda isoladas, sem prévio contato. A colonização européia contribuiu severamente para a redução das populações indígenas e a manutenção da cultura e dos costumes tradicionais dos grupos remanescentes continua um desafio.

O Brasil possui seis grandes biomas: Amazônia (incluindo a parte norte e sul), Caatinga, Cerrado, Chaco (Pantanal), Mata Atlântica e Pampa, além das Zonas Costeira e Marinha. É considerado um país Megadiverso, com cerca de 13% de toda a biota mundial (Lewinsohn e Prado 2005) e 45 ecoregiões (Olson & Dinerstein 1998). A Bacia Amazônica concentra cerca de 40% de todas as florestas tropicais do mundo (Peres 2005) e o Pantanal representa a maior área alagada tropical em todo o planeta. Infelizmente os números referentes à perda da diversidade também são altos. A Mata Atlântica representava a segunda maior floresta tropical do continente americano sendo que hoje restam apenas cerca de 7% da vegetação original (Fundação SOS Mata Atlântica e INPE 2001). Situações graves de perda de vegetação original também ocorrem no Cerrado e no Pampa, onde agricultura, pecuária e plantações de árvores exóticas estão em acelerada expansão. Duas regiões foram identificadas como hotspots devido a perda de habitat e elevada diversidade (Mata Atlântica e Cerrado; Myers et al. 2000). No caso da Amazônia a situação ainda não é muito séria e apesar das crescentes taxas de desmatamentos, cerca de 80% da floresta ainda permanece preservada.

Um dos maiores desafios enfrentados atualmente no Brasil é a conciliação de um desenvolvimento e crescimento sócio-econômico sustentável aliado à conservação ambiental. Apesar da sociedade em geral apresentar uma clara preocupação com as questões ambientais, ainda não se conhece o melhor caminho a ser seguido e nem as soluções para muitos dos conflitos. Em alguns casos essa preocupação se reflete em ações concretas como a criação de novas unidades de conservação públicas e privadas (RPPNs), licenças ambientais bastante restritas para implantação de novos empreendimentos, organizações não-governamentais (ONGs) comprometidas, atuantes e bem articuladas com o governo e uma massiva atenção da mídia para o assunto.

Mamirauá IBA (BR023) é uma estado de área protegida que abrange mais de um milhão de hectáreas na Amazônia brasileira. O lugar suporta globalmente importantes populaçoes de Wattled Curassow (*Crax globulosa*) e Harpia (*Harpia harpyja*)
Foto: Pedro F. Develey

Conservação e sistema de áreas protegidas

Seguindo acordo firmado durante a 7ª Conferência das Partes da Convenção sobre Diversidade Biológica (CDB) o Brasil estabeleceu, em 2006, um Plano Nacional de Áreas Protegidas (PNAP) com o compromisso de reduzir a taxa de perda da biodiversidade por meio do estabelecimento e manutenção de sistemas nacionais e regionais de áreas protegidas. O Governo Brasileiro trabalhou com a sociedade civil através do Fórum Nacional de Áreas Protegidas na elaboração do plano. O PNAP é o instrumento de planejamento e gestão que define princípios, diretrizes, objetivos e estratégias para o estabelecimento de um sistema abrangente de áreas protegidas, ecologicamente representativo e efetivamente manejado. Há um acordo de cooperação para a implementação do PNAP, instituído por decreto presidencial, representado pelos governos federal, distrital, estaduais e municipais, povos indígenas, comunidades quilombolas e extrativistas, setor empresarial e sociedade civil.

O PNAP engloba prioritariamente as categorias definidas no Sistema Nacional de Unidades de Conservação da Natureza (SNUC), legalmente estabelecido em 2000: 1 - unidades de proteção integral, cujo objetivo principal é conservar amostras representativas dos ecossistemas e da biodiversidade que contêm; e 2 - unidades de uso sustentável, cuja função primordial é a exploração sustentável dos recursos naturais e como objetivo secundário a proteção da biodiversidade (MMA-SNUC 2000), juntamente com as terras indígenas e as terras quilombolas. As demais áreas protegidas, as Áreas de Preservação Permanente (APPs) previstas no Código Florestal brasileiro (áreas com declividade superior a 45º ou beiras de córregos e corpos d'água, entre outras) e as Reservas Legais (Lei no. 4.771/1965), onde uma porcentagem de qualquer propriedade rural é mantida com vegetação nativa (essa porcentagem apresenta variações de acordo com o bioma ou tamanho da propriedade, de 80% no caso da Amazônia Legal a 20% no caso da Mata Atlântica e demais formações vegetais).

A proteção de grandes áreas de hábitat intocado é, sem dúvida, a maneira mais eficaz para a conservação das espécies. As áreas de proteção integral somam 37 milhões de hectares, enquanto as unidades de uso sustentável totalizam 111 milhões de hectares (Rylands e Brandon 2005). Além das unidades de conservação na Amazônia, as reservas indígenas representam quase 20% de todo o território (Rylands e Brandon 2005). Entre os conservacionistas existe uma discussão grande em relação à efetividade das unidades de uso sustentável e de terras indígenas e quilombolas dentro do conceito de áreas protegidas. No entanto, existem casos onde terras indígenas muitas vezes acabam barrando o desmatamento e a exploração madeireira na região (Schwartzman e Zimmerman 2005). Assim, num sistema ideal, as categorias de proteção integral e uso sustentável devem se complementar de acordo com as realidades de cada local.

"O Plano de Ação Nacional de Áreas Protegidas compromete-se à redução da medida de perda de biodiversidade através de sistemas nacionais e regionais de áreas protegidas. "

Fazendeiros de cacau em Serras das Lontras e do Javi (BR110) implementaram um sistema tradicional de cultivo, favorecendo a conservação da biodiversidade (Quadro 3).
Foto: Joaquim Blames

"Vários planos de ação das espécies provêem de um guia detalhado para a preservação das espécies como também são ferramentas vitais para arrecadação de fundos. "

Além da proteção de áreas, mecanismos políticos podem contribuir para a conservação da biodiversidade, através de convenções, acordos e tratados internacionais planejados na escala governamental. Algumas dessas convenções das quais o Brasil faz parte são: Convenção sobre Diversidade Biológica (CDB); Convenção Ramsar em áreas úmidas de importância internacional; Convenção sobre o Comércio Internacional de Espécies Ameaçadas de Fauna e Flora Silvestres (CITES); Convenção do Patrimônio Mundial (WHC); entre outras.

Apenas à 40 km de Manaus no Rio Negro, o Arquipélago de Anavilhanas (BR024) consiste em mais de 400 ilhas e é considerado o maior arquipélago fluvial do mundo.
Foto: Pedro F. Develey

Especificamente em relação às aves, ainda não existe no Brasil uma estratégia nacional para a sua conservação. No entanto, o ICMBio (Instituto Chico Mendes de Conservação da Biodiversidade) órgão federal de meio ambiente, vem publicando, em parceria com organizações da sociedade civil e institutos de pesquisa, planos de ação para a conservação de espécies ou grupos de espécies. Algumas das espécies que já tem o plano publicado são: a arara-azul-de-lear (Anodorhynchus leari; IBAMA 2006), o pato-mergulhão (*Mergus octosetaceus* Hughes *et al.* 2006), o mutum-do-sudeste (*Crax blumenbachii* Silveira *et al.* 2005), o grupo dos albatrozes e petréis (Neves *et al.* 2006) e o soldadinho-do-araripe (*Antilophia bokermanni*; Aquasis 2006). A meta do ICMBio é que todas as aves ameaçadas no país estejam contempladas em algum plano de ação específico. Além de funcionar como um guia detalhado de todas as ações necessárias para a conservação das espécies, enfocando desde a pesquisa científica até políticas públicas, esses planos também podem ajudar na captação de recursos financeiros para as espécies, já que existem alguns editais públicos enfocando espécies com planos de ação já publicados.

Importância Ornitológica

O Brasil possui 1822 espécies de aves sendo que 232 são endêmicas do país (CBRO 2008). O Brasil está entre os três países do mundo com a maior riqueza de aves (juntamente com a Colômbia e o Peru), porém é o primeiro em número de espécies globalmente ameaçadas de extinção com um total de 122 espécies, sendo 23 criticamente ameaçadas, 30 em perigo, 66 vulneráveis, e 93 quase-ameaçadas (BirdLife International 2007).

A lista nacional de aves ameaçadas considera um total de 160 táxons, incluindo subespécies ameaçadas o que, em parte, explica as diferenças em relação à lista global (Machado 2005). A maior parte das aves brasileiras é residente; apenas algumas áreas, localizadas principalmente na costa sul do país, podem ser consideradas importantes pontos de alimentação para cerca de 63 espécies migratórias que se reproduzem no Hemisfério Norte.

"O Brasil tem o incrível número de 232 espécies endêmicas e 122 espécies de aves globalmente ameaçadas."

O Brasil possui o maior número de espécies de distribuição restrita (A2) e restritas ao bioma (A3) nas Américas. Um total de 75 espécies estão restritas a 15 *Endemic Bird Areas* (sete estão localizadas exclusivamente no país) e nove Áreas Secundárias (Stattersfield *et al*. 1998). Esse total inclui o caranguejeiro (*Buteogallus aequinoctialis*) proposto para uma nova Área Secundária nos manguezais situados na costa da Guiana Francesa e do Brasil. Um total de 470 espécies estão restritas a um dos sete biomas brasileiros utilizados para identificação das IBAs, de acordo com Stotz *et al*. (1996), incluindo duas na região Amazônica. A Mata Atlântica é o bioma que concentra cerca de 80% de todas as aves ameaçadas no país.

Algumas áreas são de extrema importância para a conservação e merecem destaque como a Estação Ecológica de Murici (IBA – BR 122) no estado de Alagoas (Quadro 2), onde podem ser encontradas 14 espécies globalmente ameaçadas e outras seis Quase -ameaçadas ou Boa Nova (IBA – BR 105), no estado da Bahia (Quadro 1) com dez espécies globalmente ameaçadas e outras 17 Quase-ameaçadas.

Alagoas Barranqueiro (*Philydor novaesi*) Foto: Ciro Albano

Araripe Manakin (*Antilophia bokermanni*) Foto: Ciro Albano

Restinga Formigueiro (*Formicivora littoralis*) Foto: Joao Quental

O Brasil tem mais espécies criticamente em risco de extermínio do que qualquer outro país no mundo. O Programa de Prevenção de extinções da BirdLife (ver P25) saiu para parar que essas espécies sejam extintas através da nomeação da Species Champions para financiar ações de conservação e da Species Guardians para implementá-los. Estas espécies criticamente em risco de extermínio foram beneficiadas no programa, com projetos de conservação de três anos atualmente em curso para ambos Soldadinho-do-araripe e Formigueiro-do-litoral.

[1] As mudanças para as categorias da lista vermelha do IUCN resultante da avaliação de 2008 são as seguintes. Listas de cima: Tristan Albatroz (*Diomedea dabbenena*) - EN ao CR; Atlântico Petrel (*Pterodroma incerta*) - VU ao EN; Jandaia-amarela (*solstitialis Aratinga*) - LC ao EN; Hoary-throated Spinetail (*Synallaxis kollari*) - VU ao EN. Listas de baixo: Choca-Rondônia (*Atrogularis Clytoctantes*) - CR ao VU; Rio Branco Formigueiro (*Cercomacra carbonaria*) - VU ao NT. Este diretório usa as categorias de 2007 en todas as partes.

Visão Geral das IBAs

O programa mundial de IBAs da BirdLife International foi oficialmente apresentado à comunidade ornitológica brasileira durante o VIII Congresso Brasileiro de Ornitologia, em 2000. Em abril de 2001, uma parceria com a Fundação Zoobotânica do Rio Grande do Sul deu início ao programa geral de identificação de IBAs no Brasil. Na ocasião, definiu-se a estratégia de trabalho a ser adotada, bem como se estabeleceu um cronograma de ação. A partir de então, iniciaram-se contatos com organizações governamentais e não-governamentais envolvidas na coordenação de iniciativas prévias de identificação de áreas prioritárias para a conservação da biodiversidade no Brasil, com o intuito de se obter amplo acesso às informações reunidas durante esses levantamentos. Em março de 2006 foi lançado o livro "Áreas Importantes para a Conservação das Aves no Brasil, Parte I – Estados do Domínio da Mata Atlântica" (Bencke et al. 2006). A identificação das áreas importantes para a conservação das aves nesta região preencheu a primeira etapa de atividades do programa de IBAs no Brasil. A Mata Atlântica foi escolhida entre os biomas brasileiros como ponto de partida para o trabalho de identificação das IBAs no país. Esta escolha justificou-se duplamente, tanto pelo elevado nível de ameaça a que estão expostos os ecossistemas que compõem o domínio da Mata Atlântica, quanto pelo volume relativamente grande de informações disponíveis sobre a avifauna do bioma. A segunda parte da identificação das IBAs no Brasil inclui todos os estados situados na região Norte e Centro Oeste, englobando três biomas: Amazônia, Cerrado e Pantanal (De Luca et al. 2009).

"A Mata Atlântica foi escolhida como um ponto de partida para a identificação do IBA devido ao seu alto nível de ameaças, como tambem à grande quantidade de informações sobre sua avefauna.

O processo de identificação das IBAs no Brasil envolveu um total de cerca de 60 biólogos/ornitólogos, 450 áreas analisadas e 700 espécies consideradas para aplicação dos critérios. No total 234 IBAs foram identificadas no Brasil (Tabela 1, Figura 1), totalizando 93.713.597 hectares que representam 11% de todo o território nacional. Noventa e três IBAs ou 40% não se encontram oficialmente protegidas dentro do sistema nacional de áreas protegidas, noventa e duas (39%) estão parcialmente protegidas e apenas 51 (21%) são consideradas de proteção integral. No total, as áreas protegidas dentro das IBAs correspondem a 27.687.893 hectares. A maior IBA no Brasil é a Tabocais (BR 059), entre os estados do Amazonas e Acre, com 7.351.066 hectares e apenas uma espécie ameaçada e quatro quase–ameaçadas. A menos IBA é a Ilha dos Currais (BR 209) com apenas 13 hectares identificada devido a presença de uma colônia reprodutiva de Fragatas (Fregata magnificens). No estado de Pernambuco existem 16 IBAs que abrigam 18 espécies ameaçadas, totalizando 529.104 hectares sendo 70 mil dentro de unidades de conservação. Em contraste, no Amazonas foram definidas 13 IBAs, totalizando 28,5 milhões de hectares que abrigam seis espécies ameaçadas e 8,5 milhões de hectares dentro unidades de conservação. Essa comparação deixa clara a grande diferença entre as IBAs no Brasil e reforça a importância de um processo de priorização na determinação das áreas que necessitam ações imediatas para assegurar a sua conservação.

"Considerando os limitados recursos disponíveis para a conservação, um exercício de definição de prioridades é crucial para definir quais IBAs têm necessidade imediatas de atividades práticas para garantir a sobrevivência à longo prazo das aves ameaçadas."

A ameaçada especie endêmica Saíra-pintor (*Tangara fastuosa*) provoca critérios do IBA em 14 locais no Brasil.

O criticamente ameaçado e endêmico Periquito-sujo (*Pyrrhura griseipectus*) só sobrevive em um lugar, Serra do Baturité (BR041).
Fotos: Ciro Albano

Figura 1. Localização das Áreas Importantes de Aves no Brasil.

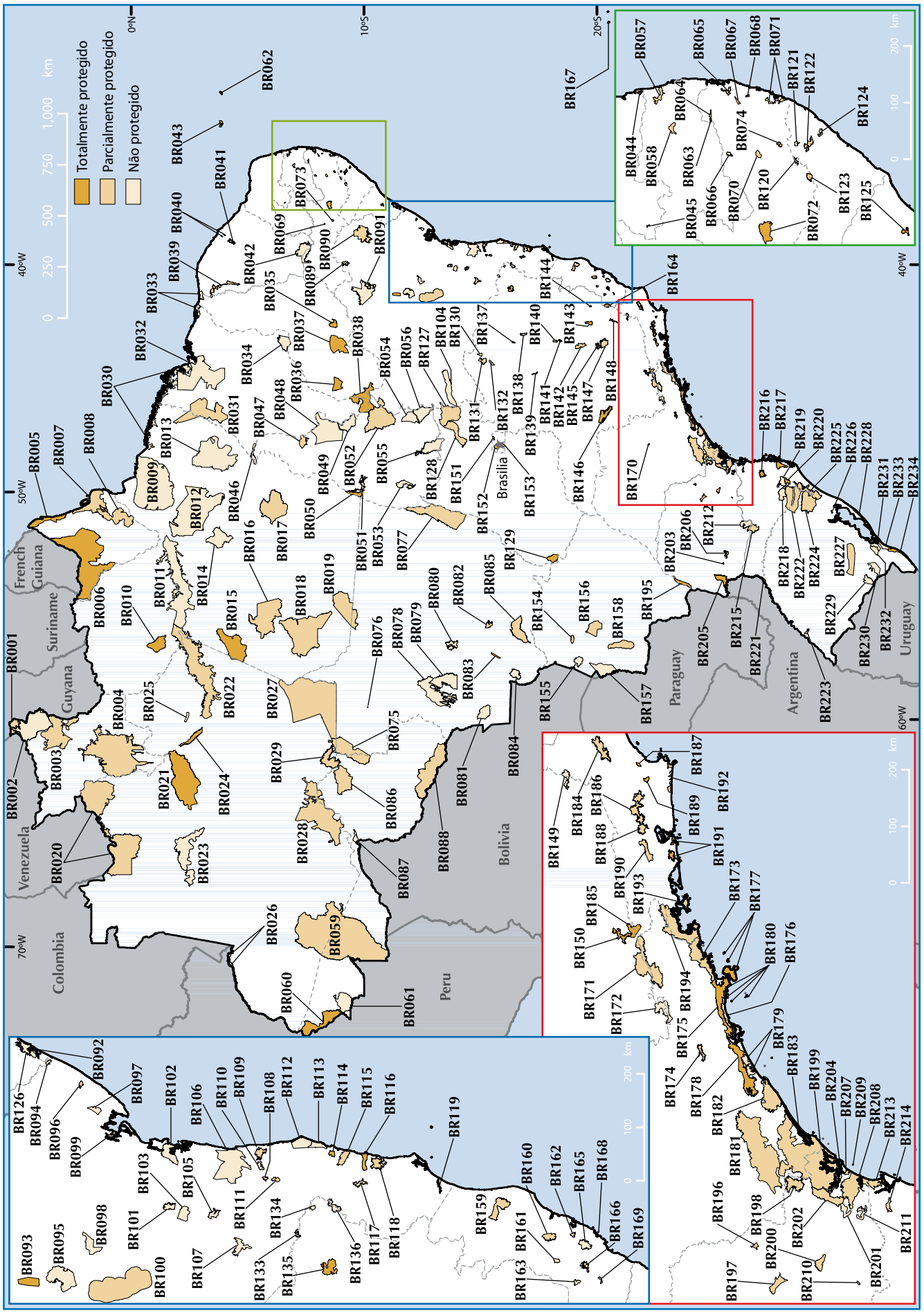

Tabela 2. Importantes Áreas de Aves no Brasil

Código do IBA	Nome do IBA	Unidade Adm	Área (ha)	A1				A2	A3	A4			
				CR	EN	VU	NT			A4i	A4ii	A4iii	A4iv
BR001	Tepuis de Roraima	Roraima	248,250					X					
BR002	Savanas do Rio Cotingo	Roraima	1,499,454			1	1	X					
BR003	Lavrados de Roraima	Roraima	1,477,273			2		X					
BR004	Campinas e Várzeas do Rio Branco	Roraima	3,859,627			1	3	X	X				
BR005	Parque Nacional do Cabo Orange	Amapá	410,424					X					
BR006	Parque Nacional Montanhas do Tumucumaque	Amapá, Pará	3,882,120				1		X				
BR007	Goiabal / Piratuba	Amapá	968,625					X		X			
BR008	Savanas do Amapá	Amapá	766,643				3						
BR009	Ilha de Marajó	Pará	3,910,144			1	1	X					
BR010	Reserva Biológica do Rio Trombetas	Pará	409,585					X	X				
BR011	Várzeas de Monte Alegre	Pará	2,664,834				1	X					
BR012	Caxiuanã / Portel	Pará	3,422,612		1		4						
BR013	Rio Capim	Pará	2,141,584		1		2						
BR014	Baixo Rio Xingu	Pará	622,266		2		4						
BR015	Parque Nacional da Amazônia	Amazonas, Pará	1,161,379		1				X				
BR016	Jamanxim / Altamira	Pará	1,541,628		2								
BR017	Serra dos Carajás	Pará	1,223,610		1		6		X				
BR018	Novo Progresso	Pará	2,621,296		1	1		X					
BR019	Cristalino / Serra do Cachimbo	Mato Grosso, Pará	1,123,562		3		2		X				
BR020	Tepuis do Amazonas	Amazonas	4,429,575					X	X				
BR021	Parque Nacional do Jaú	Amazonas	2,377,889				2	X	X				
BR022	Várzeas do Médio Rio Amazonas	Amazonas, Pará	2,875,752				1	X					
BR023	Mamirauá	Amazonas	1,124,000			1	2	X					
BR024	Arquipélago de Anavilhanas	Amazonas	197,812				2	X					
BR025	Área de Relevante Interesse Ecológico Projeto Dinâmica Biológica de Fragmentos Florestais e Entorno	Amazonas	46,208						X				
BR026	Baixo Rio Javari	Amazonas	77,158		1			X					
BR027	Alto Sucunduri	Amazonas	4,629,900	1			1	X					
BR028	Campos de Humaitá-Lábrea	Amazonas, Rondônia	2,724,632			2						X	
BR029	Campo do Alto Marmelos	Amazonas, Rondônia	451,017				2						
BR030	Reentrâncias Maranhenses/Paraenses	Maranhão, Pará	1,134,852					X		X		X	
BR031	Gurupi	Maranhão, Pará	1,392,974		1								
BR032	Baixada Maranhense	Maranhão	2,045,444							X			
BR033	Delta do Parnaíba	Ceará, Maranhão, Piauí	217,139					X		X			
BR034	Barragem de Boa Esperança	Maranhão	280,547	1	1	1							
BR035	Parque Nacional da Serra da Capivara	Piauí	91,849			2	6		X				
BR036	Estação Ecológica de Uruçuí-Una	Piauí	203,445		1		2						
BR037	Parque Nacional da Serra das Confusões	Piauí	523,924			2	5		X				
BR038	Nascentes do Rio Parnaíba	Maranhão, Piauí, Tocantins	730,191		1		2						
BR039	Serra de Ibiapaba	Ceará	146,171			4	3	X	X				
BR040	Serras de Maranguape e da Aratanha	Ceará	4,649			2		X					
BR041	Serra do Baturité	Ceará	30,240	1		5		X	X				
BR042	Chapada do Araripe	Ceará, Pernambuco	394,426	1		2	5	X	X				
BR043	Atol das Rocas	Rio Grande do Norte	35,186							X	X	X	
BR044	Mata Estrela	Rio Grande do Norte	6,930			1							
BR045	Estação Ecológica do Seridó	Rio Grande do Norte	1,124				1						
BR046	São Pedro da Água Branca	Maranhão, Pará, Tocantins	112,297	1		1		X					
BR047	Monumento Natural das Árvores Fossilizadas e Adjacências	Tocantins	152,140		1	1	6	X					
BR048	Cerrados do Nordeste de Tocantins	Tocantins	1,296,041	1	1		3						
BR049	Lizarda	Tocantins	349,193		2		5						
BR050	Parque Estadual do Cantão	Tocantins	90,017			2	1	X					
BR051	Matas Ciliares do Rio do Coco e Afluentes	Tocantins	138,721	1	1	2	2	X	X				
BR052	Jalapão	Bahia, Tocantins	1,187,017	1	2	1	5		X				
BR053	Formoso do Araguaia	Tocantins	169,672				1			X		X	
BR054	Vale do Rio Palmeiras	Tocantins	272,225		1		3	X					
BR055	Interflúvio dos Rios Tocantins e Paranã	Goiás, Tocantins	472,744		1	1	2						
BR056	Aurora do Tocantins / Taguatinga	Tocantins	370,934		1		2	X					
BR057	Mamanguape	Paraíba	19,528		2	2	2						
BR058	Mata do Pau-Ferro	Paraíba	13,693			2		X					
BR059	Tabocais	Acre, Amazonas	7,351,066		1		4	X	X				
BR060	Parque Nacional da Serra do Divisor	Acre	840,955		1			X	X				
BR061	Alto Juruá	Acre	539,864		1		3	X	X				
BR062	Arquipélago de Fernando de Noronha	Pernambuco	1,827			1	1	X	X	X		X	
BR063	Mata do Estado	Pernambuco	702	1	5	1	2	X					
BR064	Serra do Mascarenhas	Pernambuco	3,311	1	4	1	1	X					
BR065	Igarassu	Pernambuco	7,766		1	2	4						
BR066	Brejo de Taquaritinga	Pernambuco	4,659		1	1							

Código do IBA	Nome do IBA	Unidade Adm	Área (ha)	A1				A2	A3	A4			
				CR	EN	VU	NT			A4i	A4ii	A4iii	A4iv
BR067	Tapacurá	Pernambuco	3,883				1						
BR068	Complexo Gurjaú	Pernambuco	1,455		3	3	2	X					
BR069	Reserva Ecológica Maurício Dantas	Pernambuco	1,798			2	1						
BR070	Brejo dos Cavalos	Pernambuco	9,061		3	1	2	X					
BR071	Guadalupe	Pernambuco	14,629	1	2	2	1		X				
BR072	Parque Nacional do Catimbau	Pernambuco	62,294			1	4	X	X				
BR073	Serra Negra (Floresta)	Pernambuco	5,448			2	5	X	X				
BR074	Serra do Urubu	Pernambuco	3,776	2	4	3	1	X					
BR075	Ji-Paraná / Roosevelt	Amazonas, Mato Grosso,	1,112,493	1	1		1	X	X				
BR076	Saltos das Andorinhas e de Dardanelos	Rondônia	740								X		
BR077	Interflúvio dos Rios das Mortes e Araguaia	Mato Grosso	1,450,560			2	4	X					
BR078	Alto Rio Juruena	Mato Grosso	910,054	1			3						
BR079	Tirecatinga / Utiariti	Mato Grosso	605,359	1			1						
BR080	Rio Claro	Mato Grosso	146,773	1									
BR081	Campos do Encanto	Mato Grosso	274,114			1		X	X				
BR082	Parque Nacional da Chapada dos Guimarães e Adjacências	Mato Grosso	66,042		1		6						
BR083	Estação Ecológica Serra das Araras	Mato Grosso	29,741	1	1	1	1		X				
BR084	Cáceres	Mato Grosso	151,172		1		1						
BR085	Reserva Particular do Patrimônio Natural SESC Pantanal e Entorno	Mato Grosso	506,607		1	2	3						
BR086	Jamari	Mato Grosso	792,165		1								
BR087	Abunã	Rondônia	79,289					X					
BR088	Vale do Guaporé	Rondônia	1,664,439				1						
BR089	Curaçá	Rondônia	32,680			1	1						
BR090	Raso da Catarina	Bahia	400,626	1		3	5	X	X				
BR091	Sento Sé / Campo Formoso	Bahia	584,813	1			2	X					
BR092	Mangue Seco	Bahia	2,635							X			
BR093	Parque Estadual do Morro do Chapéu	Bahia	48,504			1	5	X					
BR094	Matas de Conde e Baixios	Bahia	4,844		2	1	1						
BR095	Serra de Bonito	Bahia	143,677		1	2	3	X					
BR096	Itanagra	Bahia	5,848		2	2	2	X	X				
BR097	Mata da Campina e Fragmentos Adjacentes	Bahia	17,358		2	1	1						
BR098	Ibiquera / Ruy Barbosa	Bahia	52,819			1							
BR099	Santo Amaro / Cachoeira	Bahia	9,386		2	2	1						
BR100	Parque Nacional da Chapada Diamantina	Bahia	449,755		2	6	14	X	X				
BR101	Jaguaquara	Bahia	19,921		1			X					
BR102	Baixo-Sul	Bahia	60,380	1	3	4	1	X					
BR103	Jequié	Bahia	38,574		1			X					
BR104	Rio Arrojado	Bahia	423,860	1	1	1							
BR105	Boa Nova / Serra da Ouricana	Bahia	18,513		2	7	3	X	X				
BR106	Ilhéus / Itabuna	Bahia	242,353			1		X					
BR107	Vitória da Conquista	Bahia	39,394		1	1	5	X	X				
BR108	Serra do Teimoso	Bahia	4,121			2	2						
BR109	Una	Bahia	21,854	2	4	5	1	X	X				
BR110	Serras das Lontras e do Javi	Bahia	9,895		2	7	6	X	X				
BR111	Serra Bonita	Bahia	7,526		2	6	8	X					
BR112	Foz dos Rios Pardo e Jequitinhonha	Bahia	56,619			1							
BR113	Santa Cruz Cabrália/Belmonte	Bahia	25,873		2	3							
BR114	Estação Veracruz	Bahia	7,999		4	6	1						
BR115	Parque Nacional do Pau Brasil/Trancoso	Bahia	30,072		2	3							
BR116	Parque Nacional de Monte Pascoal	Bahia	22,332		4	5	1	X					
BR117	Serra de Itamaraju	Bahia	13,015		1								
BR118	Parque Nacional do Descobrimento	Bahia	32,496		2	2	1						
BR119	Rio Mucuri	Bahia	6,282		2	1		X					
BR120	São José da Laje / Canhotinho	Bahia	4,167		1	1	1						
BR121	Engenho Coimbra (Usina Serra Grande)	Alagoas, Pernambuco	4,337		6	2	1	X					
BR122	Murici	Alagoas	16,403	3	5	5	4	X	X				
BR123	Reserva Biológica de Pedra Talhada	Alagoas	9,903		6	4	4	X					
BR124	Usina Cachoeira	Alagoas, Pernambuco	5,804			2	1						
BR125	Serra de Itabaiana e Matas de Areia Branca	Alagoas	7,999		1	3	2	X					
BR126	Mata do Crasto e Restingas de Itaporanga e Estância	Sergipe	44,056		2	3							
BR127	Terra Ronca	Sergipe	676,190		2		3	X	X				
BR128	Parque Nacional da Chapada dos Veadeiros e Adjacências	Goiás	395,681	1	1	6	5		X				
BR129	Parque Nacional das Emas	Goiás	133,064	1	4	4	4		X				
BR130	Mocambinho	Goiás, Mato Grosso do Sul	18,648			1	4	X	X				
BR131	Vale do Peruaçu	Minas Gerais	64,831	1		1	3	X	X				
BR132	Januária	Minas Gerais	21,080	1		1	2	X					
BR133	Bandeira / Macarani	Minas Gerais	4,826	1	1	8	1	X					

Código do IBA	Nome do IBA	Unidade Adm	Área (ha)	A1				A2	A3	A4			
				CR	EN	VU	NT			A4i	A4ii	A4iii	A4iv
BR134	Fazenda Santana	Bahia, Minas Gerais	5,253		3	2	3	X					
BR135	Reserva Biológica da Mata Escura	Minas Gerais	50,872			1	4						
BR136	Alto Cariri	Minas Gerais	22,129		1	1	3						
BR137	Chapada do Catuni	Bahia, Minas Gerais	5,091			1							
BR138	Botumirim	Minas Gerais	24,476			1	2	X					
BR139	Baixo Rio das Velhas	Minas Gerais	10,107	1	1		1	X					
BR140	Parque Estadual do Rio Preto	Minas Gerais	14,927			3	1						
BR141	Parque Estadual do Pico do Itambé e Serra do Gavião	Minas Gerais	7,358			1	1	X					
BR142	Serra do Cipó	Minas Gerais	74,244		1	3	6	X	X				
BR143	Parque Estadual do Rio Doce	Minas Gerais	35,947		4	3	5						
BR144	Caratinga	Minas Gerais	1,288			1							
BR145	Serra do Caraça	Minas Gerais	29,500		1		9	X					
BR146	Serra da Canastra	Minas Gerais	197,810	1	1	6	12	X	X				
BR147	Ouro Preto/Mariana	Minas Gerais	96,146				1						
BR148	Parque Estadual da Serra do Brigadeiro	Minas Gerais	13,173			5	4		X				
BR149	Laranjal/Miracema	Minas Gerais	18,014			1		X					
BR150	Parque Estadual da Serra do Papagaio	Minas Gerais, Rio de Janeiro	22,929			2	3	X					
BR151	Estação Ecológica de Águas Emendadas	Minas Gerais	10,547		1	2	1						
BR152	Parque Nacional de Brasília	Distrito Federal	31,895		1		2	X					
BR153	Cerrados ao Sul de Brasília	Distrito Federal	18,952		1	1	3	X					
BR154	Nhumirim	Distrito Federal	43,887		2		2						
BR155	Maciço do Urucum e Adjacências	Mato Grosso do Sul	118,718		2		3						
BR156	Rios Negro e Aquidauana	Mato Grosso do Sul	287,852		3		2		X				
BR157	Pantanal de Nabileque	Mato Grosso do Sul	468,274		1								
BR158	Parque Nacional da Serra da Bodoquena e Entorno	Mato Grosso do Sul	326,892		1		1						
BR159	Sooretama/Linhares	Mato Grosso do Sul	60,644		6	10	4	X	X				
BR160	Santa Teresa	Espírito Santo	23,167	2	2	8	17	X	X				
BR161	Itarana	Espírito Santo	5,910		1		4	X					
BR162	Reserva Biológica de Duas Bocas	Espírito Santo	4,305				6						
BR163	Fazenda Pindobas IV e Arredores	Espírito Santo	6,711	1	1	2	4	X	X				
BR164	Parque Nacional do Caparaó	Espírito Santo	31,763			2	14	X					
BR165	Encostas da Região de Domingos Martins	Espírito Santo, Minas Gerais	24,151		1	1	3						
BR166	Complexo Pedra Azul / Forno Grande	Espírito Santo	11,168	1	1	2	3	X	X				
BR167	Trindade e Martim Vaz	Espírito Santo	1,664			1				X	X		
BR168	Ilhas do Litoral Sul do Espírito Santo	Espírito Santo	644							X			
BR169	Cafundó e Bananal do Norte	Espírito Santo	2,756		1	4	3						
BR170	Itirapina	Espírito Santo	2,907			2	3						
BR171	Serra da Mantiqueira	São Paulo	153,714			2	8	X	X				
BR172	São Francisco Xavier / Monte Verde	Minas Gerais, São Paulo	45,208		1	2	8						
BR173	Parque Estadual da Serra do Mar (entre Caraguatatuba e Picinguaba)	São Paulo	99,935	1	2	10	20	X	X				
BR174	Serra da Cantareira	São Paulo	12,776				8						
BR175	Parque Estadual da Serra do Mar (entre Santos e São Sebastião)	São Paulo	105,997	1	1	5	19	X	X				
BR176	Bertioga	São Paulo	19,876			6	1						
BR177	Parque Estadual de Ilhabela	São Paulo	29,318		1	3	10						
BR178	Parque Estadual da Serra do Mar (entre Pedro de Toledo e Cubatão)	São Paulo	111,472		1	1	1						
BR179	Itanhaém / Mongaguá	São Paulo	30,876			4	2						
BR180	Arquipélago dos Alcatrazes	São Paulo	243						X	X			
BR181	Maciço Florestal de Paranapiacaba	São Paulo	437,646		3	13	11	X	X				
BR182	Estação Ecológica de Juréia-Itatins	São Paulo	108,181		2	9	17	X					
BR183	Ilhas Comprida e Cananéia	São Paulo	22,794		2	7	3			X			
BR184	Parque Estadual do Desengano e Entorno	Rio de Janeiro	44,521		3	12	10	X					
BR185	Parque Nacional de Itatiaia	Minas Gerais, Rio de Janeiro	28,084	1	1	6	23	X	X				
BR186	Região Serrana do Rio de Janeiro	Rio de Janeiro	55,351			1							
BR187	Reserva Biológica União	Rio de Janeiro	2,923		1	3	3						
BR188	Serra dos Órgãos	Rio de Janeiro	16,885	2	1	5	18	X	X				
BR189	Reserva Biológica de Poço das Antas	Rio de Janeiro	5,065			2	2						
BR190	Serra do Tinguá	Rio de Janeiro	27,924		1	6	20	X	X				
BR191	Maciços da Tijuca e Pedra Branca	Rio de Janeiro	15,981		1	3	2						
BR192	Restinga de Maçambaba e Ilha de Cabo Frio	Rio de Janeiro	20,247	1		1		X	X				
BR193	Ilha Grande	Rio de Janeiro	18,029		1	3	4						
BR194	Serra da Bocaina / Paraty / Angra dos Reis	Rio de Janeiro, São Paulo	159,011		4	9	24	X	X				
BR195	Parque Nacional de Ilha Grande	Mato Grosso do Sul, Paraná	107,917			1							
BR196	Jaguariaíva	Paraná	10,859		1	1	5						
BR197	Cânion do Guartelá	Paraná	31,554		1	2	4						
BR198	Parque Estadual das Lauráceas e Entorno	Paraná	46,509		1	3	6						
BR199	Guaraqueçaba / Jacupiranga / Cananéia	Paraná, São Paulo	624,000		3	14	6	X	X				

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				CR	EN	VU	NT			A4i	A4ii	A4iii	A4iv
BR200	Campos Gerais do Paraná	Paraná	23,184		1	4	8	X	X				
BR201	Várzeas da Região Metropolitana de Curitiba	Paraná	19,589		1		1	X					
BR202	Serra do Marumbi	Paraná	66,842		2	4	28	X	X				
BR203	Parque Estadual do Rio Guarani	Paraná	2,113			1	5						
BR204	Baixo Curso do Rio Nhundiaquara	Paraná	2,749		1	1		X					
BR205	Parque Nacional do Iguaçu	Paraná	169,696	1	1	4	13		X				
BR206	Corredor do Iguaçu	Paraná	29,151		1		2						
BR207	Rio Guaraguaçu	Paraná	4,370		1	4	2	X					
BR208	Área de Proteção Ambiental de Guaratuba	Paraná	126,597	2	2	9	8	X	X				
BR209	Ilhas dos Currais	Paraná	13								X		
BR210	Várzeas do Curso Médio-Superior do Rio Iguaçu	Paraná	1,498		1								
BR211	Várzeas em Tijucas do Sul	Paraná	17,422		1								
BR212	General Carneiro	Paraná	132,308		1	1	3	X					
BR213	Baía da Babitonga	Santa Catarina	31,998	1	1	3	1	X					
BR214	Salto do Piraí	Santa Catarina	10,538	1			12						
BR215	Campos de Água Doce e Palmas	Paraná, Santa Catarina	118,361		1	2	1						
BR216	Região de Blumenau	Santa Catarina	57,375			2	18		X				
BR217	Parque Estadual da Serra do Tabuleiro	Santa Catarina	94,342		1	5	13		X				
BR218	Painel/Urupema	Santa Catarina	135,280			3							
BR219	Urubici	Santa Catarina	99,548	1			5						
BR220	Parque Nacional de São Joaquim	Santa Catarina	42,775			2	6						
BR221	Parque Estadual do Turvo	Rio Grande do Sul	16,979		1		9						
BR222	Campos do Planalto das Araucárias	Rio Grande do Sul, Santa Catarina	562,529	1	1	5	10	X					
BR223	Banhado São Donato	Rio Grande do Sul	16,265		1	1	1	X	X				
BR224	Campos de Cima da Serra	Rio Grande do Sul	453,244		1	5	5	X					
BR225	Região dos Aparados da Serra	Rio Grande do Sul, Santa Catarina	270,004		2	4	21	X	X				
BR226	Banhado dos Pachecos	Rio Grande do Sul	2,605		1	2	2	X					
BR227	Médio Rio Camaquã	Rio Grande do Sul	387,238			1	3	X					
BR228	Parque Nacional da Lagoa do Peixe	Rio Grande do Sul	36,722			3	3			X		X	
BR229	Campos da Região de Bagé	Rio Grande do Sul	108,836			2	2	X	X				
BR230	Região de Pinheiro Machado	Rio Grande do Sul	151,352		1		4	X					
BR231	Estuário da Laguna dos Patos	Rio Grande do Sul	103,756			2	2		X	X			
BR232	Várzea do Canal São Gonçalo	Rio Grande do Sul	82,159		1	1	4	X	X				
BR233	Banhado do Maçarico e Cordões Litorâneos Adjacentes	Rio Grande do Sul	64,703		2	2	1	X	X				
BR234	Banhado do Taim	Rio Grande do Sul	111,272			1	1		X	X		X	

Para obter informações sobre as espécies de cada IBA, consulte as contas individuais no site: www.birdlife.org/datazone/sites/

Oportunidades

A conservação das aves no Brasil ainda representa um grande desafio. Dez por cento de todas as espécies de aves globalmente ameaçadas estão no Brasil e muitas correm risco de extinção eminente. Ao mesmo tempo o número de novas aves descritas é crescente: 21 novas espécies foram descritas no Brasil entre os anos de 1996 e 2006. As duas maiores florestas tropicais brasileiras também apresentam situações opostas: a Mata Atlântica é uma das florestas tropicais mais ameaçadas em todo o planeta, com cerca de 7% de florestas remanescentes enquanto na Amazônia, 80% da floresta ainda permanece preservada. Esses contrastes fazem do Brasil um país único em termos de conservação da biodiversidade, mas com perspectivas bastante favoráveis. Atualmente existe um interesse crescente da sociedade pelas aves. Nos últimos três anos o número médio de participantes nos congressos brasileiros de ornitologia foi de cerca de 500 pessoas/ano, em sua grande maioria estudantes. A Sociedade Brasileira de Ornitologia (SBO) também está crescendo e hoje já conta com mais de 800 membros. A feira nacional de observadores de aves, Avistar, vem se estabelecendo no Brasil e teve, em sua última edição em 2008 a participação de 5.000 pessoas.

"Dez por cento de todas as aves globalmente ameaçadas são encontradas no Brasil e muitas estão em risco de extinção iminente."

O desprotegido IBA de Matas Ciliares do Rio do Côco e Afluentes (BR051) detêm globalmente populações importantes de uma espécie criticamente ameaçada de Kaempfer Woodpecker (*Celeus obrieni*) e o vulnerável chororó-de-goiás (*Cercomacra ferdinandi*).
Foto: Pedro F. Develey

A elaboração de um plano estratégico único para a conservação das aves no país considerando todas essas particularidades é uma medida extremamente importante que deve ser realizada de maneira participativa envolvendo ONGs, pesquisadores e setores governamentais. As IBAs constituem uma ferramenta básica na elaboração dessa estratégia e podem ser adotadas como base de planejamento de conservação na escala da paisagem. No caso da Mata Atlântica as IBAs já vêm contribuindo de modo concreto com o planejamento da conservação, levando à criação de novas unidades de conservação. Por exemplo, Murici (BR 122; Quadro 2) onde foi criada uma Estação Ecológica. As IBAs também são ferramentas úteis em campanhas de disseminação e educação levando uma mudança da percepção ambiental da comunidade local (Boa Nova, Serra do Urubu). A definição das IBAs também auxiliam na busca de alternativas de renda para a população de maneira sustentável e alinhada à conservação ambiental (Serra das Lontras; Quadro 3) e na pesquisa científica enfocando aves ameaçadas (Chapada do Araripe, Maçambaba). Finalmente a identificação das IBAs tem ajudado na ampla participação no processo de definição de áreas prioritárias para a conservação no país liderado pelo governo federal.

"A conclusão do inventário do IBA é uma contribuição inestimável para a conservação de aves no Brasil, porém este é apenas o primeiro passo de um longo processo."

Quadro 1

Programa de conservação muda a percepção da comunidade local em relação ao meio ambiente em Boa Nova

Boa Nova (BR 105), localizada no sul do estado da Bahia, é de grande importância para as aves por estar situada em uma área de transição entre a Mata Atlântica e a Caatinga levando a uma elevada diversidade local com 391 espécies de aves identificadas até o momento, sendo que 10 são consideradas globalmente ameaçadas de extinção. Nesta área de transição encontra-se a mata-de-cipó, hábitat do ameaçado gravatazeiro (Rhopornis ardesiacus) uma das aves mais raras no Brasil. Apesar de sua riqueza biológica, a região vem sofrendo constante pressão causada pela extração de lenha, atividade madeireira, caça e tráfico de animais silvestres, e desmatamento para agricultura e pastagens. A SAVE Brasil desenvolve, desde 2004, um programa de conservação em Boa Nova com ações em pesquisa científica, engajamento comunitário, educação e sensibilização ambiental, manejo da paisagem e articulação de políticas públicas, especialmente voltadas à criação de áreas protegidas. Um dos grandes resultados do projeto foi a mudança de comportamento e percepção da população local em relação ao meio ambiente. As campanhas de disseminação e educação atingiram, até o momento, 1.100 pessoas entre crianças e adultos e acabaram levando à adoção do gravatazeiro pela comunidade como ave símbolo da cidade. Proprietários de terra estão engajados no projeto, conservando 840 hectares de florestas onde a espécie pode ser encontrada. Uma proposta de criação de uma unidade de conservação com 32 mil hectares foi elaborada e se encontra para avaliação junto ao Governo Federal. Em paralelo, trabalhos de pesquisa científica geraram dados inéditos sobre a biologia do gravatazeiro, inclusive a descrição inédita do ninho e de seu comportamento reprodutivo. Os próximos passos é restaurar áreas degradadas e nascentes com participação da comunidade e continuar a articulação com o governo federal para a criação da unidade de conservação.

Gravatazeiro
(*Rhopornis ardesiacus*)
Foto: Ciro Albano

Boa Nova (BR105)
Foto: Pedro F. Develey

Pacto Murici assegura conservação de centro de endemismo de aves com importância global

Quadro 2

O Complexo Florestal de Murici é uma das mais importantes florestas do mundo para a conservação de aves. Está localizado em uma região rica em biodiversidade e com uma história evolutiva única: o Centro de Endemismo Pernambuco. Nessa região está inserida a Estação Ecológica de Murici (ESEC Murici) com 6.116 hectares localizada na Zona da Mata Alagoana. Murici possui 14 espécies de aves globalmente ameaçadas de extinção, entre elas algumas criticamente ameaçadas, como o gavião-de-pescoço-branco (*Leptodon forbesi*), a choquinha-de-alagoas (*Myrmotherula snowi*) e o limpa folha-do-nordeste (*Philydor novaesi*). As ações em Murici tiveram início em 2000. Atualmente o trabalho é realizado em parceria com outras sete organizações que, juntamente com a SAVE Brasil, formam o Pacto Murici, que visa assegurar a conservação dos remanescentes florestais do Centro Pernambuco e cujo foco principal é Murici. O principal resultado do projeto foi a criação da Estação Ecológica de Murici (ESEC Murici) em 2001, que assegurou oficialmente a conservação da área. Após a criação da ESEC os trabalhos vêm enfocando a capacitação de comunidades locais que vivem no entorno da reserva e o apoio à formação de gestores de unidades de conservação na região. Um passo necessário é a elaboração e implantação do plano de manejo da unidade. Também há um trabalho em conjunto com grandes proprietários locais (produtores de cana-de-açucar) nas ações de restauração florestal e criação de reservas particulares na região do Centro Pernambuco.

Assinatura do Pacto Murici, Senado Federal, maio de 2004.
Foto: Anon.

Mata Atlântica, em Murici (BR122).
Foto: Pedro F. Develey

Quatro 3

Produção tradicional de cacao favorece a conservação na Serra das Lontras

Localizado no sul da Bahia, o complexo montanhoso da Serra das Lontras abrange florestas de baixada e de montanha. Esse gradiente altitudinal e de vegetação permite a ocorrência de uma rica diversidade de aves: 310 espécies foram registradas até o momento, 18 delas globalmente ameaçadas de extinção e duas novas para a ciência. A região é caracterizada pelo tradicional cultivo de cacau em cabruca, sistema agroflorestal que favorece a biodiversidade por estar associado a áreas de Mata Atlântica nativa. A SAVE Brasil vem trabalhando em parceria com organizações locais para implementar um modelo de desenvolvimento sustentável que integre a proteção das florestas com a promoção de uma agricultura ambientalmente adequada e o desenvolvimento social das comunidades locais. Através da capacitação técnica dos agricultores na produção orgânica, e de cooperativas e associações locais no gerenciamento dos negócios e comercialização nos mercados nacional e internacional o projeto já beneficiou cerca de 400 produtores e suas famílias e certificou 1.800 hectares de produção orgânica. Além disso, 650 hectares de Mata Atlântica estão em processo de averbação de Reserva Legal e uma proposta de criação de um Parque Nacional com 16 mil hectares se encontra em avaliação pelo Governo Federal. A SAVE Brasil também desenvolve pesquisas científicas e monitoramento da avifauna para avaliar os impactos das técnicas da agricultura sustentável na comunidade de aves, enfocando nas espécies ameaçadas e endêmicas. Alguns obstáculos a serem superados na continuidade do projeto se refere a estratégia de marketing do cacao orgânico considerando a pequena escala de produção e a necessidade de fortalecimento das cooperativas locais.

Chocolate orgânico (à esquerda) produzido pelo sistema Cabrucá na Serra das Lontras (BR110).
Foto: Patricia Ruggiero

Mais Informações

Fontes de dados

National IBA Directories

Áreas Importantes para a Conservação das aves no Brasil. Parte 1 - Estados do Domínio da Mata Atlântica (Bencke *et al.* 2006)

Áreas Importantes para a Conservação das aves no Brasil. Parte II - Amazônia, Cerrado e Pantanal (De Luca *et al.* 2009)

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A arara-azul-de-lear (*Anodorhynchus leari*) é uma espécie criticamente ameaçada que provoca critérios do IBA em apenas dois locais.
Foto: Andy & Gill Swash; www.rarebirdsyearbook.com

SPATIAL AND TEMPORAL PATTERNS OF BIRD SPECIES DIVERSITY IN THE PANTANAL OF MATO GROSSO, BRAZIL: IMPLICATIONS FOR CONSERVATION

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ABSTRACT

Analysis of a three-year bird survey in the pantanal of Poconé revealed that most of the resident and seasonal birds are habitat generalists, using two or more habitats. In this study, previously sampled habitats were ranked in relation to species richness and stability (as measured by the ratio of seasonal to resident species). In all, nine habitats were grouped into three categories; results are as follows: 1) forests: more species-rich and more stable; 2) cerrado: intermediate levels; and 3) aquatic: less species-rich and less stable. The number of seasonal species remained relatively constant in forests throughout the year, while increasing in the other habitats during the dry season. The abundance of resident species seems to be related to species use of multiple habitats. Although many species were found to be habitat generalists, we discuss possible consequences of habitat loss and other human impacts on efforts to conserve this important bird community.

Keywords: flooding cycle, habitat heterogeneity, habitat stability, species abundance and richness, seasonal species

RESUMO

Padrões espaciais e temporais de diversidade de espécies de aves no Pantanal

Análises de um levantamento de três anos da avifauna do Pantanal de Poconé indicam que a maioria das espécies residentes e estacionais utiliza dois ou mais tipos de habitats. Estes habitats podem ser ordenados num gradiente de riqueza de espécies e estabilidade (medida pela proporção de espécies estacionais): 1) matas - mais ricas e estáveis; 2) cerrados e pastos – intermediários; e 3) campos inundáveis/aquáticos – menos ricos e menos estáveis. Enquanto a proporção de espécies estacionais nas matas permanece relativamente constante ao longo do ano, há aumento significativo destas espécies nos outros habitats durante a estação seca. A abundância das espécies residentes parece ligada ao uso de maior variedade de habitats. São discutidas possíveis implicações decorrentes da destruição de habitats e perturbações antrópicas na conservação desta comunidade de aves.

Palavras-chave: ciclos de inundação, espécies estacionais, estabilidade de habitat, heterogeneidade de habitats, riqueza e abundância de espécies.

INTRODUCTION

Environmental variability is part of what determines which bird species will occupy and persist in a given habitat, thereby shaping community composition and structure. In relatively stable environments, a time lag exists between climatic changes and corresponding changes in resource availability, leading to the unpredictability observed in the local dynamics of many bird communities. However, when climatic changes are extreme, changes in resource levels can be immediate and closely followed by changes in the community structure (Wiens, 1986). Extreme climatic seasonality occurs in the Pantanal of Mato Grosso, the largest flood plain in the world (Alho *et al*., 1988). This seasonality, in turn, results in equally extreme changes in local bird communities. The Pantanal is a rich hydrological complex within a lowland area, formed by tributaries of the Paraguay river. Large areas are covered by water during annual flooding that extends from December to May, although small land areas and some isolated hills remain above water. Different habitats, soil types, and inundation levels are responsible for the great variety of vegetation, producing a mosaic landscape (Adámoli, 1986; Rizzini, 1979; Zeilhofer & Schessi, 1999). The cerrados, which are never flooded, are located in upland areas at the periphery of the Pantanal, while xerophytic vegetation occurs near the Chaco and on limestone formations. The rich aquatic vegetation found in the Pantanal occurs in flooded depressions, while grass fields are present in areas where the water drains away quickly (Rizzini, 1979).

Severe weather and the unpredictable duration of dry periods result in strong pressures on plant and animal populations, favoring dispersive or migratory species capable of taking advantage of the abundant, yet seasonal and transitory, resources found in the Pantanal (Brown, 1986). The presence of many plant and animal species adapted to this unpredictability support these affirmations. Many of the herbaceous plants within the flood plains die during flooding, reappearing again in the outflow period (Conceição & Paula, 1986; Pott, 2002). As water level declines, vegetative reproduction of *Salvinia auriculata* (Salviniaceae) is inhibited by crowding while sporocarp production is enhanced (Coelho, 1997). During the dry season, there are local migrations of alligators (*Caiman crocodilus yacare*), in groups of anywhere from 3 up to 52 individuals, searching for pools of water and/or small lakes, where food is concentrated (Campos, 2002). During this period, fish gather in the rivers, form schools, migrate upstream, and reach the upper courses. Once there, at the beginning of the rainy season, they breed (Willink *et al*., 2000). In response to significant variation in water level and resource availability, there are also migrations of aquatic birds, such as wood storks, egrets, terns, ducks, sandpipers, hawks (*e.g*., snailkite), swallows, tyrant flycatchers, and many others (Antas, 1994; Oliveira, 2006; Cintra pers. obs.). However, even though the Pantanal is recognized as a threatened area of international importance for conservation, information regarding its biodiversity is still scarce and fragmented (Silva, 2002).

A recent and detailed review made by Tubelis & Tomas (2001; 2003) points out that researchers and collectors have surveyed the Pantanal bird fauna since the beginning of the nineteenth century. Among these, one can cite Brown (1986), who compiled the first species list. This author, who studied the origin and distribution of 658 species throughout the entire Pantanal region, concluded that the area did not favor speciation. Instead, it acts both as a dispersion corridor and barrier, as well as a breeding site for animals searching for easily found and abundant food resources. Tubelis & Tomas (2001, 2003) updated the species list and identified the better-known study areas, as well as the geographic locations still not scientifically investigated. In addition, they concluded (Tubelis & Tomas, 2003) that this region contains the highest wetland-bird richness in the world: 463 species. Antas (1994) pointed out that, besides the importance of the Pantanal to wading and aquatic birds, it acts as a migration route to transitory species annually arriving from the southern part of the continent as well as from the Northern Hemisphere. The area also receives migrants from the Atlantic Forest in the eastern part of Brazil and from the pampas in the south (Silva, 1998). In addition, Cintra & Yamashita (1990) assessed the bird fauna of the pantanal of Poconé, identifying 317 species, of which 86 occurred seasonally.

The species lists compiled by Brown (1986), Antas (1994), Tubelis & Tomas (2001; 2003), Cintra & Yamashita (1990), and others offer important

data regarding the species richness and distribution in the Pantanal. However, these lists have never been statistically analyzed for the purpose of furthering what is now known of bird community dynamics in the Pantanal. The species list of Cintra & Yamashita (1990) also included the habitat, a subjective abundance index (rare *vs*. common), and the period in which each species occurred. Their data offer a preliminary description of bird-community spatial and temporal distribution in the pantanal of Poconé.

The objective of this work was to statistically analyze this information and study it from a new, ecological perspective, in order to find patterns of bird species distribution and habitat use in the Pantanal, which could aid in future conservation efforts.

The main hypotheses are: a) use of multiple habitats by birds are a common occurrence and may be the rule in the Pantanal; b) differences in proportion between seasonal and resident species reflect habitat instability, which is higher in open habitats that are more prone to severe droughts and/or flooding; and c) cycles of seasonal species differ between bird species occurring in the uplands and those in the floodplains.

METHODS

The 15,800 km^2 pantanal of Poconé is covered by a mosaic of swamps, fields, cerrado, and semideciduous and gallery forests (Allem & Valls 1987). The region is part of the *Alto Pantanal* sub-area, 20% of which is inundated for 2 to 3 months annually (Alho *et al*., 1988). Due to ease of access, the bird fauna surveys conducted by Cintra & Yamashita (1990) between 1982 and 1986 were confined mainly in a particular region of the pantanal of Poconé. The authors surveyed bird species in nine habitats: semideciduous and gallery forests, cerrado, pastures, seasonally flooded fields, *corixos* (outlets of ponds, small lakes, or marshes), "bays", rivers, and swamps (see descriptions in Cintra & Yamashita, 1990). Each habitat was sampled once a month for 3 years, either between 6 h and 9 h or 16 h and 18 h. Sampling was conducted along 1 km transects on abandoned trails and roads that were traveled on for about one hour, complemented by sampling in habitat edges along the Transpantaneira Road and captures using mist nests. Rare species were those classified as seen only a few times and in small numbers; common species, as those seen frequently, and at times in groups; and seasonal species, those seen only some months out of the year. Registers of relative abundance (rare vs common) and seasonality (seasonal vs resident or number of month the species was observed) were not available for all species.

The Spearman correlation was used a) to investigate whether temporal stability of the different species (number of months of occurrence) could be explained by the number of habitats used; and b) to verify whether the species abundance (rare (0) *vs*. common (1)) was correlated to the number of habitats and/or to their stability through time. The dissimilarity between habitats, based on species co-occurring in each pair of habitats, was determined by comparing their Euclidian distances. A dissimilarity dendogram was generated, using the simple linkage method, *i.e*., the nearest neighbor distance. Species occurrences throughout the year (number of species occurring per habitat per month) were also analyzed. The relative stability of the different habitats was evaluated by dividing the number of seasonal species by that of resident ones, and also by calculating the corresponding coefficient of variation (CV) during the year. In order to minimize the error entailed by not sampling species present, a possibility when dealing with rare species, seasonality effects on abundant and rare species were analyzed separately. All analyses followed Zar (1984), using the statistical program SYSTAT 5.0. The statistical work here, by J. E. C. Figueira, was based on censuses by Cintra & Yamashita (1990), while L. R. Viana helped with the revision, based on work in a similar ecosystem (the Everglades).

RESULTS

Of the 317 species recorded by Cintra and Yamashita (1990), 188 occurred in semideciduous forests, 164 in gallery forests, 103 in pastures, 88 in cerrado, 87 in the seasonally flooded fields, 79 in *corixos*, 74 in bays, 50 in swamps, and 57 in rivers. Most of the species (70%) for which records were available occurred throughout the entire year, while the seasonal species were present from between 2 to 10 months annually (Fig. 1).

Ninety-four percent of seasonal and resident species used 2 or more habitats (Fig. 1).

The habitat dissimilarity dendrogram generated from Table 1 separates the habitats into three groups: 1) FORESTS (semideciduous and gallery forests); 2) CERRADO (cerrado and pastures); and 3) AQUATIC (rivers, bays, swamps, *corixos*, and seasonally flooded fields) (Fig. 2). One hundred ninety-two species were present in the gallery and semideciduous forests, of which 160 were found in both forests. Fifty-five species occurring in cerrado were also found in the semideciduous forests. Of these species, 44 were also found in gallery forests. Fifty-three species were present in cerrado and pastures, while 18 species were present in all aquatic habitats.

In this study, sixty-three percent of the seasonal species were considered abundant. Seasonal species comprised 16% of all species in the forests, 25-27% of those in cerrado, and 46-54% of those in the aquatic habitats (Fig. 3). The total number of seasonal species (abundant plus rare) decreases during the rainy season and increases during the dry season is shown in Fig. 4.

TABLE 1
Dissimilarity coefficients between the bird fauna from the different habitats. SWA: swamp; RIV: river; BAY: bay; COR: corixo; SFF: seasonally flooded field; PAS: pasture; CER: cerrado; GAL: gallery forest; SEM: semideciduous forest.

	BAY	RIV	COR	SWA	SFF	PAS	CER	SEM	GAL
BAY	0.000	-	-	-	-	-	-	-	-
RIV	0.323	0.000	-	-	-	-	-	-	-
COR	0.292	0.398	0.000	-	-	-	-	-	-
SWA	0.421	0.417	0.386	0.000	-	-	-	-	-
SFF	0.369	0.413	0.382	0.474	0.000	-	-	-	-
PAS	0.709	0.684	0.725	0.658	0.666	0.000	-	-	-
CER	0.707	0.668	0.723	0.651	0.714	0.519	0.000	-	-
SEM	0.871	0.859	0.888	0.842	0.919	0.757	0.725	0.000	-
GAL	0.834	0.825	0.844	0.800	0.884	0.757	0.720	0.318	0.000

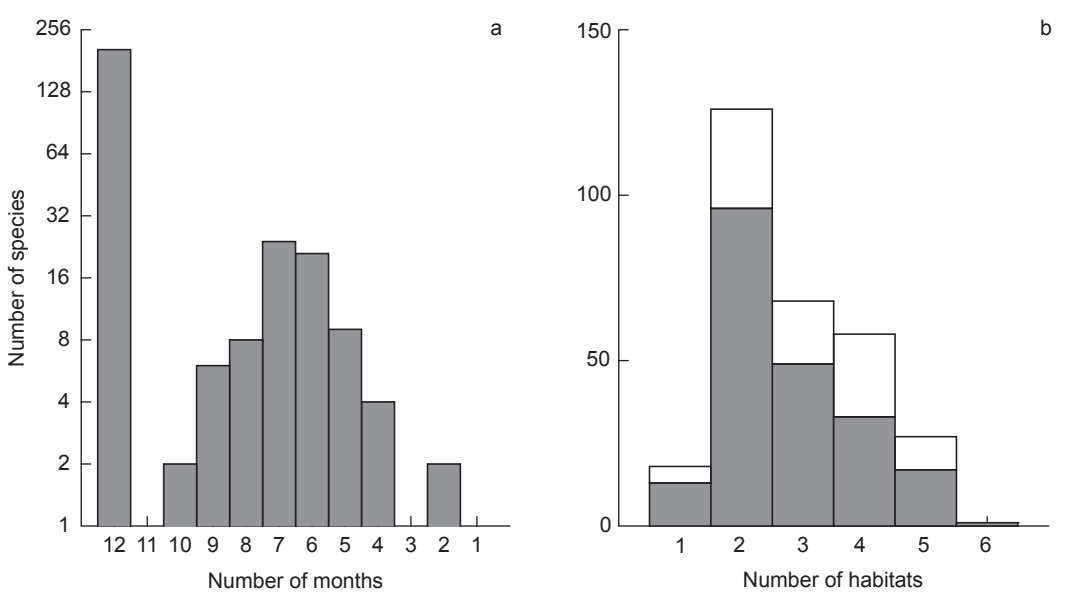

Fig. 1 — a) Number of months; and b) number of habitats in which the resident (gray bars) and seasonal species (white bars) occurred.

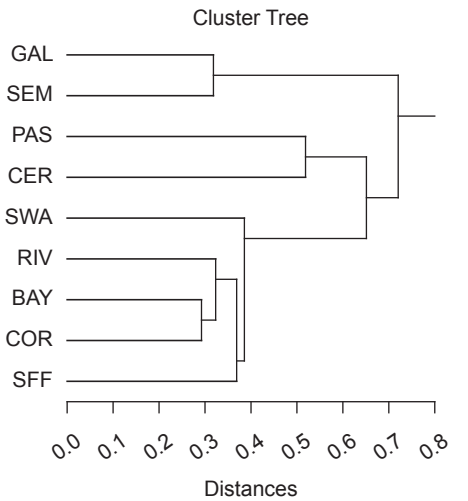

Fig. 2 — Similarities between habitats determined by their bird fauna: SWA = swamp, RIV = river, BAY = bay, COR = corixo, SFF = seasonally flooded field, PAS = pasture, CER: cerrado, GAL = gallery forest, SEM = semideciduous forest.

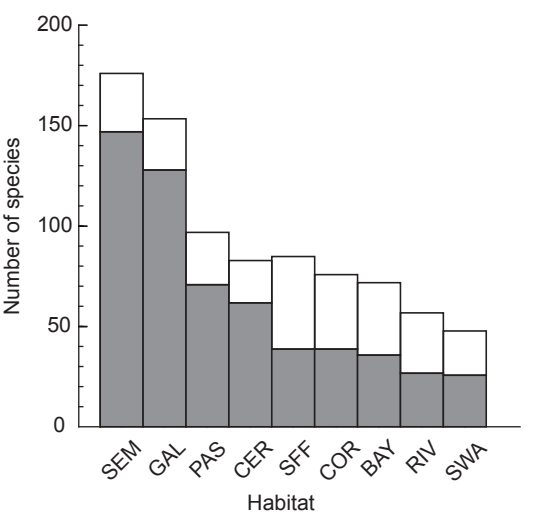

Fig. 3 — Species richness of birds in the different habitats (resident species: gray bars; seasonal species: white bars). SEM: semideciduous forest; GAL: gallery forest; PAS: pasture; CER: cerrado; SFF: seasonally flooded field; COR: corixo; BAY: bay; RIV: river; and SWA: swamp.

Variation in the forest habitats (CV = 0.07) was smaller than in the cerrados (CV = 0.24) and aquatic habitats (CV = 0.21). However, this variation was accounted by species abundance (CV = 0.06, forests; 0.31, cerrado areas; and 0.19, aquatic habitats). The abundance index of the resident species correlated positively to the number of habitats used by these birds ($r_s = 0.283$, $P < 0.005$, $n = 209$). When the abundance of seasonal species was analyzed, no significant correlation was found with either the number of habitats used ($r_s = 0.195$, $n = 89$, $P > 0.05$) or the number of months in which these species were recorded ($r_s = 0.172$, $n = 77$, $P > 0.10$).

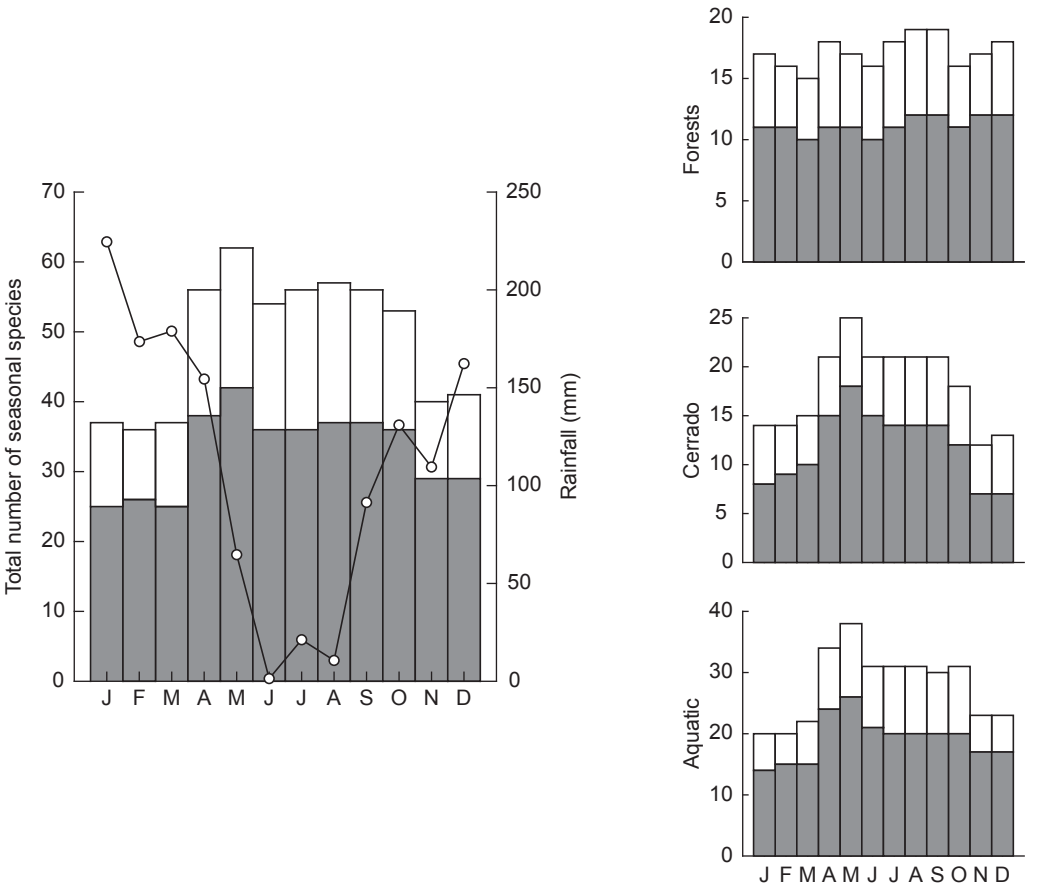

Fig. 4 — Variation in the total number of seasonal species throughout the year, showing their concentration during the dry season (common species: gray bars; rare species: white bars). The average values of precipitation are from the Cuiabá region during the 1982-1986 period. The variation in the seasonal species number is shown separately for birds from the forests, cerrado, and aquatic habitats.

DISCUSSION

In spite of the modest sampling effort in the sampling procedures used by Cintra & Yamashita (1990), patterns of bird species occurrence in the different habitats were based on species presence or absence during the whole study, which certainly minimized errors. On the other hand, the seasonal patterns could have been more susceptible to errors entailed by lack of sampling of some species throughout the year, with the highest chances of error related to rare species. However, temporal patterns were very similar when all species were considered (rare plus abundant), or abundant species only. For this reason, the data presented in this study is believed to reflect, approximately, bird distribution within the various habitats throughout the year.

The patterns observed suggest that the structure and dynamics of the Pantanal bird community are strongly linked to environmental heterogeneity and flooding cycles. Furthermore, they corroborate the hypothesis that transient, generalist species are favored within the temporally variable and patchy habitats occurring in the Pantanal. Cunha *et al*. (2002) pointed out the importance of environmental heterogeneity to fauna: different landscape units may function as dispersion corridors, stepping-stones, refuges, and feeding sites in the Pantanal. Brown (1986) observed that climate and resource instability and the abundance of large generalist predators in the floodplains favored large, mobile individuals,

resistant to long dry periods and associated with aquatic environments. Besides that, cold fronts that periodically occur in the Pantanal during July and August could favor omnivorous species (Willis, 1976). In addition, the quantity of fish in the Pantanal, which is among the greatest on the planet (Conceição & Paula, 1986), partially explains the present regional abundance of aquatic birds.

Brown (1986) considers the Pantanal a dispersion corridor rather than a speciation center, a view supported by a sampling conducted by Cintra & Yamashita (1990), which found no endemic species. According to Brown (1986), 60% of Pantanal bird species are broadly distributed, and composed of 20% aquatic species, 40% from open environments (cerrado and Chaco), and 30% from other forests (the Amazon and Atlantic). Although not updated (see Tubelis & Tomas, 2003), Brown's bird list (1986) clearly shows the importance of environmental heterogeneity in determining species diversity in the Pantanal. Similarly, the gallery and semideciduous forests in the pantanal of Poconé host a higher number of forest-dependent or semi-dependent bird species, thus reinforcing the importance of these vegetation types in increasing local bird diversity in the Pantanal. This was also observed for birds and mammals in the cerrado region (Negret & Negret, 1981; Negret *et al*., 1984; Silva, 1995). The gallery forests among the cerrado areas function as mesic corridors, providing suitable habitats and increasing the geographic extension of birds and mammals that are essentially of forest environments. Accordingly, species from the Amazon and Atlantic Forest are also found in the cerrado fauna (Silva, 1995; Redford & Fonseca, 1986). A total of 44% of the birds from the Brazilian cerrado areas (366 species) depend totally or partially on forests (Silva, 1995). Considered key areas for maintaining bird fauna diversity (Silva, 1995; Silva & Bates, 2002), these areas offer refuge, food, and water to mammals, birds, and other non-resident animals (Medellin & Redford, 1992; Ribeiro *et al*., 2002). Forests become especially important during the dry period and occasional drought years, as well as during fire periods, when they function as refuges and sources of dispersing re-colonizers (Cavalcante, 1992; Redford & Fonseca, 1986). Ecotones and forest edges also appear important in supporting populations of some cerrado bird species that would otherwise be forced to migrate elsewhere. This is the case for some bird species that depend on seasonal resources, *e.g.*, fruits and flowers, as well as species that take advantage of different resources that become sporadically available in cerrado areas and along the forest edges (Cavalcanti, 1992; Lins, 1994), such as tinamous, pigeons, doves, macaws, parrots, hummingbirds, tyrant-flycatchers, thrushes, caciques, warblers, tanagers, and seedeaters. In Poconé, bird similarity in cerrado areas resembles more that of pastures, although pastures are structurally more like seasonally flooded fields. The difference is that agriculture and orchards occur in pastures while murundus (patches of non-floodable shrubs and trees) (Oliveira-Filho, 1992a, b) occur in the flooded fields (Cintra & Yamashita, 1990). This supports Stotz *et al*. (1996), who observed that few grassland bird species tolerate agricultural areas or pastures, while the many species found in their study originated from nearby habitats with shrub vegetation, recovering forests, or wooded-area edges. However, the seasonally flooded fields, when periodically submersed, allow for aquatic bird occurrence, which results in a higher species-composition similarity with other aquatic environments.

Aquatic birds showed less habitat preference than all other species, and that their aquatic habitats can be described as fine-grained (Ricklefs, 1990) is suggested by the fact that they present many bird species in common. However, according to Stotz *et al*. (1996), birds are not good indicators of aquatic environmental conditions, because they occur in multiple habitats and are often more influenced by conditions around water bodies than conditions within them.

Habitat specialization in birds is measured by the number of habitats they use (Stotz *et al*., 1996). The data from Cintra & Yamashita (1990) suggest that as a rule bird fauna, resident species as well as seasonal, from the pantanal of Poconé occur in different habitats. In relation to habitat sharing by species, this reflects ecological flexibility and/or similarities among these habitats regarding structure, microclimate, food availability, and refuge conditions. Habitat sharing also indirectly indicates the potential flux of individuals and species between different habitats and, consequently, the complexity, interconnectedness, and flexibility of interactions in a trophic web. Habitat heterogeneity

in space and time is, therefore, fundamental not only to increasing, but also to maintaining local diversity of aquatic and terrestrial birds. According to Wilson & Willis (1975), the persistence of certain species is favored by ecologically appropriate habitat patches that allow reciprocal intercolonization events through time, which could potentially trigger metapopulational dynamics (Levins, 1969).

Habitat specialist birds represent only 6.3% of the total number of species identified in the pantanal of Poconé. None of these, which are generally rare and of open habitats (Cintra & Yamashita, 1990), are on the Brazilian endangered species list (CEMAVE, 2004). The positive correlation observed between abundance and the number of habitats used by resident species suggests that abundance is determined by the capacity to tolerate different environmental conditions and/or to exploit a greater variety of resources. Furthermore, ecologically more flexible resident species appear more able to maintain larger populations (see alternative hypothesis in Hanski *et al*., 1993). Conversely, the lack of correlation between abundance of seasonal species and the number of habitats they use suggests that, contrary to that of resident species, seasonal species abundance is not determined by capacity to occupy and/or to exploit habitats. In addition, no correlation was found between abundance and the number of months in which seasonal species occurred, suggesting that seasonal species abundance is not contingent on the stability of resources through time.

The Pantanal flooding cycle is annual. However, there are multiyear cycles in which severe flooding and droughts occur (Cunha *et al*., 2002). During these events fauna invade the floodplains from more stable and safer, non-flooding habitats, creating sporadic but ephemeral populational increases (Brown, 1986; see also Antas, 1994; and the recent results of Oliveira (2006)). As a group, different seasonal birds occurred in forest, cerrado, and aquatic habitats in both rainy and dry periods of the year, suggesting that for the pantanal of Poconé no optimal period exists for all seasonal species.

For habitat stability, a ranked gradient based on the proportion of seasonal to resident species was determined. Forest areas proved more stable than those of cerrado (in agreement with Lins, 1994, for birds from gallery forests within the cerrado), which in turn were more stable than the aquatic habitats. This pattern is partially confirmed by the monthly variations in the seasonal species number (forests > aquatic > cerrado).

Migration is pronounced among aquatic birds: 35% of the species using freshwater habitats and reproducing in the Neotropics are migratory and, even among resident species, many move regularly responding to water level or resource availability fluctuations (Stotz *et al*., 1996). The temporal patterns observed in the present work indicate that most aquatic bird migrations from the pantanal of Poconé coincide with the beginning of the rainy period, while the return occurs during the dry period. This supports an observation of Antas (1994), to the effect that many migratory aquatic birds leave the Pantanal (heading for the humid areas of Rio Grande do Sul and Vale do Rio Paraná) during flooding. The dry period provides greater quantities of fish, amphibians, mussels, snails, crabs, insect larvae, and other aquatic invertebrates that can easily be captured when water levels fall, as many of these organisms are caught in pools or mud (see also Antas, 1994; Silva *et al*., 2002). Oliveira (2006) found that the abundance of aquatic birds increases as the amount of rain (pluviosity) decreases in the Pantanal of Poconé.

Even with the possibility of using other nearby habitats during the non-favorable periods, 27% of the birds identified in cerrado of the pantanal of Poconé still occur only seasonally. However, contrary to what had been expected, these seasonal species become more abundant specially during the dry season, when resources are expected to be scarcer. This increase in abundance could be because birds in nearby habitats have few or no established territories during the dry period and so expand their home ranges into adjacent habitats, including temporary presence in the cerrado (suggested by Coelho (2000) for birds of small Atlantic forest fragments). On the other hand, the number of seasonal species in the forests is lower and seasonality is less distinct than that found in the cerrado and aquatic environments, thus suggesting more predictable resource availability throughout the year. Observations made by Cavalcanti (1992) indicate that gallery forests support a bird fauna different from that of cerrado, with a greater number of resident species, some of which use cerrado seasonally, specially during the rainy

periods when winged termites and fruits become abundant. The forests and other non-floodable vegetation patches allow occurrence of organisms not tolerant to floods, thus considerably increasing local biodiversity (Cunha *et al*., 2002).

Temporal variations observed in bird communities should reflect a dynamic balance occurring in two ways: a) individuals in populations and communities closely following variations in resource availability, through short-term adjustments in their behavior, demography, and distribution; and b) individuals in populations and communities not closely following the variations in resource availability brought about by periods of severe climate or resource depletion, alternating with periods of resource superabundance (Wiens, 1994). Data from the present work suggest that, in the Pantanal bird community, these two strategies occur. Therefore, resident species would try to find necessary resources in different habitats to compensate for availability fluctuations, while the seasonal species would abandon the area cyclically.

Many have suggested the Pantanal of Mato Grosso as a region for establishing conservation reserves (*Fundação Pró-Natureza*, Conservation International, *Fundação Biodivérsitas*, Universidade de Brasília, 2000; Wege & Long, 1995). However, current as well as pending anthropic impacts are already reducing habitat diversity and threatening to alter flooding cycles. Alho & Vieira (1997), Alho *et al*. (1988), and Mittermeier *et al*. (1990) have alerted the public to an increase in agricultural areas, deforestation, and gold-mining, consequent loss to species of food and refuge sites, and rising numbers of fish and aquatic birds (like cormorant, snail kite, and limpkin) presenting high mercury levels. To cite just one cause for concern, widespread deforestation can also interfere with bird migration from seasonally dry environments (Willis & Oniki, 1990). Severe impacts are also foreseen resulting from the construction of dams along the Paraguay river (and, if implemented, with Paraná-Paraguay waterway dredging), which could alter the seasonal flood regime (Antas, 1994). This alteration in flood regime could impact diverse vegetation forms, many of which within the Pantanal are sensitive to flooding. While some, such as the *canjiqueira* are capable of expanding during the dry season others, like the *cambarazal* may retreat (see Silva *et al*., 2002). In the Everglades, vegetative islands similar to those found in the Pantanal and that are also sensitive to flooding are disappearing due to water level increase and an increased period of inundation caused by water management. These islands are important since they serve as biodiversity centers, and provide refuge and nesting sites for fauna from nearby flooded areas (USGS, 2003). Man-made fires can also be detrimental because they can cause abnormal migratory movements (Alho *et al*., 1988). Besides these impacts, cities in the region are growing quickly and floodable areas have been drained for agricultural purposes (Stotz *et al*., 1996).

Aquatic and woodland habitat divisions into several sub-habitats (Cintra & Yamashita, 1990) may artificially decrease the apparent susceptibility of Pantanal bird species to human occupation, seeming to induce a wider ecological flexibility in habitat use, including by the apparently more generalist aquatic birds. However, several species require specific resources, habitat types, and/or specific environmental conditions. Therefore, changes in flooding cycle and the destruction of alternative key resources/habitats can, besides lowering population numbers, also cause species loss. For instance, most shorebird species need shallow water habitats covered with sparse vegetation, adequate amounts of mudflats, and sufficient invertebrate populations (Davis & Smith, 1998; Isola *et al*., 2000). Wading birds, such as herons and storks, need a series of drying ponds spatially and temporally spread out in which to prey on concentrated fish resources (Kushlan, 1976; Silva *et al*., 2000). Colonies of these birds also need patches of woods composed of trees resistant to flooding, such as *Crataeva pavia* and *Albizia polyantha*, in order to build nests. When these birds leave the region during the flooding period, they are replaced by cormorants and anhingas that forage in deeper waters (Silva *et al*., 2002). In Florida, nesting initiation, production, and survival of young in wood storks (*Mycteria americana*) was related to seasonal fluctuations in the water level (Clark, 1978). The gallinule *Porphyrula martinica* disappeared from a lake in southeastern Brazil because the cat-tail swamps that it occupied in the shade at midday, and in which it made its nests, were cleared, even though early and later feeding

sites in the day still remained intact and even increased (Willis, 2003).

The prey specialist snail kite (*Rosthramus sociabilis*) can also be threatened by the elimination of aquatic plants that harbor one of its main food items, the snail *Pomacea* (Sick, 1984). Also, the trees *Ficus calyptroceras* and *Erythrina dominguezzi* of deciduous forests in the western Pantanal provide parrots, parakeet, toucans, and several other bird species with a remarkable supply of fruits and nectar, especially in the dry season, a period of generalized food scarcity (Ragusa-Netto, 2002a; b). In the Pantanal the very specialized hyacinthine macaw (*Anodorhynchus hyacinthinus*) feeds only on the fruits of the palm trees *Acromia aculeata*, and *Attalea phalerata*. The *Sterculia apetala* tree, its primary nesting site, has been destroyed by windstorms and fire (Guedes 1993, Johnson *et al*., 1997). These examples point to a much more complex type of habitat dependency then that suggested for generalist species. Therefore, within the Pantanal, although many species may be habitat generalists those habitats may not be perfectly interchangeable, so that each habitat could be providing its own crucial key resources, suggesting the importance of protecting as many different types of habitats as possible in order to maintain the high levels observed of species diversity. This would be in accordance with an observation of Law & Dickman (1998): "the requirement by many species for multiple habitats suggests that their conservation will be most effective in a mosaic environment and that protection of certain high profile habitats alone will be insufficient to achieve conservation goals".

The observed patterns in the present work are mainly suggestive, and should be interpreted cautiously. However, they indicate that the Pantanal is an extremely complex and dynamic ecosystem spatiotemporally. These patterns also underscore the need for an extensive regional-level preservation effort aimed at maintaining the different landscape units, as well as the seasonal flood cycles that determine the structure and dynamics of their ecological communities.

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ANÁLISE DA PECUÁRIA NO PANTANAL MATO-GROSSENSE

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Resumo

Este artigo analisa a pecuária no Pantanal mato-grossense a partir da abordagem da sustentabilidade. Os resultados apresentados são fruto de um projeto de pesquisa financiado pelo Instituto Nacional de Áreas Úmidas – INAU / Centro de Pesquisas do Pantanal – CPP[3]. A pecuária é a principal atividade econômica do Pantanal brasileiro e tem sido desenvolvida na região há pelo menos dois séculos. O caráter extensivo da atividade pecuária no Pantanal, alicerçado em outros elementos da questão agrária nacional, contribuiu por muito tempo para a manutenção do bioma sem grandes impactos ambientais. Contudo, com as transformações agrárias e produtivas da agropecuária brasileira, ocorridas a partir da década de 1970, a pecuária pantaneira tem sofrido alterações e se tornado mais impactante no bioma. Ao mesmo tempo, a região apresenta um quadro de estagnação econômica e baixa qualidade de vida da maior parte da população, já que a atividade pecuária é dominada por um pequeno grupo que concentra as terras. Assim, como pensar a pecuária no contexto do desenvolvimento regional sustentável? Quais as perspectivas para a atividade na região e quais os sentidos das alterações de suas práticas para a sustentabilidade, se é que isso é possível?

Palavras-chave: Pantanal; Mato Grosso, pecuária, sustentabilidade; desenvolvimento regional.

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Introdução

O Pantanal é o bioma com menor extensão no território brasileiro, mas se estende também pela Bolívia e Paraguai. Sua biodiversidade, diversidade paisagística e ecossistêmica são, assim como nos demais biomas, de inquestionável interesse para conservação. O Pantanal brasileiro está localizado nos estados de Mato Grosso e Mato Grosso do Sul, que compreendem, respectivamente, 35% e 65% da área do bioma. Apenas cinco por cento da área do Pantanal está protegida na forma de reservas ambientais, sendo o restante áreas privadas. Embora existam outras atividades econômicas ligadas aos centros urbanos, mineração, pesca e turismo, a pecuária de corte é a principal atividade desenvolvida no Pantanal brasileiro, estando na base de sua ocupação pós-cabralina.

Neste artigo temos como objetivo divulgar e discutir os primeiros resultados de uma pesquisa financiada pelo INAU – Instituto Nacional de Áreas Úmidas/CPP-Centro de Pesquisas do Pantanal. O foco nessa pesquisa é analisar a pecuária na porção mato-grossense do Pantanal brasileiro, especificamente nos municípios de Cáceres, Poconé, Barão de Melgaço e Santo Antônio do Leverger. Nosso referencial analítico é a sustentabilidade socioambiental, o que nos permite indagar sobre as contribuições positivas e negativas da atividade pecuária para o ambiente natural do Pantanal e para a população da região. Neste sentido, indagamos sobre quais são as perspectivas desta atividade dominante e se ela pode contribuir de alguma forma para reverter o quadro de estagnação regional com base em estruturas sociais – principalmente agrária - menos concentradas e, por isso, mais próximas da sustentabilidade. Também questionamos sobre o papel da pecuária extensiva para a conservação do bioma e se este papel ainda permanece ou tende a mudar.

Nesta etapa da pesquisa estão sendo desenvolvidas as seguintes atividades: levantamento e análise de informações gerais sobre a área de estudo e a atividade pecuária; revisão de literatura relacionada ao tema; realização de trabalhos de campo e entrevistas com proprietários de grandes e médios estabelecimentos pecuaristas, assalariados rurais e assentados da reforma agrária. Alguns dos primeiros resultados da pesquisa são apresentados neste artigo e a sua discussão será importante para aprimorarmos os resultados e prosseguimento.

O pantanal

O Pantanal integra uma rede mundial de áreas úmidas de extrema importância para a manutenção da qualidade de vida dos habitantes do planeta. As áreas alagadiças envolvem uma ampla variedade de ecossistemas aquáticos, entre eles rios, zonas costeiras/marinhas e zonas úmidas artificiais, tais como lagos, açudes e represas. Existem inúmeras definições do termo "áreas úmidas", algumas baseadas em critérios essencialmente ecológicos, outras mais relacionadas ao seu manejo. Junk e Silva (1999) conceituam as áreas úmidas (*wetlands*) como aquelas que não se enquadram em águas lênticas (lagos) e nem tampouco em águas lóticas ou de correnteza (rios, córregos, igarapés entre outras), constituindo-se em áreas intermediárias, como os diferentes tipos de pântanos e brejos. A Convenção sobre as áreas úmidas ou *Wetlands* ocorrida em 1971 adota o seguinte conceito:

> Toda a extensão de pântano, charco ou turfa, ou superfícies cobertas de água, de regime natural e artificial, permanente ou temporárias, com água parada ou corrente, doce, salobra ou salgada. As áreas marinhas também são consideradas úmidas contanto que a profundidade da maré baixa não exceda a seis metros. As áreas úmidas podem compreender as regiões ribeirinhas ou costeiras adjacentes, assim como as ilhas ou extensões de áreas marinhas de uma profundidade superior aos seis metros em maré baixa. (Word Wildlife Fund (WWF), 1999, p. 06).

Os ecossistemas das áreas úmidas desenvolvem importantes processos hidrológicos e ecológicos. Entre os processos hidrológicos ressalta-se a recarga de aqüíferos quando a água acumulada pelas inundações atinge os lençóis subterrâneos, aumentando as reservas de água potável. Esse aspecto justifica a conservação das áreas úmidas, posto que a obtenção de água potável surge como um dos problemas mais graves para as próximas décadas.

As *wetlands* são consideradas depositárias de grande diversidade biológica, são importantes para a estabilidade climática e estão entre as áreas mais produtivas do mundo. As populações que neles habitam desenvolvem a pecuária, a agricultura, o

turismo, a recreação, além de utilizarem os elementos naturais, tais como, água, materiais para construção, lenha e alimentos. Portanto, o valor econômico direto das áreas alagadiças é incontestável e pode ser avaliado através do uso que se faz dos seus elementos naturais, dos bens e serviços que oferecem. O valor econômico indireto está associado ao controle de enchentes, retenção de nutrientes, estabilização de zonas costeiras e conservação da biodiversidade.

As preocupações com as paisagens alagadiças surgem na pauta dos eventos ambientais em 1968, na Conferência Intergovernamental de Especialistas sobre as Bases Científicas para Uso e Conservação Racionais dos Recursos da Biosfera, ou Conferência da Biosfera, realizada em Paris. (McCORMICK, 1992). Naquele momento, discutia-se, entre outros temas, o impacto humano sobre a biosfera, incluindo os efeitos nocivos da poluição do ar e da água, a retirada em excesso da cobertura vegetal e a drenagem das áreas alagadiças. A referida conferência enfatizou o caráter inter-relacionado do meio ambiente, abordando os efeitos nocivos da urbanização e industrialização aceleradas, entre eles, o êxodo rural crescente, o desaparecimento de tradições, direitos costumeiros e mudanças em estilos de vida.

Em dois de fevereiro de 1971 ocorreu a Convenção de Ramsar (Irã), na qual foi celebrado o primeiro tratado específico para as áreas alagadiças. Os pressupostos resultantes desse evento entraram em vigor em 21 de dezembro de 1975 e estavam centrados inicialmente na proteção de uma cadeia global de áreas alagadiças, utilizadas por aves aquáticas em seus movimentos migratórios anuais. McCormick (1992) enfatiza que a Convenção de Ramsar se diferencia das demais conferências ambientais por defender o uso sustentável das áreas alagadiças em contraposição ao pressuposto da separação das áreas destinadas exclusivamente à proteção, tendência presente à época.

Segundo Vila da Silva e Abdon (1998a), o Pantanal brasileiro está inserido na área contínua denominada Bacia do Alto Paraguai, que apresenta 361.666 quilômetros quadrados, dos quais 138.183 Km² (38,21%) constituem-se em terras pantaneiras. Esta imensa planície representa três por cento das áreas úmidas da Terra e é definida como a maior planície de inundação continental do planeta. Por conseguinte, a paisagem natural pantaneira caracteriza-se pela rara beleza da sua flora e fauna distribuídas em um mosaico de áreas alagáveis, não alagáveis ou sazonalmente inundadas.

Sua grande diversidade biológica deve-se a diversos fatores, como a localização geográfica no limite entre três grandes regiões naturais: o bioma cerrado no Brasil

central, o chaco na Bolívia e a região amazônica ao norte; à combinação de habitats terrestres e aquáticos e à baixa altimetria do relevo, que possibilita as inundações periódicas. A paisagem natural pantaneira caracteriza-se por várias fitofisionomias que integram um conjunto de habitats: ilhas circulares de matas mais elevadas que a planície inundável; cordilheiras, cordões arenosos com altura de um a três metros acima da planície alagável, ambos recobertos por vegetação de cerrado, cerradão e mata; lagoas permanentes (baías), corixos e vazantes. (JUNK e SILVA, 1999).

Tarifa (1986) classifica o clima do pantanal como tropical, ressaltando a necessidade de observar a influência dos aspectos físicos e geográficos, como sua localização, altimetria e geomorfologia, na definição das características de temperatura, precipitação e umidade. Dessa forma, a latitude tropical e a continentalidade do Pantanal associadas à sua topografia plana são determinantes na ocorrência de altas temperaturas com máximas que variam de 35º C a 40º C e mínimas que podem chegar até 10º C. A distribuição das chuvas não é uniforme em todo o Pantanal e variam entre 800 a 1.500 mm. anuais. (SETTE, 2000, p.90). Estudos feitos na região pantaneira revelam ciclos de intensidade das chuvas (altos e baixos) que duram entre dez e vinte anos. Assim, pode-se distinguir dois tipos de ciclos: um anual e outro de décadas ou plurianuais.

Nesse contexto, *os habitats pantaneiros passam, durante um ciclo hidrológico anual, "de uma área seca, sujeita a estresse por falta de água, para uma área úmida com solo encharcado, ou para um lago raso e, até mesmo, para um lago de alguns metros de profundidade e vice-versa*". (JUNK e SILVA, 1999, p.19, grifo nosso). As condições ambientais do Pantanal na atualidade representam a síntese dos contextos históricos e das formas de apropriação e produção do espaço geográfico via atividades econômicas, especialmente a pecuária.

Os quatro municípios selecionados para a pesquisa compreendem 80,1% do Pantanal mato-grossense. Barão de Melgaço possui toda sua área dentro dos limites do bioma e Cáceres, Poconé e Santo Antônio do Leverger possuem, todos, mais de 70% de sua área no Pantanal. A população dos quatro municípios em conjunto é de 145.990 habitantes, sendo Cáceres o município mais populoso, com 87.912 habitantes em 2010 – trata-se de um centro regional pelos serviços oferecidos na cidade. Barão de Melgaço tem população de 7.591 habitantes, sendo que 54,9% residem na zona rural. A população de Poconé é de 31.778 habitantes, sendo 27,4% população rural. Santo

Antônio do Leverger tem 18.709 habitantes e 60,2% são rurais. A população rural de Cáceres é a menos representativa com relação a população total do município – 12,9%. A taxa de ruralização média da população no conjunto dos quatro municípios é de 24,3%.

A região analisada possui, à exceção de Cáceres, alguns dos mais altos índices de ruralização dentre os municípios brasileiros, o que constitui um argumento para a necessidade de políticas voltadas ao campo. Quando analisamos o IDH dos municípios estudados a necessidade dessas políticas torna-se mais evidente, já que dois municípiois – Poconé e Barão de Melgaço – estão em 122º e 124º lugar no *ranking* estadual do IDH de 2000, cujo município em pior condição está em 127º lugar. Santo Antônio do Leverger está em 88º lugar e Cáceres em 60º. Adicionalmente aos dados, os trabalhos de campo têm demonstrado que os municípios analisados possuem significativa população com baixa qualidade de vida, grande dependência da pecuária, concentrada por um pequeno número de proprietário de terras, e encontram-se economicamente estagnados.

A pecuária no pantanal Mato-Grossese

Na história da ocupação do território brasileiro pela sociedade pós-cabralina, a pecuária teve importante papel na inserção de diversas porções do território na economia nacional. Em alguns casos, como no período da mineração e da cana-de-açúcar no Nordeste do país, a pecuária foi desenvolvida como atividade subsidiária da atividade principal, fornecendo carne e tração animal. No estabelecimento da pecuária, quando não há a disponibilidade de pastos naturais, faz-se necessária remoção da vegetação arbórea natural para a criação de pastagens plantadas. No Brasil os pastos naturais ocorrem com maior abundância em dois biomas: o Pampa e o Pantanal.

No caso do Pantanal, a pecuária de corte, que é a finalidade predominante do rebanho da região até hoje, foi inserida como subsidiária e paralela às atividades mineradoras de ouro e pedras preciosas, a partir do século XVIII, e da atividade extrativista da erva mate e da poaia, no final do século XIX e início do XX. O início da ocupação efetiva do estado de Mato Grosso foi baseado nessas atividades e teve início no Pantanal e bacia do Alto Paraguai, de forma que os primeiros estabelecimentos pecuaristas da região foram concedidos sob o regime das sesmarias, que constituem a

origem agrária do Pantanal. Além do aspecto econômico, a ocupação da região também teve papel estratégico na definição dos limites do território brasileiro a oeste pelo fato configurar uma vasta fronteira com o domínio espanhol e depois Paraguai e Bolívia. O evento mais marcante da característica estratégica da região foi a Guerra do Paraguai entre 1865 e 1870.

O regime hidrológico e a baixa fertilidade *natural* dos solos foram os principais responsáveis pelo estabelecimento de uma pecuária extensiva relativamente pouco impactante no meio natural do Pantanal, porém não os únicos. Para a manutenção deste quadro também contribuíram outros elementos da questão agrária brasileira, como a forma de apropriação privada da terra, que remonta ao período colonial; a expansão da agropecuária brasileira para o Cerrado e a Amazônia; o baixo preço da terra e os laços tradicionais das famílias pecuaristas centenárias na região.

Rossetto (2004) buscou compreender a dimensão da cultura nos processos que envolvem vantagens econômicas e grupos considerados tradicionais em parcela do Pantanal mato-grossense, concluindo que o estereótipo de convivência harmônica entre as atividades econômicas e o ambiente natural pantaneiro vem passando por transformações, através de rupturas no modo de vida e nas técnicas de manejo da pecuária, como correlato, passam a imperar os valores capitalistas e não mais os da tradição, reconfigurando as identidades tradicionais e imprimindo novas marcas na paisagem.

A antropização de novos espaços ou a intensidade da antropização é um processo complexo que não pode ser relacionado unicamente com uma atividade isolada; ele deve ser considerado no contexto geral da produção do espaço de um país, de suas políticas econômica, regional, territorial e populacional. Por isso, a ocupação, por exemplo, do Pantanal, está ligada a outros processos nacionais e internacionais que influenciam a sua dinâmica, de forma que ela não é imutável e as formas de apropriação da natureza podem passar por transformações, sendo mais ou menos depredatórias. O conjunto de fatores que permitiram o tipo de pecuária desenvolvida no Pantanal dá sinal de mudanças, o que pode alterar a relação de baixo impacto que a atividade tem tido com o Pantanal por séculos, indicando assim a necessidade de ações mais diretas para a conservação do bioma, como, por exemplo, a criação de Unidades de Conservação.

Atualmente o Brasil é o maior exportador de carne bovina do mundo, com 28% de sua produção destinada à exportação. O país possui vantagens para o setor como a

disponibilidade de terras baratas e a vasta extensão territorial. Esses elementos influenciam diretamente no custo da produção, de US$ 1,60 por quilo no Brasil. Outros países com importante produção possuem os seguintes custos de produção: Uruguai US$ 1,60, Argentina US$ 1,50, Austrália US$ 2,45 e Estados Unidos US$ 3,20, de acordo com dados de Assad e Pinto (2008).

O Brasil tem o maior rebanho bovino comercial do planeta que, segundo os dados do Censo Agropecuário de 2006, era de 171,6 milhões de cabeças. Deste total, apenas quatro milhões estavam em sistema de confinamento. Para manter este rebanho no sistema extensivo, dos 329,9 milhões de hectares dos estabelecimentos agropecuários brasileiros, 167 milhões (50,6% da área) eram de pastagens, contra apenas 59,8 milhões de hectares ocupados com lavouras. Em 2009 a Pesquisa Pecuária Municipal do IBGE informa que o rebanho bovino brasileiro era de 205,3 milhões de cabeças, o que já ultrapassa a quantidade de habitantes do país em 2010, de 190,7 milhões de habitantes.

O Pantanal é uma das regiões do Brasil com a maior concentração de terra. Em 2006 o índice de Gini da estrutura fundiária dos municípios estudados eram considerados altos, estando todos acima de 0,850, assim detalhados: Barão de Melgaço 0,951, Cáceres 0,910, Poconé 0,899 e Santo Antônio do Leverger 0,916. Barão de Melgaço é o município com maior concentração de terra, de forma que mais de 90% das terras (402,9 mil hectares) está sob controle de estabelecimentos grandes, com mais de mil hectares. No conjunto dos três municípios, o índice de Gini médio é de 0,919 e 84% da área dos estabelecimentos agropecuários está sob o controle dos grandes proprietários.

A mesma concentração não ocorre, porém, com o rebanho bovino. A comparação dos dados das tabelas 01 e 02 mostram que, ao contrário do que se podia esperar, os estabelecimentos agropecuários pequenos e médios têm maior participação no rebanho do que na terra. Por exemplo, no conjunto dos quatro municípios, os estabelecimentos pequenos e médios compreendem 16% das terras, mas são responsáveis por 33,9% do rebanho bovino. Desta constatação surgem as seguintes hipóteses: os estabelecimentos pequenos e médios são mais eficientes na atividade pecuária porque a) as fazendas pequenas e médias estão em locais mais altos e com melhor qualidade de pastagem; b) os estabelecimentos pequenos e médios precisam otimizar a atividade pecuária para obter maior lucro por unidade de área.

TABELA 01 - ESTRUTURA FUNDIÁRIA DOS MUNICÍPIOS ANALISADOS - 2006

CLASSES DE ÁREA	Barão de Melgaço			Cáceres			Poconé			Santo Antônio do Leverger			Total dos quatro municípios		
	Estabele-cimentos	Área (ha)	% Área	Estabele-cimentos	Área (ha)	% Área	Estabele-cimentos	Área (ha)	% Área	Estabele-cimentos	Área (ha)	% Área	Estabele-cimentos	Área (ha)	% Área
TOTAL	**834**	**441.535**	**100**	**2.524**	**1.182.936**	**100**	**1.509**	**613.851**	**100**	**1.877**	**694.759**	**100**	**6.744**	**2.933.081**	**100**
Mais de 0 a menos de 0,1 ha	3	-	-	1	-	-	2	-	-	-	-	-	6	-	-
De 0,1 a menos de 0,2 ha	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
De 0,2 a menos de 0,5 ha	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-
De 0,5 a menos de 1 ha	23	12	0,0	3	2	0,0	2	-	-	5	3	0,0	33	17	0,0
De 1 a menos de 2 ha	73	77	0,0	24	31	0,0	30	34	0,0	81	83	0,0	208	225	0,0
De 2 a menos de 3 ha	40	82	0,0	52	114	0,0	59	120	0,0	91	186	0,0	242	502	0,0
De 3 a menos de 4 ha	32	97	0,0	33	110	0,0	35	108	0,0	70	215	0,0	170	530	0,0
De 4 a menos de 5 ha	19	77	0,0	48	211	0,0	18	72	0,0	44	180	0,0	129	540	0,0
De 5 a menos de 10 ha	81	532	0,1	124	904	0,1	92	636	0,1	175	1.169	0,2	472	3.241	0,1
De 10 a menos de 20 ha	127	1.662	0,4	297	4.480	0,4	357	5.163	0,8	300	4.344	0,6	1.081	15.649	0,5
De 20 a menos de 50 ha	146	4.523	1,0	1.106	32.632	2,8	266	7.577	1,2	566	17.105	2,5	2.084	61.837	2,1
De 50 a menos de 100 ha	92	6.163	1,4	294	20.328	1,7	106	7.047	1,1	168	10.947	1,6	660	44.485	1,5
De 100 a menos de 200 ha	64	7.998	1,8	152	21.101	1,8	79	10.283	1,7	89	11.509	1,7	384	50.891	1,7
PEQUENO (menos de 200 ha)	**700**	**21.223**	**4,8**	**2.134**	**79.913**	**6,8**	**1.047**	**31.040**	**5,1**	**1.589**	**45.741**	**6,6**	**5.470**	**177.917**	**6,1**
De 200 a menos de 500 ha	28	9.069	2,1	152	48.522	4,1	87	27.331	4,5	106	31.128	4,5	373	116.050	4,0
De 500 a menos de 1000 ha	12	8.382	1,9	94	67.743	5,7	80	55.428	9,0	65	43.265	6,2	251	174.818	6,0
MÉDIO (de 200 a menos de 1000 ha)	**40**	**17.451**	**4,0**	**246**	**116.265**	**9,8**	**167**	**82.759**	**13,5**	**171**	**74.393**	**10,7**	**624**	**290.868**	**9,9**
De 1000 a menos de 2500 ha	11	19.557	4,4	67	104.969	8,9	57	90.829	14,8	49	75.408	10,9	184	290.763	9,9
De 2500 ha e mais	26	383.307	86,8	75	881.789	74,5	46	409.223	66,7	50	499.219	71,9	197	2.173.538	74,1
GRANDE (1000 ha e mais)	**37**	**402.864**	**91,2**	**142**	**986.758**	**83,4**	**103**	**500.052**	**81,5**	**99**	**574.627**	**82,7**	**381**	**2.464.301**	**84,0**
Produtor sem área	57	-	-	2	-	-	192	-	-	18	-	-	269	-	-

Dados: Censo Agropecuário 2006 - IBGE

TABELA 02 - DISTRIBUIÇÃO DOS BOVINOS NAS CLASSES DE ÁREA DOS ESTABELECIMENTOS AGROPECUÁRIOS DOS MUNICÍPIOS ANALISADOS - 2006

Classes de área dos estabelecimentos agropecuários	Barão de Melgaço		Cáceres		Poconé		Santo Antônio do Leverger		Total dos quatro municípios	
	Cabeças	%	Cabeças	%	Cabeças	%	Cabeças	%	Cabeças	%
TOTAL	**104.979**	**100.0**	**583.728**	**100.0**	**196.766**	**100.0**	**322.590**	**100.0**	**1.208.063**	**100**
Mais de 0 a menos de 0,1 ha	-	-	-	-	-	-	-	-	-	-
De 0,1 a menos de 0,2 ha	-	-	-	-	-	-	-	-	-	-
De 0,2 a menos de 0,5 ha	-	-	-	-	-	-	-	-	-	-
De 0,5 a menos de 1 ha	-	-	-	-	-	-	-	-	-	-
De 1 a menos de 2 ha	827	0.8	96	0.0	42	0.0	56	0.0	1.021	0.1
De 2 a menos de 3 ha	87	0.1	443	0.1	69	0.0	133	0.0	732	0.1
De 3 a menos de 4 ha	211	0.2	561	0.1	112	0.1	189	0.1	1.073	0.1
De 4 a menos de 5 ha	420	0.4	542	0.1	32	0.0	212	0.1	1.206	0.1
De 5 a menos de 10 ha	1.598	1.5	2.112	0.4	445	0.2	1.226	0.4	5.381	0.4
De 10 a menos de 20 ha	3.928	3.7	7.237	1.2	2.909	1.5	4.374	1.4	18.448	1.5
De 20 a menos de 50 ha	6.328	6.0	34.035	5.8	4.876	2.5	13.081	4.1	58.320	4.8
De 50 a menos de 100 ha	5.458	5.2	25.273	4.3	3.934	2.0	10.537	3.3	45.202	3.7
De 100 a menos de 200 ha	5.104	4.9	26.093	4.5	6.439	3.3	7.862	2.4	45.498	3.8
PEQUENO (menos de 200 ha)	**23.961**	**22.8**	**96.392**	**16.5**	**18.858**	**9.6**	**37.670**	**11.7**	**176.881**	**14.6**
De 200 a menos de 500 ha	5.616	5.3	56.534	9.7	17.677	9.0	23.473	7.3	103.300	8.6
De 500 a menos de 1000 ha	4.593	4.4	62.958	10.8	26.035	13.2	36.496	11.3	130.082	10.8
MÉDIO (de 200 a menos de 1000 ha)	**10.209**	**9.7**	**119.492**	**20.5**	**43.712**	**22.2**	**59.969**	**18.6**	**233.382**	**19.3**
De 1000 a menos de 2500 ha	9.750	9.3	77.780	13.3	43.892	22.3	38.068	11.8	169.490	14.0
De 2500 ha e mais	61.029	58.1	289.985	49.7	89.908	45.7	186.746	57.9	627.668	52.0
GRANDE (1000 ha e mais)	**70.779**	**67.4**	**367.765**	**63.0**	**133.800**	**68.0**	**224.814**	**69.7**	**797.158**	**66.0**
Produtor sem área	-	-	-	-	380	0.2	125	0.0	505	0.0

Dados: Censo Agropecuário 2006 - IBGE

Desde a década de 1970 o rebanho bovino brasileiro dobrou. Isso ocorreu principalmente pela abertura da fronteira agropecuária no Cerrado e na Amazônia, também a partir da década de 1970. A atividade pecuária no Pantanal é anterior a este período, de forma que o crescimento de 28,5% entre 1975 e 2006 do rebanho dos municípios estudados ocorreu não pela ocupação de novas áreas, mas pela melhoria da qualidade do gado e do seu manejo que, em geral, ainda são menos modernos em relação ao restante do país. Uma das ações realizadas para a melhoria da produtividade é a substituição de pastos naturais e de florestas por pastagens plantadas, o que é

proibido no Pantanal pela legislação atual, mas é praticado. Outra prática ilegal da pecuária que impacta fortemente o Pantanal é a construção de tanques para reservar a água do período chuvoso para suprir a necessidade do gado no período de seca.

A demanda por novas pastagens no Brasil nos últimos dez anos ocorre por duas razões: a primeira é o crescimento da produção de cana-de-açúcar em São Paulo, Paraná, Minas Gerais, leste de Mato Grosso do Sul e sul de Goiás, regiões com importante rebanho bovino e que tiveram grande parte de suas pastagens convertidas em lavouras de cana. O Zoneamento da Cana de Açúcar de 2009 proíbe o seu plantio nos biomas da Amazônia, Pantanal e no Alto Paraguai. Contudo, o documento não diz nada sobre o avanço e intensificação da pecuária nessas regiões. Desta forma, a cana tem intensificado indiretamente o avanço da pecuária sobre outros biomas.

Em segundo lugar está o aumento constante da demanda e do preço da carne bovina, ambos subsidiados por políticas governamentais intensas. O preço pago ao pecuarista praticamente dobrou desde 2005, chegando a US$ 55 por arroba no final de 2010. A conjunção desses fatores incentivou os pecuaristas a aumentar a produção, o que pode ocorrer pelo melhoramento genético e de manejo ou pela ampliação da área de pastagens – este segundo caso é mais comum no Brasil.

TABELA 03 - REBANHO BOVINO, USO DO SOLO E DESFLORESTAMENTO NOS MUNICÍPIOS ANALISADOS

MUNICÍPIO	REBANHO BOVINO (cabeças)		PASTAGENS (hectares)						ÁREA MÉDIA DE PASTO POR BOVINO (hectares)	DESFLORESTAMENTO (hectares)	
	Total 2006	Evolução 1995-2006	Total 2006	Naturais 2006	Plantadas 2006	% Plantadas 2006	Evolução Plantadas 1995-2006	% Evolução Plantadas 1995-2006		Desflorestamento entre 2002 e 2008	Area total desflorestada em 2008
Barão de Melgaço	104.979	- 42.484	270.084	168.991	101.093	37.4	26.905	36.3	2.6	22.200	79.200
Cáceres	583.728	93.317	826.825	434.364	392.461	47.5	85.196	27.7	1.4	63.300	446.600
Poconé	196.766	- 34.512	413.756	282.521	131.235	31.7	- 4.433	-3.3	2.1	13.100	131.900
Santo A. do Leverger	322.590	36.778	457.154	258.372	198.782	43.5	- 5.562	-2.7	1.4	27.400	192.100
TOTAL	**1.208.063**	**53.099**	**1.967.819**	**1.144.248**	**823.571**	**41.9**	**102.106**	**14.2**	**1.6**	**126.000**	**849.800**

Dados: Censos Agropecuários 1995 e 2006 - IBGE ; Ministério do Meio Ambiente

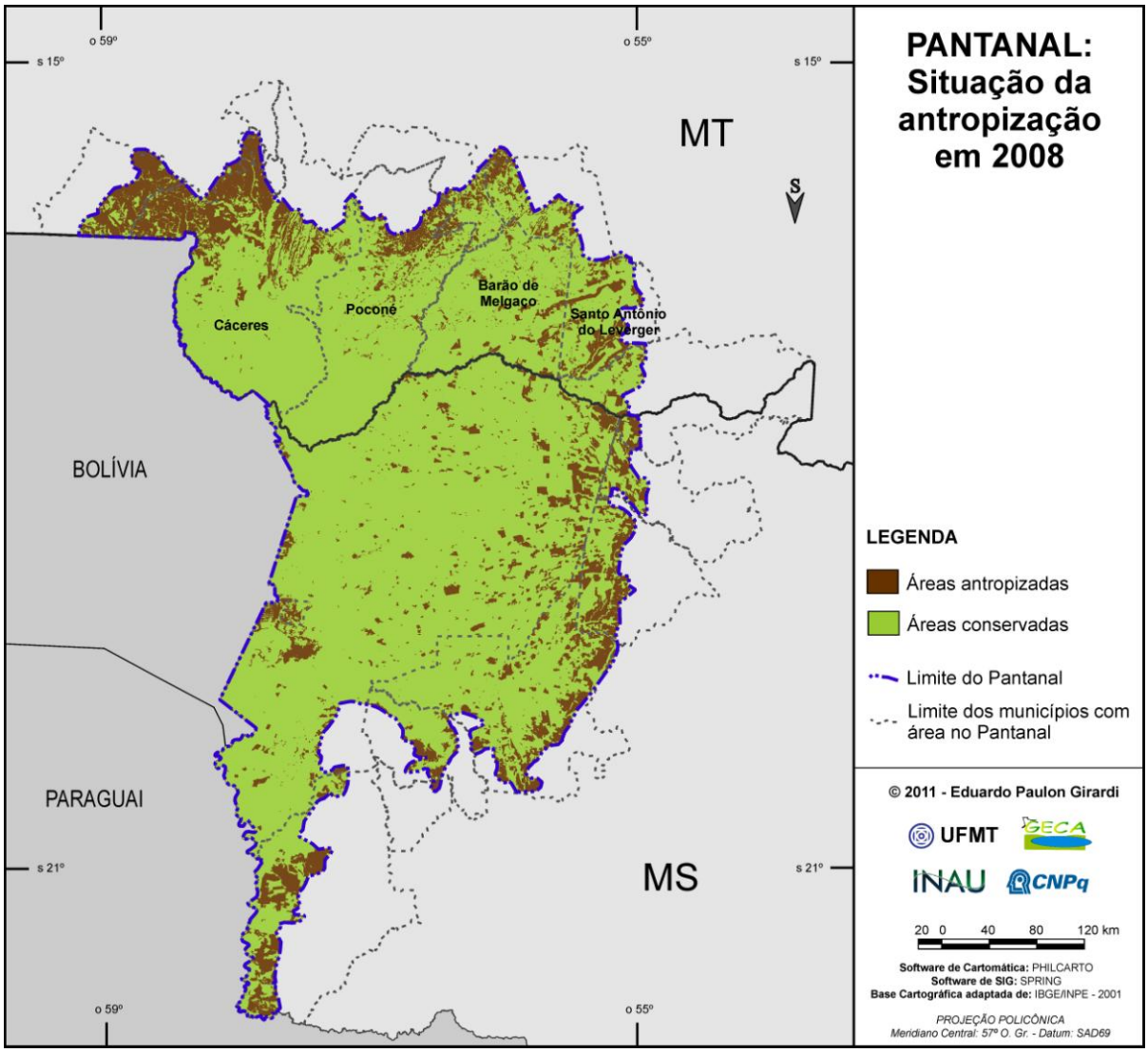
O uso e ocupação do solo rural nos quatro municípios estudados demonstra a especialização na pecuária. Em 2006 a área total dos estabelecimentos agropecuários dos municípios era de 2,9 milhões de hectares, dos quais apenas 4,8% (139,3 mil hectares) estavam ocupados com lavouras, 67% (1,97 milhões de hectares) com pastagens e 25,6% (752 mil hectares) com matas nativas. Das pastagens, 58% eram naturais e 42% plantadas, sendo que deste último tipo, dez por cento foram declarados como "pastagens plantadas degradadas". O rebanho bovino dos quatro municípios pantaneiros era em 2006 de 1,2 milhões de cabeças, perfazendo uma média de 1,6 hectares para cada cabeça de bovino, enquanto a média nacional é de 0,97

hectares/bovino[4]. Barão de Melgaço é o município com a maior área média por bovino, de 2,6 hectares para cada animal, seguido por Poconé, com 2,1, médias muito superiores à média nacional. Cáceres e Santo Antônio do Leverger têm média de 1,4, mais próxima da média brasileira.

Uma das explicações para a elevada área de pastagem per capita de bovino em Barão de Melgaço e Poconé é a localização de suas terras em regiões mais baixas do Pantanal, sendo mais afetadas pelas inundações no período de cheia. Isso inutiliza o pasto no período das cheias, sendo necessário levá-lo para terras mais altas. Também são esses municípios que apresentam menor porcentagem de pastagens plantadas, já que esta prática não é adequada para áreas que sofrem alagamento intenso. Contudo, Barão de Melgaço apresentou o maior crescimento proporcional de pastagens plantadas entre 1995 e 2006. No período, a área de pastagem plantada cresceu 14,2% no conjunto de municípios analisado. Os municípios de Poconé e Santo Antônio do Leverger apresentaram pequena redução, que pode estar ligada ao caráter declaratório dos dados do Censo Agropecuário, mas Cáceres e Barão de Melgaço apresentaram crescimento significativo na área de pastagem plantada. Este é um importante indicativo da mudança pela qual passa a pecuária no Pantanal.

No período 2002-2008 o Pantanal brasileiro sofreu desflorestamento de 4,3 milhões de hectares (2,8% da área total do bioma) e acumulava em 2008 cerca de 23 milhões de hectares desflorestados - 15,2% da área do bioma. O desflorestamento verificado no período de seis anos corresponde a 23% de toda a área desflorestada durante mais de duzentos anos de ocupação da região pela pecuária extensiva tradicional, o que indica mudanças negativas da pecuária em relação à conservação do bioma. A liberação de CO_2 na atmosfera neste período pelo desflorestamento foi de 270,9 milhões de toneladas. Os desflorestamentos ocorreram principalmente nas bordas do bioma, em áreas mais elevadas, onde o plantio de pastagens é mais produtivo. Desta forma, a pressão da pecuária na década passada não impactou somente a Amazônia, mas também o Pantanal, com a destruição de áreas naturais para formação de pastagens.

[4] Este é um cálculo aproximado, já que por um lado nem toda a área de pastagem é efetivamente utilizada e por outro há diferentes rebanhos que ocupam as pastagens, como os eqüinos, asininos, muares, bubalinos, ovinos e caprinos. O fato é que a predominância do uso das pastagens no Brasil é para o rebanho bovino.



Nos municípios analisados, o total desflorestado do Pantanal em 2008 era de 849,8 mil hectares, área muito próxima da área de pastagem plantada nesses municípios em 2006, que totalizava 823,6 mil hectares. Nos municípios de Barão de Melgaço e Cáceres a evolução da área de pastagem plantada no período 1995-2006 é semelhante à área desflorestada no período 2002-2008, se considerarmos a diferença dos períodos e o caráter declaratório do Censo Agropecuário. O total de desflorestamento no período 2002-2008 nos quatro municípios foi de 126 mil hectares, com a emissão de 7,9 milhões de toneladas de CO_2 na atmosfera. Na lista de municípios que mais desflorestaram no Pantanal brasileiro entre 2002 e 2008, Cáceres e Santo Antônio do Leverger estão em terceiro e quarto lugar, respectivamente, ficando atrás somente de Corumbá e Aquidauana, em Mato Grosso do Sul.

Embora seja uma área já ocupada há muito tempo e por isso consolidada, o rebanho bovino nos municípios estudados teve acréscimo de 4,6% entre 1995 e 2006, aumentando em 53 mil cabeças. Os dados mostram que em Barão de Melgaço e Poconé houve diminuição do rebanho bovino, mas Cáceres e Santo Antônio do Leverger apresentaram crescimentos significativos que contribuíram para o saldo positivo para a região estudada. Os dados negativos de evolução do rebanho bovino em Barão de Melgaço e em Poconé são conflituosos quando comparamos com a evolução da área de pastagem plantada e desflorestamento nesses municípios. Uma hipótese é de que esteja havendo o abandono das áreas mais baixas do Pantanal nesses dois municípios que possuem maior proporção dessas áreas. Assim, os pecuaristas estariam investindo na formação de pastagens nas partes mais altas. Os dados de Barão de Melgaço são aqueles que mais podem subsidiar a apresentação desta hipótese. Os dados de Poconé também contribuem, mas deixam uma lacuna porque apresentou diminuição da área de pastagens plantadas.

Além dos dados, as entrevistas realizadas nos trabalhos de campo sugerem que este movimento está ocorrendo. Se nossa hipótese for verdadeira, quais os impactos dela para a conservação do Pantanal? Será positivo ou negativo o saldo do abandono de áreas mais baixas e intensificação da pecuária em áreas mais altas?

Quanto à tecnificação da pecuária nos municípios analisados, os dados e os trabalhos de campo indicam índices muito baixos. Por exemplo, se tomarmos os dados do Censo Agropecuário 2006 sobre um indicador mínimo de tecnologia que é a prática de inseminação artificial, em Barão de Melgaço, apenas um dos 233 estabelecimentos com mais de cinqüenta cabeças de bovino pratica; para Cáceres são 27/868, Poconé 11/328 e Santo Antônio do Leverger 23/387. A suplementação animal com outros produtos que não o sal mineral (ração, grãos e subprodutos industriais) também não é uma prática comum. Em Barão de Melgaço são apenas 12 dos 233 estabelecimentos com mais de 50 cabeças que fornece suplementação ao gado, em Cáceres, apenas 250 dos 868, Poconé 78/328 e Santo Antônio do Leverger são 158 dos 387 estabelecimentos.

Por fim, o último indicador de tecnologia é a rastreabilidade, também baixa, realizada em dois estabelecimentos agropecuários de Barão de Melgaço, 224 de Cáceres, 23 de Poconé e 43 de Santo Antônio do Leverger. A análise conjunta desses dados mostra que os municípios com práticas mais modernas de pecuária são Cáceres e

Santo Antônio do Leverger, que possuem maior proporção de terras altas; já Poconé e Barão de Melgaço são caracterizados por práticas pecuárias mais tradicionais, provavelmente porque uma grande proporção de sua área seja afetada de forma mais intensa pelas cheias

A pecuária na porção mato-grossense do Pantanal brasileiro, especificamente nos municípios de Cáceres, Poconé, Barão de Melgaço e Santo Antônio do Leverger ainda apresenta indicadores de baixo impacto ambiental no que concerne à tecnificação da pecuária, entretanto, com a intensificação desse processo a sustentabilidade socioambiental encontra-se ameaçada. Por um lado, a substituição das pastagens nativas pelas exóticas resulta em maior produtividade e rentabilidade econômica, por outro, as características naturais dessa área úmida paulatinamente sofrem alterações podendo influenciar na sazonalidade climática e na manutenção do equilíbrio ecológico dessa importante área úmida. Para a população da região, principalmente para os trabalhadores assalariados rurais, as transformações nas técnicas de manejo resultam em desemprego e baixo índice de qualidade de vida, evidenciados através das taxas de IDH dos municípios em questão. Assim, o quadro de estagnação regional apontado pelas pesquisas de campo tende a se manter, uma vez que as políticas públicas pouco influenciam para o desenvolvimento socioeconômico sustentável do Pantanal.

Considerações finais

No bojo do processo de modernização do pantanal, é possível visualizar alternativas econômicas que viabilizem o desenvolvimento sustentável, de forma que os aspectos naturais, humanos, econômicos e políticos, como dimensões interligadas entre si, colaborem para o equilíbrio ecológico e social. Sob a ótica conservacionista, o manejo das pastagens deve atender a legislação ambiental vigente no que concerne à proteção das áreas de reserva legal e de preservação permanente situadas ao longo dos rios ou de qualquer curso d´água, protegendo os locais como as cordilheiras, de extrema importância para a fauna.

Enfatiza-se também a necessidade de revisão urgente das legislações ambientais federal e estadual vigentes que tratam o ecossistema pantaneiro de forma similar aos demais, desconsiderando as características naturais dessa área alagadiça. Essa ação deve ocorrer paralelamente à reestruturação da atuação dos órgãos públicos, no sentido de

enfrentar os problemas da realidade pantaneira, a começar pelo desmatamento, implementando ações educativas, de fiscalização e punição, rompendo com a situação de anonimato e impunidade que ora prevalece. Ao mesmo tempo o Pantanal necessita de uma política regional de desenvolvimento que permita atividades econômicas sustentáveis para que a pressão sobre a intensificação da atividade pecuária não aumente os graus de antropização do bioma.

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POTENTIAL EFFECTS OF A MAJOR NAVIGATION PROJECT (PARAGUAY–PARANÁ HIDROVÍA) ON INUNDATION IN THE PANTANAL FLOODPLAINS

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ABSTRACT

The Pantanal wetland of Brazil, a vast complex of seasonally inundated floodplains along the Paraguay River, is renowned for its outstanding biological resources. A proposed navigation project known as the Paraguay–Paraná Waterway (or Hidrovía) would deepen the Paraguay River channel to facilitate year-round navigation through the Pantanal. The possibility of decreases in river levels (stage) has aroused concerns in relation to the potential environmental impacts, however the poor understanding of the hydrological relationships between rivers and floodplains has hampered evaluation of these impacts. The present study evaluates the potential impact of river modifications on adjacent floodplains by examining the relationship between the Paraguay River stage and the extent of floodplain inundation. Satellite observations of flooded area (from passive microwave emission; monthly data for 1979–1987) are plotted against river stage from several stations throughout the region to show the stage–inundation relationships for eight subregions along the Paraguay River. Scenarios in which the Paraguay River stage is decreased from the 20th and 80th percentile values reveal large potential impacts on inundation. For stage decreases of 0.10 and 0.25 m, the total flooded area is reduced by 1430 and 3830 km^2 at low-water, and by 2410 and 5790 km^2 at high-water, respectively. The floodplains of the two northernmost subregions appear to be most susceptible to reductions in flooding, losing more than half of their flooded area with a 0.25-m decrease in the low-water stage. The ecological impacts of these reductions in flooded area may be particularly severe at low water, when the few areas that typically remain flooded throughout the dry season serve as important refuges for aquatic animals. These results underscore the need for better understanding of the hydrology of the integrated river floodplain systems in the Pantanal before river channel modifications are carried out. Copyright © 1999 John Wiley & Sons, Ltd.

KEY WORDS: navigation; floodplains; inundation

INTRODUCTION

The Pantanal wetland is a vast complex of seasonally inundated floodplains along the upper Paraguay River, located mostly in Brazil with smaller areas in Bolivia and Paraguay (Figure 1). The region is widely recognized for its outstanding biological resources and is considered a priority for Brazilian and international conservation efforts (Mittermeier *et al.*, 1990). A recently proposed project known as the Paraguay–Paraná Waterway (or Hidrovía) would modify the Paraguay River channel to facilitate year-round navigation of barge trains through the Pantanal. The river channel alterations required for this project have aroused concerns in relation to the potential environmental impact on adjacent floodplains (summarized by Hidrovía Panel of Experts, 1997). The Paraguay River is the major river draining the floodplains of the Pantanal, and the seasonal inundation of much of the region has often been attributed to the inability of the river and its tributaries to carry the seasonal increase in runoff. Therefore, an important consideration regarding channel modifications in this region is the possibility that the channel

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capacity will be increased, leading to more efficient conveyance of flood waters, decreases in river levels, and hence, reduced extent and duration of floodplain inundation (Ponce, 1995).

Seasonal inundation of tropical floodplains is a predominant force determining the structure and function of these ecosystems, and changes in the extent and duration of inundation can produce a myriad of ecological consequences, leading to the degradation of the overall integrity of the ecosystem (Junk, 1997). Plants and animals in the floodplains cope with, and are often highly adapted to, the seasonal alternation between flooding and desiccation, and thus might appear resilient to hydrological variability. Individual species have distinct ranges of tolerance, however, and subtle differences in inundation patterns often produce striking spatial variability in species abundance and diversity, as evidenced by the typical patchy distribution of vegetation in the floodplains of the Pantanal (Prance and Schaller, 1982; Dubs, 1992). In addition, both aquatic and terrestrial organisms in floodplain environments may endure considerable stress at some point during the seasonal cycle, and this natural stress may make populations more vulnerable to additional stress factors resulting from anthropogenic changes (Beissinger, 1995).

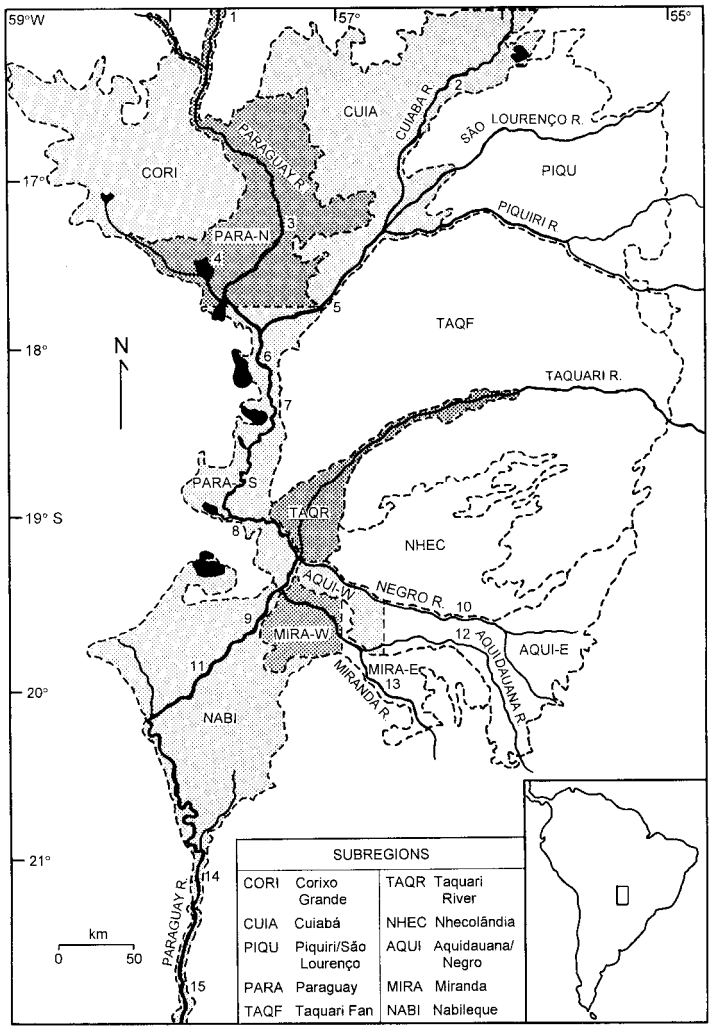

Figure 1. Map of the Pantanal showing the subregions and river stage stations considered in the present study. The shading indicates the subregions that are potentially affected by the water level of the Paraguay River and hence were included in this study. River stage stations are numbered as follows: 1, Cáceres; 2, Retiro Biguaçal; 3, Porto Conceição; 4, Bela Vista do Norte; 5, Porto Alegre; 6, Amolar; 7, São Francisco; 8, Ladário; 9, Porto Esperança; 10, Fazenda Rio Negro; 11, Forte Coimbra; 12, Porto Ciriaco; 13, Ticão de Fogo; 14, Barranco Branco; 15, Porto Murtinho.

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The maintenance of the integrity of floodplain ecosystems in the Pantanal is important for current economic activities in the region. The floodplains provide productive natural pastures for cattle as a result of the seasonal floods, and ranching has long been the main economic use of the seasonally inundated land (Allem and Valls, 1987). Ecological tourism is becoming increasingly prominent, and much of the renowned wildlife of the Pantanal is dependent on floodplain environments (Mittermeier *et al*., 1990). Sport and commercial fishing are also important activities on the Pantanal, and the floodplains are essential to most fish species because they provide spawning grounds and food sources, even for species that spend much of their life-cycles in the rivers (Welcomme, 1985).

The channel modifications that would be required for the Hidrovía include dredging of shallow reaches, excavation of rock outcrops and straightening of some curves. As part of the environmental impact analysis of the Hidrovía project, the effects of the channel modifications on river levels were evaluated using one-dimensional flow-routing models (TGCC, 1996). The results generally indicated decreases in average river levels, but these predicted decreases were small (< 10 cm). This modeling has recently been challenged however, in part because of the lack of information on river floodplain exchanges of water in the Pantanal (Dunne, 1997). Despite its poorly understood environmental impacts, the project remains under consideration.

The present study examines the relationship between water levels in the Paraguay River and the extent of inundation on the adjacent floodplains with the objective of estimating the potential impact of water level reductions on the floodplain ecosystems. Satellite observations of the inundated area derived from passive microwave emission are combined with government records of river stage measured throughout the region to generate empirical predictive models of the relationship between river levels and floodplain inundation. These models are used to produce scenarios of the changes in inundated area that may result from decreases in river levels. These scenarios reveal that river channel modifications associated with the Hidrovía project could strongly impact the inundation of floodplains in the Pantanal.

FLOODPLAIN INUNDATION IN THE PANTANAL

Seasonal inundation of floodplains in the Pantanal can occur in three ways: (1) overbank flow of river water across natural levees and onto lower-lying floodplains when channel capacity is exceeded; (2) a 'backwater effect' in which drainage from the floodplain and tributaries is impeded by the surface profile of the Paraguay River; and (3) pooling of local rainfall on gently sloping land where drainage to river courses is delayed. The first two causes of flooding have the potential to be affected by river channel modifications and hence are the subject of the present study. Pooling of local rainfall often occurs in areas distant from river channels and can be independent of river levels. Local rainfall is the predominant source of floodwaters in some of the more elevated parts of the Pantanal, such as the Taquari alluvial fan, as evidenced by the timing of flooding as well as the chemical composition of the floodwaters (Hamilton *et al*., 1998a).

In floodplains close to the Paraguay River inundation is driven largely by the river and its major tributaries. The timing of seasonal inundation in these areas reflects control by the river. Maximum flooding correlates well with river stage, which peaks several months later than the local rainfall in the central and southern Pantanal because of the delayed passage of the flood wave through the region (Hamilton *et al*., 1996). The chemical composition of the floodwaters in these areas generally reflects that of the parent river (e.g. Calheiros and Hamilton, 1998; Hamilton *et al*., 1998a).

The backwater effect can result in the decoupling of river discharge and water levels (Meade *et al*., 1991). The restricted capacity of the Paraguay River channel to convey floodwaters maintains water in the adjacent floodplains and slows or stops the inflow of tributaries, causing them to overflow onto their floodplains. The backwater effect can be propagated far up-river along the tributaries because of their small elevational gradients within the Pantanal. Thus, the source of the floodwaters may be local rainfall, tributaries, or the Paraguay River itself, but the depth and extent of flooding can be controlled by the backwater effect of the Paraguay River. The backwater effect is important in maintaining water on the

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floodplain during the dry season, when relatively little exchange of water between the river and floodplain may occur and local rainfall and runoff have essentially ceased. It is hypothesized that natural geomorphological barriers in the river channels cause the backwater effects in the Pantanal (EDIBAP, 1979). Along the Paraguay River, these barriers include occasional bedrock outcrops, as well as erosion-resistant soil hardpans (Ponce, 1995), some of which have been identified as points where the channel must be deepened or widened to facilitate navigation.

The Pantanal basin is geomorphologically complex, being comprised of several coalesced alluvial fans (Klammer, 1982), and various authors have distinguished subregions with distinct geomorphological, hydrological, and ecological characteristics. Hamilton *et al.* (1996) identified ten subregions on the basis of geomorphological maps produced from Side-Looking Airborne Radar images (RADAMBRASIL, 1982), with additional information obtained from LANDSAT images and field observations. Each of the ten subregions has a unique pattern of seasonal and interannual variation in flooded area, as shown by the passive microwave satellite observations of inundation reported by Hamilton *et al.* (1996). In general, the flood pulse travels from north to south across the region, and in the southernmost parts of the Pantanal the peak flooding occurs during the local dry season, when the source of the flood waters is largely overbank flow from the Paraguay River.

METHODS

The subregions identified by Hamilton *et al.* (1996) have been modified to provide better resolution of the floodplains where inundation is potentially controlled by the Paraguay River (Figure 1). In this analysis, the Piquiri, Taquari Fan and Nhecolândia subregions are excluded because of their distance from, and elevation above, the Paraguay River. I have also excluded the eastern portions of the Miranda subregion (east of 57°00′W longitude) and the Aquidauana/Negro subregion (east of 56°45′W longitude), since these areas are more hydrologically isolated from the Paraguay River. The Paraguay River subregion was split into northern and southern halves at 17°45′S latitude (at Lake Gaíba).

The observations of floodplain inundation are derived from satellite measurements of the passive emission of microwave radiation. Sippel *et al.* (1994) and Hamilton *et al.* (1996) describe the sensor system, global data sets and development of algorithms to estimate inundation area in the Pantanal. The difference between the horizontally and vertically polarized emission at 37 GHz provides a sensitive indicator of the presence of surface water. Unlike optical remote sensing systems such as LANDSAT, observations of passive microwave emission at 37 GHz are available throughout the year because they are affected little by cloud cover, and the presence of surface water affects the emission even when the water is largely obscured by overlying vegetation canopies.

In this study, monthly observations of inundation area for a 9-year period (January 1979–August 1987) derived by Hamilton *et al.* (1996) from measurements made by the Scanning Multichannel Microwave Radiometer (SMMR; Nimbus-7 satellite) are analyzed. Global SMMR observations are available for approximately 6-day intervals, and are compiled separately for day and night (local equator crossings at noon and midnight). The daytime observations were ranked within each month and the second-lowest value (out of four or five) was selected, thereby yielding one observation per month (Choudhury, 1989). This screening served to eliminate outlying values that might have resulted from atmospheric scattering by heavy rainfall, or from temporary pooling of water on the land surface after heavy rainfalls. The original 0.25° latitude-by-longitude satellite observations were aggregated into the modified subregions shown in Figure 1 using the same methods as in Hamilton *et al.* (1996).

The flooded area estimates reported by Hamilton *et al.* (1996) include both seasonally flooded land and permanent open-water bodies (mainly lakes). Open water comprises less than 2% of the overall Pantanal region, but is a more significant fraction of the total area in some subregions (Table I). Open-water area is not included in the flooded area estimates used in this study.

The river stage data are from stations along the Paraguay River throughout the Pantanal as well as along the major tributaries (Figure 1), and correspond in time with the satellite observations. At the time

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Table I. Characteristics of the subregions potentially affected by the stage of the Paraguay River, and of the river stage sites that best predict their inundation

Subregion	Total area (km^2)	Open water (km^2)	River stage site	*n*	20th percentile stage (m)	80th percentile stage (m)
Corixo Grande	11 479	243	Porto Conceição	70	4.20	5.10
Cuiabá	14 406	213	Porto Conceição	70	4.20	5.10
Paraguay River, North	9592	865	Bela Vista do Norte	104	3.80	5.40
Paraguay River, South	6666	580	Ladário	104	2.50	5.05
Taquari River	2927	22	Ladário	104	2.50	5.05
Aquidauna/Negro, West	1300	22	Porto Esperança	104	2.45	5.05
Miranda, West	2165	33	Porto Esperança	104	2.45	5.05
Nabileque	13 662	210	Barranco Branco	104	4.20	7.45

For each subregion, the table gives the total area (as depicted in Figure 1), the open-water area (mainly permanent lakes), the stage measurement site and the number of stage measurements that were available for that site (*n*; monthly means), and the stage values at the 20th and 80th percentiles for the available stage data.

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at which the data were gathered, most of these stations were operated by the Brazilian firm Hidrologia S.A., under contract to the Departamento Nacional de Obras Sanitárias (DNOS); the Brazilian Navy also collected data at several sites. Monthly means were calculated from the daily stage observations for comparison with the monthly satellite observations of inundation area.

The river stage site showing the best relationship with flooded area for each subregion was selected based on Pearson product-moment correlations between the monthly flooded area estimates and the mean monthly stage data for sites within, or close to, the subregion. Cross-correlation functions were computed to check for time lags between stage and flooding, but the contemporaneous correlation was superior for all subregions. Some stage data for the period of satellite observations were missing for the selected stage sites, but all had at least 70 months, and for six of the eight subregions there were stage data for the appropriate sites corresponding to all 104 months of satellite observations.

The relationship between stage and flooded area was described graphically using an iterative smoothing procedure known as Locally Weighted Scatterplot Smoothing (LOWESS) (Chambers *et al*., 1983; Hirsch *et al*., 1993). Compared to linear or curvilinear regression models, LOWESS is superior for describing complex, non-linear relationships, which might be expected between stage and flooded area in floodplains of variable geomorphology. LOWESS also provides a better characterization of the data at the extremes of the range of observations, which is important for the present study. Compared to smoothing using a running mean, LOWESS is preferable because it is less sensitive to outliers. The LOWESS curve is fit to the center of the local data by a weighted least squares procedure, in which the strongest weights are applied to the closest points and the weights become progressively weaker with distance to a user-defined limit. The limit is defined by a 'tautness' criterion (F), which is the proportion of the total data to be included in the weighting procedure and determines the smoothness of the resulting curve (Wilkinson *et al*., 1996). In the present study, all of the LOWESS curves were produced using $F = 0.5$, and the computations were performed using SYSTAT Version 5.0 software.

The LOWESS curves were employed to develop scenarios for average low-water and high-water conditions. For each local stage site, I calculated the 20th and 80th percentiles for the 9 years of river stage observations (Table I). These values were taken to represent typical low- and high-water conditions, and thus provide a conservative estimate of the changes that could occur. I used the LOWESS curves to estimate flooded area at low and high water under these typical conditions and under scenarios of decreased water levels. Decreases of 0.10 and 0.25 m were chosen arbitrarily because the actual decreases that would result from the proposed channel modifications remain unknown. These scenarios did not extend outside of the range of the observations, and thus extrapolation was not required. The curves were interpreted visually using enlarged plots.

RESULTS

The river stage sites showing the best correlation with flooded area in each subregion are listed in Table I. Among the stage sites identified in Figure 1, sites on the Paraguay River yielded the best predictive power in all cases. Scatterplots of the stage and flooded area observations for each subregion are depicted in Figure 2, which also shows the LOWESS curves. The smaller subregions show the poorest relationships between river stage and flooded area, with particular scatter above the LOWESS lines. Much of the scatter above the LOWESS lines in these and the other subregions can be explained by a clockwise hysteresis in the relationships. During the rising limb of the hydrographs, the floodplains may fill with water from local precipitation and overbank flow originating upstream a few weeks before the concomitant rise in river levels at the stage measurement stations, which are mostly located downstream of much of the flooded area.

Predictions of the decrease in flooded area that would accompany reductions in water level of the Paraguay River are shown in Table II (low water) and Table III (high water). Results are expressed as the flooded area that would remain, and as the percent change in flooded area in that subregion compared to no change in water levels. The results for the individual subregions are also summed to show the total decrease in flooded area within the subregions influenced by the Paraguay River.

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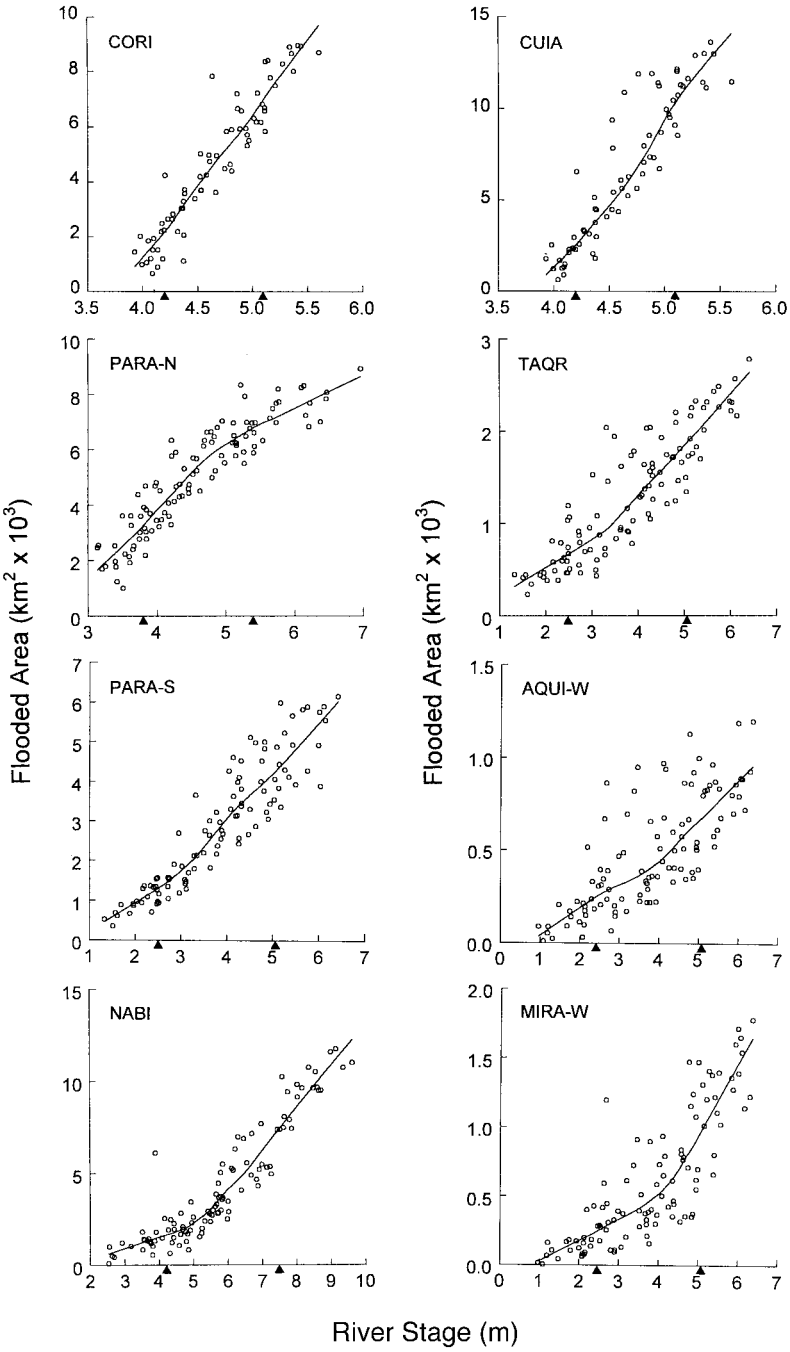

Figure 2. Relationships between river stage and flooded area for the eight subregions that are potentially affected by the stage of the Paraguay River. The curves were determined by the LOWESS smoothing procedure (see text for explanation). Triangles below the abscissa mark the 20th and 80th percentiles for the stage observations. Figure 1 provides the locations and full names of the subregions, and Table I lists the river stage sites

At low water, the sum of the predicted flooded areas for the individual subregions shows the total flooded area to be reduced by 1430 and 3830 km^2 for respective decreases in river stage of 0.10- and 0.25-m. At high water, the predicted reductions are 2410 and 5790 km^2 for respective decreases in stage of 0.10- and 0.25-m. The results of the scenarios for individual subregions show that these decreases are

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Table II. Predicted decreases in flooded area for subregions along the Paraguay River at low water, based on the relationships between flooded area and river level in each subregion

Low water	Flooded area (km^2)			Percentage decrease	
Subregion	No change	Stage −0.10 m	Stage −0.25 m	Stage −0.10 m	Stage −0.25 m
Corixo Grande	2212	1757	1067	20.6	51.8
Cuiabá	2587	2128	1058	17.7	59.1
Paraguay River, North	3276	3002	2657	8.4	18.9
Paraguay River, South	1301	1230	1114	5.5	14.4
Taquari River	667	632	592	5.2	11.2
Aquidauna/Negro, West	257	241	219	6.2	14.8
Miranda, West	248	230	207	7.3	16.6
Nabileque	1672	1566	1472	6.3	12.0
Sum of individual subregions	12 219	10 785	8385	11.7	31.4

Estimates are provided for the present situation (no change in stage; 20th percentile stage value) and for hypothetical decreases in stage that may result from river channel modifications. Subregions are depicted in Figure 1, and the stage stations and 20th percentile stage values for each subregion are listed in Table I

not evenly distributed throughout the region, and that certain subregions would have more extreme reductions in flooded area. Flooded areas in the two northernmost subregions—Corixo Grande and Cuiabá—are reduced by more than half with a 0.25-m decrease in river levels during a typical low-water period. Decreases in flooded area on the order of 10–20% are also predicted for the other subregions with a 0.25-m decrease at low water.

At high water, the Corixo Grande and Cuiabá subregions are also the most strongly affected by reductions in river levels. The northern and southern Paraguay River subregions are predicted to be least affected by a decrease in river levels at high water, reflecting the deeper flooding in those areas.

DISCUSSION

The reductions in flooding predicted to result from decreased river levels are large and would have strong impacts on the floodplain ecosystem. Reductions in flooded area are largest during high water but are proportionately greater during low water (Table II), when they would be particularly critical for aquatic animals that depend on the few remaining flooded areas for refuge, including fishes, giant river otters, and

Table III. Predicted decreases in flooded area for subregions along the Paraguay River at high water. See Table II for explanation

High water	Flooded area (km^2)			Percentage decrease	
Subregion	No change	Stage −0.10 m	Stage −0.25 m	Stage −0.10 m	Stage −0.25 m
Corixo Grande	7067	6463	5632	8.5	20.3
Cuiabá	10 422	9375	7740	10.0	25.7
Paraguay River, North	6821	6664	6421	2.3	5.9
Paraguay River, South	4255	4150	3969	2.5	6.7
Taquari River	1872	1804	1731	3.6	7.5
Aquidauna/Negro, West	670	651	612	2.8	8.7
Miranda, West	961	910	830	5.3	13.6
Nabileque	7425	7061	6766	4.9	8.9
Sum of individual subregions	39 493	37 078	33 701	6.1	14.7

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caiman. In the longer term, major changes in vegetation would be expected in areas where the average flooding period is reduced significantly, or flooding is eliminated. The reduced extent of inundation at high water, which ranges from 6-26% for individual subregions (Table III), would represent a significant loss of floodplain area at the regional scale.

The scenarios offered in this study represent typical conditions during the past few decades. Since 1974, water levels in the Paraguay River have been higher than the mean for the past century, as revealed by the stage record for Ladário, which dates from 1900 (Hamilton *et al*., 1997). The long-term mean stage of the Paraguay River at Ladário is 2.66 m (1900–94), while for the 1979–87 period analyzed in this study the mean stage is 3.80 m and the 20th percentile stage is 2.50 m. Given that the impacts of reduced river levels on flooded area may be greatest at lower river stages, it would be expected that when dryer periods occur again in the future, the impacts of channel modifications on floodplain inundation would be even greater than these scenarios suggest. Prolonged dry periods spanning several years have occurred on several occasions during the period of record. Such dry periods would probably impede normal navigation and lead to the desire for further channel modifications beyond those now proposed, exacerbating the impacts on floodplain inundation.

The scenarios presented here are conservative because they use the 20th and 80th percentiles of river levels as the starting points. From an ecological perspective, the minimum and maximum stage levels might be more relevant. The minimum stage determines how much aquatic habitat persists through the dry season, and the maximum stage defines the boundaries of the floodplain ecosystem. I did not use the minimum and maximum stage for my predictions because the stage–inundation relationship is not as well-defined at the extremes, and in the case of low water, the scenarios would have required extrapolation below the range of observations for the 9-year period. Although statistical extrapolation is not advisable, examination of the curves in Figure 2 strongly suggests that the two northernmost subregions would be more likely to dry completely for at least one month at low water with a 0.25-m decrease in river levels. Even a brief complete desiccation of the floodplain at low water would result in the loss of critical floodplain refuges for aquatic animals, and the river channel may not suffice as a refuge if it is used regularly for navigation.

It is conceivable that flooded area and river level are independent of each other and controlled by some external factor such as local rainfall, but there is abundant evidence to support the conclusion that the major rivers control the extent of inundation on adjacent floodplains in much of the Pantanal. Hydrological studies of the region have consistently concluded that overbank flow and the backwater effect are the main drivers of inundation in the region (UNESCO, 1973; EDIBAP, 1979; RADAMBRASIL, 1982; PCBAP 1996). Flooded area in the southern Pantanal, as observed by passive microwave remote sensing, correlates well with river stage but is 3–5 months out of phase with the seasonal peak in local rainfall (Hamilton *et al*., 1996). The chemical composition of floodwaters in the subregions analyzed in this study generally shows that they originate from river water (either the Paraguay River or its major tributaries), rather than from local rainfall (Calheiros and Hamilton, 1998; Hamilton *et al*., 1998a,b).

The empirical models presented in this study provide only an approximate indication of the manner in which river channel modifications might reduce the inundation of the adjacent floodplains. The models describe the present hydrological system, but do not consider the mechanisms that may control inundation of the floodplains, and how they might be subject to change as the river channel is altered. Interactions and feedback among these mechanisms, which include groundwater exchange and evapotranspiration, as well as rainfall and riverine overflow, could result in fundamental changes in the hydrological dynamics of the system. Hydraulic models of flow-routing may be capable of demonstrating the effects of channel modifications in this kind of system, but at present their application to the Pantanal is severely limited owing to insufficient understanding of the hydrological linkages between the rivers and floodplains and the controls on floodplain inundation. A major new data collection effort spanning several years would be required to obtain the information required to adequately model the hydrology of such a vast region. Until such information is available, the empirical relationships between river levels and flooded area presented here provide the best available indication of the potential impact of river channel

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modifications on the hydrology of floodplain ecosystems. The results of the scenarios demonstrate how seemingly small decreases in river levels may result in large reductions in flooded area, and underscore the importance of understanding the hydrology of the river–floodplain systems in the Pantanal before major river channel modifications are carried out.

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Safeguarding the Pantanal Wetlands: Threats and Conservation Initiatives

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Abstract: *The Pantanal, one of the largest wetlands on the planet, comprises 140,000 km² of lowland floodplain of the upper Rio Paraguai basin that drains the Cerrado of central Brazil. The diverse mosaics of habitats resulting from the varied soil types and inundation regimes are responsible for an extraordinarily rich terrestrial and aquatic biota, exemplified by the bird richest wetland in the world—463 birds have been recorded there—and the largest known populations of several threatened mammals, such as Pampas deer (*Ozotoceros bezoarticus*), marsh deer (*Blastocerus dichotomus*), giant otter (*Pteronura brasiliensis*), and jaguar (*Panthera onca*). Until recently, deforestation of the adjoining Brazilian central plateau was considered the major threat to this area, but now deforestation is a critical problem within the floodplain itself. More than 40% of the forest and savanna habitats have been altered for cattle ranching through the introduction of exotic grasses. And there are other threats that lead to large-scale disruption of ecological processes, severely affecting biodiversity. Although the Pantanal wetland is a Biosphere Reserve and is considered a Wetland of International Importance, only 2.5% of the upper Paraguai River basin is formally protected. To date, protected areas have been created opportunistically and as such, although of undoubted value, protect only a fraction of the Pantanal's wildlife and habitats. Among the conservation initiatives in the area, the private sector is increasingly participating in the establishment of private reserves. The prospects are far from optimistic, however, and the major challenge is to find alternative socioeconomic models that allow for conservation and economic uses of the land in association with the development of specific environmental legislation that reflects the unique characteristics of the region.*

Protegiendo a los Humedales del Pantanal: Amenazas e Iniciativas de Conservación

Resumen: *El Pantanal, 140,000 km² de llanura inundable de la cuenca alta del Río Paraguai que drena el Cerrado en el centro de Brasil, es uno de los humedales más extensos del planeta. Los diversos mosaicos de hábitats que resultan de diversos tipos de suelo y regímenes de inundación son responsables de una biota terrestre y acuática extraordinariamente rica, ejemplificada por el humedal con mayor riqueza de aves en el mundo – se han registrado 463 especies de aves – y las mayores poblaciones conocidas de varios mamíferos amenazados, como el venado de las Pampas (*Ozotoceros bezoarticus*), el venado de pantano (*Blastocerus dichotomus*), la nutria gigante (*Pteronura brasiliensis*) y el jaguar (*Panthera onca*). Hasta hace poco, la deforestación de la meseta central Brasileña adyacente era considerada como la mayor amenaza a esta área, pero ahora la deforestación es un problema crítico dentro de la misma llanura inundable. Más de 40% de hábitats de bosque y sabana han sido alterados para producción de ganado mediante la introducción de pastos exóticos. Y hay otas amenazas que conducen a la disrupción de los procesas ecológicos a gran escala*

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que afectan severamente a la biodiversidad. Aunque el humedal del Pantanal es una Reserva de la Biósfera y es considerado un Humedal de Importancia Internacional, solo 2.5% de la cuenca alta del Río Paraguai está protegido formalmente. A la fecha, las áreas protegidas han sido creadas oportunísticamente y por lo tanto, aunque de valor indudable, solo protegen a una fracción de la vida silvestre y hábitats del Pantanal. Entre las iniciativas de conservación del área, el sector privado está incrementando su participación en el establecimiento de reservas privadas. Sin embargo, las perspectivas están lejos de ser optimistas y el mayor reto es encontrar modelos socioeconómicos alternativos que permitan la conservación y utilización económica de tierras en asociación con el desarrollo de legislación ambiental específica que refleje las características únicas de la región.

Brazilian Pantanal Wetlands

The Pantanal is one of the largest continuous wetlands on the planet, covering approximately 140,000 km^2 of low-elevation floodplain of the upper Rio Paraguai and its tributaries, which drain the Cerrado of the central plateau of Brazil. The vegetation is heterogeneous and influenced by four biomes: Amazon rainforest, Cerrado (predominant), Chaco, and Atlantic Forest (Adámoli 1981). Different habitats, soil types, and inundation regimes are responsible for the great variety of vegetation formations and the patchy landscapes, which harbor a rich terrestrial and aquatic biota (Pott & Adámoli 1999). Sixteen vegetation classes based on phytophysiognomy have been identified (Silva et al. 2000), the most important being grassland (31%), cerrado woodland (*cerradão*) (22%), cerrado (bush savanna) (14%), marshes (7%), semideciduous forest (4%), gallery forest (2.4%), and floating mats (2.4%). Summers (November–March) are hot and rainy and winters (April–October) are warm and dry, except for occasional cold spells (Soriano 1997).

The main ecological factor that determines patterns and processes in the Pantanal is the flooding pulse (Junk & Silva 1999; Oliveira & Calheiros 2000), which follows an annual, monomodal cycle with amplitudes from 2 to 5 m and a duration of 3 to 6 months. There is a delay of about 4 months before the peak water level passes through the Pantanal from north to south (Heckman 1999). The dry season is already under way in the northern Pantanal when water levels reach a peak in the south. Water levels in any one season in the north are extremely variable, rising and falling in close response to rainfall. Water levels in the south, on the other hand, rise and fall more smoothly during the year because natural flood retention dampens the fluctuations caused by heavy rainstorms (Heckman 1999). The Pantanal is also subject to a multiyear variation of flooding intensity, with an alternation of high-flood years and significantly drier ones (Mourão et al. 2000; Cunha et al. 2002).

Although species diversity is not particularly high (greater in the south than in the north) and endemism is practically absent (probably related to the geomorphological youth of the floodplain—a desert in the Pleistocene), the region is notable for its extraordinary concentration and abundance of wildlife (Heckman 1999; Swartz 2000). About 124 species of mammals occur there, and the Pantanal has the largest known populations of several threatened species, such as the Pampas deer (*Ozotoceros bezoarticus*), marsh deer (*Blastocerus dichotomus*), giant otter (*Pteronura brasiliensis*), and jaguar (*Panthera onca*) (Alho & Lacher 1991; Mourão et al. 2000; Tomas et al. 2000; Sanderson et al. 2002). Mittermeier et al. (2003) report 423 birds in the Pantanal, but a recent review by Tubelis and Tomas (2003) resulted in a list of 463 species, making it the richest single wetland site for birds in the world. From this total, 117 species are included on at least one state, national, or international list of threatened species; the best-known is the Hyacinth Macaw (*Anodorhynchus hyacinthinus*) (Tubelis & Tomas 2003; Tomas et al. 2004). The Pantanal is also an important migratory route, with more than 130 species arriving there from the southern continent (Pampas), the Northern Hemisphere, and the Atlantic Forest (Antas 1994; Nunes & Tomas 2004). A large number of species are seasonal (Cintra & Yamashita 1990) and transient. Generalist species are favored within the temporally variable and patchy habitats (Figueira et al. 2005). Forty-one amphibians, 177 reptile species (Médri & Mourão 2004), and more than 260 fishes have been recorded in the Pantanal (Britski et al. 1999).

The Pantanal wetland is recognized as a "National Heritage" in the 1988 Constitution of Brazil and as a Wetland of International Importance in the Ramsar Convention. In 2000, it was designated a Biosphere Reserve by the U.N. Educational, Scientific, and Cultural Organization, and part of it is also a World Heritage Site, affording a unique opportunity for biodiversity conservation in conjunction with sustainable development. Referring to its biological distinctiveness, conservation, and priority status, Olson et al. (1998) concluded that the Pantanal is a region that is "globally outstanding, vulnerable and with highest priority for conservation at regional scale." Despite this, the available data on its biological diversity are still poor and fragmentary (Silva et al. 2001; Silva 2002).

The fragile equilibrium of the Pantanal ecosystems, defined by the dynamics of the periodic flooding, is threatened by recent tendencies in economic development. The traditional models of fishing and cattle ranching are

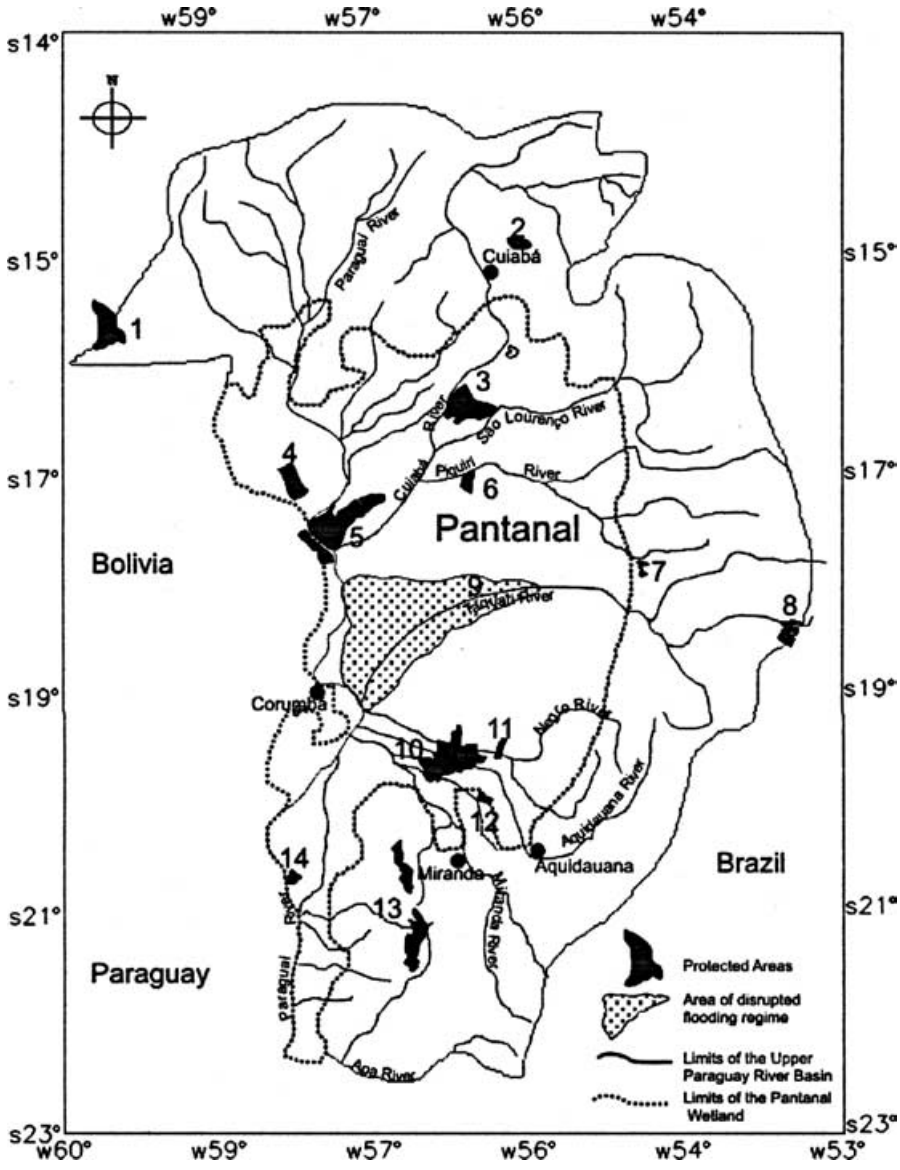

Figure 1. Map of the Upper Paraguay River basin and the Pantanal, showing the area where the flooding regime of the Rio Taquari has been disrupted. Also shown are some of the existing federal, state, and private protected areas:1, Serra de Ricardo Franco State Park; 2, Chapada dos Guimarães National Park; 3, Serviço Social do Comércio Pantanal Private Reserve; 4, Guira State Park; 5, Complex of the Pantanal Matogrossense National Park and the Private Reserves of Acurizal and Doroche; 6, Fazenda Poleiro Grande Private Reserve; 7, Serra de Sonora State Park; 8, Nascentes do Rio Taquari State Park; 9, Fazenda Nhumirim Private Reserve; 10, Complex of the Pantanal do Rio Negro State Park and the Private Reserves Fazendinha and Santa Sofia; 11, Fazenda Rio Negro Private Reserve; 12, Dona Aracy Private Reserve; 13, Serra da Bodoquena National Park; 14, Fazenda Rancho Seguro and Tupaciara Private Reserves.

being rapidly replaced by intensive exploitation, accompanied by deforestation and the degradation of the natural vegetation and watercourses.

Major Present and Future Threats

Habitat Loss

Until recently, the major threat to the region was deforestation of the surrounding plateau. Today, however, this is a critical problem within the Pantanal itself. By 2000, the total area where the original vegetation had been removed and replaced with exotic grasses was estimated at 12,182 km^2 (Padovani et al. 2004). More than 40% of the forests and savanna habitats have already been altered for cattle ranching through the introduction of exotic grass species (Padovani et al. 2004). Burning—a practice to renew pasture and control weeds and cattle pests such as ticks—is on the increase, and frequently leads to uncontrolled fires. The effects of introduced grasses (and herbicides) are still poorly known, although reduced densities and species richness of small mammals in areas that are heavily grazed have been documented (Lacher & Alho 1989).

Conversion of natural habitats in the neighboring Cerrado has led to severe erosion, causing sediment deposition in the lowlands of the Pantanal and altering the patterns of water flow and hydrological regimes. In the last 30 years, for example, the Rio Taquari has been overflowing and permanently flooding extensive areas that previously flooded only seasonally (Fig. 1). Unsustainable development practices in the upper reaches of the rivers are creating severe and long-lasting environmental impacts and even bankruptcy for those living in the lower reaches.

Development Projects

Large infrastructure projects also threaten the Pantanal. The Manso hydroelectric dam, completed in 2000, is the largest of the nine reservoirs in the area and has altered natural hydrological patterns throughout the basin of the Rio Cuiabá. The immediate effect on fish populations appears to have been substantial, but the long-term effects are as yet unknown (Resende 1994).

In the mid-1990s, Argentina, Bolivia, Brazil, Paraguay, and Uruguay began collaborating on the construction of the Paraguay–Paraná waterway, or *Hidrovia*. The project, supported by the Inter-American Development Bank, aims to dredge and change the course of the Rio Paraguai to allow for fluvial transport of mainly agricultural produce. Models have already indicated that the proposed changes would alter the flow of the Rio Paraguai and cause the loss of large areas of wetland in the Pantanal (Hamilton 1999), with subsequent large-scale disruption of the fragile ecological processes that determine the spatiotemporally variable mosaic of habitats so vital for the enormous wealth of wildlife. The Brazil–Bolivia natural gas pipeline will intensify the mining of iron and manganese in the Urucum Mountains in the state of Mato Grosso do Sul. As a result, projects for the installation of large steelworks and petrochemical plants are already under way. These projects will be significant sources of pollution, and their effects will pose unpredictable challenges to the Pantanal and its surroundings.

Hunting

Hunting was a major concern in the past. Species such as the Paraguayan caiman (*Caiman crocodilus yacare*) were extensively harvested before Brazil imposed a ban in 1967. Although the state government made efforts to enforce the law, extensive caiman poaching diminished only when it coincided with a drop in the prices of skins on the international market (Mourão et al. 1996). Giant otters were hunted until they almost disappeared from the Pantanal in the late 1960s. From 1960 to 1969, records indicated a regional harvest of 12,390 giant otter skins—over 24% of the Brazilian production in that period. Currently, the population is recovering and appears to be sparking a new threat for the species: conflict with fishers (Tomas et al. 2000; Zucco & Tomas 2004). Overall, poaching pressure is not a major issue in the Pantanal. Exceptions are the jaguar and puma (*Puma concolor*), which are persecuted by cattle ranchers because they prey on cattle (Alho & Lacher 1991; Crawshaw 2002; Dalponte 2002).

Exotic Species

Three of the world's 100 worst invasive alien species (Lowe et al. 2000) already occur in the Pantanal. The Chinese golden mussel (*Limnoperna fortunei*) and the African giant snail (*Achatina fulica*) are of major concern for biodiversity conservation, public health, and economic development in the Pantanal (Darrigan & Pastorino 2003). Feral pigs, introduced more than a century ago, are now widespread and abundant in the Pantanal, but their effects on the native peccaries (*Tayassu tajacu* and *T. pecari*) are still unknown (Mourão et al. 2002*a*).

Two fishes have been introduced from the Amazon basin: the tucunaré (*Cichla cf. ocellaris*) and the tambaqui (*Colossoma macropomum*). Both were released into the Rios Itiquira and São Lourenço. The tucunaré is a voracious predator, and its introduction elsewhere (in southeastern Brazil) has resulted in widespread local extinctions. Other exotic fishes are still farmed in the Rio Paraguay river basin and pose a serious threat to the fish communities of the Pantanal.

Water buffalo (*Bubalus bubalis*) were introduced to the Pantanal as an alternative to the Nelore cattle (*Bos indicus*), the most common breed of the region. At least four populations of feral buffaloes have now been established in the wetland (W.M. Tomas & G.M. Mourão, unpublished data), the Taboco marshland, the Forte Coimbra, the Rio Taquari, and the region of Ilha de Taiamã. They trample and consume vegetation along riverbanks with evident but poorly understood impacts, and the idea that water buffalo decrease the risks of jaguar predation on cattle (Hoogesteijn et al. 2002) is highly controversial.

Pollution

Pesticides are a major threat because of the enormous areas of agricultural land surrounding the Pantanal and along the headwaters of the main rivers that feed the floodplain (Alho et al. 1988). Distilleries for producing alcohol from sugarcane produce toxic stillage that is frequently dumped in nearby streams and fields. It is a significant source of pollution, killing fish and cattle (Alho et al. 1988). Traces of pesticides from soybean plantations have been found in the Rios Taquari and São Lourenço (Mourão et al. 2002*b*). Mercury was used in gold mining in the Poconé region until around 1994, when the mining was forbidden, but contamination of the food web has been detected (Vieira et al. 2004).

Current Conservation Status

Only 2.5% of the Upper Paraguai River basin is formally protected in national and state parks and in private protected areas (Fig. 1). The first protected area in the Pantanal was the Pantanal Matogrossense National Park, created with the Taiamã Ecological Station in 1981 (Table 1). The Serra das Araras Ecological Station was created in 1982, the Chapada dos Guimarães National Park in 1989, and finally the Bodoquena National Park in the state of Mato Grosso do Sul in 2000. These areas total 264,300 ha of federal strictly protected areas in the Pantanal and the surrounding Cerrado. There are five state parks totaling 245,320 ha, and two environmental protection areas with a combined area of 725,157 ha. Finally, there are five highway parks that cover a distance of 294

Table 1. Federal and state protected areas in the Pantanal region of Brazil in the states of Mato Grosso (MT) and Mato do Grosso do Sul (MS).

Name	*State*	*Date of decree*	*Area/length*
Pantanal Matogrossense National Park*	MT	1981	135,000 ha
Chapada dos Guimarães National Park*	MT	1989	33,000 ha
Taiamã Ecological Station	MT	1981	11,200 ha
Serra das Araras Ecological Station	MT	1982	28,700 ha
Águas Quentes State Park	MT	1978	1,487 ha
Serra de Ricardo Franco State Park*	MT	1997	158,621 ha
Gruta da Lagoa Azul State Park	MT	2000	12,512 ha
Aguas do Cuiabá State Park	MT	2002	10,600 ha
Dom Osório Stofell State Park	MT	2002	6,421 ha
Guirá State Park*	MT	2002	100,000 ha
Cachoeira da Fumaça Highway Park	MT	1998	20 km
Transpantaneira Highway Park	MT	1999	140 km
Santo Antônio–Porto de Fora Highway Park	MT	2000	74 km
Poconé–Porto Cercado Highway Park	MT	2000	45 km
Cuiabá–Mirante Highway Park	MT	2000	60 km
Chapada dos Guimarães State Environmental Protection Area	MT	1995	251,847 ha
Cabeçeiras do Rio Cuiabá State Environmental Protection Area	MT	1999	473,410 ha
Serra da Bodoquena National Park*	MS	2000	76,400 ha
Várzeas do Rio Ivinhema State Park	MS	1998	73,345 ha
Pantanal do Rio Negro State Park*	MS	2000	78,303 ha
Nascentes do Rio Taquari State Park*	MS	2000	35,000 ha
Matas do Segredo State Park	MS	2000	178 ha
Serra de Sonora State Park*	MS	2001	7,913 ha
Prosa State Park	MS	2002	135 ha
Rio Cênico Rotas Monçoeiras State Environmental Protection Area	MS	2000	–

**Shown in Fig. 1.*

km (Table 1). These areas were established opportunistically and protect only a fraction of the diversity of the upper Paraguay River basin fauna and flora. Some areas of unique landscape features are still poorly protected, such as the brackish and freshwater pools of Nhecolândia.

Cattle ranching has long been the predominant human activity in the Pantanal, and the rich and abundant fauna has persisted in large part because of the low human population and the lack of hunting (Alho & Lacher 1991). Feral pigs are hunted as an alternative source to beef, diverting the hunting pressure from native species. A more intensive use of the Pantanal habitat has been limited by cultural factors (the traditional way of raising cattle) and the lack of technology and low capital input. Until recently, agriculture was limited in its extent because of the seasonal flooding, resulting in the preservation of vast areas of natural habitats (Alho & Lacher 1991). This situation is changing rapidly, however, with cattle ranching becoming increasingly competitive and intensive and irrigated agriculture spreading inside the floodplain.

Major Conservation Initiatives

The Brazilian Agricultural Research Corporation (Empresa Brasileira de Pesquisa Agropecuária [Embrapa]) established a research center in the Pantanal in the mid-1970s (Embrapa Pantanal), focusing on alternatives and strategies for the sustainable development of the region. Besides its support for the principal economic activities of the region, over the years it has made enormous contributions to our understanding of the ecological dynamics and conservation of the floodplain, besides wildlife and fish management and monitoring. Long-term research on the ecology of the Paraguayan caiman, for example, supported the removal of the species from the U.S. Endangered Species Act (Mourão et al. 2000). This allowed for the export of skins of caimans bred on ranches in the Pantanal. In the face of increasing threats from industry and potentially prejudicial changes in land use, in 1997 the Ministry of the Environment set up the Program for the Sustainable Development of the Pantanal—Pantanal Program to improve the sustainability of resource use in the upper Rio Paraguai basin, directly or indirectly affecting approximately 80 municipalities, and 39 Indian villages (MMA 1997). Although as yet incipient, components of this program include research and measures directly related to protected areas, urban environments, sustainable economic activities, and the management of hydrographic basins. A collaborative venture between the federal government and the state governments of Mato Grosso and Mato Grosso do Sul, it was formally implemented in 2001, and financed by the Brazilian government, the Inter-American Development Bank and the Japan Bank for International Cooperation.

A Government Center for Conservation Data focusing on species and ecosystems in the Mato Grosso was established in 1989 with the support of the World Wildlife Fund and The Nature Conservancy, to support conservation planning for the Pantanal in the Upper Paraguai river basin (Brito et al. undated). This resulted in Law

5993 of 1992, which indicated 19 priority zones for environmental conservation in the region. The incentives for the implementation of this law came later, in 1993, with the establishment of the Mato Grosso State Program for Environmental Development and the creation of 10 state-protected areas in the Mato Grosso portion of the Upper Paraguai river basin (Table 1).

In 1998 the government-sponsored Cerrado-Pantanal Conservation Priority-Setting Workshop (Fundação Pró-Natureza et al. 2000) resulted in the delineation of an initial corridor design for the Pantanal. This addressed the need for a more extensive and connected protected area system and later supported the creation of two state parks (Rio Negro and Nascentes do Taquari) and a national park (Serra da Bodoquena) in Mato Grosso do Sul. In collaboration with the U.S. Agency for International Development and in partnership with local organizations, Conservation International has embarked on an initiative to establish a biodiversity corridor that links the Pantanal and the Cerrado, covering 800 km from the swamps of the Pantanal's Rio Negro to the cerrado of Emas National Park in Goiás.

Two projects with flagship species in the Pantanal deserve mention. Since 1991, the Hyacinth Macaw Project has been monitoring the populations of this species and conducting environmental education initiatives for local communities. The Hyacinth Macaw population has begun to recover since the project began and is currently estimated at 5000 individuals in the wild (Guedes 2002). The second is the Jaguar Conservation Fund, a project promoting environmental awareness among local communities and providing compensation to ranchers from cattle losses. For the first time ranchers are coming to accept recovery of the jaguar population, and at least those engaged in tourism now recognize the potential of the species as a source of income. Benefiting from federal and state legislation, numerous landowners have already protected 2618 km^2 of the Pantanal, and the creation of the Private Protected Areas Association (REPAMS) in 2002 will further stimulate what is seen as a most important tool for the conservation of the region. The change in attitudes of the cattle ranchers in the Pantanal exemplifies the gradual increase in the participation of the private sector. The prospects are far from optimistic, however, the continuous engagement of the private sector in addition to effective government actions are necessary measures to ensure both conservation and the sustainable economic use of the land.

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Dimensão: *INSTITUCIONAL*

Tema: *CAPACIDADE DE GESTÃO*

Sub-Tema: *GASTO PÚBLICO*

Indicador: *Receitas originadas do "ICMS ecológico"*

Impactos Correlacionados: Aumento da arrecadação de impostos.

Descrição: Proporção das receitas municipais advindas do Imposto sobre Circulação de Mercadorias e Prestação de Serviços de Transporte Interestadual e Intermunicipal e de Comunicação - ICMS - recolhido pelo estado e repassadas aos municípios que possuem restrições de uso do solo em virtude de existirem em seus territórios, unidades de conservação e/ou terras indígenas. O repasse de recursos, popularmente conhecido como "ICMS Ecológico" ou "ICMS verde", foi instituído através da Lei 73/2000 que definiu novos critérios para a distribuição dos 25% dos recursos do ICMS arrecadados e que deverão ser repassados aos municípios. Dentre eles, está o que destina 5% para os municípios que possuem áreas de proteção ambiental ou terra indígena. O objetivo do "ICMS ecológico" é incentivar os municípios a implementar medidas de proteção ao meio ambiente e compensar financeiramente aqueles que possam ser prejudicados economicamente pela não utilização das áreas de conservação. Para definir o valor que cada município irá receber são utilizados critérios relativos ao tamanho da área, e o quanto ele representa em comparação ao tamanho do município, bem como o fator de conservação das unidades e o tipo de manejo. Para estes dados, são atribuídos valores que irão compor os índices e que definirão a divisão dos recursos no exercício posterior ao cálculo.

Método de Cálculo: Para identificar os valores recebidos pelos municípios, utilizou-se o valor total recebido de ICMS (divulgado pela SEFAZ) X índice de unidade de conservação/terra indígena (índice UC/TI). O resultado divide-se pelo índice final de participação no ICMS.

(Valor recebido de ICMS x Índice UC/TI)/(Índice Final)

Unidade de Medida: Percentual

Periodicidade: Anual

Desagregação dos dados: Municipal

Classificação do Indicador: Estado

Fonte 1: Tesouro Nacional / SICONFI / Consultas / Consultar FINBRA Contas Anuais
https://siconfi.tesouro.gov.br/siconfi/index.jsf;jsessionid=PCa2kjlnu65mQ1kQ82Bz-wlo.node1

Fonte 2: Secretaria de Estado do Meio Ambiente de Mato Grosso – SEMA / Superintendência de Mudanças Climáticas e Biodiversidade / Coordenadoria de Unidades de Conservação e Áreas Protegidas

DIMENSÃO INSTITUCIONAL			
TEMA: CAPACIDADE DE GESTÃO			
SUB-TEMA: GASTO PÚBLICO			
Indicador:	Receitas originadas do ICMS ecológico		
Ano dos Dados Levantados:	2014		
Municípios	Unidade: receitas orçamentárias (R$)	Unidade: Estimativa de recursos oriundos do ICMS Ecologico (R$)	Unidade: participação do ICMS Ecológico do município em sua receita orçamentária (%)
Acorizal	Não informado	0,00	-
Água Boa	71.112.136,18	8.537,06	0,01%
Alta Floresta	Não informado	75.473,95	-
Alto Araguaia	82.861.794,74	523.764,52	0,63%
Alto Boa Vista	Não informado	2.812.772,00	-
Alto Garças	29.365.658,61	0,00	0,00%
Alto Paraguai	18.845.449,31	351.031,32	1,86%
Alto Taquari	Não informado	864.077,08	-
Apiacás	27.874.213,99	2.685.301,03	9,63%
Araguaiana	13.744.674,39	11.003,32	0,08%
Araguainha	Não informado	0,00	-
Araputanga	37.353.694,23	0,00	0,00%
Arenápolis	Não informado	0,00	-
Aripuanã	58.417.854,55	1.426.258,38	2,44%
Barão de Melgaço	15.661.517,59	441.034,08	2,82%
Barra do Bugres	84.259.641,75	273.502,15	0,32%
Barra do Garças	Não informado	1.298.518,65	-
Bom Jesus do Araguaia	19.859.655,99	49.246,20	0,25%
Brasnorte	51.404.670,20	573.390,15	1,12%
Cáceres	Não informado	287.746,40	-
Campinápolis	42.029.921,78	2.119.863,00	5,04%
Campo Novo do Parecis	125.759.874,50	1.558.013,70	1,24%
Campo Verde	98.847.137,35	28.362,01	0,03%
Campos de Júlio	Não informado	89.402,00	-
Canabrava do Norte	14.255.247,66	82.192,93	0,58%
Canarana	Não informado	1.103.510,04	-
Carlinda	26.154.479,43	0,00	0,00%
Castanheira	20.525.603,66	0,00	0,00%
Chapada dos Guimarães	45.302.465,17	476.826,50	1,05%
Cláudia	30.059.141,56	284,57	0,00%
Cocalinho	Não informado	906.019,35	-
Colíder	67.768.142,62	0,00	0,00%
Colniza	59.200.589,69	2.285.276,47	3,86%
Comodoro	57.934.651,36	3.346.101,20	5,78%
Confresa	55.700.228,56	180.938,27	0,32%
Conquista d'Oeste	Não informado	2.467.100,07	-
Cotriguaçu	Não informado	1.677.121,51	-
Cuiabá	Não informado	939.645,89	-
Curvelândia	13.890.233,13	40.313,90	0,29%
Denise	17.228.190,10	0,00	0,00%
Diamantino	67.171.655,97	69.782,57	0,10%
Dom Aquino	Não informado	0,00	-

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Municípios	Unidade: receitas orçamentárias (R$)	Unidade: Estimativa de recursos oriundos do ICMS Ecologico (R$)	Unidade: participação do ICMS Ecológico do município em sua receita orçamentária (%)
Feliz Natal	34.402.746,59	2.393.380,96	6,96%
Figueirópolis d'Oeste	12.606.896,01	0,00	0,00%
Gaúcha do Norte	Não informado	2.593.938,67	-
General Carneiro	21.146.203,65	1.235.739,63	5,84%
Glória d'Oeste	13.344.579,02	0,00	0,00%
Guarantã do Norte	70.359.578,43	675.550,31	0,96%
Guiratinga	31.432.914,22	249.045,05	0,79%
Indiavaí	13.582.666,25	0,00	0,00%
Ipiranga do Norte	33.678.283,55	0,00	0,00%
Itanhangá	16.648.347,36	0,00	0,00%
Itaúba	19.665.382,61	0,00	0,00%
Itiquira	64.183.546,32	0,00	0,00%
Jaciara	64.519.983,11	17.137,36	0,03%
Jangada	14.902.544,94	0,00	0,00%
Jauru	29.226.324,90	0,00	0,00%
Juara	74.008.589,89	665.985,64	0,90%
Juína	93.318.304,37	3.432.657,52	3,68%
Juruena	Não informado	0,00	-
Juscimeira	Não informado	0,00	-
Lambari d'Oeste	18.558.555,02	0,00	0,00%
Lucas do Rio Verde	197.890.713,41	5.406,81	0,00%
Luciara	Não informado	405.984,70	-
Marcelândia	34.490.330,39	623.442,62	1,81%
Matupá	41.786.348,52	1.021.743,96	2,45%
Mirassol d'Oeste	47.752.154,07	0,00	0,00%
Nobres	48.123.432,94	963.897,46	2,00%
Nortelândia	18.969.172,57	0,00	0,00%
Nossa Senhora do Livramento	30.371.960,25	163.453,11	0,54%
Nova Bandeirantes	28.138.017,72	347.205,45	1,23%
Nova Brasilândia	15.617.315,98	359.030,86	2,30%
Nova Canaã do Norte	36.915.999,49	2.893,12	0,01%
Nova Guarita	14.898.496,14	0,00	0,00%
Nova Lacerda	27.391.464,75	837.548,96	3,06%
Nova Marilândia	15.794.702,84	0,00	0,00%
Nova Maringá	Não informado	346.067,17	-
Nova Monte Verde	23.324.266,63	0,00	0,00%
Nova Mutum	122.384.191,50	0,00	0,00%
Nova Nazaré	16.163.401,52	2.375.990,65	14,70%
Nova Olímpia	51.051.687,43	0,00	0,00%
Nova Santa Helena	15.805.504,08	0,00	0,00%
Nova Ubiratã	42.783.348,47	755.103,08	1,76%
Nova Xavantina	Não informado	33.089,02	-

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Municípios	Unidade: receitas orçamentárias (R$)	Unidade: Estimativa de recursos oriundos do ICMS Ecologico (R$)	Unidade: participação do ICMS Ecológico do município em sua receita orçamentária (%)
Novo Horizonte do Norte	14.527.228,13	0,00	0,00%
Novo Mundo	23.933.256,21	1.692.994,12	7,07%
Novo Santo Antônio	Não informado	2.930.441,17	-
Novo São Joaquim	23.118.964,81	118.127,63	0,51%
Paranaíta	53.941.194,85	0,00	0,00%
Paranatinga	54.382.237,78	911.109,97	1,68%
Pedra Preta	41.422.837,34	63,24	0,00%
Peixoto de Azevedo	63.328.348,66	2.296.311,41	3,63%
Planalto da Serra	Não informado	40.630,09	-
Poconé	45.771.231,49	652.689,96	1,43%
Pontal do Araguaia	15.752.886,87	0,00	0,00%
Ponte Branca	Não informado	158.220,20	-
Pontes e Lacerda	81.701.100,81	604.360,71	0,74%
Porto Alegre do Norte	Não informado	908.849,23	-
Porto dos Gaúchos	23.417.951,99	0,00	0,00%
Porto Esperidião	31.987.914,57	398.506,86	1,25%
Porto Estrela	13.214.894,76	1.063.022,23	8,04%
Poxoréo	Não informado	422.173,49	-
Primavera do Leste	191.294.105,65	0,00	0,00%
Querência	62.216.968,73	2.179.132,34	3,50%
Reserva do Cabaçal	12.099.649,34	0,00	0,00%
Ribeirão Cascalheira	Não informado	930.650,35	-
Ribeirãozinho	Não informado	100.278,85	-
Rio Branco	16.661.523,89	0,00	0,00%
Rondolândia	16.310.594,78	2.472.617,54	15,16%
Rondonópolis	579.263.784,51	431.390,36	0,07%
Rosário Oeste	Não informado	575.872,22	-
Salto do Céu	Não informado	0,00	-
Santa Carmem	18.830.667,74	0,00	0,00%
Santa Cruz do Xingu	15.576.492,56	1.465.022,97	9,41%
Santa Rita do Trivelato	22.538.878,97	496.430,12	2,20%
Santa Terezinha	Não informado	1.017.949,71	-
Santo Afonso	Não informado	0,00	-
Santo Antônio do Leste	20.924.245,48	839.825,51	4,01%
Santo Antônio do Leverger	Não informado	175.136,23	-
São Félix do Araguaia	36.903.494,65	837.232,77	2,27%
São José do Povo	12.520.235,43	0,00	0,00%
São José do Rio Claro	43.144.901,85	0,00	0,00%
São José do Xingu	19.541.506,46	961.747,39	4,92%
São José dos Quatro Marcos	39.074.459,30	0,00	0,00%
São Pedro da Cipa	11.971.187,27	0,00	0,00%
Sapezal	Não informado	1.886.089,80	-

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Municípios	Unidade: receitas orçamentárias (R$)	Unidade: Estimativa de recursos oriundos do ICMS Ecologico (R$)	Unidade: participação do ICMS Ecológico do município em sua receita orçamentária (%)
Serra Nova Dourada	13.608.410,23	0,00	0,00%
Sinop	329.014.953,26	0,00	0,00%
Sorriso	238.117.679,80	7.588,50	0,00%
Tabaporã	31.724.653,10	398.981,14	1,26%
Tangará da Serra	200.070.992,50	2.726.294,74	1,36%
Tapurah	Não informado	0,00	-
Terra Nova do Norte	30.657.675,66	0,00	0,00%
Tesouro	Não informado	3.620,35	-
Torixoréu	Não informado	0,00	-
União do Sul	16.129.437,22	0,00	0,00%
Vale de São Domingos	13.750.241,33	0,00	0,00%
Várzea Grande	Não informado	95.425,37	-
Vera	29.679.187,82	0,00	0,00%
Vila Bela da Santíssima Trindade	54.413.235,90	691.375,50	1,27%
Vila Rica	45.001.397,26	0,00	0,00%

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SOURCE–SINK DYNAMICS IN A TEMPORALLY HETEROGENEOUS ENVIRONMENT

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Abstract. In traditional source–sink models, vital rates and movement probabilities are assumed to be temporally homogeneous. Numerous studies, however, have demonstrated that temporal heterogeneity is the rule rather than the exception in natural systems. A case of particular interest is an expanding and contracting population where determination of source and sink populations is dependent on the timing and duration at which population growth rates are measured. Thus, ecologists have been perplexed about what is the proper scale to test for source–sink dynamics. In this study, I present a temporally variable source–sink dynamic driven by flooding disturbance. I measured population growth rates of an herbivorous neotropical rolled-leaf beetle, *Cephaloleia fenestrata* (Chrysomelidae), at different temporal scales in this expanding and contracting population. I demonstrate that flooding created a strong sink, but the system lacked source–sink dynamics during nonflood periods. The sink is caused by a flood-related sevenfold decrease in survival probability. There was no evidence for effects of flooding on recruitment. Migration was directional from the upland to the flood zone habitat, supporting the conclusion that the population in the flood zone is a sink. A Monte Carlo simulation demonstrated that whether the population in the flood zone is a sink, and the intensity of the sink, ultimately depend on the flooding frequency. Given an observed flood frequency of approximately once per year, the flood zone population was determined to be a long-term sink. This study provides evidence of high temporal variability resulting in fluctuations in and out of a source–sink dynamic and implicates a causal factor (increased mortality due to flooding). These results illustrate the importance of considering temporal variability in source–sink dynamics, and in choosing the proper temporal scale at which to test for source–sink dynamics.

Key words: Cephaloleia fenestrata; *dispersal; disturbance; flooding; mark–recapture;* Pleiostachya pruinosa; *source–sink dynamics; survival; temporal heterogeneity.*

INTRODUCTION

Classic source–sink dynamics occur in spatially heterogeneous, but temporally constant, environments (Pulliam 1988). Numerous studies, however, have demonstrated that temporal heterogeneity is the rule rather than the exception in natural systems. Temporal heterogeneity takes a number of forms including seasonality (Andrewartha and Birch 1954), year-to-year environmental variation (Andrewartha and Birch 1954), El Niño events (Schreiber and Schreiber 1984), climate change (Glynn 1991), and disturbances (Connell 1978). Determination of source–sink dynamics requires calculating premigration population growth rates (λ), where $\lambda > 1$ indicates a source and $\lambda < 1$ indicates a sink population. Ecologists have been perplexed about what is the proper scale to detect source–sink dynamics because, in temporally variable systems, determining source and sink habitat is dependent on the timing and duration at which population growth rates are measured. This dilemma is clear in the case of an expanding and contracting population in which λs may fluctuate above and below unity. Herein, I measure λs of an expanding and contracting population of a neotropical rolled-leaf beetle, *Cephaloleia fenestrata* Weise (Chrysomelidae), at multiple temporal scales. Population contractions are associated with flood events, while population expansions are associated with nonflood periods. I distinguish between short-term (25 d) and long-term (1 yr and indefinite) source–sink dynamics in the system and demonstrate that understanding temporal variation in population demography is crucial to determining long-term source–sink dynamics.

In a source habitat, reproductive output exceeds mortality, while in a sink habitat mortality exceeds reproductive output and population density is maintained by net migration from a source habitat. Herein, I will use ''sink'' as a general term referring to both true sinks and pseudosinks. I define a true sink as one that, without immigration, has an equilibrium density of zero. A pseudosink is a viable population, but where deaths exceed births and immigrants exceed emigrants, thus, inflating population size above a nonzero equilibrium which would be realized if the population was isolated (Watkinson and Sutherland 1995). Distinguishing between the two requires experimental manipulation or

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information on density dependence in vital parameters. Because I have neither, I will use the general term ''sink'' hereafter.

There are several potential consequences of temporal variation in source–sink dynamics. An extreme example is a source–sink inversion, where a source switches to a sink and vice versa. Theoretical pursuits and anecdotal evidence suggest that such an inversion may occur on an evolutionary time scale, where an organism's adaptation to habitat of a sink population turns it into a source (Dias 1996). Source–sink inversions could hypothetically occur on an ecological time scale as well, caused by relatively rapid (i.e., seasonal) temporal variation in environmental factors. In another example, variation in environmental factors was shown to inflate the effects of sources on sinks, raising population sizes in sinks higher than if there were no variation. This has implications on community structure, potentially increasing the population size (thus, the community-wide impact) of a species that otherwise would have been rare or excluded (Holt et al. 2003). Also, numerous studies have demonstrated that variability, especially in conjunction with spatial synchrony (i.e., the Moran effect), can reduce population persistence times. Thus, studies that discount temporal variation in source–sink dynamics risk missing the complex dynamics of a system and its effects on community structure.

There is a paucity of empirical studies on temporal variation in source–sink dynamics, probably because of the difficulty in identifying the cause of temporal change and separating its effect from demographic variation. Boughton (1999), however, found a decline in quality of butterfly habitat over time, causing the population in the habitat to shift from a source to a sink. In a theoretical framework, Walters (2001) demonstrated how shifting patterns of resource productivity could alter the source–sink dynamics of deer in the northeastern United States.

Stochastic flooding of the Puerto Viejo River in Costa Rica completely inundated a subset of patches of a prayer plant, *Pleiostachya pruinosa* (Marantaceae), the host plant of *C. fenestrata*. In this study, I estimate survival and movement probabilities and per capita recruitment of *C. fenestrata* during both flood and nonflood periods. I ask the following questions. (1) Does flooding induce short- and long-term source–sink dynamics in this system? (2) If so, is this dynamic caused by flood-induced decreases in survival and recruitment? (3) Does observed directional movement of *C. fenestrata* support the presence of a source–sink dynamic? (4) Are the observed effects of flooding on population dynamics of *C. fenestrata* consistent among patches in the study area?

METHODS

Study site and study system

This study was carried out at La Selva Biological Station in the lowland tropical wet forest of Costa Rica (10°26′ N, 83°59′ W). La Selva is a 1500-ha reserve on the Caribbean slope contiguous with Braulio Carrillo National Park to the south. Mean (±1 SD) yearly rainfall at La Selva was 4242 ± 785 mm from 1958 to 2002 (La Selva Biological Station, meteorological data). Yearly rainfall during this study, 4152 mm (1999), 4465 mm (2000), and 5163 mm (2001), was within the normal range (0.11, 0.28, and 1.17 standard deviations from the mean, respectively).

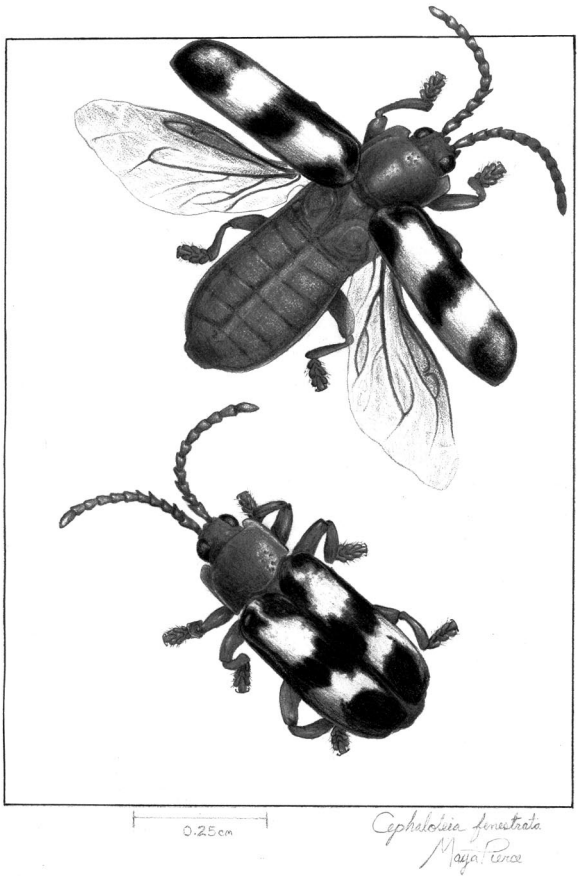

PLATE 1. *Cephaloleia fenestrata* Weise (Hispinae: Chrysomelidae: Coloptera). Illustration by Maya Pierce.

Cephaloleia fenestrata (see Plate 1) is a member of the guild of rolled-leaf hispines that feed on plants in the order Zingiberales and family Arecaceae (Staines 1996). Rolled-leaf beetles are so named because they live and feed primarily in the immature rolled leaves of their host plants. *C. fenestrata* is a specialist herbivore, spending its entire lifetime on *P. pruinosa* plants. Adults feed primarily on the tender tissue in rolled leaves. Females lay eggs and larvae feed and pupate in the concavity of the leaf petioles. Larval dispersal is minimal, probably limited to plants of which the leaves are touching (Strong 1977; D. Johnson, *personal observation*). Generation time of *C. fenestrata* is ~6 mo (Johnson 2003).

P. pruinosa grows in discrete patches ranging from one to 735 ramets in and near the floodplain of the Puerto Viejo River at La Selva Biological Station. I defined a patch as a group of *P. pruinosa* that are at least 17 m away from the nearest conspecifics (a distance determined in a concurrent metapopulation study so interpatch migration was below 20% [Johnson 2003]).

Flood frequency

The probability of a flood event in any 25-d period was estimated based on three years of data from December 1998 to October 2001 (D. Johnson, *unpublished data*). The 95% confidence interval was estimated based on the binomial distribution (Zar 1999). A definition of the flood zone that is most relevant to this study is an area covered by at least 1.5 m of water. This is deep enough to cover rolled leaves and leaf petioles, and thus, to inundate adults and immature stages.

Adult population dynamics

To detect the effects of flooding on adult *C. fenestrata* survival and movement, I conducted a mark–recapture study from January 1999 to January 2000 with 14 sample periods ~25 d apart. The sample area consisted of 75 *P. pruinosa* patches distributed primarily along a 1.5-km stretch of the Puerto Viejo River. Plants in 17 of the 75 patches were located in the flood zone of the river.

During each sampling period, all of the 75 patches were censused. *C. fenestrata* were removed from all rolled leaves with a diameter of 2 cm or greater at the apex. Each adult beetle was given a unique mark with a series of gentle punctures of the elytra. This marking method does not appear to harm the beetles (Unruh and Chauvin 1993; D. Johnson, *personal observation*). The leaves were carefully rerolled, and the beetles were released into the same rolled leaves from which they were removed.

To estimate parameters for survival, capture, and movement probability, analyses were run in the program MARK, version 1.8 (White and Burnham 1999). I estimated probabilities of survival (S), capture (p), and movement between the two strata (ψ; flood zone and upland) from a multistrata model. The product of survival and movement probabilities is represented by ϕ (Fig. 1). For example, the probability of a beetle in the upland (u) at time t being alive in the flood zone (f) at time $t + 1$ is expressed as $\phi_{uf} = S_u\psi_{uf}$. This model assumes that the survival of a beetle that moves between strata is the same as that of a beetle remaining in the donor stratum. Capture probability is defined as the probability of capturing an organism conditional on it being present in that stratum during that sample period.

I derived the most parsimonious two-stratum model by starting with the simplest model. The simplest model is denoted $S(.)p(.)\psi(.)$ in which the population pattern is explained by the three constant parameters: survival, recapture, and movement probabilities. A ''.'' indicates that the parameter is constant in all factor dimensions (time [t], habitat [h], and flood [f]). Then, in a forward step-wise fashion (i.e., t, $t + h$, $t + h + f$) for each of these parameters, I added functional dependency on the three factors. For example, the model described by $S(t)p(.)\psi(h,f)$ includes time-dependent survival, constant capture probability, and movement probability dependent upon both habitat and flood status. The model with the lowest Akaike's Information Criterion value (AIC, Akaike 1973) is the best fit model. Herein I report the ΔAIC value, which is the difference between the lowest AIC value and the AIC value of the generalized model.

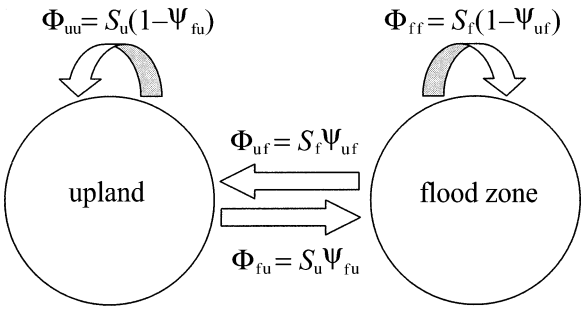

FIG. 1. Graphical illustration of a two-stratum mark–recapture model. The transition probability ϕ is the product of the survival probability S and the movement (or lack of movement) probability (ψ is the probability). Subscripts u and f refer to the upland and flood zone, respectively.

Recruitment

I surveyed immature stages of *C. fenestrata* on eight occasions at three-month intervals from March 1999 to December 2000. Immature stages (eggs, larvae, and pupae) were surveyed in the concavity of the leaf petioles of ramets in each patch. Mean and standard deviations of the stage-specific ratios (eggs:adult, larvae:eggs, pupae:larvae, and adults:pupae) were calculated to detect habitat specific differences in egg production and transition probabilities (an indicator of stage-specific survival probabilities).

The effects of flooding on larval *C. fenestrata* were investigated with a simulated flooding experiment. Flooding of *P. pruinosa* was simulated in a 1.5 m deep tub. Unchlorinated well water was pumped into the tub such that the water level rose at ~1 m/h until full. There were four treatments: 6 h, 12 h, 24 h, and a control (not flooded). Twelve to 14 potted *P. pruinosa* plants were used per treatment, each with one to 13 larvae.

Patch-level analyses

The source–sink analysis described in the next subsection treats the flood zone and upland each as one population. Each habitat, however, is composed of mul-

tiple patches (17 flood zone and 58 upland), both categories of which are distributed from one end of the somewhat linear study area to the other. Thus, each can be treated as an independent measure of the effects of flooding on population dynamics as compared to the other habitat. Numbers of adults and immatures in each patch were classified either as increasing, decreasing, or remaining the same following a flood. Fisher's exact test was used to test for significant differences in the numbers of increases and decreases between the upland and flood zone habitat concurrent with a flood.

Source–sink analysis

Following the birth-immigration-death-emigration (BIDE) model (Pulliam 1988), one must decouple local (recruitment and survival probability) and regional (immigration and emigration) sources to a population to detect source–sink dynamics. Herein, I first estimate habitat-specific population sizes and then decouple local and regional sources of these populations. Then I investigate source–sink dynamics in the system by calculating population growth rates with migration excluded from the estimations.

I estimated adult *C. fenestrata* abundance in habitat i at time t [$\hat{n}_i(t)$] by dividing the number of captures [$n_i(t)$] by the estimate of capture probability $\hat{p}_i(t)$,

$$\hat{n}_{\text{tot},i}(t) = \frac{n_i(t)}{\hat{p}_i(t)} \tag{1}$$

for each habitat: upland and flood zone. The total number of individuals in upland habitat i at time t can be separated into three categories (survivors, recruits, and immigrants from patch j):

$$n_{\text{tot},i} = n_{\text{surv},i}(t) + n_{\text{recr},i}(t) + m_{ij}(t). \tag{2}$$

The number of beetles moving from habitat j to i [$\hat{m}_{ij}(t)$] was estimated by multiplying the abundance [$\hat{n}_j(t-1)$] and probability of survival [$\hat{S}_j(t-1)$] in patch j, and movement probability from j to i [$\hat{\psi}_{ij} = (t-1)$]:

$$m_{ij}(t) = \hat{n}_{\text{tot},j}(t-1)\hat{S}_j(t-1)\hat{\psi}_{ij}(t-1). \tag{3}$$

The number of survivors from time $t-1$ to t in habitat i is estimated by the product of estimated population size at time $t-1$ and the probability of surviving and staying within the habitat:

$$\hat{n}_{\text{surv},i}(t) = \hat{n}_{\text{tot},i}(t-1)\phi_{ii}(t-1). \tag{4}$$

The number of recruits in habitat i at time t could then be estimated by subtracting the estimated number of survivors and immigrants from the total estimated in Eq. 1:

$$\hat{n}_{\text{recr},i}(t) = \hat{n}_{\text{tot},i}(t) - \hat{n}_{\text{surv},i}(t) - \hat{m}_{ij}(t). \tag{5}$$

The time-specific population growth rate in a given habitat was estimated by dividing the estimated number of beetles ''produced'' in the habitat (survivors, emigrants, and recruits) by the estimated number of beetles in the habitat during the previous time step:

$$\lambda_i(t) = \frac{\hat{n}_{\text{surv},i}(t) + \hat{m}_{ji}(t) + \hat{n}_{\text{recr},i}(t)}{\hat{n}_{\text{tot},i}(t-1)} = \frac{\hat{n}_{\text{tot},i} + \hat{m}_{ji}(t) - \hat{m}_{ij}(t)}{\hat{n}_{\text{tot},i}(t-1)}. \tag{6}$$

Variance for the numerator and denominator of Eq. 6 was calculated assuming a binomial distribution (Zar 1999). Variances of λs were calculated based on the delta method for calculating the variance of a ratio (Lynch and Walsh 1998) assuming independence of the estimates of the numerator and denominator. Standard error in a binomial distribution is the square root of the variance (Zar 1999).

To estimate long-term population growth rates at different flooding probabilities, simulations were run where the flood probability in any 25-d period was varied from 0 to 0.3. For each of 1000 time steps, a flood or nonflood period was randomly selected based on the given flood probability. When a flood period was randomly sampled, the population growth rate from the corresponding flood period was selected. During a simulated nonflood period, the population growth rate was randomly selected from the empirical distribution of population growth rates during nonflood periods. The long-term population growth rate for each flood probability was estimated by calculating the geometric mean of the series of 1000 population growth rates.

RESULTS

Flood frequency

The Puerto Viejo River flooded in four out of 44 25-d periods over the course of this study: December 1998, November 1999, December 2000, and June 2001. The estimated probability of a flood event in a 25-d period is 0.091 with a 95% confidence interval of 0.025–0.216. The Puerto Viejo River flooded on two occasions that affected the mark–recapture study: in December 1998 (one month prior to initiation of the mark–recapture study), and in late November 1999 (between the 12th and 13th sampling periods).

Adult population dynamics

Over the year-long study, I uniquely marked 1199 adult beetles and recorded a total of 2019 captures. An average of 144 ± 31 (mean ± 1 SD) adult beetles was captured per sampling period. In the upland, the numbers of captures ranged from 88 to 163 per sampling period. The numbers of captures in the flood zone ranged from 0 to 71. The upland contained an estimated 2508 ramets of *P. pruinosa* compared to 642 ramets in the flood zone. Thus, based on estimated capture probabilities (see next paragraph), there was a range of 0.109–0.203 captures per ramet in the upland (coeffi-

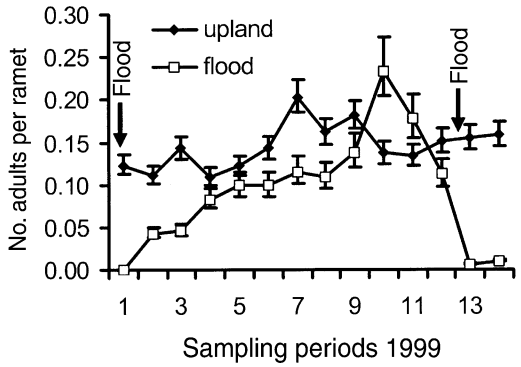

FIG. 2. *Cephaloleia fenestrata* density (mean ± 1 SE) in the upland and flood zone. A flood preceded the first and 13th sampling periods. Arrows indicate flood events.

cient of variation = 0.18) and 0.000 to 0.230 captures/ramet in the flood zone (coefficient of variation = 0.74; Fig. 2). Following the December 1998 flood, no adult beetles were captured in the flood zone. In the subsequent sample periods, density in the flood zone continued to increase and by the 10th sample period surpassed that of the upland (0.23 vs. 0.14 adult beetles per ramet, respectively). However, by the 12th sample period, density in the flood zone had dropped below that of the upland, and by the 13th sampling period, after the November 1999 flood, density in the flood zone dropped to fewer than 0.01 captures per ramet.

The most parsimonious multistrata model [$(S(t,f)p(h)\psi(h,f)$, 25 parameters] was a significantly better fit than the generalized model [$(S(t,h)p(t,h)\psi(t,h)$, 71 parameters] as indicated by a ΔAIC = 17.79. In the most parsimonious model, survival probability was significantly dependent on time (Likelihood ratio test, $\chi^2 = 40.241$, df = 12, $P = 0.0001$), but not on habitat, except for during the flood period. During the flood period, survival in the flood zone ($S = 0.11 \pm 0.07$) was reduced to 1/7 of the survival in the upland ($S = 0.76 \pm 0.09$; $\chi^2 = 23.34$, df = 1, $P < 0.0001$; Fig. 3). All

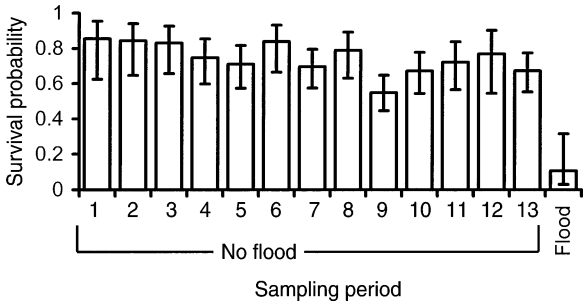

FIG. 3. Survival probability (mean ± 1 SE) of *C. fenestrata* adults over 13 sampling periods in 1999. Sampling periods 1–11 and 13 represent the combined survival probability in the upland and flood zone. The sampling period labeled ''12'' is the survival probability in the upland only. The survival probability labeled ''Flood'' occurred in the flood zone during the 12th sampling period (when the habitat flooded).

TABLE 1. Pairwise likelihood ratio tests for significance of fits of the independent variables (time, habitat, and flood) to dependent variables (survival, capture probability, and movement) in the selected model.

Dependent variable	Independent variable	χ^2	df	*P*
Survival	time	40.24	12	0.0001
Survival	flood	23.34	1	<0.0001
Capture probability	habitat	17.35	1	<0.0001
Movement	habitat	8.38	1	0.0038
Movement	flood	6.37	1	0.0116

probabilities reported herein are for any 25-d period. Except in the flood zone during a flood, survival probability ranged from 0.55 to 0.86. Beetles were 1.7 times more likely to be captured in the flood zone than in the upland ($p_f = 0.47 \pm 0.03$; $p_u = 0.32 \pm 0.02$; $\chi^2 = 17.35$, df = 1, $P < 0.0001$). Movement was affected by habitat ($\psi_{uf} = 0.015 \pm 0.003$ and $\psi_{fu} = 0.05 \pm 0.02$ during nonflood periods; $\chi^2 = 8.38$, df = 1, $P = 0.0038$) and movement from the flood zone to the upland was affected by flooding (during a flood $\psi_{fu} = 0.76 \pm 0.23$; $\chi^2 = 6.37$, df = 1, $P = 0.01$). A summary of likelihood ratio statistics testing the significance of effects in the selected model is provided in Table 1.

Recruitment

The mean densities of immature stages were all higher in the upland than in the flood zone, while the coefficient of variation was higher in the flood zone (Table 2). Immature density was always lower in the flood zone than in the upland immediately following a flood (sign test; $P < 0.05$; Ambrose and Ambrose 1987). Egg densities in the flood zone increased and matched those of the upland by 3–6 mo following floods. Larval density in the flood zone increased and matched those of the upland following the first flood; but after the second flood they remained below that in the upland. Pupal density in the flood zone required 6–9 mo after a flood to recover to nonflood levels.

To test for stage-specific differences in *C. fenestrata* egg production and immature transition probabilities, I compared ratios of successive stages between the upland and flood zone habitat. There were no detectable between-habitat differences in egg:adult (*t* test, df = 4, $P = 0.80$), larvae:eggs (*t* test, df = 10, $P = 0.63$), pupae:larvae (*t* test, df = 10, $P = 0.053$), and recruits:

TABLE 2. Densities (per ramet), standard deviations, and coefficients of variation (CV) of immature *Cephaloleia fenestrata* (a rolled-leaf beetle) on *Pleiostachya pruinosa* (a prayer plant) in the upland and flood zone habitats.

Stage	Upland			Flood zone		
	Mean ± 1 SD	CV	*N*	Mean ± 1 SD	CV	*N*
Eggs	0.09 ± 0.04	0.47	8	0.06 ± 0.05	0.92	8
Larvae	0.21 ± 0.04	0.21	8	0.14 ± 0.09	0.62	8
Pupae	0.03 ± 0.02	0.70	8	0.01 ± 0.01	1.50	8

TABLE 3. Effects of three simulated flooding regimes (24 h, 12 h, and 6 h of submersion) and respective controls on the survival of *C. fenestrata* larvae.

Treatment	No. larvae	Survival probability	No. plants with: Increase/ same no. larvae	No. plants with: Decrease in no. larvae	Contingency table analyses χ^2	df	*P*
24-h flood	33	0.00	0	14	16.09	3	0.002
Control	47	0.96	9	3			
12-h flood	39	0.00	0	14	13.49	3	0.007
Control	45	0.98	8	4			
6-h flood	33	0.94	8	4	0.00	3	1.000
Control	44	0.68	8	4			

pupae (*t* test, df = 4, $P = 0.68$) ratios. Thus, there was no evidence for differences in per capita recruitment or stage-specific immature survival probabilities between habitats.

There was, however, evidence for flooding reducing survival probability in larvae. In the flooding experiment, one-day survival probability of the larvae in the 12- and 24-h treatments was 0% ($N = 39$ and 33, respectively) compared to 96% and 98% in the respective controls (Table 3; contingency table analysis; $P = 0.002$ and 0.007, respectively). There was no difference in changes in the number of larvae between the 6-h flood and the control ($P = 1.00$).

Patch-level analyses

To demonstrate that the effect of the flood was consistent throughout the flood zone, I compared the number of beetles in the flood zone and in the upland on a patch-by-patch basis before and after the November 1999 flood. The patches were sampled one week after the flood, leaving little time for beetles to recolonize the area. In the sampling that followed the flood, immature population size decreased in a significantly higher proportion of patches in the flood zone (10 decreased and zero increased) than in the upland (17 decreased and 12 increased; Fisher's exact test, $P = 0.03$).

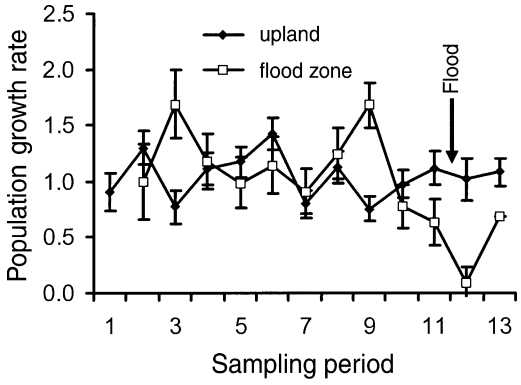

FIG. 4. Time-specific population growth rates (and 95% confidence intervals) in the upland and flood zone habitat. The flood zone flooded between the 11th and 12th sampling periods.

Likewise, adult population size decreased in a significantly higher proportion of the patches in the flood zone (eight decreased and zero increased) than in the upland (six decreased and eight increased, Fisher's exact test, $P = 0.03$).

Source–sink analysis

Time-specific population growth rates for a 25-d period were calculated for the upland and flood zone habitats (Fig. 4). With a Bonferroni correction for the number of lambdas estimated, none of the population growth rates were significantly different from 1 except for that for the flood zone in sampling period 12 just before the flood ($\hat{\lambda}_f = 0.63 \pm 0.10$ [mean ± 1 SE], $Z = 3.62$, $P = 0.0001$) and that for sampling period 13 just after the flood ($\hat{\lambda}_f = 0.08 \pm 0.04$, $Z = 21.28$, $P < 0.0001$). This suggests that the flood zone becomes a sink habitat when it is flooded. When the habitats were not flooded, the population growth rates in the upland and the flood zone were similar ($\hat{\lambda}_u = 1.02 \pm 0.06$, $n = 14$ sampling periods; $\hat{\lambda}_f = 1.03 \pm 0.11$, $n = 13$ sampling periods; *t* test, $P > 0.05$). Thus, during nonflood periods, there appears to be no source–sink dynamics between the upland and flood zone habitats.

The low numbers of beetles in the flood zone after the flood resulted in a migration imbalance, meaning that a greater number of beetles migrated from the upland to the flood zone than vice versa (Fig. 5A). As the time since that flood lengthened, the population attained approximately balanced dispersal. Nonetheless, overall, significantly more beetles dispersed from the upland to the flood zone than vice versa (*t* test, df = 13, $P = 0.006$; Fig. 5B).

Bootstrap estimates of the population growth rate with different flood frequencies are provided in Fig. 6. Above, I calculated the 95% confidence interval the probability of flooding to be 0.025–0.216 in any 25-d period. The estimated population growth rate within this range of flood probabilities is less than one, suggesting that the population in the flood zone is a sink in the long term (in the order of years). The analysis suggests that the flood zone could be a source habitat if flooding frequency were less than 0.01 floods per 25-d period (or ~0.14 floods per year).

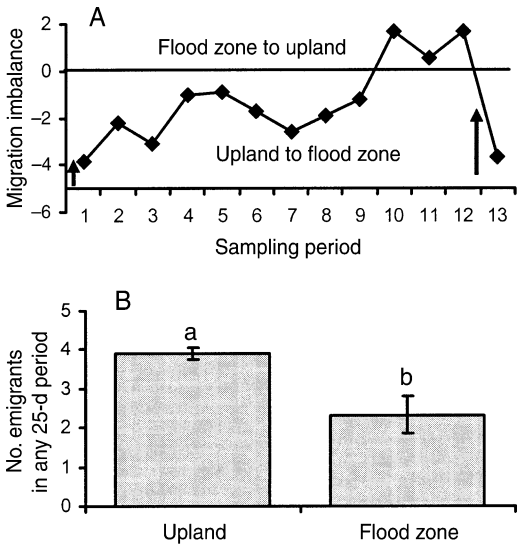

FIG. 5. (A) Estimated migration imbalance over time (total number of migrants between upland and flood zone per time step) and (B) number of emigrants in any 25-d period (±1 SE) between the upland and flood zone habitats. Migration imbalance is the net movement of beetles between the two habitats (i.e., a negative value indicates that more beetles moved from the upland to the flood zone than the opposite direction). Lowercase letters indicate that the overall direction of movement was significant between the upland and the flood zone. Arrows indicate flood events.

DISCUSSION

Despite theorists' focus on source–sink dynamics (Holt 1985, Pulliam 1988, Watkinson and Sutherland 1995, Loreau and DeAngelis 1997), few empirical studies have provided strong evidence for sources and sinks in nature. Although comparative movement across habitats is an integral part of source–sink theory (Pulliam 1988), field studies with information on immigration and emigration are generally lacking (but see Breininger and Carter 2003, De Bruijn 1994, and for a laboratory system see Donahue et al. 2003). Some studies circumvented the problem of measuring migration by assuming that migration had negligible effects on population sizes (Brawn and Robinson 1996, Boughton 1999), or that differences in net migration between habitats were zero (Walters 2001). These essentially assumed balanced dispersal, a postulate counter to fundamental source–sink theory (Diffendorfer 1998). Source–sink dynamics can be demonstrated without observing actual movement events if habitats are closed systems in which two habitats can be experimentally connected and isolated (Kadmon and Tielbörger 1999, Amezcua and Holyoak 2000). In such a case, sources, true sinks, and pseudosinks are distinguishable. In the present study, I individually marked adult *C. fenestrata*; thus, recapture data provided both immigration and emigration data. The data indicated that ~80% more beetles dispersed from the upland to the flood zone than vice versa over the course of a year.

Movement rates of *C. fenestrata* for a 25-d period were low (<5%) except during flood events when the probability of migration from the flood zone to the upland increased to 76%. Doak (1995) demonstrated that the viability of a source–sink population of grizzly bears is sensitive to movement rates, in which low movement rates between habitats facilitate high population viability, and high rates of movement endangered the population. Thus, if movement from the source to the sink is too great, the source cannot maintain its own population density. The population density of *C. fenestrata* in the upland remained near an equilibrium level, suggesting that the population growth rate of this source habitat is sufficient to maintain even with the observed levels of emigration.

The data indicate that a nearly sevenfold reduction in *C. fenestrata* adult survival probability in the flood zone during a flood event was the primary cause of the flood zone being a sink. In periods without flooding, survival probability did not differ between upland and flood zone habitat. Nor did per capita recruitment differ between habitats. These findings are similar to those of the Iberian lynx in which a sink was characterized by a reduction in survival but there was no difference in fecundity (Gaona et al. 1998).

The present study empirically demonstrates temporally variable source–sink dynamics (as do Virgl and Messier [2000] and Walters [2001]). Boughton (1999) found that the same population acted as a source for resident butterflies, but as a sink for immigrant butterflies. The difference was caused by a difference in the timing of oviposition between residents and immigrants. Timing is important in the *C. fenestrata* system as well. Beetles in the flood zone during flood periods suffered high mortality, thus making the flood zone a sink. Conversely, in periods without flooding, population growth rates were no different between habitats.

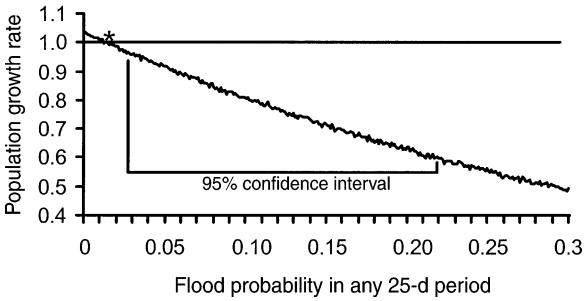

FIG. 6. Projected population growth rate in the flood zone as a function of flood frequency. Population growth rate was estimated by bootstrapping observed population growth rates during flood and nonflood periods. The 95% confidence interval was calculated from the binomial distribution based on four observed flood events over 44 sampling periods (N = 44, mean = 0.091, 95% confidence interval 0.025–0.216). The asterisk indicates the threshold for becoming a source habitat.

Floods greatly reduced the densities of *C. fenestrata* adults in the flood zone. A simulated flood experiment showed that larvae suffer nearly 100% mortality when their host plants are flooded for 12 h or more, conditions that occurred during the November 1999 flood (D. Johnson, *personal observation*). In accordance, immature densities were lower in the flood zone than in the upland in this study.

In this study, source–sink dynamics were driven by flooding. Source–sink dynamics were expected in a population of Sitka mice in and near a floodplain, but instead it was found that differences in demographic parameters were greater between replicate sites than between the floodplain and upland (Hanley and Barnard 1999). Doak (1995) demonstrated how habitat degradation due to disturbance can significantly affect source–sink dynamics of grizzly bears. The patch-level analysis in my study demonstrates that the negative effects of flooding on *C. fenestrata* are consistent across patches in the flood zone.

In source–sink theory, the population growth rate (λ) in a source is greater than one and in a sink is less than one in the absence of immigration (Pulliam 1988). Based on these criteria, the flood zone is a long-term sink habitat for *C. fenestrata*. The sink seems to be caused mainly by high mortality of both adults and larvae during a flood. While determining that the flood zone was a sink habitat suggests that the upland is a source, this cannot be confirmed by this study because the estimated population growth rate in the upland was not significantly different from one. An alternative possibility is that a *C. fenestrata* population outside the study area acts as the source. This is unlikely because known dispersal distances (Johnson 2003) are less than the distance to the nearest *C. fenestrata* populations outside the study area. The more likely explanation is that the population growth rate in the upland actually is above 1. This explanation is supported by the observed overall directional migration of *C. fenestrata* from the upland to the flood zone.

Distinguishing between true sinks and pseudosinks is not a trivial task. A pseudosink will look like a true sink in that its level of population density is maintained by immigration from a source habitat (e.g., Holt 1985). The difference between the two is that in the absence of immigrants from a source, a true sink will go extinct while a pseudosink will still be viable, just at a lower population size. A pseudosink has density dependence in vital rates where, for example, if survival probability is negatively related to population density then immigration would be required to maintain a high density, but would not be required to maintain a low density. I do not have information on density dependence of vital rates for *C. fenestrata*. Mortality caused by flooding, however, was the primary cause of sink dynamics in the flood zone and would likely act in a density-independent fashion, thus, suggesting that the flood zone is a true sink rather than a pseudosink.

Asking whether a system displays source–sink dynamics requires stating a time scale and moment at which population growth rates are measured. In this study, I demonstrated that population growth rates varied above and below unity in an expanding and contracting population. During flood periods the flood zone acted as a strong sink while during non-flood periods there was no sink dynamic in the flood zone. Whether the flood zone was a long-term sink or not was dependent on the frequency of flooding. These results illustrate the importance of accounting for temporal variation and explicitly defining the time scale examined when investigating source–sink dynamics.

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Aquatic Sciences

Overview Article

Biodiversity and its conservation in the Pantanal of Mato Grosso, Brazil†

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Abstract. The Pantanal of Mato Grosso, Brazil, is famous for its luxurious plant and animal life. We combine a literature review with recent work and show that species diversity is large but that most major plant and animal groups contain a large number of not wetland-specific species that depend on permanently terrestrial habitats within the Pantanal, or are restricted to dry areas during the low water period. These species occur also in the neighbouring biomes of Cerrado, Amazon Forest or Chaco. Until now, very few endemic species have been described, however, there are large populations of species in the Pantanal that are considered rare or endangered in South America. The number of trees adapted to long term flooding is low in comparison with the Amazon River floodplain. We hypothesize that the reason for the lack of local endemisms and the occurrence of a large number of species with a large ecological amplitude is the climatic instability of the region of the Pantanal, which suffered severe drought during glacial periods. The instability of the actual climate, which is characterized by multi-annual wet and dry periods, has a strong impact on distribution, community structure and population size of many plant and animal species and hinders spatial segregation of populations. The dependence of the system on the flood pulse makes the Pantanal very vulnerable to human induced changes in hydrology and the predicted changes in global climate.

Key words. Pantanal; seasonal wetland; floodplain; neotropics; Paraguay River.

Introduction

Wetlands are among the most fragile and threatened ecosystems on earth as they are subject to the impact of human activities – both on land and in water (Gopal and Junk, 2000). They accumulate substances from the catchment area that can be detrimental to environmental conditions and wetland organisms. Changes in hydrology, as for instance water deviation for agriculture, channelization to improve ship traffic or the construction of dams for hydroelectric power generation, may seriously affect fundamental wetland structures and functions. Natural

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† Dedicated to our collegue Dr. Vangil Pinto da Silva, who was killed in March 2004 by African bees during an excursion in the Pantanal.

multi-annual dry and wet episodes affect wetlands much more than most other ecosystems because a change in the annual amount of precipitation of a few decimeters often changes considerably the area covered by water, the water depth and the water balance with dramatic consequences for the organisms living there.

Despite a heavy and still increasing human pressure on extent and integrity of wetlands in general and tropical wetlands in specific (Junk, 2002; Tockner and Stanford, 2002), there are heavy deficits in knowledge of aquatic biodiversity, mostly in the tropics. Studies concentrate on few plant and animal groups only and often draw conclusions about biodiversity from rather incomplete species lists. Ecological information is dispersed in individual publications and there is a lack of a comprehensive analysis of the available data under conceptional considerations.

The Pantanal of Mato Grosso, a large wetland in the center of South America, is a good example for this situation. A comprehensive taxonomic inventory exists about fishes (Britski et al., 1999). A checklist of the flora was published by Pott and Pott (1996). Aquatic macrophytes have been well described including information on growth form and utility by Pott and Pott (2000). Regional inventories also exist of terrestrial grasses, herbs and trees (Prance and Schaller, 1982; Prado et al., 1992; Lemes do Prado et al., 1994; Schessl, 1999). Dispersed information is available about vertebrates, however at varying level of taxonomic and geographic scope, e.g., Schaller (1983) and Mauro and Campos (2000) on mammals from the municipality of Corumbá, Cintra and Yamashita (1990) and Strüssmann and Sazima (1993) on birds and snakes, respectively, from the region of Poconé, and Leite et al. (1998) on bats from Aquidauana and Nhecolândia. Gray literature from the Pantanal largely surpass indexed articles and there are many doubtful and not documented records. Inventories of aquatic and terrestrial invertebrates are incomplete or totally missing. First attempts have been made to relate general information on biodiversity with ecological concepts (da Silva et al., 2001).

In this paper we summarize data on species numbers of major plant and animal groups and classify them according to their distribution and life form under the theoretical framework of the Flood Pulse Concept (Junk et al., 1989; Junk, 2005; Junk and Wantzen, 2004). The description of the species categories reflects the differences in the amount of available information. References are given to the neighbouring Amazon River floodplain that shares many species with the Pantanal, but differs with respect to environmental variables, such as amount and distribution of rainfall, amplitude of the flood pulse, and nutrient status of water and sediments. The results are discussed in the light of the data about actual climate and paleoclimatic history, management policy and predictions about global climatic change.

Definition and classification of wetland species

The Pantanal belongs to the category of temporary wetlands subject to a predictable monomodal flood pulse (Junk et al., 1989). This wetland type is very common in the tropics and sub-tropics with a strongly seasonal rainfall pattern. Large parts of these wetlands become completely dry during the low water period and are colonized by terrestrial plant and animal species that may or may not be wetland specific. However, these species are integral parts of the wetlands because they contribute considerably to bioelement cycles, food webs, primary and secondary production, community structure and biodiversity.

These considerations have been taken into account by Gopal and Junk (2000) who define as wetland species "all those plants, animals and microorganisms that live in a wetland permanently or periodically (including migrants from adjacent or distant habitats), or depend directly or indirectly on the wetland habitat or on another organism living in the wetland". To be useful in practice, this comprehensive definition requires a subdivision in different categories according to distinct taxonomic units: (a) residents of the proper wetlands (specific to wetlands in general with a subgroup of endemics and residents not specific to wetlands), (b) regular migrants from deep water habitats, (c) regular migrants from terrestrial uplands, (d) regular migrants from other wetlands (for instance waterfowl), (e) occasional visitors, and (f) those dependent on wetland biota (for instance epiphytes, canopy invertebrates, and parasites).

This broad view and classification of species living in wetlands allows further sub-classification according to adaptations and life history traits that are driven by specific environmental variables. The level of complexity of reactions of the biota to the environmental conditions of a specific wetland is, in addition to the number of species and their singularity, an important parameter for environmental analyses. It allows the formulation of criteria for comparison of biodiversity between wetlands and the development of hypotheses about their role in speciation of organisms. A broad definition of wetland biodiversity is also essential for the management of biodiversity in a landscape perspective.

Ecological characterization of the Pantanal

The Pantanal is situated in the depression of the upper Paraguay River 16–20° S and 55–58° W that extends between the old crystalline shield of Central Brazil and its transition zone to the foothills of the geologically young Andes. The upper Paraguay River catchment area covers about 496,000 km^2, the Pantanal about 160,000 km^2, of which about 140,000 km^2 belong to Brazil, 15,000 km^2 to

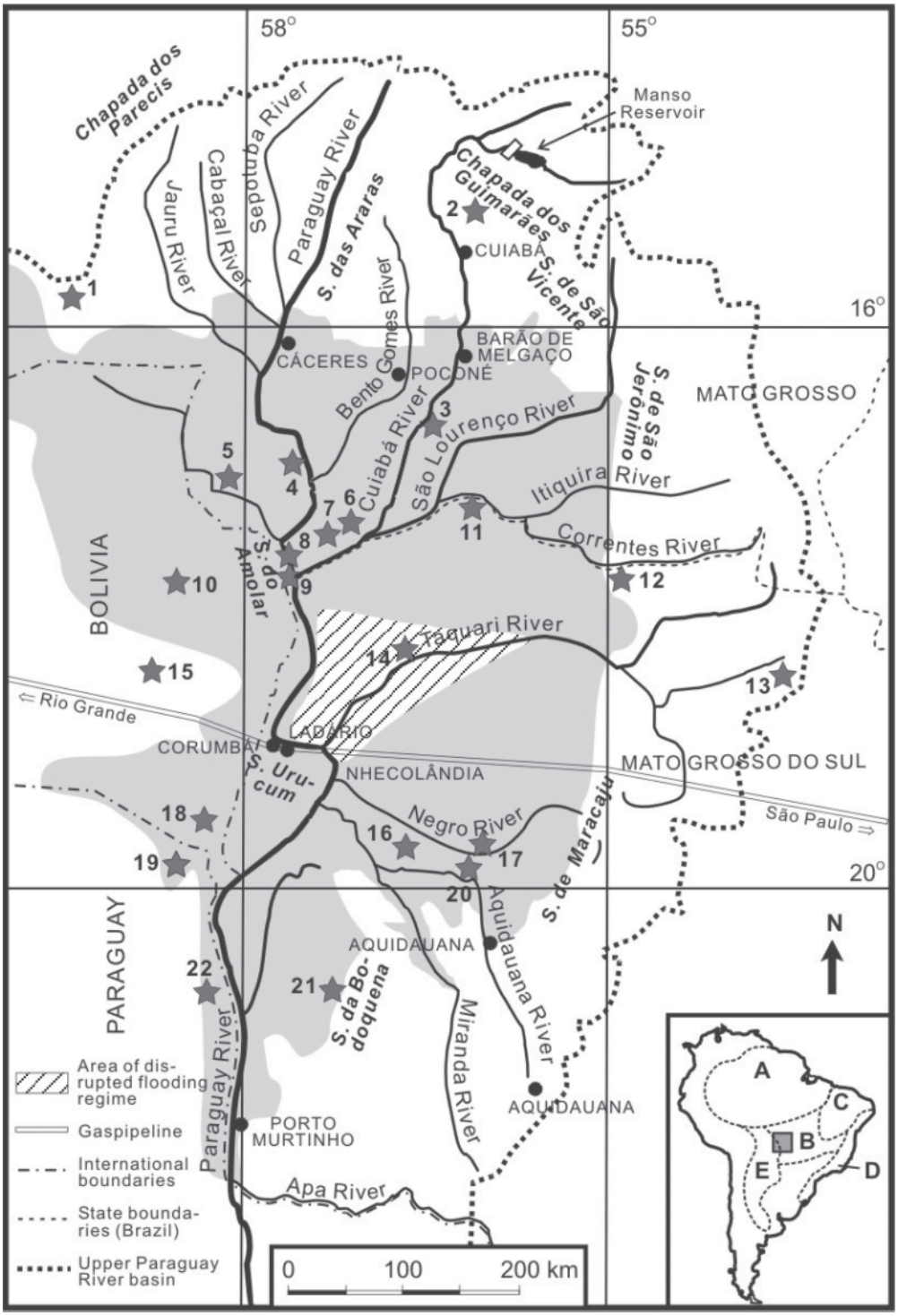

Figure 1. Map of the Pantanal and its catchment area and position of protected areas. 1 = Serra de Ricardo Franco State Park, 2 = Chapada dos Guimarães National Park, 3 = Serviço Social do Comércio Pantanal Private Reserve, 4 = Ecological Station Taiamã, 5 = Guira State Park, 6 = Private Reserve Dorochê, 7 = Pantanal National Park, 8 = Private Reserve Acurizal, 9 = Private Reserve Penha, 10 = National Reserve of Integrated Management San Matias, 11 = Fazenda Poleiro Grande Private Reserve, 12 = Serra de Sonora State Park, 13 = Nascentes do Rio Taquari State Park, 14 = Fazenda Nhumirim Private Reserve, 15 = Reserva Municipal del Valle de Tucavaca, 16 = Complex of the Pantanal do Rio Negro State Park and the Private Reserves Fazendinha and Santa Sofia, 17 = Fazenda Rio Negro Private Reserve, 18 = National Park and National Reserve of Integrated Management Otuquis, 19 = Rio Negro National Park, 20 = Dona Aracy Private Reserve, 21 = Serra da Bodoquena National Park, 22 = Fazenda Rancho Seguro and Tupaciara Private Reserves. For details see chapter 6. The hatched area around Nr. 14 indicates the area affected by the the hydrological changes at the lower Taquari River. The small map indicates the position of the Pantanal in South America and the biomes indicated in the text. A = Amazon forest, B = Cerrado, C = Caatinga, D = Atlantic forest, E = Chaco.

Bolivia and 5,000 km^2 to Paraguay (Fig. 1). The main period of subsidence resulting in the wetland depression is very likely related to the last compressional pulse of the Andes during the upper Plio- lower Pleistocene about 2.5 million years ago. The depression is surrounded by different geological formations which form the catchment area of the upper Paraguay River and its tributaries (Ussami et al., 1999). On the Brazilian side, eastwards, most common are sandstones of different age (Chapada dos Parecis, Chapada dos Guimarães, Serra de Maracaju, Serra de São Jeronimo). The Serra das Araras and Serra da Bodoquena are build by limestones (Fig. 1). There are also some minor granitic outcrops (Serra de São Vicente). In the western border Precambrian massifs of Urucum and Amolar establish abrupt ecotones with the seasonally flooded plains of the Brazilian Pantanal.

The major part of the depression is covered by leached Pliocene/Pleistocene sediments of fluvial and lacustric origin which are in part consolidated and lateritic. They are sandy and acidic with varying clay content and high aluminum content. 92 % are hydromorphic, 66 % are sandy and 70 % are of low fertility (Amaral Filho, 1986). In some areas soils have a high sodium content (RADAM-Brasil, 1982). Along the river courses deposits of recent sediments are found.

The Pantanal is situated in a circumglobal belt of climatic instability. Dramatic climatic changes during the Quaternary led to intermittent periods of large scale flooding and severe drought. During the last glacial period rainfall in the catchment area of the Paraguay River was much lower than today. Superficial but intense erosive processes in neighboring plateaus occurred, as well as continuous accumulation of sediments inside the depression, as indicated by studies on the alluvial fan of the Taquari River (Short and Blair, 1986; Ab'Saber, 1988). The Pantanal was almost dry and offered only scarce opportunities for wetland ecosystem development. During the Holocene, the Pantanal passed through different climatic episodes that are not fully understood yet (Assine and Soares, 2004). The following climatic episodes can be distinguished: 40,000–8,000 BP cool and dry, 8,000–3,500 BP warm and wet, 3,500–1,500 BP warm and dry and 1,500–Present warm and wet (Iriondo and Garcia, 1993, Stevaux, 2000).

Today, the climate in the Pantanal is hot with a pronounced dry season from May to September and a rainy season from October to April (Fig. 2). Annual rainfall decreases from 1,250 mm in the northern part near Cáceres to 1,089 mm in the southern part near Corumbá. Near Cuiabá, mean monthly temperature varies between 27.4 °C in December and 21.4 °C in July. Short-term ingressions of subpolar air masses can lead to a drop in air temperature to 0 °C. Pluriannual extreme dry and wet periods lead to extreme flood and drought events combined with large wild fires inside the Pantanal with dramatic consequences for fauna and flora (Fig. 3).

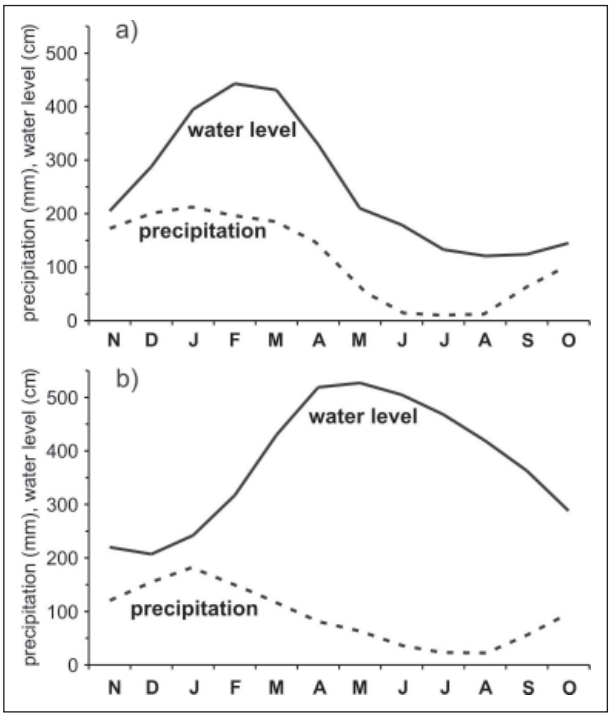

Figure 2. a) Mean monthly precipitation near Cuiabá (1933–1993) and mean water level of the Cuiabá River at Cuiabá (1971–1988), northern Pantanal, (according to Zeilhofer, 1996), and b) mean monthly precipitation near Corumbá (1912–1971) and mean water level of the Paraguay River at Ladário (1979–1987), southern Pantanal (according to Hamilton et al., 1999).

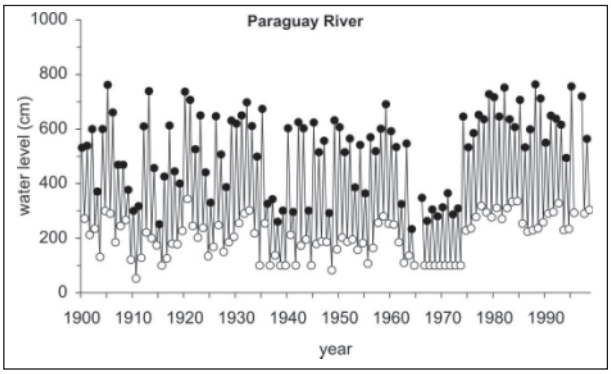

Figure 3. Annual water level fluctuations of the Paraguay River at Ladário from 1900 to 2000 (data according to DNAEE – Departamento Nacional de Águas e Energia Elétrica). ● = maxima; ○ = minima.

Flooding occurs by transbording rivers and local rainfall. Therefore the flood regime inside the Pantanal is variable and flow direction in the drainage system may change frequently from and to the river depending on the relationship of local rainfall and river stage. Because of the slight declivity of the terrain of 2–3 cm per kilometre in north to south and 5–25 cm in east to west direction flood waters require about 3–4 months to pass the Pantanal (Alvarenga et al., 1984). Therefore the flood pulse in the northern part coincides with the rainy season but

there is a time lag of about 3 months between rainy season and flooding in the southern part (Fig. 2b).

Different discharge patterns of the Paraguay River and its tributaries during geological time periods resulted in a mosaic of geomorphologic formations and large habitat diversity inside the Pantanal (Jimenez-Rueda et al., 1998). Remnants of paleo-levees, for example, which rise one to two meters above the mean flood level, locally called *capão,* if circular, and *cordilheira*, when string-like, occur throughout the Pantanal and are important habitats for little flood adapted plants and refuges for terrestrial animals during floods. A characterization of the different habitats is given by Nunes da Cunha et al. (in press) and Wantzen et al. (2005).

Tributaries of the Paraguay River have individual flood patterns and sediment load. Therefore the Pantanal has been divided into 10 different subunits by Adámoli (1981), 12 subunits by Alvarenga et al. (1984), and 11 subunits by Silva and Abdon (1998). Flooding level and discharge of the sub-basins varies considerably according to regional rainfall (Hamilton et al., 1996).

Because of the large impact of local rainfall, the chemical composition of the water of the Paraguay River and its large tributaries can be traced only in areas near the river channels. Biogenic processes and evapotranspiration further modify the chemical characteristics of the water bodies inside the Pantanal. Depending on the position in the floodplain, lake water can be concentrated by evaporation, diluted by rainwater and enriched or diluted by the rivers. Mean electrolyte content of the upper Paraguay River is 47 μS cm^{-1} that of major tributaries varies between 32 μS cm^{-1} (Taquari River) and 159 μS cm^{-1} (Miranda River). Electric conductance of permanent lakes varies between 10 and 240 μS cm^{-1}. Isolated lakes (*salinas*) in the southern Pantanal have brackish water with electric conductance of up to 5,200 μS cm^{-1}. pH values in rivers and lakes vary between 5.5 and 7.5 but reach up to 9.8 in salinas (Hamilton et al., 1999). Algal blooms are frequently observed during low water period because of nutrient enrichment by decomposing organic material and animals that concentrate in and around remaining water bodies. Large differences in water chemistry and hydraulic conditions between catchment zone streams and floodplain water bodies inhibit a colonization of the Pantanal by rheophilic and oxygen-demanding aquatic organisms from the small tributaries, such as many fish species and Podostemaceae (Willink et al., 2000).

Biodiversity of different plant and animal groups

Algae

Algae occur in the Pantanal as periphyton on macrophyte roots and logs, as phytoplankton in lakes and rivers and – as an intermediate form of both types – as flakes of metaphyton, i.e. conglomerates of algae (mainly desmids and diatoms) and dead organic matter (Adler, 2002). The organic core of these flakes derives mostly from decomposing macrophytes (e.g., Fellerhoff et al., 2003). We believe that many of the algal species can occur in all three communities.

Table 1. Number of the algae species in the Pantanal according to De-Lamônica-Freire and Heckman (1996). The Desmidiaceae (numbers in parentheses) make up the largest part of the Chlorophyta. Some taxa occur during more than one phase of the flooding cycle.

		Water level			
	Sum	rising	high	falling	low
Cyanophyta	17	7	0	6	9
Euglenophyta	56	30	11	17	44
Pyrrophyta	2	1	0	0	2
Chlorophyta	226	127	124	82	77
Desmidiacea	(138)	(78)	(92)	(61)	(30)
Chrysophyta	7	3	1	3	7
Bacillariophyta	28	11	8	18	21
Charophyta	1	0	0	1	0
Total	337	179	144	127	160

Currently, 337 species have been identified from various floodplain habitats in the Pantanal, most of which are cosmopolitan or circumtropical (De-Lamônica-Freire and Heckman, 1996; Table 1). Following the floodpulse-induced change from dilution and concentration of the nutrients, the algae show a characteristic seasonal change. During the rising water period, diversity was reduced and tolerant species like *Scenedesmus quadricauda* and *Closterium ehrenbergi* prevailed. When the water level was highest, the water became crystal clear, as planktonic and benthic algal densities were strongly reduced in the open water and on open sediments, respectively. Differently from temperate lakes, algal grazing by cladoceran crustaceans plays a minor role as a cause for this clear-water stage in the Pantanal. When the water level dropped again, De-Lamônica-Freire and Heckman (1996) observed only few changes in the species assemblages, but a strong increase in the abundance of diatoms. In the water bodies remaining during the dry phase, the prevalence of desmid species from the former phases changed into an assemblage composed by larger proportions of euglenophyte, bacillariophyte and other chlorophyte species (De-Lamônica-Freire and Heckman, 1996). In puddles where caimans and large numbers of fish get crowded, the water becomes intensively colored by high concentrations of blue-green algae (especially *Microcystis*) including highly toxic strains (S. Azevedo,

São Paulo, pers. comm. to KMW). These habitats show extremely high day to night oxygen variability (Nogueira et al., 2002).

In a quantitative study on the purely planktonic species of the Paraguay River and a floodplain lake near the City of Corumbá, Oliveira and Calheiros (2000) identified 82 taxa, dominated by chlorophytes (23 species). The river plankton was quantitatively dominated by cryptophytes (e.g., *Cryptomonas brasiliensis*) most of the year and showed high proportions of bacillariophytes (e.g., *Aulacoseira distans*) and cyanophytes (e.g., *Oscillatoria* sp.) during the falling water level. They also observed a seasonal change in the community composition but comparisons with the former study are difficult due to methodological differences. Oliveira and Calheiros (2000) measured a strong increase of the algal density in the floodplain during the flooding phase and an increase of phyto- and zooplankton abundance in the river when the water left the floodplains.

In the shallow flooded areas of the Pantanal, the sequential dominance of algae (at the beginning of the flooding) and aquatic macrophytes (at the peak of the flood) can be observed every year. These alternating stable states (Scheffer and Jeppesen, 1998) are probably caused by the fast numerical response of algae to increased nutrient availability and the accessibility of nutrients from the sediments during the high water phase to the roots of the macrophytes which also reduce the algal densities by shading (Adler, 2002). These spatiotemporal patterns in algal diversity and abundance underline the importance of the floodpulse as a driving agent in floodplain structure and productivity.

Higher Plants

The Pantanal belongs to the Cerrado biome, a vegetation complex that is composed by different savanna types. It borders in the south on the Chaco biome and in the north on the Amazon forest biome. According to Eiten (1982), the Pantanal is considered a "hyperseasonal savanna" that means a savanna subject to prolonged flooding. The floodplain is interspersed with small elevations of ancient and recent fluvial origin. Few decimeters change in elevation have dramatic importance for the environmental conditions in floodplain habitats because they influence length and depth of inundation and drought stress. Highest elevations in the Pantanal floodplain reach only about two meters above the mean flood level and are permanently dry or flooded for very short periods only during extreme flood events. They are covered by deciduous or semi-deciduous forests with trees shedding leaves during the dry season. Near the edges of the floodplain, there are some isolated outcrops from the surrounding mountains ("inselbergs") that are covered by deciduous forest and Cerrado vegetation. In lower areas along rivers and channels, evergreen floodplain forests are found, although they may shed part of their leaves during extreme drought or flood stress. At intermediate levels, different types of periodically flooded savannas occur, such as termite mound savannas, seasonally flooded woodland savannas and low tree-and-scrub woodland savannas (Eiten, 1982; Coutinho, 1982; Ratter et al., 1988; Nunes da Cunha et al., in press).

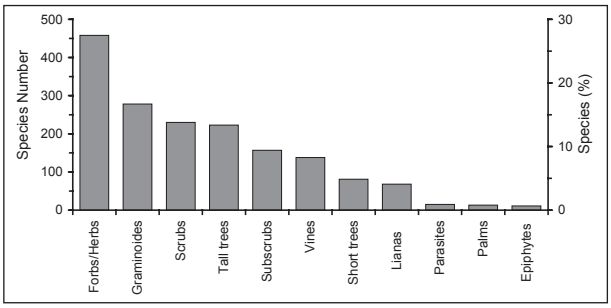

Figure 4. Species number and percentage of terrestrial herbaceous and woody plants in the Pantanal according to growth forms following species lists of Pott and Pott (2000). Total number 1,656.

About 144 families of phanerophytes are estimated for the Pantanal (Pott and Pott, 1996; 1997): 104 families are exclusively terrestrial, 21 families exclusively aquatic and 19 families include terrestrial and aquatic species. The total number of species yet recorded amounts to 1,903, with 247 species considered aquatic macrophytes or hydrophytes and 1,656 species terrestrial (Pott and Pott, 2000). Of this number 900 species are grasses, herbs, vines, epiphytes, and parasites and 756 species are woody plants (shrubs, sub scrubs, trees, lianas and palms) (Fig. 4). Considering the fact that not all parts of the Pantanal have been sampled adequately, total species number may rise to about 2,000. The common occurrence of cacti (*Cereus kroenleinii, C. peruvianus, Harrisia bonplandii, Opuntia bergeriana, O. retrorsa, Aporocactus flagelliformis, Pereskia sacharosa*) and the low number

Table 2. Number of families, genera and species of terrestrial graminoids, herbs, vines, epiphytes and parasites in the Pantanal of Mato Grosso (according to Pott and Pott, 1996).

Growth habit	Families (n)	Genera (n)	Species (n)	Cultivated	Ruderal
Forbs/herbs	62	226	458	15	60
Graminoides	2	84	278	4	33
Vines	25	60	138	8	6
Epiphytes	3	9	11		
Parasites	2	6	15		
Total	76	381	900	27	99

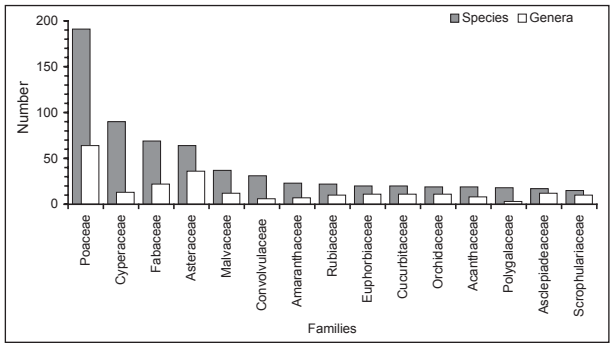

Figure 5. The most species-rich families of terrestrial herbaceous plants in the Pantanal (according Pott and Pott 1996).

of epiphytes point to the periodically pronounced dry climate.

Terrestrial herbaceous plants. The 900 terrestrial herbaceous plant species include grasses, herbs, vines, epiphytes and parasites. Herbaceous plants contribute with 51 % and graminoids with 31 % to the total. The number of vines is relatively high (15 %), the number of epiphytes (1.2 %) very low. Number of families, genera and species and the number of ruderal plants (introduced weeds) are indicated in Table 2, the most species-rich families are indicated in Fig. 5.

Herbaceous plants colonize the entire gradient from permanently dry to permanently wet conditions. Most of them are annual. There is one endemic species in the Santa Cruz Mountain near Corumbá, at the border of the Pantanal (*Aspilia grazielae*, Pott & Damasceno unpubl.) In the aquatic-terrestrial transition zone, terrestrial plants die when the water floods the area but seeds survive the flood period. There is a rich seed bank in the sediment that becomes partly activated when the sediments fall dry. The activation of only parts of the seed bank increases the resilience of the herbaceous plant community against irregular precipitation patterns or unpredicted short floods that may lead to losses of saplings. Germination and plant growth is highest at the beginning of the rainy season.

A similar strategy is used by many aquatic macrophytes, that start to grow from the seed bank with increasing soil moisture and continue growth after inundation thereby substituting the terrestrial plant community. Therefore aquatic and terrestrial herbaceous plant species are often found together (Fig. 6), however with larger biomass of terrestrial plants during the dry period and of aquatic plants during the water-logged and flood period, respectively. According to Pott and Pott (2000), *Arachis diogoi, Habranthus pantanensis, Stilpnopappus pantanalensis* and *Xanthosoma pottii* are endemic.

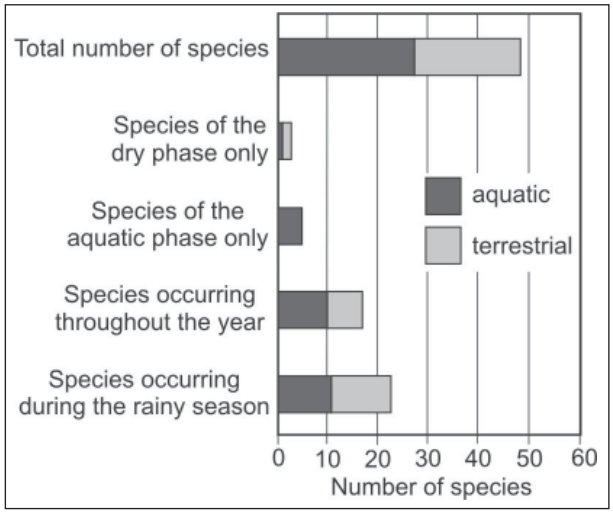

Figure 6. Distribution of 48 herbaceous plant species in a seasonally inundated savanna area according to the flood and drought pattern (Nunes da Cunha, unpubl. data).

Aquatic macrophytes. Hydrophytes or aquatic macrophytes are defined as "plants growing in water, in soil covered with water or in soil that is usually saturated" (Weaver and Clements, 1938). In the Pantanal this group consists of 248 species representing 108 genera and 57 families. Several genera are represented by a large number of species (Table 3; Pott and Pott, 2000). Many species have a large distribution area in Central and South America, some are pantropic as for instance *Ceratophyllum demersum, Eichhornia crassipes, Pistia stratiotes* and *Salvinia auriculata*, but there are no endemic species described for the Pantanal, yet.

Aquatic macrophytes can be classified according to their growth forms. However, many species show heterophylly and a large morphological and physiological plasticity and the attributes of several classes during their life cycle and under different environmental conditions. In this case, the species was located in the class corresponding to the quantitatively more important attributes. An analysis of the aquatic macrophytes according to their growth form is given in Table 4.

The analysis of life forms shows that most aquatic macrophytes in the Pantanal are rooted in the ground and belong to the submerged, floating-leaved and emergent sub-classes. These points to shallow water bodies, relatively small water level fluctuations and good light conditions in the water. Species diversity is very large and comprises all life forms. The annual set-back of the herbaceous plant communities by the flood pulse and a large habitat diversity reduce competitive exclusion of smaller species by vigorously growing ones.

These conditions strongly contrast to the Central Amazon River Floodplain. An analysis of a species list from Junk and Piedade (1993) of the growth conditions inside the floodplain shows that from a total number of

Table 3. The most species rich families and genera of aquatic macrophytes in the Pantanal (according Pott and Pott, 2000).

Family	Genera (n)	Species (n)
Poaceae	10	24
Paspalum		6
Luziola		5
Panicum		5
Scrophulariaceae	7	20
Bacopa		12
Cyperaceae	6	19
Eleocharis		7
Cyperus		6
Onagraceae	1	16
Ludwigia		16
Leguminosae	5	13
Aeschynomene		6
Alismataceae	2	13
Echinodorus		10
Pontederiaceae	3	11
Pontederia		5
Lemnaceae	4	9
Lentibulariaceae	1	9
Utricularia		9
Nymphaeaceae	2	8
Nymphaea		7
Polygonaceae	1	7
Polygonum		7

Table 4. Classification of aquatic macrophytes of the Pantanal and the central Amazon floodplain according to growth forms, based on the species description of Pott and Pott (2000) and Junk and Piedade (1993). * = species growing on floating islands (*matupá*).

Life form	Number of species	
	Pantanal	Central Amazon
Free floating		
Emergent	12	11
Leaves at the surface	13	10
Submersed	10	7
Rooted in the sediment		
Emergent	175	17 + 9*
With floating leaves	15	2
Submersed	23	0

387 herbaceous species 47 can be considered aquatic or palustric, 28 are free floating and 19 rooted in the ground. Of the rooted species 4 become uprooted with rising water level and continue growing at least periodically free floating, 9 are rooted on free floating organic material, for instance some ferns and the orchid *Eulophia alta*. There are 7 free floating submerged species but no submerged rooted species.

However, a classification in aquatic, palustric and terrestrial species is difficult because of the large water level fluctuations. For instance, many Cyperaceae and Onagraceae occur outside the floodplain in moist conditions and have to be considered as palustric species**,** but inside the floodplain they grow during low water period on the dry sand and mud flats. These species are considered by Junk and Piedade (1993) as "terrestrial" species. A considerable number of "terrestrial" species grow on floating islands of organic debris, locally called *matupá*, but only the most typical species have been listed as palustric.

In comparison to the Pantanal, the growth of aquatic macrophytes in the Amazon River floodplain is strongly hindered by the large annual water level fluctuations of about 10m and the low transparency of the water of 1–2.5 m Secchi depth. Only few species with quick growth in length can accompany the rise in water level. There is a strong selection for a floating habit that allows the plants to maintain their position near the surface in suitable light conditions.

Woody plants. Pott and Pott (1996) list a total number of about 756 woody plant species in the Pantanal, corresponding to about 39.7 % of the higher plants. The most species-rich families are given in Fig. 7.

About 60 % of the woody plants belong to the category of scrubs and small trees up to 10m high, 29 % are tall trees and 9 % are lianas (Table 5). Palms make up a small portion of 0.2 %, however, one species, *Scheelea phalerata*, has to be considered a key-species because of its abundance and large fruit production that is of great importance for many mammals, birds and insects (e.g., Marques et al. 2001).

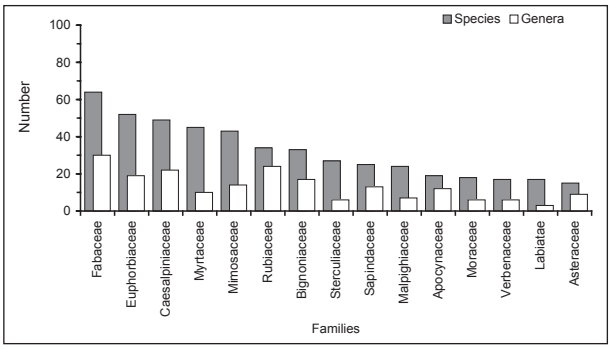

Figure 7. The most species-rich families and genera of terrestrial woody plants in the Pantanal (according to Pott and Pott, 1996).

Table 5. Number of families, genera and species of woody plants in the Pantanal of Mato Grosso according to growth habits (based on Pott and Pott, 1996). The total numbers of families and genera do not correspond to the sum of the numbers of the respective growth habit categories, because 37 families have representatives in several categories.

Growth habit	Families (n)	Genera (n)	Species (n)	Cultivated (n)	Ruderal (n)
Scrubs	43	96	223	3	7
Subscrubs	22	61	149	5	15
Small trees	27	63	83	4	2
Tall trees	43	148	220	12	2
Palms	1	11	13	1	
Lianas	14	36	68		1
Total	70	380	756	25	27

The characterization of the woody plants according to habitat preferences clearly shows the strong impact of the pronounced dry season on the vegetation. Despite an annual precipitation of 1,200 mm and an extended flood period, most trees and shrubs are drought resistant savanna species, with a tolerance to periodic flooding.

The number of species adapted to long-term flooding is small. A detailed analysis of the distribution of 85 tree species along the flood gradient in the northern part (Pantanal of Poconé) shows that 45 species are restricted to permanently dry areas and only 18 species show preference to habitats subject to extended annual flooding. 22 species tolerate a very broad spectrum of flood and dry conditions, a behavior that is favored by pluriannual extreme dry and wet periods. (Fig. 8; Nunes da Cunha and Junk, 1999). If we consider this relationship representative for the entire Pantanal, 355 species (47 %) would show flood tolerance however to different degrees.

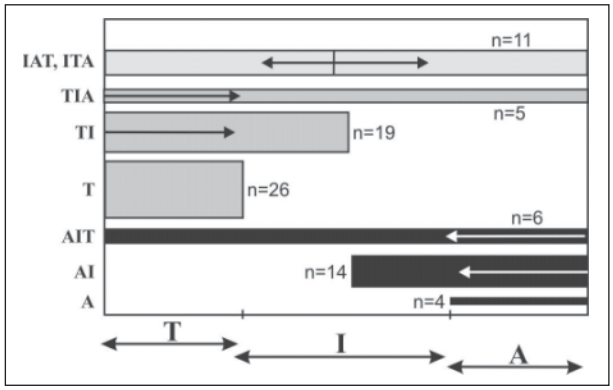

Figure 8. Distribution of 85 tree species in the Pantanal of Poconé according to their preference along the flood gradient. T = terrestrial habitats normally not subjected to inundation; I = habitats inundated during short periods (<two months), A = habitats with a pronounced aquatic phase (up to 6 month). Arrows indicate the supposed direction of expansion of the species from the center of maximum density (according to Nunes da Cunha and Junk, 1999).

There are no endemic tree species in the Pantanal. Most terrestrial species are immigrants from the adjacent savanna (Cerrado) biome. Species with a large tolerance to periodic dry and wet conditions are often found in gallery forests along Cerrado streams. Some of the very flood tolerant species are described from Amazonian river floodplains, such as *Licania parviflora, Triplaris americana, Vochysia divergens, Eugenia inundata,* and *Pouteria glomerata*. Some are immigrants from the Chaco biome, for instance, *Copernicia alba* in the periodically flooded areas, and *Schinopsis balansae, Calycophyllum multiflorum, Seguieria paraguayensis, Pterogyne nitens*, and *Perescia sacharosa* in the dry areas.

Estimates for Amazonian river floodplains show the existence of more than 1,000 flood resistant woody species. At the Mamirauá Reserve for Sustainable Development (Amazon River floodplain), 224 tree species were recorded on an area of 4 ha. 103 species were restricted to areas of high lying *várzea*, corresponding to mean flood levels <3 m and inundation periods of <45 days, and 94 species were restricted to areas of low lying *várzea*, corresponding to mean flood levels of up to 8 m and mean inundation periods up to 230 days per year. Only 27 species occurred in both areas. About 17 % of the species recorded in the floodplain were also found in the adjacent non flooded upland. All of them occurred in the high *várzea* and only 3.9 % occurred also in the low *várzea* (Wittmann et al., 2002). Amazonian floodplain forests are much more differentiated with respect to flood tolerance than Pantanal floodplain forests that are more drought tolerant.

Terrestrial arthropods

Knowledge on the taxonomy, geographical distribution and ecology of terrestrial arthropods of the Pantanal is poor, even on common representatives like ants and termites, and general statements on species number, origin and endemism cannot be given at this stage. However, pilot studies realized during the last five years revealed species numbers, survival strategies and seasonality in selected groups. In addition, data on the group spectrum and dominance of terrestrial arthropods are available from two monodominant floodplain forests. Data indicate that the flood pulse influences the community structure and ecology of terrestrial arthropods in Pantanal floodplains.

Soil fauna. In forest stands of *Vochysia divergens* (Vochysiaceae) (locally called *cambarazal*), Acari (70 %, 1,800 ind m^{-2}) and Collembola (11 %, 290 ind m^{-2}) dominated in the litter and upper soil layer (0–4 cm), followed by Formicidae (7 %, 175 ind m^{-2}) and Coleoptera

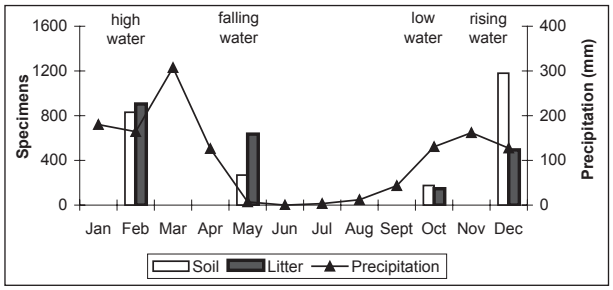

Figure 9. Coleoptera (larvae and adults) obtained from soil and litter during four characteristic water stages in the Pantanal floodplains of Poconé, Mato Grosso (Pinho et al., unpubl.).

(5 %, 120 ind m^{-2}). Adult Coleoptera represented 28 families and 357 morphospecies. Scarabaeidae (26.5 %), Staphylinidae (24.1 %) and Ptiliidae (19.0 %) dominated. Staphylinidae had the highest species richness (71 morphospecies), followed by Pselaphidae (32) and Ptiliidae (24). The dominant trophic groups were predators (35.0 %; mostly Staphylinidae & Scydmaenidae), herbivores (33.0 %; mostly Scarabaeidae & Curculionidae) and saprophages (23.5 %; mostly Ptiliidae), followed by fungivores (8.5 %; mostly Pselaphidae) (Fig. 10).

Highest abundance of arthropods (particularly of Acari, Collembola and Thysanoptera), was obtained during low water (October) when the amount of litter on the forest floor was highest. Other taxa like Araneae, Homoptera and Pseudoscorpiones were more abundant with the beginning rainy season during rising water (December). The highest density of Coleoptera during rising and high waters (Fig. 9) was due to the eclosion of adult beetles in litter and soil, while larvae dominated during falling water in the litter.

In forest stands of the palm *Attalea phalerata* (Arecaceae) (locally called *acurizal*), Acari (67 %, 858 ind m^{-2}) dominated in the litter and upper soil layer (0–4 cm), followed by Collembola (9 %, 122 ind m^{-2}) and Coleoptera (9 %, 121 ind m^{-2}). Adult Coleoptera represented 27 families and 195 morphospecies. Staphylinidae (36 %) and Ptiliidae (22 %) dominated. These two families accounted for the dominant trophic groups, i.e. predators (54.7 %) and saprophages (27.3 %), followed by herbivores (11.5 %; mostly Scarabaeidae) and fungivores (6.5 %; mostly Pselaphidae) (Fig. 10). Staphylinidae had the highest species richness (46 morphospecies).

Abundance of Acari in the upper soil was lowest during low water of the dry season. In Diptera and Hemi-

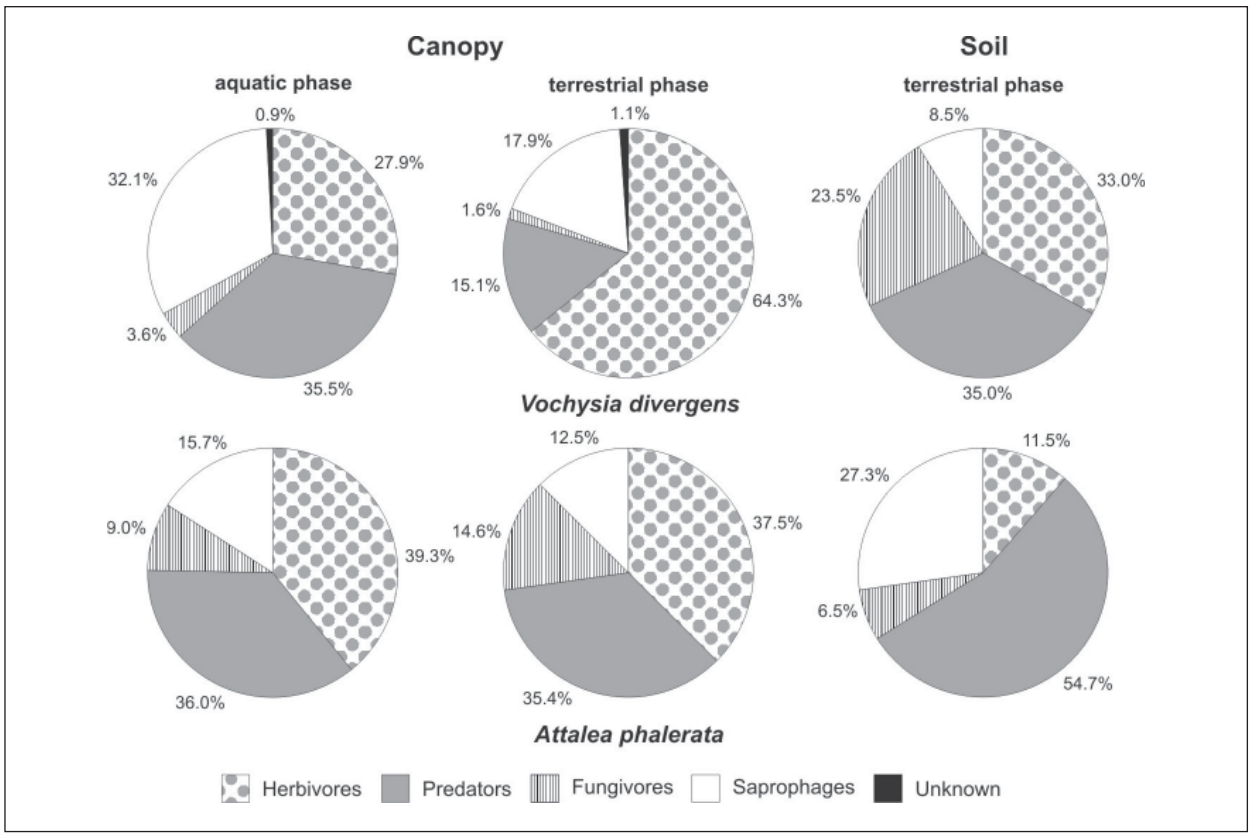

Figure 10. Proportion (%) of trophic guilds assigned to adult Coleoptera obtained from *Vochysia divergens* (soil; canopy: 1 and 2 trees during the aquatic and terrestrial phase, respectively) and *Attalea phalerata* (soil; canopy: 6 trees each during the aquatic and terrestrial phase) (Marques et al., unpubl.).

ptera abundance was highest during rising water at the beginning rainy season. About 69 % of all adult Coleoptera was obtained during high waters.

Soil living termites (*Cornitermes* spp.) play a key role as bioengineers in shallowly flooded areas of the Pantanal. Termite mounts, locally called *murunduns*, form non-flooded islands that are covered with terrestrial woody and herbaceous vegetation and are important refuges for terrestrial animals during flood periods, and possibly also during fire events. Samples taken during high water (February) showed an arthropod density two times higher compared to falling water (May).

Canopy fauna. In the canopy of *V. divergens*, arthropod abundance during the terrestrial phase (181 ± 65 ind m^{-2}) was comparable to that during the aquatic phase (188 ± 77 ind m^{-2}). Formicidae (30–50 % of the total catch) and Coleoptera (11–21 %) dominated independent of season, indicating that the canopy represents an important habitat. Some groups like Acari, Araneae, Coleoptera and Psocoptera showed greater abundances during the aquatic phase, while Thysanoptera, Homoptera and Collembola were more abundant during the terrestrial phase. Seasonality in Thysanoptera is attributed to flowering of the host plant during the terrestrial phase, and seasonality in Araneae to the temporary use of trees by terricolous species during the aquatic phase. More than 85 % of immature Blattodea, Homoptera and Heteroptera were obtained during the aquatic phase, indicating that the canopy is used by some groups for reproduction.

Coleoptera represented 37 families and 256 morphospecies. Nitidulidae (18 % of the total catch), Anobiidae (17 %), Meloidae (11 %) and Curculionidae (8 %) dominated. Rare species (102 (40 %) singletons, 47 (18 %) doubletons) caused the great diversity in adult Coleoptera. Distribution of species was even, however their abundance and richness was greater during the aquatic phase. The majority of morphospecies (46 %) was obtained exclusively during the terrestrial phase, 29 % only during the aquatic phase and 25 % during both phases. Five families were more abundant during the terrestrial phase (above all Nitidulidae), and nine families during the aquatic phase (above all Anobiidae). Herbivores and predators were the dominating trophic groups (Fig. 10). Predominance of predators during the aquatic phase is attributed to the flood pulse, that of herbivores during the terrestrial phase to seasonal phenological changes in the host plant (Marques et al., 2001; unpubl.).

In the canopy of *Attalea phalerata*, Coleoptera (27 % of the total catch) and Formicidae (19 %) dominated during the terrestrial phase (239 arthropods/m^2), Acari (40 %) and Coleoptera (12 %) during the aquatic phase (643 arthropods/m^2). Adult beetles represented 48 families and 326 morphospecies during the terrestrial phase. Tenebrionidae (23 %) and Curculionidae (22 %) were the most dominant families. Curculionidae (44 spp.) and Staphylinidae (40 spp.) had the highest number of morphospecies. During the aquatic phase, adult beetles represented 48 families and 467 morphospecies. Endomychidae (23 %) and Nitidulidae (16 %) were the most dominant families. Staphylinidae (89 spp.) and Curculionidae (56 spp.) had the highest number of morphospecies.

The aquatic phase showed a 2.6 times higher arthropod abundance and a greater diversity of adult beetles (141 more morphospecies) than the terrestrial phase. However, arthropod biomass was 2.2 times less during the aquatic phase (0.4 mg m^{-2}), indicating a higher amount of smaller-sized animals (e.g., Acari, Coleoptera: Ptiliidae) and a different structure of its canopy community. This also mirrors in the trophic guilds of Coleoptera, with fungivores being less dominant during the aquatic phase (Fig. 10). Differences may be attributed to restricted availability of habitats and their resources when wide areas are flooded. Data indicate, that the palm tree *A. phalerata* is used both as temporal refuge during flooding (e.g., Acari, Araneae, Isopoda, polydesmidan Diplopoda, Formicidae) and reproduction place by different arthropod taxa (Santos et al., 2003; Battirola et al., 2004; 2005).

A comparison of the Pantanal with Amazonian floodplains. In forest stands of *V. divergens*, total abundance of soil arthropods (≤2,600 ind m^{-2}) was much lower than in floodplain forests of Central Amazonia (whitewater region: ≤13,400 ind m^{-2}, blackwater region: ≤22,500 ind m^{-2}, Adis 1997). Compared to blackwater floodplain forests in Central Amazonia, several taxa common in the soil were lacking in the *cambarazal* (e.g., Pauropoda, Protura, Schizomida), others were less abundant (e.g., Chilopoda, polydesmidan Diplopoda, Isopoda, Opiliones, Pseudoscorpiones and Symphyla). Some of the reasons to be investigated include occasional strong fires, the island character of *cambarazal* forests and/or extreme dryness, low pH and a high aluminum content of sandy soils and litter.

The most common response of terricolous arthropods in Central Amazonian floodplain forests to the flood pulse is a temporal vertical migration to the trunk/canopy region were they pass inundation of 5–7 months duration (Adis, 1997; 2000). Similar survival strategies were observed in the Pantanal, at least in some species (Adis et al., 2001). In Central Amazonian floodplains, several arthropod species of different taxa survive under water (dormant and active stages) when being submerged (Adis, 1997; Adis and Junk, 2002). Up to now, this survival strategy has only been observed for Collembola (Symphypleona) in Pantanal floodplains (Adis, Marques and Battirola, unpublished).

Aquatic invertebrates

Due to inconsistencies in taxonomy and geographically isolated studies, the diversity of benthic invertebrates can

only be partly assessed. Many taxa have remained undescribed. Some abundant groups, such as nematodes, have not been studied at all in the Pantanal. In a first attempt to summarize the known taxa, Heckman (1998a, 1998b) has listed the species from various habitat types (floodplain water bodies, root zones of macrophytes, river and stream benthos), indicating 55 ciliates, 97 amoeba, 151 rotifer species, 6 gastrotrichs, 6 oligochaetes, 5 gastropods and 5 bivalves among the non-arthropods. Species lists are continuously being updated, e.g., Wantzen, Callil & Butakka (unpublished manuscript) report 23 bivalve species, Marchese et al. (2005) 37 oligochaete species, and Brandorff, Pinto-Silva & Morini (unpublished manuscript) report planktonic species numbers of 81 cladocera, 33 copepoda, 16 ostracoda, 246 testacea and 285 rotifer. Until now, only one endemic copepod (*Argyrodiaptomus nhumirim*) has been described from the area (Reid, 1997).

Among studied sites, the precision of the taxonomic analysis differs greatly, therefore beta- and gamma-diversities can be reliably compared only within the dataset of individual studies. Seasonal occurrence of some species should also be taken into consideration. Morini-Lopes (1999) found 47 rotifers, 22 cladocerans, 7 copepods and 1 phantom-midge in the zooplancton community of the river-connected lake "Sinhá Mariana" near Barão de Melgaço, northern Pantanal. In the same lake, 24 genera of chironomids have been identified so far (Butakka, 1999).

The littoral stations were characterized by filter-feeders *(Caladomyia),* gatherer-collectors *(Polypedilum*, *Aedokritus, Fissimentum)*, and predators *(Cryptochironomus* and *Ablabesmyia (Karelia)*. Some taxa occurred only during the low water period, including collectors like *Zavrelliela* and predators like *Larsia*. Others occurred only during the high water period, such as gatherer-collectors *(Chironomus* gr. *salinarius*, *Beardius*, *Chironomus* gr. *decorus*), filterer-collectors (*Rheotanytarsus*) and one predator *(Tanypus punctipennis)* (Butakka et al., in press).

Among the insects, chironomids are by far the most diverse group in the Pantanal and in the surrounding rivers and streams, e.g., the Bento Gomes river, where Stur (2000) identified 48 genera during a 3-year study. In the large Paraguay River, 20 genera were found in a survey by Marchese et al. (2005). The known chironomid diversity can be expected to increase manyfold as soon as adult chironomids are systematically identified to species level.

Because of the alternating inundations and harsh dryness, permanent rivers and lakes, and especially the connectivity between them, play important roles for the survival of aquatic biota. Benthic invertebrates show seasonal patterns and adaptations both to local changes (moving littoral) and hydraulic changes due to increased current and particulate organic and inorganic matter input. Lake centers and moving sand substrata are the least densely and less diversely colonized habitats whereas sites with high gradients (e.g., connection channels between lakes and rivers, large woody debris, gravel substrates) reveal high biodiversity and abundance.

Along floodplain rivers, as the Paraguay River, transversal habitat diversity is strongly increased compared with longitudinal dimensions (Wantzen et al., 2005) and species diversity accompanies this pattern (Marchese et

Table 6. Survival strategies of aquatic invertebrates in the Pantanal of Mato Grosso (from Wantzen, Callil and Butakka, unpublished manuscript, and several authors).

Strategy	Organism	Description
horizontal migration within the water body	*Campsurus* mayfly larvae	follow the adequate hydro-sedimentological conditions in floodplain lakes
estivation on trees	*Drulia* sponges	propagules (gemmulae) survive several months of drought
diapause in sediments (mature organisms)	ampullarid snails, some bivalves	avoidance of dessication by burrowing into the moist part of the sediments
diapause in sediments (resting eggs or cysts)	copepods and microzoobenthos	avoidance of dessication in hard-shelled propagules in the sediments
"pond-hopping"	small-bodied, winged insects, e.g., chironomids	performing short migrations between neighboring waterbodies
"long distance flyers"	large, winged insects, e.g., waterbugs and dragonflies	performing long-distance migrations between remote waterbodies
"drifting"	root fauna of aquatic macrophytes	dispersal on drifting macrophyte mats
r-strategy	most invertebrates	production of large numbers of small propagules, short life cycles
Parental care	trichodactylid crabs	carry offspring in brood-pouch to next water body during dry phase
short life cycles and badly synchronized emergence	most small-bodied insects, e.g., chironomids	avoidance of total population loss by presenting different life-cycle stages at the same time

al., 2005). Additional control on aquatic invertebrate diversity is caused by the periodical dryness of many habitats which can be recolonized from resistant eggs, diapause forms or by immigration (Table 6). Far-travelling insect taxa such as water bugs, beetles, mole-crickets and the *Campsurus* mayflies were observed to make dispersal migrations at the beginning of the freshet. Small taxa, such as the chironomid *Apedilum elachistum* which develops within less than one week (Nolte, 1995), have short life cycles enabling them to perform a kind of "pond-hopping" during the expansion or shrinkage of the floodplain water bodies. Consequently, long-lived, low-mobility species have the hardest stay in the Pantanal as they need to survive under severe drought conditions. The molluscs such as the large ampullariid snails (e.g., *Pomacea linata, P. scalaris* and *Marisa planogyra*) suffer high mortalities during the estivation in the sediments (Kretzschmar and Heckman, 1995), especially at the beginning of the wet season due to mass predation by birds (*Rosthramus sociabilis*, da Silva et al., 2001). The most endangered invertebrates, however, are the bivalves which suffer additional stress from heavy metal pollution (Callil and Junk, 2001) and by recently invading golden mussels (*Limnoperna fortunei*, Mytilidae) which settle on the shells and compete for plankton (Ezcurra de Drago and Wantzen, unpublished data).

Fishes

Fishes generally belong to the best studied animal groups in the Pantanal. However, there are still many gaps because many areas are not yet adequately sampled and life history traits are little known. Britski et al. (1999) list 263 fish species belonging to 161 genera and 36 families (Table 7). Characiformes with 65 genera and 129 species and Siluriformes with 61 genera and 105 species predominate, a pattern that is characteristic for neotropical freshwaters. The family Cichlidae that is very diverse in African fresh waters, is represented by only 11 genera and 16 species, less than 7 % of total number.

According to Junk et al. (1997) the impact of the flood pulse on the fish fauna of the Amazon River floodplain selects for r-strategies, great mobility, adaptations to varying water quality (hypoxia) and an explicit seasonality in an environment with weak climatic seasonality. This statement also holds true for the fish fauna of the Pantanal, however, knowledge about the biology and ecology of many species is limited (Resende and Palmeira, 1999; Machado, 2003). Feeding habits vary according to food availability between low water and high water period. The number of omnivorous species is large (Resende 2000). The changes in feeding habits between low and high water period are also reflected by their changing stable isotope ratios, pointing to the importance of flood plain resources during floods (Wantzen et al., 2002).

The fish fauna of river floodplain systems, including the Pantanal, can be divided into "white" fish, "black" fish and "gray" fish according to their migration and spawning behavior (Welcomme, 1985; Welcomme and Halls, 2001). White fish are more rheophilic species that move with receding water level from the floodplain into the river channels and perform large up-river spawning migrations. These species are one-shot spawners. Some white fish species are restricted to the river channel. Most white fish are of medium to large size to be able to perform the extended spawning migrations. Black fish are limnophilic species that retreat at low water level in the remaining water bodies inside the floodplain. Black fish often show parental care and extreme resistance to low oxygen concentration (Welcomme, 1985; Junk et al., 1997). Gray fish are eurytopic species that are intermediate between white and black fish in that they live in the main channel during the dry season, move on to the floodplain during floods and undertake short distance spawning and dispersal migrations. They are marginal spawners that deposit eggs in one or more batches on riparian vegetation and include one-shot spawners and species that produce several batches of eggs per year.

To the white and gray fish of the Pantanal belong *Pellona flavipinnis* (Pristigasterinae) and representatives of the families Characidae (mainly members of the subfamilies Bryconinae, Triporteinae, Salmininae, Myleinae, Serrasalminae, Cynodontinae), Prochilodontidae, Curimatidae, Anostomidae, Ageneiosidae, and Pimelodidae. Large upriver spawning migrations locally called *piracema*, are known for several species as for instance *Pseudoplatystoma corruscans, P. fasciatum, Paulicea luetkeni, Sorubim lima, Hemisorubim platyrhynchos, Piaractus mesopotamicus, Brycon microlepis*, *Leporinus macrocephalus* and *Prochilodus lineatus.* White and gray fish provide the bulk of the yield of the inland fishery in Amazonia and the Pantanal.

Most of the other species belong to the group of black fish. Typical black fish species are *Lepidosiren paradoxa* (Lepidosirenidae), *Synbranchus marmoratus* (Synbranchidae), and representatives of the families Characidae (Subfamily Tetragonopterinae and other subfamilies with small species,) Lebiasinidae, many Gymnotiformes, Callichthyidae, Loricariidae, Poecilidae, Rivulidae, Sciaenidae, Cichlidae. Parental care is known for Cichlidae, Scoloplacidae, Callichthyidae, Loricariidae, and *Pygocentrus nattereri* (Serrasalmidae). Some Ageneiosidae, Pimelodidae and Auchenipteridae have internal fertilization but parental care is only known for *Centromochlus perugiae* (Auchenipteridae) from the upper Amazon basin. Freshwater sting rays (Potamotrygonidae) are viviparous and *Pamphorichthys hasemani* (Poecilidae) is ovoviviparous. According to Resende and Palmeira (1999) of 101 species studied in 4 different environments along Miranda River, 15 % are white fish, 43 % black fish and 42 % gray fish.

Table 7. Families, genera and number of fish species in the Pantal of Mato Grosso according to Britski et al. (1999).

Order	Family	Genera (n)	Species (n)
Myliobatiformes	Potamotrygonidae	1	3
Clupeiformes	Pristigasteridae	1	1
Characiformes	Characidae	43	76
	Gasteropelecidae	1	1
	Cynodontidae	1	1
	Crenuchidae	1	3
	Parodontidae	2	2
	Hemiodontidae	2	3
	Prochilodontidae	1	1
	Curimatidae	6	8
	Anostomidae	4	10
	Lebiasinidae	1	1
	Erythrinidae	3	3
Gymnotiformes	Rhamphichthyidae	2	2
	Gymnotidae	1	1
	Sternopygidae	2	4
	Hypopomidae	1	3
	Apteronotidae	2	2
Siluriformes	Doradidae	8	8
	Auchenipteridae	6	8
	Ageneiosidae	1	3
	Pimelodidae	16	24
	Aspredinidae	2	3
	Cetopsidae	1	1
	Trichomycteridae	4	8
	Scoloplacidae	1	1
	Callichthyidae	4	13
	Loricariidae	18	36
Cyprinodontiformes	Poeciliidae	1	1
	Rivulidae	6	9
Beloniformes	Belonidae	2	2
Perciformes	Sciaenidae	2	2
	Cichlidae	11	16
Synbranchiformes	Synbranchidae	1	1
Pleuronectiformes	Achiridae	1	1
Lepidosireniformes	Lepidosirenidae	1	1
Total	36	161	263

In comparison with the fish fauna of the large Amazonian river floodplains, the fish fauna of the Pantanal is relatively species-poor. Bayley (1982) collected during a two-year period in the bay at the mouth of Camaleão Lake at the Amazon River near Manaus more than 226 species belonging to 132 genera and 40 families. Santos et al. (1984) found about 300 species in the lower Tapajos. Goulding et al. (1988) collected in a stretch of 1,200 km of the lower and middle Negro River between Manaus and Barcelos 450 species belonging to 202 genera and 39 families. Considering also literature data, the authors estimated a total of about 700 species in that area.

Fishery in the Pantanal is highly selective and concentrates mostly on carnivorous and frugivorous species

that can be fished with hooks, for instance *Pseudoplatystoma corruscans, P. fasciatum, Paulicea luetkeni, Sorubim lima, Hemisorubim platyrhynchos, Serrasalmus nattereri, Hoplias malabaricus* (carnivorous) *Piaractus mesopotamicus* and *Brycon microlepis* (omnivorous). Of the iliophagous species only *Leporinus macrocephalus* and *Prochilodus lineatus* are of economic importance, but catch is low because fishing with nets is prohibited.

Fishery statistics indicate that in 1999 about 59,000 sport fisherman were registered in Mato Grosso do Sul (southern part of the Pantanal) that contributed about 75% of the total catch of about 1,400 tons (Catella, 2001). Similar numbers are expected for the northern part (Mato Grosso). Small fishes, mainly gymnotids and synbranchids, are used as living baits. Bait fishery is an economically important activity of the local population and is estimated to reach 17 million specimens per year. The demand is rising and ecologists are afraid of negative impacts of bait fishery on the stocks.

Amphibians and reptiles

First publications dealing with amphibians and reptiles from the Pantanal region base on material obtained by Captain Thomas J. Page, from the U.S. Navy, during fluvial exploration of tributaries of the River La Plata and adjacent countries in the years 1853, '54, '55, and '56 (Cope, 1863a, b; 1868). The first attempt to compile an herpetofaunal species list for the whole Upper Paraguay River Basin (UPRB), including the headwaters of all water courses flowing to the Pantanal, was presented by PCBAP (Brasil, 1997), a huge conservation plan undertaken by Brazilian government in the nineties. Among a total of 167 species of reptiles recorded for the whole basin, 83 were assigned as occurring in the floodplain. No similar indication was done regarding the 35 species of amphibians listed by the PCBAP (Brasil, 1997).

A recent examination of the material deposited in small regional collections, coming from different subregions of the Pantanal, allowed updating the UPRB herpetofaunal list (Strüssmann et al., in prep.). The herpetofauna presently known for the whole basin consists of 198 species of reptiles plus 72 species of amphibians. The herpetofauna of the Pantanal wetlands alone consists of at least 135 native species (40 anuran amphibians, three turtles, 25 lizards, two amphisbaenians, 63 snakes, and two crocodilians) (Table 8). The gekkonid lizard *Hemidactylus mabouia* is the only exotic species in the area. Both lists are by no means complete and undescribed species are being discovered after every field inventory (Strüssmann, 2003; Strüssmann et al., 2000; Strüssmann et al., in press).

In many hydrologic systems showing diverse aquatic habitats, great age and environmental stability lead to an explosive radiation of aquatic herpetofauna, which in some cases comprises strongly differentiated species (e.g., McCoy, 1984). In the Pantanal, however, in spite of the abundance and diversity of aquatic habitats, there are no strictly endemic amphibians or reptiles, indicating no long persistence of the environmental scenario, and a recent colonization by invading faunal elements. This invasion is still in progress, mainly from adjacent Cerrado, Gran Chaco and Amazonia domains, and apparently also from Atlantic and Chiquitan forests in a lesser extent. Therefore, species presently known only from peripheral elevated habitats may also be found in the Pantanal wetlands.

Additionally, some of the taxa in the list present taxonomic problems pending solution. Chelonia is certainly

Table 8. Higher taxa, families and numbers of genera and species of amphibians and reptiles in the Pantanal (in parenthesis, total number of genera and species presently known for the entire Upper Paraguay River Basin).

Higher taxa	Families	Genera (n)		Species (n)	
Amphibia	**Total 5**	**16**	**(21)**	**40**	**(71)**
Anura	Bufonidae	1	(2)	3	(6)
	Dendrobatidae	1	(2)	1	(3)
	Hylidae	6	(7)	16	(26)
	Leptodactylidae	5	(7)	16	(30)
	Microhylidae	3	(3)	4	(6)
Reptilia	**Total 17**	**63**	**(82)**	**96**	**(187)**
Chelonia	Testudinidae	1	(1)	2	(2)
	Chelidae	1	(2)	1	(3)
Sauria	Iguanidae	1	(1)	1	(1)
	Polychrotidae	2	(2)	2	(4)
	Tropiduridae	2	(2)	4	(7)
	Gekkonidae	4	(6)	4	(7)
	Gymnophthalmidae	4	(6)	4	(9)
	Teiidae	5	(6)	7	(13)
	Scincidae	1	(1)	3	(3)
	Anguidae	1	(1)	1	(1)
Amphisbaenia	Amphisbaenidae	1	(4)	2	(18)
Serpentes	Boidae	4	(4)	5	(6)
	Typhlopidae	1	(1)	1	(2)
	Colubridae	30	(39)	52	(92)
	Elapidae	1	(1)	2	(6)
	Viperidae	2	(3)	3	(9)
Crocodylia	Alligatoridae	2	(2)	2	(4)
Total	22 (27*)	79	(103)	136	(258)

* Families known exclusively from elevated areas of Upper Paraguay River Basin (number of genera/number of species): Amphibia – Gymnophiona: Caecilidae (1/1); Reptilia – Sauria: Hoplocercidae (1/1); Serpentes: Aniliidae (1/1); Leptotyphlopidae (1/6); Anomalepididae (1/2).

one of the poorest known reptile groups in the floodplain. Only three species are reliably recorded: *Geochelone* (*Chelonoidis*) *carbonaria*, *G. denticulata*, and *Acanthochelys macrocephala*. Nevertheless, the total number of vouchered records is incredibly low. The present analysis, then, must be considered provisional, as it is based on a still incomplete knowledge of a rich fauna.

The total number of species of the herpetofauna recorded for the Pantanal is roughly the same of that presently known for the entire Cerrado, the second largest biome in South America, with nearly two million square kilometers (Colli et al., 2002). Richness of the Pantanal herpetofauna is indeed increased by the position on major faunal boundaries that results in juxtaposition or interdigitation of Cerrado elements with those from adjacent biomes.

In a preliminary analysis of the zoogeographical relationships of reptiles from the Pantanal, Alho et al. (2001) found that at least 25 % of the species were ubiquitous, having an almost-continental distribution. These species were already recorded in at least five distinct biomes (Amazonian and Atlantic Forests, Cerrado, Caatinga and Gran Chaco), although local subspecies are occasionally recognized. Examples of these widely distributed species are the tortoise *Geochelone carbonaria*, the lizard *Iguana iguana,* the amphisbaenian *A. alba*, and the snakes *Boa constrictor*, *Liophis almadensis, Mastigodryas bifossatus*, and *Spilotes pullatus*. According to the same authors, species occurring in all extension of the "great diagonal belt of open formations" (which includes, from Northeast to Southwest, the Caatinga, the Cerrado, the Pantanal, and the Gran Chaco) represented 24 % of the reptiles from the Pantanal. This figure is elevated to more than 50 % when species occurring only in restricted parts of this "diagonal" are considered (Alho et al., 2001).

It is extremely difficult to generalize about ecology of amphibians and reptiles of the Pantanal, due to the lack of direct observations or published information on most of the taxa. Documented records in the literature and specimens in collections, however, seem sufficient to tentatively search for general patterns of distribution. The results of this analysis are presented below (Table 9).

Most of the herpetofauna of the Pantanal (including all aquatic species) are widely distributed in the floodplain. Among these "better-adapted" species, affinities with Amazonian taxa are more evident (although not taxonomically clear) among aquatic or semiaquatic species. The possibility that some related taxa occurring in the Pantanal and in Amazonia are in reality conspecific occasionally arise in the literature (Strüssmann et al., in press), corroborating the hypothesis of inexistence of a long-term abrupt boundary between aquatic herpetofaunas in the UPRB (Upper Paraguay River Basin) and in meridional Amazonia.

Although some of the aquatic reptiles in the Pantanal have been occasionally treated as endemic species (including the yellow-anaconda *Eunectes notaeus*, the paraguayan caiman lizard *Dracaena paraguayensis* and the freshwater turtle *Acanthochelys macrocephala*), their actual distributions are wide enough to not support this statement. *Eunectes notaeus*, as an example, is a common species also at Yaciretá Dam, on the Paraná River between Argentina and Paraguay, while *A. macrocephala* (originally described from Cáceres, UPRB) also occurs in aquatic habitats in the Mamoré river valley, a region belonging to the Amazonas River Basin.

According to their general distribution pattern in the Neotropical region, species already recorded in the Pan-

Table 9. Classification of amphibian and reptile species according to general patterns of distribution in the Upper Paraguay River Basin.

	Amphibians	Reptiles
a) Species widely distributed in the floodplain	31	65
b) Species peripheral or with restricted distribution in the floodplain	7	26
c) Species insufficiently known or rare, but reliably recorded from the floodplain	2	5
Total species in the floodplain (Pantanal wetlands)	40	96
d) Species widely distributed in the periphery of the floodplain	10	10
e) Species with restricted distribution in the periphery of the Pantanal, mainly Amazonian	6	27
f) Species with restricted distribution in the periphery of the Pantanal, mainly in Cerrado areas	13	34
g) Species with restricted distribution in the periphery of the Pantanal, mainly Chacoan	1	7
h) Species with restricted distribution in the periphery of the Pantanal, mainly Atlantic	0	3
i) Species with very limited distribution in the periphery of the Pantanal and/or uncertain zoogeographical affinities	2	21
Total species in the peripheric plateaus	32	102

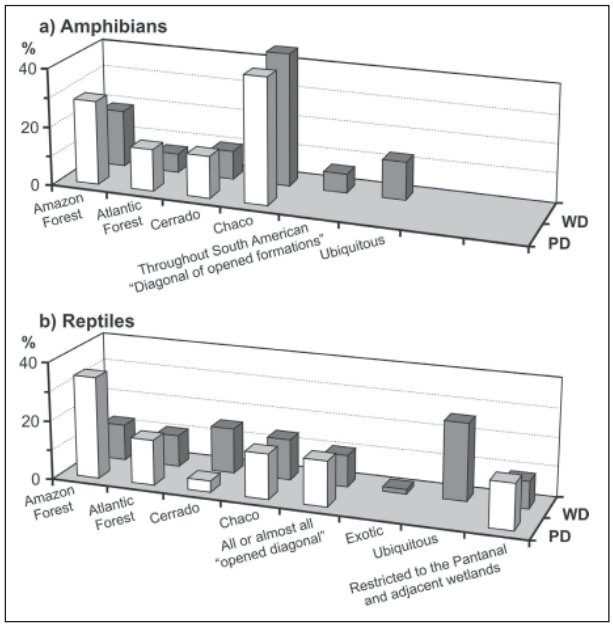

Figure 11. General patterns of distribution of the species already recorded in the Pantanal wetlands in other neotropical major formations; **a)** amphibians; **b)** reptiles. (Abbreviations: **PD** – species peripherally distributed in the floodplain; **WD** – species widely distributed in the floodplain).

tanal wetlands (those 40 amphibians and 96 reptiles included in the upper half of Table 9) can be subdivided in several categories (Fig. 11a, b). Among the amphibians widely distributed in the floodplain, and also among those with more limited distributions in the Pantanal, most species are considered Chacoan forms (Fig. 11a). "Amazonian" species are frequent among that subset of amphibian species occurring peripherally in the Pantanal, especially on its western border, a pattern that is also observed amongst Pantanal reptiles with limited distributions in the floodplain (Fig. 11b). Approximately one third of the widely distributed reptiles are also widely distributed in other opened formations, as well as in Amazon and Atlantic forests (Fig. 11b).

Ecologically 52 % of the reptile species of the Pantanal wetlands are terrestrial species, 21 are arboreal or semiarboreal (22 %), 12 are aquatic or semiaquatic (13 %), and 12 are fossorial, semi-fossorial or cryptozoic (13 %). When total herpetofauna of the floodplain is considered, figures are roughly the same: 52 % terrestrial (among anurans, all bufonids, leptodactylids, and the only dendrobatid), 26 % arboreal (nearly all hylid species), 12 % fossorial, and 10 % aquatic or semiaquatic (among anurans, only *Lysapsus limellus* and *Pseudis paradoxa* can be considered as such).

Although the overall herpetofauna of the Pantanal is comparatively poor in aquatic or semiaquatic species, local assemblages may harbor higher proportions of these specialized taxa than in other neotropical sites. In a snake assemblage studied in the northern part of the Pantanal, aquatic/semiaquatic species represented around 15 % of the total richness (Strüssmann and Sazima, 1993). In the same assemblage, another 15 % of the snake species were fossorial or semifossorial, an ecological category found to be fairly better represented at Acurizal reserve, Serra do Amolar, in the western border of the Pantanal. Fossorial and semifossorial snakes comprised 25 % of the species (43 in total) and 35 % of the individuals (308 in total) recorded in a recently-finished 1-year study at Acurizal, one of the private protected areas contiguous to the Pantanal National Park (Strüssmann, Ribeiro & Carvalho, unpublished data).

Data from both regional collections and unpublished field inventories indicate that around 30–35 species of anurans, 20–25 lizards, three to five amphisbaenians, and at least 40 snakes can be found in the same site, in the better-sampled localities within the Pantanal (e.g., Corumbá, Aquidauana, Cáceres, Serra do Amolar, Pantanal National Park). Some species have restricted distributions within the floodplain which results in distinct herpetofaunal assemblages on each of the distinct sub-regions recognized by different authors (Adamoli, 1981; Silva and Abdon, 1998). Additionally, among those species that are widely distributed in the floodplain, individual patterns of abundance may vary in every sub-region. These differences were not yet adequately evaluated.

Threatened species resume to those belonging to genera listed in Appendix II of CITES: *Geochelone carbonaria*, *G. denticulata*, *Caiman yacare*, *Paleosuchus palpebrosus*, *Iguana iguana*, *Dracaena paraguayensis*, *Tupinambis* spp., all boids, and *Hydrodynastes gigas*. Local status of these species, however, are better than in any other parts of their range, due to lower perspectives of habitat conversion in the Pantanal.

Birds

Birds are without doubt the best known faunistic group in the Pantanal. General knowledge about distribution and ecology of most species is now sufficiently advanced (e.g., del Hoyo et al., 1992–2003; Parker et al., 1996; Ridgely and Tudor, 1989, 1994) to give rather precise ideas about the bird species to be expected in the Pantanal.

The number of bird species of the "Pantanal region" is usually given as something between 600 and 700 species (e.g., Cintra and Antas, 1996; Heckman, 1998a; Por, 1995; Swarts, 2000), a number derived from a comprehensive review of Brown (1986). If all published species lists for the region of the Pantanal (Brown, 1986; loc. cit., Dubs, 1983a, 1992; Forrester, 1993; Mauro and Tomás, 1994; Heckman, 1998a; Tubelis and Tomás, 2001) are combined the total rises to 766 species. However, recently Tubelis and Tomás (2001) have

estimated the number of species for the "Pantanal floodplain" only as 469 "confirmed" species plus 31 species not with certainty recorded inside the floodplain. Moreover, if the criteria for acceptable species records of the Brazilian Ornithological Records Committee (Comitê Brasileiro de Registros Ornitológicos, CBRO, 2000) are applied to this list, many of these 500 species also must be considered "unconfirmed", as there is no published evidence (specimens, photographs, voice recordings, etc.). Some species can even be shown to be included in error, as the record is not from the Pantanal region or identification of the species is dubious, at least. Apparently, the compilation of a bird species list of "the Pantanal" is not as straightforward as it would seem (da Silva et al., 2001).

Attempts to compile species lists have suffered from three main problems:

Spatial definition of the Pantanal. As there are surprisingly few species lists from the Pantanal floodplain, most comprehensive compilations have included records from adjacent regions. Obviously, the distinctiveness of the Pantanal avifauna will be obscured when tracts of the Cerrado, southern Amazonia, the Chaco and the Atlantic rainforest are all included in a vaguely delimited "region of the Pantanal".

Poor quality of records. The most reliable source of data is still Naumburg (1935), who critically reviewed the bird collections of the Roosevelt-Rondon Expedition together with previous collections from the Mato Grosso (Dubs, 1983a). In later decades, some collections have been obtained in the Pantanal, but the published lists (e.g., Aguirre and Aldrighi, 1983, 1987; Moojen, 1940) suffer from unreliable species identification, as apparently no comparison with major museum collections was possible. Many records are therefore not acceptable without a critical review of specimens (see Pacheco in Tubelis and Tomás, 2001). Additionally there are many published records of observations, which often lack even the most basic documentation (data, precise locality, description of species), let alone physical evidence (specimen, photographs, recordings).

Status of the species. For the evaluation of regional biodiversity, regularly occurring species (residents or migrants) should receive more attention than rare visitors. "Rarities" may gain some local economic importance, though, due to the rapidly growing birding tourism industry, estimated to move 25 billion Dollar per year in North America alone (source: Audubon Society Website, 2000). Due to its central geographic position, the Pantanal has a great potential to receive vagrants from neighboring biomes. The challenge is to distinguish these visitors from originally "rare" species with very low population density, that greatly contribute to the diversity of tropical ecosystems.

For this review, we critically re-evaluated the species lists, applying the criteria of CBRO where possible. However, this analysis should be seen as preliminary. Brazilian field ornithology is advancing fast (Alves et al., 2000; Pacheco, 2003), and excellent field guides combined to better means of documentation will soon greatly improve the available information on the Pantanal avifauna. In particular, one long-term study of bird communities in the northern Pantanal is close to conclusion (João Batista de Pinho, in prep.) and will greatly advance our knowledge.

Caution is also necessary as we still know very little about fluctuations in the distribution of neotropical bird species and in the composition of their communities. The Pantanal is subject to climatic fluctuations, which have repeatedly caused large-scale environmental changes. Anthropogenic landscape changes, and global climatic change are likely to have an impact. Responses of the regional avifauna must be expected, and should be carefully monitored.

How many bird species have been recorded from the Pantanal? Of 766 species mentioned for the "region of the Pantanal", 390 can be considered "confirmed". At least 58 of these species have so far been recorded only from peripheral areas in the extreme south or north of the Pantanal. 153 species have been mentioned without adequate documentation for the Pantanal, and many of these may probably be found in peripheral areas in the future, as some of them are common in adjacent regions. The remaining 223 species have been recorded from areas distant from the Pantanal, or may have been misidentified. The complete list with comments will be published elsewhere. A summary is given in Table 10.

Table 10. Bird species of the Pantanal according to the quality of data (Petermann unpubl.)

	All published records	Confirmed records	Confirmed, but occurring only peripherally	Unconfirmed, but occurrence possible	Not recorded in Pantanal, unlikely to occur
Species	766	390 (51 %)	58	153 (20 %)	223 (29 %)
Genera	431	282			
Families	68	61			

The biogeographical relationships of the Pantanal avifauna. To analyze the biogeographical relationships we excluded exotic species and nearctic migrants, and compared the list of the remaining 368 confirmed species with species lists of the surrounding biomes, Cerrado (Silva, 1995), Chaco (Hayes, 1995: Paraguayan provinces Alto Chaco and Matogrosense), Southern Amazonia and Mata Atlântica (Parker et al., 1996).

358 species of the Pantanal (97 %) have also been recorded in the Cerrado, and between 234 (64 %) and 277 (75 %) in each of the remaining three biomes. 151 species (39 %) have been found in all four biomes and the Pantanal. Both the Cerrado and Pantanal lists include an important group of Southern Amazonian species, which are generally found in gallery forests, and in geographical proximity to Amazonia (Silva, 1996). The avifauna of the Pantanal is thus basically a part of the Cerrado fauna.

There is, however, a small but remarkable influence of the Chaco. Though only a handful of typical Chaco species appear in the Pantanal, several of these are widespread and abundant (e.g., *Paroaria coronata*). On the other hand, no noteworthy influence of the avifauna of the Atlantic rainforest is apparent, though there are some unconfirmed records of typical Atlantic Rainforest species mostly from the southeastern periphery of the Pantanal. Obviously though, none of these is widespread in the Pantanal. Similarly we did not find any evidence that species of the Andes region have ever been recorded in the Pantanal (*contra* Eckstrom and Lanting, 1996).

There are no endemic bird species in the Pantanal (Tubelis and Tomás, 2001). Some species, though, have the center of the distribution in the Pantanal (Table 11), where they are generally common. All of them are weakly differentiated, and are replaced by closely related forms in adjacent regions.

Ecological differentiation of the avifauna: Wetland species vs. terrestrial species. To analyze the degree of dependence of bird species on wetland habitats, we define three categories: "Aquatic species" are those birds, that feed almost exclusively by diving, swimming or wading, or that feed on shores or mudflats in the vicinity of water.

"Wetland dependent species" are species inhabiting chiefly wetland specific habitats, like floodplain forests, palm swamps, marshes, reed beds, or open water (including the "aquatic species").

"Terrestrial species" are all other species, that don't show any preference for wetland habitats, though they may occur there as well.

Table 12 shows, that the vast majority of the species of the Pantanal are terrestrial birds. Among the 64 "aquatic species" the dominant groups are wading birds (Ciconiiformes: Egrets, Herons, Storks, Ibises, Spoonbills: 21 spp.), Shorebirds (Charadriiformes: Sandpipers, Stilts, Plovers and allies: 16 spp., among these 11 nearctic migrants), and Kingfishers (Alcedinidae: 5 spp.), while Waterfowl (Anseriformes: Screamers, Ducks and allies: 8 spp.) is relatively poorly represented.

For most species no breeding records from the Pantanal have ever been published. Most published information regards few conspicuous species (Yamashita and Valle, 1990; Antas and Nascimento, 1996; Guedes and Harper, 1995; Dubs, 1983a, b, 1988, 1992). The estimation of the numbers of breeding species in Table 13 is based on general information about migratory behavior (del Hoyo et al., 1992–2003; Ridgely and Tudor, 1989, 1994; Parker et al., 1996; Sick, 1997; Cintra and Yamashita, 1990; Forrester, 1993) and observations by Petermann (unpubl.).

Colonially breeding species. A number of aquatic and terrestrial species are social breeders. The number of colonial species among terrestrial birds is rather low, with the Monk Parakeet (*Myiopsitta monachus*), several species of Blackbirds (Icteridae) and Swallows (Hirundinidae) as most prominent examples. Of the aquatic birds of the Pantanal, 17 species (36 %) are breeding in colonies: three species of Kingfishers in river banks, and Terns and Skimmers on sandbars. Most conspicuous, however, are the large colonies of wading birds (Storks, Herons, Spoonbills).

In a part of the Pantanal of Poconé, approximately 10 % of the Pantanal, Yamashita and Valle (1990) calculated the total number of wading birds in 10 colonies (of

Table 11. Range-restricted species in the Pantanal (information about distribution from different sources).

Distribution pattern:	Pantanal and E-Bolivia	Pantanal, E-Bolivia, W- Paraguay, NW-Argentina	Pantanal and Bananal (Rio Araguaia)
Species:	n = 5 *Phaethornis subochraceus* *Pseudoseisura unirufa* *Cercomacra melanaria* *Thryothorus guarayanus* *Sporophila nigrorufa*	n = 6 *Ortalis canicollis* *Celeus lugubris* *Xiphocolaptes major* *Inezia inornata* *Cyanocorax cyanomelas* *Paroaria capitata*	n = 1 *Synallaxis albilora*

Table 12. Habitat requirements and status of bird species of the Pantanal (n=390 confirmed spp.).

Aquatic species?	yes	no	no	
Wetland dependent?	yes	yes	no	Total
Species	64	40	286	390
*Genera**	*51*	*36*	*208*	*282*
*Families**	*20*	*18*	*45*	*61*
Breeding	43–47	33–39	220–275	297–361

* some families and genera appear in more than one category

Table 13. Migratory status of bird species of the Pantanal.

Aquatic species?	yes	no	no	
Wetland dependent?	yes	yes	no	Total
Nearctic migrants	13	1	6	20
Austral migrants wintering	4	1	6	11
Other austral migrants	5	2	37	44
Nomadic	11	0	2	13

13 colonies found) as 40–50.000. The largest colonies had more than 10.000 birds. However, this number does not reflect the total population of colonial breeding waterbirds in this area. The timing of breeding activities depends on the water level and there are differences between the species, the regions, as well as between years (Yamashita and Valle, 1990; Willis, 1995). Diving species (*Phalacrocorax brasiliensis, Anhinga anhinga*) begin the breeding activity earlier, while the water level is still high. As these species are dark colored the respective colonies are locally called "*viveiros pretos*" ("black colonies"; Willis, 1995), in contrast to the "white colonies" of Egrets and Roseate Spoonbills, which become active during the dry season. "Black colonies" are more difficult to find (Yamashita and Valle, 1990), which is especially true for the nocturnal species Night Heron and Boat-billed Heron, which form well concealed colonies in riparian forest, sometimes together with Agami Herons or other species (Petermann, unpubl.).

Migrant species. The number and origin of migrant species in relationship to habitat is shown in Table 13. Migration is better known in nearctic species, as for neotropic species the exact limits of the breeding area are usually not well established, and an overlap of breeding and wintering areas is frequent. A few nearctic migrant species also have resident populations in South America, including the region of the Pantanal (*Elanoides forficatus, Gallinago* sp.*, Himantopus* sp.*, Vireo olivaceus*). However, nearctic migrants of those species apparently do not reach the Pantanal. "Other austral migrants" in Table 13 includes resident species of the Pantanal, which leave at least partially the Pantanal in the non-breeding season, as well as passing migrants.

Due to its geographic position the Pantanal has very limited importance for wintering migrant waterfowl (Anseriformes). Of some 20 nearctic migrants wintering in the Neotropics, only one (*Anas discors*, not known from the Pantanal) regularly migrates to the south of the equator (Rappole et al., 1995), while austral waterfowl species do not perform long-distance migrations (de la Peña and Rumboll, 1998), and only few species reach the Pantanal as rare visitors.

Very different is the situation among shorebirds. 25 nearctic species are known to winter in the southern Neotropics, mostly along the coasts. There is considerable migration through central South America (Antas, 1983; Stotz et al., 1992; Hayes et al., 1990) to important wintering areas in eastern Argentina. All of those species which take a continental migration route should be expected in the Pantanal. Until now, up to 22 species of nearctic shorebirds have been mentioned for the Pantanal (e.g., Dubs, 1992; Antas, 1994), though only 14 species are confirmed. There is a very limited number of austral migrant shorebirds in South America, and none of those migrate as far north as the Pantanal.

The Pantanal bird fauna in comparison to other neotropical wetlands. A comparison of the major neotropical wetlands clearly reveals the difference between temperate wetlands (e.g., in the High Andes; Fjeldså and Krabbe, 1990), with higher numbers of swimming species (Waterfowl, Grebes, Rails) and tropical wetlands which are characterized by a high number of wading birds (Storks, Herons, Ibises) and Kingfishers (see Reichholf, 1975). The Pantanal clearly classifies as tropical wetland, along with the Llanos of the Orinoco and the Amazonian floodplains. The composition of the group of aquatic species in these three large wetlands is extremely similar, indeed, with few exceptions all species can be encountered in all three regions. In Amazonia, several species are restricted to the more coastal areas.

As concerns wetland dependent terrestrial species, the biodiversity of Amazonia is much higher with some 100 species depending on floodplain habitats (Remsen and Parker, 1983). Remarkably, many of these species have also been found in the Llanos, but very few in the Pantanal.

The importance of the Pantanal for the conservation of avian biodiversity. As could be shown before, the Pantanal has little importance for endemic bird species, as all

species have also been found in adjacent regions. The total species number of the Pantanal is high, but does not reach the extraordinary diversity of amazonian rainforest sites. This was to be expected, as only a limited portion of the Pantanal is forest. Further the notably more seasonal climate of the Pantanal as compared to Amazonia or the Llanos of the Orinoco must be expected to limit the southward expansion of Amazonian species.

Of all the species recorded from the Pantanal, very few are considered threatened on a global scale (Wege and Long, 1995). According to BirdLife International (2004) are critically endangered: *Numenius borealis*; endangered: *Anodorhynchus hyacinthinus, Harpyhaliaetus coronatus, Sporophila palustris*; vulnerable: *Penelope ochrogaster, Sporophila cinnamomea, S. nigrorufa, Alectrurus risora*; near threatened: *Rhea americana, Amazona xanthops, Neochen jubata, Polystictus pectoralis, Euscarthmus rufomarginatus*. However, this is a circular argument: due to the size and still excellent conservation of the Pantanal, any species with a healthy population in the Pantanal will not be considered endangered on a global scale. But this should no longer be taken as granted. The environmental impact studies concerning the improvement of the Paraguay River for navigation (Hidrovia Paraguay-Paraná-project, e.g., Huszar et al., 1999; EDF and CEBRAC, 1997) have shown, that even limited interventions could affect a great proportion of the gallery forests of the Pantanal, which in turn are a key resource for colonially breeding waterbirds (Schnack and Petermann, 1999), and other fauna (Lourival et al., 1999).

Though reliable numbers of population sizes are available for few species only, there is no doubt, that many bird species of the Pantanal, especially aquatic ones, have a major part of their global population in the Pantanal wetland. Among those are some very "charismatic" or endangered (Bird Life International, 2004) species, like the Jabiru stork, Hyacinth Macaw, Golden-collared Macaw, or Chestnut-bellied Guan (*Jabiru mycteria, Anodorhynchus hyacinthinus, Ara auricollis, Penelope ochrogaster*). It will depend on the conservation of the Pantanal, whether these and other species can be kept out of the "Red lists" of endangered species in the future.

Mammals

Similar to the birds, several species lists exist about the mammals of the Pantanal, however, a full record is still missing. Especially the small, species-rich taxa such as bats and small rodents require a thorough revision. Highest numbers of regional inventories are given by Schaller (1983) and PCBAP (Brasil, 1997) with 64 and 75 species, respectively. For the entire floodplain Rodrigues et al. (2002) indicate 93 species (Table 14). This is less than 50 % of the species number of the Cerrado (194 species, e. g. Marinho Filho et al. (2002). However, new records are reported frequently as, for instance, by a rapid assessment that was realized in 2001 in the National Park of the Pantanal of Mato Grosso and the Reservas Particulares do Patrimonio Natural (RPPN) Acurizal and Penha (Rossi et al., unpubl.). It lists 56 species belonging to 49 genera, 20 families and 8 orders and includes a couple of species not mentioned in the list of Rodrigues et al. (2002). An analysis of different inventories of mammals in and around the Pantanal and the extrapolation of distribution patterns of mammals in the Brazilian Cerrado and the Argentinean Chaco lead to an estimated number of 132 mammal species in the Pantanal (Alho and Lacher, 1991; Fonseca et al., 1996; Marinho Filho et al., 1998; Brasil, 1997). 91 % of the Pantanal-species also occur in the Cerrado, 85 % in Amazonia and 84 % in the Chaco. Total number of species in the Pantanal, the surrounding areas of Cerrado and Chaco and adjacent areas of Amazonia reaches 149 species, that should be the maximum number to be expected (Table 14). In all inventories, bats make up for about one third of the total species number.

Contrary to the African savannas, the Pantanal wetland is not characterized by large herbivorous mammals and its diversity and abundance of native ungulates is relatively low. Carrying capacity for large ungulates, however, is high as shown by the large number of cattle that maintain the "parkland" aspect in wide areas of the Pantanal for over 200 years. Schaller (1983) estimated a mammalian biomass of 380 kg km^2 for native species, mainly tapir, deer, peccary and capybara, and of 3,750 kg km^2 for cattle, thus a ratio of 1:10 between natural and introduced mammal biomass on the Acurizal ranch, now a private reserve, in the southern Pantanal. The most conspicuous native ungulates are the marsh deer *(Blastocerus dichotomus)* and the pampas deer (*Ozotocerus bezoarticus*) which are listed as endangered in Brazil and need efficient monitoring and conservation programs (Mourão et al., 2000). Tomas et al. (2001) report population densities of 0.382 ± 0.362 ind km^{-2} for the dry and 0.395 ± 0.144 ind km^{-2} for the wet season for the marsh deer.

The capybara (*Hydrochoerus hydrochaeris)* is a large rodent which is highly adapted to the changing environmental conditions in the Pantanal. Capybara live in organized families that forage on grasses and aquatic macrophytes along the borders of rivers and lakes where they can find water, feeding grounds and some woody vegetation as shelter (Schaller and Crawshaw, 1981; Schaller, 1983), therefore, proposals have been made to manage it as a protein source (e.g., Alho, 1986). Top predators of the Pantanal are the jaguar *(Panthera onca)* and the giant river otter *(Pteronura brasiliensis)* which are both well adapted to wetland conditions. Also well adapted is the crab-eating raccoon *(Procyon cancrivorus)*.

Apart from these flood adapted species, the Pantanal also harbors a relatively large numbers of more terrestrial

Table 14. Orders, families, and number of genera and species of mammals in the Pantanal of Mato Grosso, in the Pantanal and surroundings (*), and in adjacent areas of Amazonia, *Cerrado* and *Chaco* (in parentheses), according to Rodrigues et al. (2002) and Brasil (1997). (Differences in the number of genera in some families, e.g., in the Felidae and Tayassuidae are the result of different taxonomic systems. The listed species are identical.)

Order	Family	Genera (n)	Species (n)
Didelphimorpha	Didelphidae	7 (11) 11*	7 (15) 14*
Xenarthra	Dasypodidae	4 (5) 5*	4 (7) 7*
	Myrmecophagidae	2 (2) 2*	2 (2) 2*
Chiroptera	Emballonuridae	4 (4) 4*	4 (4) 4*
	Noctilionidae	1 (1) 1*	2 (2) 2*
	Mormoopidae	0 (1) 1*	0 (1) 1*
	Phyllostomidae	15 (18) 16*	19 (30) 21*
	Vespertilionidae	2 (3) 3*	3 (4) 4*
	Molossidae	5 (5) 5*	8 (9) 8*
Primates	Callitrichidae	1 (1) 1*	1 (1) 1*
	Cebidae	3 (5) 5*	3 (5) 5*
Carnivora	Felidae	5 (6) 6*	6 (8) 8*
	Canidae	4 (5) 5*	4 (5) 5*
	Procyonidae	2 (3) 3*	2 (3) 3*
	Mustelidae	5 (5) 5*	5 (5) 5*
Perissodactyla	Tapiridae	1 (1) 1*	1 (1) 1*
Artyodactyla	Tayassuidae	2 (2) 1*	2 (2) 2*
	Cervidae	3 (3) 3*	4 (4) 4*
Rodentia	Sciuridae	1 (1) 1*	1 (2) 2*
	Muridae (Cricetidae*)	7 (13) 11	7 (23) 18*
	Erethiozontidae	1 (1) 1*	1 (1) 1*
	Caviidae	1 (2) 1*	1 (2) 1*
	Hydrochoeridae	1 (1) 1*	1 (1) 1*
	Agoutidae	1 (1) 1*	1 (1) 1*
	Dasyproctidae	1 (1) 1*	1 (2) 2*
	Ctenomyidae	0 (1) 1*	0 (1) 1*
	Echimyidae	2 (6) 6*	2 (7) 7*
	Leporidae	1 (1) 1*	1 (1) 1*
Total	28	82 (109) 103*	93 (149) 132*

mammals, like the coati *(Nasua nasua),* the puma *(Felis concolor)*, ocelot *(Felis pardalis)*, jaguarundi *(Felis yagouarundi)*, and the giant anteater *(Myrmecophaga tridactyla)*. Traces of the extremely rare giant armadillo *(Priodontes maximus)* are regularly reported however its current status in the Pantanal is uncertain. Non flooded *terra firme* islands and levees are indispensable for their occurrence during the flooding period. Some species such as the maned wolf *(Chrysocyon brachyurus)* seem to migrate between the Pantanal and the surrounding Cerrado habitats. The rareness of contiguous dense forests seems to be the reason for the low numbers of rodents and monkeys.

The role of exotic species

The physiological stress related with the change between pronounced terrestrial and aquatic conditions make floodplains a difficult place for exotic species. But there are exceptions, such as flood-tolerant species from other floodplain areas or ruderal plants with short life cycles, high reproduction rates and flood resistant propagules. Rivers serve as natural dispersal and migrating routes for plant and animal species of the entire catchment area and from abroad. Seidenschwarz (1986), studying the vegetation of the upper Amazon River floodplain points to the importance of river floodplains in the distribution of rud-

eral plants. Frequent disturbance by floods and droughts reduces competition with native species and favors colonization of strongly disturbed erosion and deposition areas along the main river channels.

Major scale introduction of exotic plants and animals into South America started with the arrival of the Europeans. A few exotic bird species established themselves in Brazil, such as Feral Rock Dove and the House Sparrow from Europe, or the African Common Waxbill (*Columba livia, Passer domesticus, Estrilda astrild*). However, in the region of the Pantanal these species are still restricted to urban centers at the periphery, but have not established inside the Pantanal. The only colonization of near-natural habitats by a non-native bird species is the paleotropic Cattle Egret (*Bubulcus ibis*), which has invaded the Americas at the turn of the 19th century, following the spread of domestic cattle throughout the Neotropics. In the Pantanal it must have arrived in the middle of the 20th century, but when it was first recorded in the 1960s it was already common. The gekkonid lizard *Hemidactylus mabouia* that possibly arrived together with the slaves from Africa, is well established in almost every periantropic habitat in farms and settlements throughout the Pantanal, as it is elsewhere in Brazil (Avila-Pires, 1995). The grasses *Cynodon dactylon* (Africa or Indo-Malaysia), *Eleusine indica* (probably S.E. Asia), *Dactylotenium aegyptium* (trop. Africa), *Panicum repens* (Australia), the herb *Sphenoclea zeylanica* (trop. Africa), and the tree *Acacia lebbeck* (S.E. Asia) are common but they do not create problems for the native fauna and flora. Two African grasses, *Hyparrhenia rufa* and *Panicum maximum*, have been introduced in high lying areas to improve pasture, but both species are little flood tolerant. There is rising concern about *Brachiaria subquadripara* (tanner grass), an aggressive old world wetland grass, that was introduced some years ago and is spreading now in some parts of the Pantanal near the Pantanal National Park (Pott et al., 2001).

Cattle and horses were introduced about 300 years ago in the Pantanal and developed specific wetland races (*tucura,* and *cavalo pantaneiro*). During the last decades, the *tucura* became substituted by nelore that is more productive (Mazza et al., 1994). Aerial surveys (with correction of visibility), indicate 4.5 million cattle in the Brazilian part of the Pantanal, densities being higher in less inundated areas and lower in deeply inundated or forested areas (Mourão et al., 2002). Cattle play an important role in maintenance of the parkland aspect of the Pantanal and low density cattle ranching is considered an ecologically sound and sustainable management method. Major risks arise from high stocking rates and increasing deforestation of forested areas to increase pasture area. About 49,000 horses exist in the Pantanal being used mainly for the management of the cattle population.

Probably during the Paraguay War (1864–1870), pigs developed a feral population (*porco-monteiro*) that is managed by the local population. Aerial surveys indicate about 9,800 groups. A few decades ago, water buffaloes (*Bubalus bubalis*) were introduced, reaching now a population of about 5,100 specimen (numbers not corrected for visibility, Mourão et al., 2002). Feral pigs and water buffaloes can create major problems to the ecosystem, however, there are no studies about their impact on the Pantanal.

Of major importance are some animal diseases that were introduced with cattle and horses. Mal-de-cadeiras (*Trypanosoma evansi*) was probably introduced by Spanish settlers in the sixteenth century and affected also the populations of the capybara (*Hydrochoerus hydrochaeris*) (Franke et al., 1994, Silva et al., 1995). The parasite has also been found in coatis (*Nasua nasua*) and dogs (Nunes and Oshiro, 1990). Since the 1930s the viral Foot- and Mouth-Disease is observed and severely affected the populations of deers (Wilcox, 1992). To what extent recently introduced diseases and parasites, such as the hornfly (*Haematobia irritans*) observed since 1991, (Barros et al., 2002), the equine infectious anaemia (swamp fever) created by a retrovirus and transmitted by horseflies (tabanids), observed since 1974 (Silva et al., 2001), and the bovine trypanosomiasis (*Trypanosoma vivax*), also transmitted by tabanids and observed since 1996 (Silva et al., 1997) can affect the populations of wild animals is not known.

Several exotic fish species are created in fish culture facilities in the catchment area of the Pantanal, such as tilapia (*Tilapia mossambica*) and the African catfish (*Clarias* sp.). Certainly, specimens have escaped into the river system, but there is no information about the establishment of these species inside the Pantanal. The Amazonian Tucunaré (*Cichla ocellaris*), a voracious predator, was introduced for sport fishing and is now abundant in the Piquirí River, left hand tributary of the São Lourenço River (F. A. Machado, Federal University of Mato Grosso, pers. comm.) and spreading in the Taquarí River system (W. J. Junk, pers. observ.).

27 foreign useful herbaceous plant species and 17 tree species are planted by local farmers without major effects on the natural vegetation. Roads constructed on dikes serve as immigration routes of strictly terrestrial plants from the uplands into the Pantanal, as can be shown by the plant communities along the roadsides. 99 species are listed but, there is no evidence that these species become permanently established in the floodplain, and create problems for the native vegetation.

Impressive examples for quick dispersal of exotic species are the African bee and the Asian golden mussel. African bees (*Apis mellifera adansoni*, *A. mellifera capensis, A. mellifera scutelata*) were introduced in 1956 to São Paulo State, where they escaped and formed hybrids with local bees introduced from Europe decades ago, such as *Apis mellifera ligustica*. These hybrids extended

theire range with a mean velocity of about 110 km yr^{-1}. The very aggressive bees (*Apis mellifera* hybrid de *ligustica* with *scutelata*) also occur in the Pantanal. In March 2004, they attacked scientists of the University of Mato Grosso and killed our collegue Vangil Pinto da Silva.

The Asian golden mussel (*Limnoperna fortunei,* Mytilidae), about one centimetre long, was introduced in 1993 probably with ballast water by ships from Asia to the La Plata system. In 1995 it reached Santo Tomé on the middle Paraná River about 400 km upstream (Darrigran and Ezcurra de Drago, 2000) and was recorded in 2001 in the Pantanal, about 2000 km from the mouth (C. T. Callil, Federal University of Mato Grosso, pers. comm.). The mussel fixes with byssus on hard substrates and creates serious problems for instance on water supply plants by clogging water intake pipes. Its impacts on the ecosystem are not studied yet. Several fish species heavily feed on it without affecting its spread. The mussel will probably negatively affect native mussel populations in the river channels and permanent water bodies by growing on their shells and hindering filtration. To what extent the species is able to colonize the floodplain proper is still unknown, but its low resistance against periodic drought will probably limit its spread.

A major point of preoccupation of the local ranchers is the undesired spread of native plants into pastures, such as the herb *Ipomoea fistulosa (algodão bravo)*, and the trees *Vochysia divergens* (*cambará*), *Combretum lanceolatum, C. laxum, Vernonia brasiliensis, Sphinctanthus hasslerianus, Mimosa pellita (M. pigra), Byrsonima orbygniana, Licania parvifolia* and *Couepia uiti*. Several authors speculate about reasons for the spread of these species, such as overgrazing by cattle, large scale changes in environmental conditions or change in global climate, however, without any data. A detailed study of Nunes da Cunha and Junk (2004) about the spread of *Vochysia divergens* points to multiannual natural dry and wet periods as determining factor. *V. divergens* is a flood adapted tree that is spreading during wet periods and restricted during multiannual droughts because it does not tolerate the impact of wild fires.

Threats and protection

Because of its long distance from major urban centers and its difficult access, the Pantanal has been on the sidelines of the economic development in South America. The European immigrants used the area mostly by low density cattle ranching on natural pastures. Pasture areas were slowly increased by cleaning parts of periodically flooded shrub-savannas (*campo sujo*) from shrubs and trees, but maintaining forested islands on elevations (*capões* and *cordilheiras*), in depressions (*landis*) and on levees along river courses and around lakes. Grazing cattle controlled the re-growth of shrubs and trees and maintained a "park-landscape" of scenic beauty with high habitat and species diversity. Most wildlife was rather well protected because of the availability of cheap beef. Travelers report on herds of 300 to 400 deer and huge numbers of peccaries, tapirs and jaguars (Ulrich, 1936). In the second half of the last century, poaching for hides strongly reduced the abundance of most species and threatened jaguars, otters, and deer, a problem that is not yet completely under control.

At the beginning of the 1970s, the Brazilian government established large development programs to stimulate economic productivity of the entire Paraguay River catchment area, including the Pantanal. Large scale soybean production in the catchment resulted in increased erosion and sediment deposition inside the Pantanal with dramatic consequences. For instance, the sediment load rose the river bed of the Taquarí River and because of the low declivity, the river left the former channel and floods, since a couple of years, an area of about 11,000 km^2 for much longer periods than before (Fig. 1).

Several hydroelectric power plants are planned or under construction on large tributaries of the upper Paraguay River. In November of 1999, a huge reservoir (428 km^2) at the Manso River near Cuiabá was closed interrupting the migration route of many fish species from the Pantanal to their upstream spawning grounds and also altering the flood regime of the Cuiabá River inside the Pantanal. The immediate effects of the lake filling on terrestrial and volant vertebrates have been monitored in detail by Alho et al. (2003), but the long term consequences of the hydrological changes on the low-lying plains are not yet understood. Some negative effects have already been observed, e.g., on shorebirds that lost their nesting areas on exposed sand beaches due to a higher discharge from the reservoir at low water period. The vegetation will require decades to readjust to the new hydrological conditions.

A major threat is the plan to rectify and deepen the sinuous channel of the Paraguay River to facilitate ship transport through the Pantanal (*hidrovia* project). This would dramatically affect the hydrology of the entire Pantanal with far reaching negative consequences for flora, fauna and the local human population (Ponce, 1995; Hamilton, 1999). In 2000, the Brazilian government stepped back from this plan, however private enterprises continue with the construction of infrastructure against heavy resistance of NGO's.

The increasing competition with the cattle ranches on artificial pastures of the surrounding upland are forcing ranchers inside the Pantanal to increase the number of animals and accelerate deforestation of forested high lying areas to provide additional pasture areas. The destruction of these key habitats will on the long term severely affect species diversity.

Conservation plans should consider the wide home range of large "flagship species" and the necessity of contiguous adequate migration corridors between the conservation units. Telemetry studies have shown territory sizes of 25 to 38 km^2 in jaguar females and 90 km^2 in males (Schaller and Crawshaw, 1980) in the Pantanal. Quigley and Crawshaw (1992) developed a comprehensive conservation plan for the species in the region in which they recommend the establishment of large reserves and the maintenance of gallery forests as corridors for inter-refugia movement. Mammals are especially sensitive to fire, and even large mobile species such as marsh deer and jaguar can become killed (Wantzen, pers. obs.).

Presence of human settlers always implies environmental problems, however, traditional farmers generally hunt moderately on more common species as the paca (*Agouti paca*), brocket deer (*Mazama* spp.), and nine-banded armadillos (*Dasypus novemcinctus).* There is also heavy pressure on predators, e.g., jaguar, puma and eagles. Large raptors are usually not tolerated near fazendas because they frequently attack free-living domestic fowl. Cats and dogs often hunt in the surroundings of the settlements, but are not able to survive in the wilderness. Increasing ecotourism is beginning to stimulate the local economy, however, it is also bringing many environmental and socio-cultural problems to the area, mainly by little controlled sport fishers (more than 100,000 sport fishers in the Brazilian Pantanal) and little adapted tourist facilities (about 20,000 eco-tourists per year in the northern Pantanal; Köhnlein, 1995).

Rising concern about the future of the Pantanal led to a variety of activities by universities, state- and government agencies, and national and international NGO's (Harris et al., 2005). According to a conservation assessment of the WWF and the Biodiversity Support Program, the Pantanal was considered "globally outstanding" (rank 1 of 4), in terms of biological distinctiveness, "vulnerable" (rank 3 of 5) in terms of conservation, and has "highest priority" (rank 1 of 4) in regional priorities for conservation action (Olson et al., 1998). In 1988, the Pantanal was proclaimed by the Brazilian Constitution as National Heritage, in 1993 by UNESCO as Ramsar Site, and in 2000 as World Biosphere Reserve. In the same year, UNESCO also granted the Pantanal the Natural World Heritage certificate, and in 2002 the Pantanal Regional Environmental Program related to the United Nations University (UNU/PREP) was founded at the University of Mato Grosso, Cuiabá. UNU/PREP pretends to establish a network of national and foreign institutions interested in sustainable management and protection of the Pantanal.

Actually, there are two national parks and one ecological station under federal administration in the Brazilian part of the Pantanal, some state parks and an increasing number of private protected sites (e.g., Reservas Particulares do Patrimonio Natural – RPPN, administrated by the NGO ECOTROPICA and the by Social Service of Commerce – SESC). Total protected area corresponds to 360,000 ha (2.6 % of the Brazilian Pantanal) (http://www.ibama.gov.br/). In Paraguay, the National Park Rio Negro was recently expanded to 123,786 ha. In Bolivia there are the Natural Area of Integrated Management San Matías (ANMI San Matías) of 2,918,500 ha, the National Park and Area of Integrated Management Otuquis (PN-ANMI Otuquis) of 1,005,950 ha and the Municipality Reserve of Tucavaca of 262,305 ha. These areas include flooded areas but also uplands in different proportions (http://www.fobomade.org.bo/pantanal_bolivia/conociendo.php) (Fig. 1).

Discussion and conclusions

The geographic isolation and the very slow economic growth of the Pantanal led to the maintenance of rather pristine conditions of the area, but also to a dramatic lack of knowledge about structures and functions including species diversity. With the beginning of large scale development plans for the Pantanal and its catchment area, the Brazilian government also stimulated research projects. However, lack of infrastructure and a low number of qualified local scientists retards until today the elaboration of a sound data base that is required for of the already ongoing or planned large development projects.

A good example for this statement is the state of knowledge about species diversity, and the natural and anthropogenic factors affecting it. Species lists even on well known groups such as trees, herbaceous plants, mammals, fish and birds are incomplete and do not consider distribution pattern inside the Pantanal. Authors often include upland species of the catchment area in their species lists that have not been confirmed for the Pantanal lowland. Life history traits, ecological requirements, and migration pattern of most species are unknown. Major gaps exist about terrestrial and aquatic invertebrates (Table 15). This hinders detailed environmental impact analyses of large ongoing development projects and makes predictions about the impact of planned projects very difficult.

Species composition and diversity of the Pantanal is the result of paleoclimatic history and recent climatic and hydrological conditions. During and after the last ice age and probably also in earlier glacial periods, the Pantanal passed through periods of heavy drought. Wetland organisms were extinct or survived in refuges along the lower Paraguay River, and in moist areas of the surrounding Cerrado, the adjacent Argentinean Chaco and Amazonia. When the climate became wetter, wetland areas in the Pantanal expanded and wetland organisms immigrated from the refugia of the surroundings. Highly mobile spe-

Table 15. Number of families, genera and species of different plant and animal taxonomic categories, confirmed for the Pantanal of Mato Grosso. Species lists of higher plants and vertebrates cover about 80 to 90 % of the total. The numbers of most aquatic and all terrestrial invertebrate groups is not known. For data sources see this paper.

Taxonomic category	Families (n)	Genera (n)	Species (n)
Algae	30	63	337
Herb. terr. Plants	76	381	900
Herb. aquat. Plants	57	108	248
Woody plants	70	380	756
Aquatic Invertebrates			
Testacea	10	34	246
Ciliata	32	40	55
Rotifera	24	57	285
Cladocera	7	35	117
Copepoda	2	13	33
Ostracoda			15
Bivalves	5	10	23
Aquatic snails	3	4	5
Oligochaetes	8	20	37
Terr. Invertebrates	?	?	?
Fishes	36	161	263
Reptiles	17	63	96
Amphibians	5	16	40
Birds	61	282	390
Mammals	28	94	130

cies were more efficient in comparison to less mobile species as shown by the large number of aquatic birds.

Drought tolerant species lost part of their habitats but found refuges on high lying areas. Most mammals, 50 % of the reptiles and 73 % of the birds are terrestrial species that have a wide distribution in the dry areas of the Cerrado, Chaco and Amazonia. About 78 % of the 1,148 grasses and herbs are terrestrial. From 85 analyzed tree species 26 are terrestrial, 4 occur only in habitats subjected to long term inundation, and the other 55 species show a wide range of periodical flood and drought tolerance. An impressive morphological and physiological plasticity allows the co-occurrence of many terrestrial and wetland grasses and herbaceous plants on moist ground during the rainy season. A large seed bank in the sediments that is activated only in small portions at a time, allows the recolonization of the floodplain by terrestrial and aquatic species after floods and droughts and gives the system a high resilience against unpredictable hydrological events that frequently occur in the Pantanal. The large habitat diversity that includes permanent aquatic, periodically flooded and permanently dry habitats is the ecological basis for the species diversity.

Our knowledge about terrestrial invertebrates and their adaptations to periodic flooding is not sufficient yet to make general statements about species diversity and to build hypotheses about the impact of environmental factors. Several taxa common in Amazonian black water inundation forests were missing or less abundant in the *Vochysia divergens* forest studied in the Pantanal. Environmental factors such as fire, sandy soils, the pronounced dry periods or the island character of the study site may be the reasons. Also some adaptations to flooding, frequently found in terrestrial invertebrates of Amazonian floodplains were not yet detected in the Pantanal. These findings may point to a lower level of adaptation of terrestrial invertebrates to prolonged flooding, as already shown by the woody vegetation.

Important environmental factors for species composition are the rather predictable low flood amplitude and the pronounced seasonality in rainfall. The shallow flooding of large areas with transparent water during several months favors the development of luxuriant and species-rich submerged and emergent herbaceous plant communities. Shadowing by a flood tolerant forest is hindered by the pronounced dry periods, accompanied by frequent wild fires that restrict tree growth. This explains the very large diversity of aquatic macrophytes, but also the high number of terrestrial grasses and herbs. Wading birds find excellent living conditions in the shallowly flooded savannas and occur in large species numbers and great abundance.

Interpretation of the importance of the specific environmental conditions of the Pantanal on species diversity is facilitated when comparing them with the neighbouring Amazon River floodplains that are quite different. There, the mean flood amplitude reaches about 10 m and soil moisture allows tree growth in all habitats inundated less than about 240 d yr^{-1} and up to a water depth of about 8m. Aquatic macrophyte diversity is strongly reduced and free floating submersed and emergent plants that can accompany the fluctuating water level prevail. Submersed plants rooted in the ground are missing. Terrestrial herbaceous plants colonize very low lying areas without forest cover that fall dry during few months only or have to live under very poor light conditions in a dense floodplain forest. Large wading birds find good living conditions only during low water period. Only species that are able to fish from tree branches near the surface or from floating macrophytes such as most herons and egrets (e.g., *Ardea cocoi, Casmerodius albus*, *Egretta thula)* occur throughout the year.

There are very few endemic species described for the Pantanal. A time span of a few thousand years after the last heavy dry period was obviously not long enough to

produce endemic species. This seems to be strange, because studies on the fish fauna in the large East African lakes show, that speciation in the tropics can happen in a few thousand years period (Kaufmann et al., 1997). This process was certainly hindered in the Pantanal by the flood pulse that forces mobile species to move from the floodplain to the rivers and back, and passively transports propagules or less mobile species by water current. This active and passive mobility leads to a permanent genetic exchange in the entire area and hinders speciation by spacial segregation of populations.

The Pantanal is subject to strong multi-annual variations of flood and dry periods. These periods strongly affect aquatic and terrestrial organisms. During the very high floods in the early 1970s, about 30 % of the cattle population and an undescribed number of native terrestrial animals died (Cadavid García, 1981). Fire is an additional stress factor of the system that becomes critical in multi-annual dry periods. Populations of long living plants and animals require more time to re-establish after such periods as shown for *Vochysia divergens* (Nunes da Cunha and Junk, 2004). Climate models predicting changes in global climate indicate a rise of 1.4–5.8 °C, the larger temperature increase being in higher latitudes than in the tropics. By the second half of the 21th century, at low latitudes, both regional temperature increases and decreases are expected over land areas, with larger year-to-year variations in precipitation and associated heavy droughts and floods (Intergovernamental Panel on Climate Change; IPCC, 2001). This increase in extreme droughts and floods will heavily stress the organisms in the Pantanal and add to human induced stress factors.

Since the formation of large wetland areas inside the Pantanal, the area experienced the invasion of many plant and animal species from the surrounding biomes, a process that probably continues until today. Large habitat diversity and natural and man-induced disturbances make the Pantanal susceptible for species invasion. This also holds true for exotic species. Their number and related problems are still small, but strong efforts should be undertaken to avoid their import because negative side effects could be dramatic and their control extremely costly, or even impossible.

The Pantanal is one of the outstanding large wetlands of the world and requires highest priority in environmental protection, as indicated by all national and international environmental agencies. However, efficient protection will be reached only, when an integrated management plan for the entire upper Paraguay River basin is elaborated and implemented that considers the environmental impact on the Pantanal. Considering the overwhelming importance of the flood pulse for structures and functions and the maintenance of biodiversity of floodplain systems, development projects that modify the natural hydrological regime in large scale, such as reservoirs, dikes and channels should be avoided. Strong efforts are required to reduce the input of sediments and pollutants (agrotoxics, mercury, industrial and domestic wastes from mayor cities, etc.) into the rivers that deposit the material inside the Pantanal.

Furthermore, species diversity of the Pantanal is closely linked to habitat diversity. The maintenance and protection of key habitats, such as different types of forests, lakes and channels in areas used for cattle ranching should be given top priority. The different types of forests are key habitats for the maintenance of mammal and bird diversity, whereas permanent lakes and channels are crucial for the survival of aquatic plants and animals. More than this, connectivity of these divergent habitats must be guaranteed, as well as connectivity between rather protected areas in the core of the Pantanal and in adjacent biomes. This is the basic requirement to maintain genetic flow and survival of large, vagrant "umbrella species". In this sense, ecological corridors must be implemented and their structure and function monitored over time.

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Apresentação

Mudanças Climáticas e Biodiversidade

O fenômeno de mudança do clima, considerando a amplitude e distribuição global dos impactos sobre a biodiversidade, o setor produtivo e a sociedade, não deve ser encarado apenas como uma previsão catastrófica para um futuro distante, mas sim como um fato, vivenciado no presente. O aumento da frequência de eventos climáticos extremos é evidente e serve como alerta para a urgência na adoção de medidas de mitigação e adaptação.

Neste cenário, o Brasil tem o desafio de contribuir com o esforço de mitigação e adaptação à mudança do clima, compatibilizando o crescimento econômico do país com a sustentabilidade dos recursos naturais e com o bem-estar social.

Assim, a fim de cooperar com o empenho mundial em prol da redução das emissões de gases de efeito estufa, incentivar o desenvolvimento e aprimoramento de ações de mitigação, bem como criar condições para adaptação frente aos impactos das mudanças climáticas globais, em 2008, o Comitê Interministerial sobre Mudança do Clima apresentou o Plano Nacional sobre Mudança do Clima.

O Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio), tendo em vista sua missão de proteger o patrimônio natural e promover o desenvolvimento socioambiental no país, busca, por meio de suas diversas áreas de atuação, colaborar com o alcance de objetivos estabelecidos no Plano Nacional sobre Mudança do Clima, dentre os quais vale destacar aqui o objetivo: "Identificar os impactos ambientais decorrentes da mudança do clima e fomentar o desenvolvimento de pesquisas científicas para que se possa traçar uma estratégia que minimize os custos sócio-econômicos de adaptação do País".

O que se conhece a respeito dos efeitos das mudanças climáticas sobre a biodiversidade? Quais são as implicações socioeconômicas da mudança do clima? Quais são as soluções, na esfera de atuação do ICMBio, para mitigar esses efeitos e adaptar-se às mudanças que já estão acontecendo? Estamos prontos para lidar com o problema?

Diante do grande desafio da pesquisa para a conservação da biodiversidade em um cenário de mudança do clima, o VIII Seminário de Pesquisa e VIII Encontro de Iniciação Científica do ICMBio traz o tema "Mudanças Climáticas e Biodiversidade" e objetiva:

i. promover o debate sobre as mudanças do clima, seus impactos sociais, econômicos e ambientais e as possíveis soluções para o problema, com ênfase nas unidades de conservação do ponto de vista dos impactos e das soluções;

ii. divulgar os trabalhos conduzidos por servidores ou pesquisadores externos em unidades de conservação federais ou com espécies ameaçadas ou sobre os efeitos das mudanças climáticas sobre a biodiversidade;

iii. concluir o ciclo do Programa PIBIC/CNPq 2015/2016, com a apresentação dos trabalhos realizados pelos alunos de iniciação científica.

Comissão Organizadora

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Seção I – Programação

dia 13 de setembro	
8h às 8h30	Chegada dos participantes e inscrições
8h30 às 9h15	Cerimônia de abertura
9h15 às 10h15	**Conferência de abertura** **Adaptação às mudanças climáticas baseada em ecossistemas: uma oportunidade para o Brasil** • Fabio Scarano – Fundação Brasileira para o Desenvolvimento Sustentável – FBDS
10h15 às 11h	Debate
11h às 11h15	Intervalo
11h15 às 12h	**Palestra 1: Possíveis impactos da mudança do clima sobre a biodiversidade e implicações para o planejamento da conservação** • Ana Luisa Albernaz – Museu Paraense Emílio Goeldi (MPEG)
12h às 12h30	Debate
12h30 às 14h	Almoço
14h às 16h	**Sessão de painéis** Apresentação dos trabalhos dos estudantes do Programa de Iniciação Científica – PIBIC/ICMBio, dos servidores do ICMBio e dos pesquisadores externos com trabalhos selecionados
16h às 16h15	Intervalo
16h15 às 18h	**Mesa redonda 1: Impactos da mudança do clima sobre espécies e ecossistemas** • Mário Luiz Gomes Soares (NEMA/UERJ) – Impactos das mudanças e variabilidades climáticas sobre o ecossistema manguezal • Beatrice Padovani (UFPE) – Impactos da mudança do clima sobre ambientes recifais e possíveis soluções de manejo • Guillermo Estupiñan (WCS-Brasil) – Mudanças climáticas e grandes empreendimentos: conexões e adaptações nos peixes migradores, pesca e paisagens aquáticas na Amazônia **Moderação:** Mariana Egler – Secretaria de Mudanças Climáticas e Qualidade Ambiental – MMA
18h às 18h30	Debate

dia 14 de setembro	
8h30 às 10h45	**Mesa redonda 2: Mudanças do clima e instrumentos de gestão** • Jennifer Viezzer (SBF/MMA) – Como incorporar o enfoque da AbE em planos de manejo de UC: a experiência do Plano de Manejo da APA Cananéia-Iguape-Peruíbe • Isabel Schmidt (UnB) – Por que fazer manejo integrado do fogo em UC em um cenário de mudança do clima? • Beto Mesquita (Conservação Internacional) – Plano Municipal da Mata Atlântica com base em AbE: a experiência de Porto Seguro, BA **Moderação:** Ricardo Brochado Alves da Silva – Coordenação Geral de Criação, Planejamento e Avaliação de Unidades de Conservação – CGCAP/DIMAN/ICMBio
10h45 às 11h	Intervalo
11h às 12h	Debate
12h às 13h30	Almoço
13h30 às 15h	**Mesa redonda 3: Impactos socioambientais da mudança do clima** • Manyu Chang (Fiocruz) – Vulnerabilidade humana à mudança do clima • Beatriz Oliveira (Fiocruz) – Impactos da mudança do clima sobre a saúde humana • Manoel Cunha (CNS) – Os impactos da mudança do clima sobre comunidades extrativistas: desafios e soluções **Moderação:** Claudio Maretti – Diretor de Ações Socioambientais e Consolidação Territorial em UCs – DISAT/ICMBio
15h às 15h30	Debate
15h30 às 15h45	Intervalo
15h45 às 17h30	**Mesa redonda 4: Mudanças climáticas: como lidar com isso na prática?** • Ricardo Cardim (Ricardo Cardim Biodiversidade Nativa) – Florestas de bolso: uma iniciativa de reflorestamento na cidade de São Paulo • Bruno Rezende Silva (JBRJ) – Telhados verdes: uma alternativa para adaptação à mudança do clima em cidades? • Jorge Henrique Prodanoff (Escola Politécnica/UFRJ) – Infraestrutura verde e drenagem urbana: uma visão ecossistêmica **Moderação:** Katia Torres – Coordenação Geral de Pesquisa e Monitoramento – CGPEQ/DIBIO/ICMBio
17h30 às 18h	Debate

dia 15 de setembro	
8h30 às 10h30	**Apresentação oral dos trabalhos PIBIC selecionados**
10h30 às 10h45	Intervalo
10h45 às 12h30	**Mesa redonda 5: Contribuições do Programa de Pesquisas Ecológicas de Longa Duração - PELD/CNPq na compreensão dos impactos da mudança do clima sobre a biodiversidade** • Leandro Valle Ferreira (MPEG) – O impacto da seca artificial simulando a anomalia climática do El Nino na comunidade de plantas da floresta de sub-bosque da Amazônia Oriental • Liliana Rodrigues (NUPELIA/UEM) – Resultados do Sítio PELD Planície de Inundação do Alto Rio Paraná (PIAP) • Ben Hur Marimon Júnior (UNEMAT) – Mudanças climáticas e biodiversidade no Arco do Desmatamento: o que a transição Amazônia/Cerrado tem a nos dizer? **Moderação:** Marisa Mamede – CNPq
12h30 às 13h	Debate
13h às 14h30	Almoço
14h30 às 15h15	**Premiação dos trabalhos PIBIC**
15h15 às 16h	**Palestra 2: Conservação e restauração da vegetação nativa nos compromissos do Brasil para mitigação de mudanças climáticas** • Mercedes Bustamante – Universidade de Brasília (UnB)
16h às 16h45	Debate
16h45 às 17h	Intervalo
17h às 17h45	Reunião para definição do tema do IX Seminário de Pesquisa e IX Encontro de Iniciação Científica do ICMBio – 2017
17h45 às 18h	**Encerramento**

Seção II – Recomendações

Considerando as discussões que ocorreram nas várias palestras e mesas redondas, as quais trataram diferentes aspectos em torno do tema "Mudanças Climáticas e Biodiversidade", a seguir serão apresentadas recomendações gerais do VIII Seminário de Pesquisa do ICMBio:

- O impacto da mudança do clima é sinérgico aos impactos das infraestruturas existentes e planejadas, o que nos orienta para a integração com as informações acerca dos processos de licenciamento dos empreendimentos.

- Não é mais possível trabalhar apenas na escala das unidades de conservação – devemos fortalecer e integrar os planejamentos; atuar em escalas mais abrangentes, como mosaicos de áreas protegidas, bacias hidrográficas, bem como compreender e internalizar na gestão ambiental e da conservação da biodiversidade mecanismos como o Cadastro Ambiental Rural (CAR).

- É urgente incorporar o conhecimento tradicional aos planejamentos e ações voltadas para a mitigação dos impactos decorrentes das mudanças climáticas, orientando inclusive a construção e o uso de plataformas colaborativas.

- As estratégias de Adaptação com Base em Ecossistemas (AbE) integram ações de conservação e recuperação de ecossistemas com questões referentes à vulnerabilidade humana e econômica. Para planejar essas estratégias de forma eficiente, faz-se necessário executar ações de pesquisa e desenvolvimento, tanto para identificação dos serviços ecossistêmicos providos pelas UCs e outras áreas naturais, como para identificação comunidades vulneráveis social e economicamente.

- As experiências de uso da infraestrutura verde para a redução da vulnerabilidade urbana às mudanças do clima mostram-se promissoras. Unidades de conservação urbanas podem ser parceiras nessas iniciativas, tanto no provimento de sementes de espécies nativas a serem usadas nas infraestruturas como na sensibilização para a implantação das mesmas.

- Para promover a divulgação do conhecimento científico sobre a mudança do clima e suas consequências, é necessário usar redes de comunicação de grande abrangência.

- As Áreas de Proteção Ambiental (APA), por serem unidades de conservação com certo grau de ocupação, têm potencial para demonstrar e disseminar o sucesso na implementação de tecnologias e infraestruturas associadas à adaptação com base em ecossistemas (AbE).

- Diante das perspectivas de mudanças do clima, os instrumentos de gestão de unidades de conservação precisam ser flexíveis e incorporar o melhor conhecimento disponível, seguindo a lógica do manejo adaptativo.

Seção III – Apresentação dos Palestrantes

Conferência de Abertura – Adaptação às mudanças climáticas baseada em ecossistemas: uma oportunidade para o Brasil

Fabio Scarano *(f.scarano@conservacao.org)*

Fabio Rubio Scarano é Ph.D. em Ecologia pela Universidade de St. Andrews, na Escócia. É professor associado de Ecologia da Universidade Federal do Rio de Janeiro e membro da Sociedade Linneana de Londres. Desde 2015 é diretor executivo da Fundação Brasileira para o Desenvolvimento Sustentável, onde coordena projetos ligados à biodiversidade e serviços ambientais, adaptação às mudanças climáticas e agricultura sustentável.

Palestra 1 – Possíveis impactos da mudança do clima sobre a biodiversidade e implicações para o planejamento da conservação

Ana Luisa Albernaz *(anakma@museu-goeldi.br)*

Ana Luisa Albernaz é graduada em Ciências Biológicas pela Universidade Estadual Paulista Júlio de Mesquita Filho, com mestrado e doutorado em Ecologia pelo Instituto Nacional de Pesquisas da Amazônia. É pesquisadora do Museu Paraense Emílio Goeldi e professora e orientadora dos programas de pós-graduação da Instituição. Tem experiência na área de Ecologia, com ênfase em Ecologia Aplicada, atuando principalmente nos temas: várzea, Amazônia, biodiversidade, conservação e biogeografia.

Palestra 2 – Conservação e restauração da vegetação nativa nos compromissos do Brasil para mitigação de mudanças climáticas

Mercedes Bustamante *(mercedesmcb@gmail.com)*

Mercedes Bustamante tem mestrado em Ciências Agrárias (Fisiologia Vegetal) pela Universidade Federal de Viçosa e doutorado em Geobotânica - Universitat Trier. Atualmente é professora da Universidade de Brasília e tem experiência na área de Ecologia, com ênfase em Ecologia de Ecossistemas, atuando principalmente nos seguintes temas: cerrado, mudanças no uso da terra, biogeoquímica, mudanças ambientais globais. Foi co-coordenadora do Grupo de Trabalho Mitigação do Painel Brasileiro de Mudanças Climáticas, responsável pela elaboração do relatório técnico sobre Mitigação de Mudanças Climáticas no Brasil. Participou de comitês científicos internacionais (como UNEP e IGPB). Foi coordenadora geral de Gestão de Ecossistemas e Diretora de Políticas e Programas Temáticos do MCTI. Diretora de Programa e Bolsas no País (Capes) e co-coordenadora do capítulo Drivers of Change do 1º. Relatório Regional sobre as Américas do IPBES.

Mesa Redonda 1 – Impactos da mudança do clima sobre espécies e ecossistemas

Mário Luiz Gomes Soares *(mariolgs@gmail.com) – Ministrou a palestra*

"Impactos das mudanças e variabilidades climáticas sobre o ecossistema manguezal"

Mário Luiz Gomes Soares graduou-se em Oceanografia pela Universidade do Estado do Rio de Janeiro e é doutor em Oceanografia Biológica pela Universidade de São Paulo. É coordenador adjunto dos Programas de Pós-graduação em Meio Ambiente e de Oceanografia da Universidade do Estado do Rio de Janeiro. É colaborador do Painel Brasileiro de Mudanças Climáticas e membro da Força Tarefa para a Zona Costeira do Plano Nacional de Adaptação às Mudanças Climáticas do Ministério do Meio Ambiente. Colabora ainda com a Rede Bioclima do Ministério do Meio Ambiente. É representante do Brasil no World Ocean Assessment das Nações Unidas e membro do Laboratório Internacional em Câmbio Global.

Beatrice Padovani *(beatrice@ufpe.br) – Ministrou a palestra*

"Impactos da mudança do clima sobre ambientes recifais e possíveis soluções de manejo"

Beatrice Padovani graduou-se em Ciências Biológicas pela Universidade Santa Úrsula. É mestra em Oceanografia Biológica pela Universidade Federal do Rio Grande e doutora em Biologia Marinha pela James Cook University of North Queensland, na Austrália. Atualmente é professora adjunta do Departamento de Oceanografia da Universidade Federal de Pernambuco e membro do Programa de Pós-Graduação em Oceanografia da UFPE. Atua na área de Oceanografia, com ênfase nos temas: recifes de coral, reservas marinhas, dinâmica populacional de peixes, ictiofauna recifal e pesca artesanal.

Guillermo Estupiñan *(gestupinan@wcs.org) – Ministrou a palestra*

"Mudanças climáticas e grandes empreendimentos: conexões e adaptações nos peixes migradores, pesca e paisagens aquáticas na Amazônia"

Guillermo Estupiñan é biólogo formado pela Universidade Federal de Mato Grosso, com mestrado em Biologia de Água Doce e Pesca Interior pelo Instituto Nacional de Pesquisas da Amazônia. Atua na área de manejo de recursos pesqueiros e na criação e implementação de unidades de conservação com experiência profissional em instituições não governamentais e governamentais. Atualmente faz parte da WCS-Brasil/Programa Amazônia coordenando as ações de manejo pesqueiro e conservação de paisagens aquáticas.

Mesa Redonda 2 - Mudanças do clima e instrumentos de gestão

Isabel Belloni Schmidt *(isabels@unb.br) – Ministrou a palestra*

"Por que fazer manejo integrado do fogo em UC em um cenário de mudança do clima?"

Isabel Belloni Schmidt é bióloga, com mestrado e doutorado em Ecologia. Foi analista ambiental do Ibama, com passagem pelo Prevfogo. Desde 2012, é professora adjunta do Departamento de Ecologia e do Programa de Pós-Graduação em Ecologia na Universidade de Brasília. Tem feito o acompanhamento técnico e realizado pesquisas sobre efeitos do manejo do fogo em unidades de conservação no âmbito do Projeto Cerrado-Jalapão, que é uma parceria do MMA, ICMBio e GIZ.

Jennifer Viezzer *(jennifer.viezzer@mma.gov.br) – Ministrou a palestra*

"Como incorporar o enfoque da AbE em planos de manejo de UC: a experiência do Plano de Manejo da APA Cananéia-Iguape-Peruíbe"

Jennifer Viezzer é engenheira florestal, com mestrado em engenharia florestal, ambos pela Universidade Federal do Paraná. Analista ambiental do Departamento de Ecossistemas da Secretaria de Biodiversidade e Florestas do Ministério do Meio Ambiente. Faz parte da equipe responsável pelo capítulo de Biodiversidade e Ecossistemas do Plano Nacional de Adaptação à Mudança do Clima e atua no Projeto Biodiversidade e Mudanças Climáticas na Mata Atlântica, cujo objetivo é contribuir para a mitigação e adaptação à mudança do clima por meio da conservação e recuperação da Mata Atlântica.

Beto Mesquita *(cmesquita@conservacao.org) – Ministrou a palestra*

"Plano Municipal da Mata Atlântica com base em AbE: a experiência de Porto Seguro, BA"

Beto Mesquita é engenheiro florestal, mestre em Conservação da Biodiversidade pelo CATIE (Costa Rica) e doutor em Ciências Ambientais e Florestais pela Universidade Federal Rural do Rio de Janeiro. Atua há 20 anos em organizações do terceiro setor, tendo sido pesquisador titular e coordenador de Ecoturismo e Áreas Protegidas do Instituto de Estudos Socioambientais do Sul da Bahia (IESB) e coordenador, diretor de Programas e, por último, diretor executivo do Instituto BioAtlântica (IBio). Atualmente, integra a equipe da Conservação Internacional no Brasil, como diretor de Estratégia Terrestre. Suas áreas de interesse são conservação em terras privadas, restauração florestal, corredores ecológicos, diálogos e iniciativas intersetoriais e de múltiplos interessados, planejamento estratégico para conservação e serviços ecossistêmicos.

Mesa Redonda 3 - Impactos socioambientais da mudança do clima

Manyu Chang *(changmanyu@gmail.com) – Ministrou a palestra*

"Vulnerabilidade humana à mudança do clima"

Manyu Chang é formada em Ciências Econômicas pela Faculdade de Economia e Administração da Universidade de São Paulo, com mestrado em Desenvolvimento Rural pelo Curso de Pós-Graduação em Desenvolvimento Agrícola da Universidade Federal Rural do Rio de Janeiro. É doutora em Meio Ambiente e Desenvolvimento pela Universidade Federal do Paraná. Fez o Pós-doutorado no Instituto Virtual Internacional de Mudanças Globais da COPPE – Programa de Pós-Graduação em Engenharia da UFRJ. Atualmente, é pesquisadora associada da FIOCRUZ e desenvolve, em parceria com o MMA, a pesquisa "Vulnerabilidade das Populações à Mudança do Clima". Seus interesses de pesquisa são sistema de produção, sequestro de carbono florestal, adaptação humana à mudança do clima.

Beatriz Fátima Alves de Oliveira *(beatrizenf@gmail.com) – Ministrou a palestra*

"Impactos da mudança do clima sobre a saúde humana"

Beatriz de Oliveira é graduada em enfermagem pela Universidade do Estado do Mato Grosso e doutora em Ciências da Saúde pelo Programa de Saúde Pública e Meio Ambiente da Escola Nacional de Saúde Pública, Fundação Oswaldo Cruz. Atuou como pesquisadora em diversos de projetos com ênfase na exposição a agentes químicos, físicos e biológicos e efeitos à saúde humana na Universidade Estadual do Mato Grosso, Escola Nacional de Saúde Pública, Instituto de Medicina Social e Organização Pan-Americana de Saúde. Tem experiência com os efeitos e impactos na saúde humana decorrentes da exposição à poluição atmosférica, mercúrio e mudanças climáticas.

Manoel Silva da Cunha *(manoelcns@gmail.com) – Ministrou a palestra*

"Os impactos da mudança do clima sobre comunidades extrativistas: desafios e soluções"

Manoel Silva da Cunha é morador da comunidade São Raimundo, Reserva Extrativista do Médio Juruá. Sempre teve como base econômica o extrativismo da floresta e das águas. Tornou-se liderança muito jovem para enfrentar a situação de escravidão implantada pelos patrões na região. Lutou contra a invasão de lago feita pelas firmas pesqueira na região. Sofreu ameaça de morte pelos patrões em defesa da formação das comunidades. Foi o primeiro líder da comunidade. Fundador e presidente da Associação dos Produtor Rurais de Carauari – ASPROC. Lutou pela criação da reserva Extrativista do Médio Juruá e da Reserva de Desenvolvimento Sustentável Uacari no Médio Juruá. Foi eleito presidente por dois mandatos seguidos do Conselho Nacional dos Seringueiros, hoje denominado Conselho Nacional das Populações Extrativistas. Hoje é gestor pelo ICMBio da unidade de conservação Reserva Extrativista do Médio Juruá.

Mesa Redonda 4 - Mudanças climáticas: como lidar com isso na prática?

Ricardo Cardim *(cardim@usp.br) – Ministrou a palestra*

"Florestas de bolso: uma iniciativa de reflorestamento na cidade de São Paulo"

Ricardo Cardim é mestre em Botânica pela Universidade de São Paulo e diretor da Ricardo Cardim Biodiversidade Nativa. Suas pesquisas em biodiversidade nativa resultaram na criação das três primeiras reservas públicas naturais de Cerrado da cidade de São Paulo, em um total de 33.090 m², sendo por isso indicado "Empreendedor de Futuro" pela Folha de São Paulo e Fundação Schwab, da Suíça, e condecorado com a Medalha Anchieta e Diploma de Gratidão da Cidade de São Paulo pela Câmara Municipal. Também é responsável pelo curso de Paisagismo Sustentável do Green Building Council Brasil. É consultor desde 2013 da Rede Globo São Paulo como "Dr. Árvore" e desde 2011 escreve uma coluna semanal de Meio Ambiente no Grupo Estadão.

Bruno Rezende Silva *(aechmeio@gmail.com) – Ministrou a palestra*

"Telhados verdes: uma alternativa para adaptação à mudança do clima em cidades?"

Bruno Rezende Silva é biólogo, com bacharelado em Botânica e mestrado em Botânica no Museu Nacional/UFRJ com taxonomia de Bromeliaceae. É especialista na família Bromeliaceae, tendo descrito diversas espécies novas e revisado alguns grupos taxonômicos. Desenvolveu trabalhos com Heliconiaceae. Há 7 anos tem voltado seu esforço de pesquisa em direção à naturação urbana, especialmente o desenvolvimento de novas tecnologias para paredes e telhados verdes. Concluiu em 2016 doutorado em Engenharia Civil da Coppe/UFRJ com o título: Telhados verdes em clima tropical: uma nova técnica e seu potencial de atenuação térmica.

Jorge Prodanoff *(jorgep@poli.ufrj.br) – Ministrou a palestra*

"Infraestrutura verde e drenagem urbana: uma visão ecossistêmica"

Jorge Prodanoff é professor do Departamento de Recursos Hídricos e Meio Ambiente da Universidade Federal do Rio de Janeiro. Atua no convênio Brasil-Holanda com o tema: Serviços de Ecossistemas e Estratégias de Conservação e Manejo da Biodiversidade, Amazônia do Maranhão. É pesquisador do Instituto Virtual Internacional de Mudanças Globais – IVIG/COPPE. Na década de 1990 trabalhou em FURNAS em projetos de grandes barragens. Recebeu o prêmio CAPES de Teses em 2006 e o prêmio CREA-RJ em 2014.

Mesa Redonda 5 – Mudanças climáticas e biodiversidade no Arco do Desmatamento: o que a transição Amazônia/Cerrado tem a nos dizer?

Leandro Valle Ferreira *(lvferreira@museugoeldi.br) – Ministrou a palestra*

"O impacto da seca artificial simulando a anomalia climática do El Nino na comunidade de plantas da floresta de sub-bosque da Amazônia Oriental"

Leandro Ferreira é graduado em Ciências Biológicas pela Universidade de Brasília, com mestrado e doutorado em Ecologia pelo Instituto Nacional de Pesquisas da Amazônia (INPA) em Manaus, Amazonas. Tem especialização em botânica obtida no Royal Botanical Gardens, na Inglaterra. Desde 2002 trabalha como pesquisador e orientador de mestrado e doutorado no Museu Paraense Emílio Goeldi na área de Ecologia Vegetal e de Paisagem. Atualmente é chefe de pesquisa da Estação Científica Ferreira Penna e coordenador do sítio de Pesquisas Ecológicas de Longa Duração (PELD) – Floresta Nacional de Caxiuanã.

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"Resultados do Sítio PELD Planície de Inundação do Alto Rio Paraná (PIAP)"

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"Resultados do Sítio PELD Transição Cerrado-Floresta Amazônica: bases ecológicas e socioambientais para a conservação (TRAN)"

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Seção IV – Resumos dos Trabalhos Apresentados

A diversidade de primatas da Reserva Biológica do Jaru (Rondônia)

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Visando contribuir com a gestão das unidades de conservação e a conservação de primatas ameaçados de extinção, o projeto "Primatas em Unidades de Conservação da Amazônia" vem, desde 2010, gerando informações sobre a ocorrência de espécies em risco ou deficientes em dados para subsidiar, por exemplo, Planos de Manejo, Planos de Ação e a correta avaliação do estado de conservação das espécies. Neste contexto, no período de 30 de novembro a 11 de dezembro de 2015 foi realizada uma expedição à Reserva Biológica (REBIO) do Jaru, visando inventariar e diagnosticar a situação da comunidade de primatas, contribuindo com dados sobre ocorrência e distribuição para as espécies ameaçadas e deficientes em dados, além de apontar usos e conflitos relacionados aos primatas. A REBIO do Jaru foi criada em 1979 na porção leste de Rondônia, possui 353 mil hectares e está localizada no interflúvio Madeira-Tapajós. Somente a partir de 2003, com o apoio do Programa Áreas Protegidas da Amazônia (ARPA), é que a unidade começou a se consolidar através do aporte de recursos para a formação do conselho consultivo, fomento à pesquisa, educação ambiental, fiscalização, revisão do plano de manejo e regularização fundiária. A unidade foi escolhida por estar localizada no arco do desmatamento e na zona de endemismo meridional da Amazônia, região com alta riqueza de espécies, algumas ainda pouco conhecidas. Inicialmente foram compilados dados secundários para determinar a ocorrência provável das espécies na REBIO. Em seguida, foram identificadas as áreas para a realização do inventário, buscando amostrar a maior diversidade de ambientes e abranger a maior parte possível da unidade. Para a coleta de dados in situ três métodos foram utilizados: registros diretos e indiretos, entrevistas semiestruturadas e coleta de material biológico. Foram percorridas trilhas pré-existentes e as vias fluviais principais, registrando data/hora, local, espécie, tipo de vegetação, impactos detectados, contando com o auxílio de máquina fotográfica, binóculos, receptor de GPS, playback e gravador de áudio. As entrevistas foram realizadas no entorno da unidade, a fim de obter informações complementares sobre a ocorrência de primatas e levantar impactos sofridos pelas espécies. As amostragens foram realizadas ao longo de todo o dia, iniciando por volta das 6h com término entre 17:30h – 18h. Durante os oito dias de amostragem, 11 espécies de primatas foram registradas: *Alouatta puruensis, Ateles chamek, Lagothrix cana cana, Aotus nigriceps, Callicebus bernhardi, Chiropotes albinasus, Pithecia mittermeieri, Saimiri ustus, Sapajus apella, Saguinus* sp. e *Mico* sp. Destas, duas espécies estão ameaçadas de extinção devido à sobrecaça: *Ateles chamek* (Vulnerável) e *Lagothrix cana cana* (Em perigo). Outras três espécies estão na categoria Quase Ameaçadas: *Alouatta puruensis, Chiropotes albinasus* e *Saimiri ustus*. Esta região é uma lacuna de distribuição geográfica para o gênero Mico e, por isso, foi coletado um indivíduo para posterior identificação. Os principais impactos identificados foram o desmatamento e queimadas,

principalmente na área da UC desapropriada mais recentemente, e a caça, especialmente sobre as espécies de maior porte e aparentemente relacionada a atividades extrativistas (p.ex. castanha-do-Pará). Além de ampliar o conhecimento sobre os primatas existentes na unidade, as informações obtidas irão subsidiar a implantação dos protocolos básicos do Programa Nacional de Monitoramento in situ da Biodiversidade na REBIO.

Esta expedição recebeu apoio financeiro do ARPA.

A evolução rápida como facilitadora da expansão invasiva de uma espécie exótica

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As invasões biológicas estão entre as principais responsáveis pela perda de biodiversidade no mundo. Uma das principais barreiras às espécies exóticas invasoras em um novo ambiente é o clima. Porém, geralmente estas espécies possuem alta capacidade de se adaptarem a condições ambientais diferentes daquelas de suas zonas nativas o que pode facilitar a sua dominância nos novos habitats. Essas adaptações podem ser explicadas pela combinação entre genótipos pré-adaptados e adaptações adquiridas no novo habitat. Além disto, no trade-off entre defesa e crescimento, este último geralmente é relativamente privilegiado nos casos de invasões biológicas por conseqüência da ausência de predadores naturais no novo habitat. Em um estudo anterior com seis populações de *Pinus taeda,* introduzidas para testes de procedência a partir de fontes de sementes oriundas de uma zona climática distinta,foram encontradas alterações genéticas entre as populações-fonte e as populações introduzidas. No presente estudo, analisamos se e como essa rápida evolução genética influencia na evolução fenotípica rápida das seis populações de *P. taeda*. Utilizamos seis populações de *P. taeda*, localizadas em duas Estações Experimentais (Fazenda Experimental de Santa Maria e Estação Experimental de Rio Negro) e quatro Unidades de Conservação federais (Floresta Nacional de São Francisco de Paula, Floresta Nacional de Três Barras, Floresta Nacional de Irati e Floresta Nacional de Capão Bonito), sendo uma população representante para cada local. Em cada população, amostramos aproximadamente 50 indivíduos previamente genotipados, em um gradiente de invasão que se inicia na borda das populações naturalizadas. Para cada indivíduo, coletamos amostra de acículas para medirmos a área foliar, área foliar específica (eficiência de produtividade) e extração do conteúdo fenólico; madeira para a extração de resinas; amostra do interior do caule para determinar o crescimento médio anual; medidas de diâmetro a 1,30 m do solo; altura e distância da borda do plantio. O conteúdo de resina e fenólicos referem-se à defesa química da planta. Para as análises estatísticas, utilizamos modelos lineares de efeito misto (procedência genética e distância do plantio foi considerado efeito fixo; a idade foi considerada efeito aleatório) para identificar como as características fenotípicas mensuradas variam ao longo dos gradientes de invasão. Ocorre evolução rápida ao longo dos gradientes de invasão para os traços mensurados, mas estes não apresentaram um padrão com a evolução genética rápida. À medida que a distância dos novos propágulos aumenta em relação ao início do plantio (início dos gradientes de invasão), maior é o crescimento, indicando a necessidade de manejo para conter estas invasões. Encontramos trade-offs entre crescimento e defesa em apenas um caso. Em suma, sugerimos que a evolução fenotípica está facilitando a expansão destas populações à medida que a invasão progride, e requer urgente interferência para o controle destas invasões.

Agradecemos ao CNPq pelo financiamento do projeto e aos responsáveis pelas Unidades de Conservação e Estações Experimentais visitadas para o desenvolvimento deste trabalho.

Abundância populacional do guariba-de-mãos-ruivas (*Alouatta belzebul*) na área São João – Cafundó, Paraíba

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Os primatas do gênero Alouatta são de grande porte, robustos, com peso médio entre 5 a 12 kg, animais diurnos, conhecidos por sua vocalização característica, com dieta a base de folhas e frutos, sendo importantes dispersores de sementes. O conhecimento do tamanho ou densidade de uma população é uma informação importante para o seu manejo efetivo e um dos parâmetros mais diretos para medir o sucesso de planos de manejo ou conservação. O guariba-de-mãos-ruivas (*Alouatta belzebul*) é uma espécie ameaçada de extinção, na categoria Vulnerável (VU), e o Centro Nacional de Pesquisa e Conservação de Primatas Brasileiros (CPB/ICMBio) tem realizado, através do Plano de Ação Nacional para a Conservação dos Primatas do Nordeste (PAN-PRINE), a identificação de áreas importantes para estabelecimento e manutenção de populações viáveis da espécie e realização de estudos sobre dinâmica de metapopulações e conectividade funcional. A área Importante São João-Cafundó, próxima a João Pessoa (PB), tem 2.182 ha e apresenta uma população remanescente da espécie. Nestes termos, o presente estudo objetivou estimar a densidade populacional de *Alouatta belzebul* na área São João-Cafundó. A estimativa de abundância e densidade foi realizada através do método de transecção linear. Foi utilizado um grid com sete trilhas, e estas foram percorridas a uma velocidade aproximada de 1,5 km/h, durante o dia. Os dados foram analisados no Programa Distance 6.2. Para definir o tamanho médio do grupo foram selecionados quatro encontros, onde se considerou que houve o avistamento de todos os indivíduos do grupo. A coleta de dados foi de novembro de 2015 a julho de 2016. Foram percorridos um total de 243 km, com 41 avistamentos de *Alouatta belzebul*. A taxa de encontro foi de 1,64 grupos/10 km. Para a estimativa de densidade foi selecionado o modelo Hazard/Polynomial, com base no menor valor dos critérios de informação de Akaike (AIC). Os dados foram truncados a 30m e divididos em cinco intervalos. A densidade de *Alouatta belzebul* foi estimada em 0,032 grupos/ha (IC 95%: 0,012 – 0,086). O tamanho médio de grupo (n=4) foi de cinco indivíduos. Considerando a extensão da cobertura florestal da área (2.112 ha), estima-se a ocorrência de 67 grupos (25 – 181) e uma população de 335 (125 – 905) indivíduos. Também foram feitos registros de saguis (*Callithrix jacchus*), com 12 avistamentos e uma taxa de encontro de 0,49 grupos/10 km. Entendemos que esses resultados são importantes para a avaliação do status de conservação da espécie e para direcionar ações de manejo. Considerando o tamanho da área e da população estimada, a área São João – Cafundó é uma das mais relevantes para a conservação das populações nordestinas de *Alouatta belzebul*.

Agradecimentos ao Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) pela bolsa PIBIC e a Usina São João por permitir a realização deste estudo em sua propriedade.

Análise da conservação da biodiversidade nas Áreas de Preservação Permanente no rio Tocantins associadas à extração de areia em Imperatriz/MA

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O rio Tocantins localiza-se na divisa dos estados do Maranhão e Tocantins e se apresenta como um importante meio de subsistência para as populações que dele usufruem, inclusive para a

segunda maior cidade do estado do Maranhão – Imperatriz, esta apresentou nas últimas décadas expressivo crescimento urbano proporcionado em especial pela construção civil, sendo este fator decisivo para o desenvolvimento desta urbe, contribuindo para a extração descontrolada de areia no leito do rio Tocantins o que reflete diretamente na biodiversidade presente nas áreas de preservação permanente como também nas mudanças climáticas. Embora seja uma atividade permitida por órgãos ambientais, a quantidade de material nem sempre é fiscalizada afetando diretamente a biodiversidade do local, pois é notório que várias espécies da fauna e flora necessitam deste rio para sobreviver. O município possui cinco empresas coletoras regularizadas, entretanto apenas duas aceitaram participar da pesquisa. Esta pesquisa foi desenvolvida no período de 2013 a 2015 e tem por finalidade conhecer a realidade do funcionamento das empresas extratoras de areia em Imperatriz–MA enfatizando as técnicas de conservação da biodiversidade nas áreas de preservação permanente ao longo do rio Tocantins e os impactos ambientais decorrentes da mesma. Para desenvolver a pesquisa foi utilizado o método de revisão de literatura com dados do Departamento Nacional de Produção Mineral, resoluções do Conselho Nacional de Meio Ambiente e o novo Código Florestal; visita aos órgãos públicos ambientais competentes como Secretaria Municipal de Meio Ambiente, IBAMA e Marinha do Brasil a fim de compreender como funciona o licenciamento ambiental das empresas e a fiscalização nos empreendimentos; visita às empresas extratoras para informações e análise dos planos de conservação das mesmas, como também observação in loco no leito do rio na área que abrange o perímetro urbano da cidade a fim de analisar como está ocorrendo a preservação da biodiversidade nesta área e o reflexo da mesma nas mudanças climáticas. Em todas as visitas foi utilizado material fotográfico que serviu de subsidio comparativo da preservação da biodiversidade. Por meio da exposição dos dados obtidos foi possível observar a negligencia dos órgãos ambientais competentes em fiscalizaras atividades das empresas coletoras de areia, onde este fato ocorre somente quando há denúncia,dessa forma muitas delas não cumprem a lei e nem colocam em prática os procedimentos de conservação da biodiversidade das áreas de preservação permanente. Os principais problemas encontrados foram assoreamento dos rios, perda das matas ciliares onde a ausência das copas favorece a desestabilidade térmica dos cursos d'água, tendo em vista que são as mesmas que interceptam e absorvem a radiação solar, alteração do meio atmosférico com o aumento de poeira no ar e poluição das águas que reflete diretamente nas populações de peixes. Assim, identificou-se que os impactos de ordem negativa estão associados ao meio ambiente e a preservação da biodiversidade que favorece a desestabilidade do clima nessas áreas, enquanto os de ordem positiva estão diretamente relacionados aos benefícios sócio- econômicos. Destarte é importante ressaltar que esta pesquisa não tem o intuito de banir a extração de areia do rio Tocantins tendo em vista que este é um recurso necessário para a sociedade, mas fomentar futuras pesquisas que possibilitem equilibrar o uso sustentável dos recursos naturais às necessidades do ser humano, sem afetar bruscamente o meio ambiente e preservando a biodiversidade.

Análise da ocorrência de autos de infração nas Unidades de Conservação Federais na Amazônia Legal

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O estabelecimento de Áreas Protegidas – APs é considerado uma das principais estratégias para a conservação da natureza no mundo, apresentando benefícios para a manutenção da biodiversidade, armazenamento de estoques de carbono terrestre e fornecimento dos meios de subsistência para milhares de pessoas. O Brasil é um dos países que mais avançaram na criação de APs, mais especificamente na criação Unidades de Conservação – UCs, mas apesar dos avanços em relação ao aumento do número das UCs, muito esforços ainda devem ser realizados para a melhoria da gestão e proteção destas áreas. O presente trabalho teve como objetivo identificar a ocorrência de atividades ilegais em Unidades de Conservação Federais na Amazônia Legal por meio da análise dos autos de infração ambientais gerados em atividades de fiscalização do ICMBio no período de 2010 a 2014, e desta forma verificar quais são as atividades ilegais que mais ocorrem nestas importantes

áreas. Os autos produzidos foram sistematizados e disponibilizados pela Divisão de Informação e Monitoramento Ambiental do ICMBio – DMIF/ICMBio, e o acesso aos dados foi realizado por meio do servidor de dados geográficos do ICMBio (http://mapas.icmbio.gov.br/geoserver/web/). Foi realizada uma sumarização de todos os autos de infração do período estudado para avaliar quais foram as principais ocorrências (tipos de infração ambiental) conforme a tipificação legal dada pelo decreto 6514 e análise da descrição das ocorrências. Foi possível verificar que de 131 UCs avaliadas, 116 tiveram a ocorrência de pelo menos 1 auto de infração entre 2010 e 2014. O total de autos de infração produzidos no período foi de 4.028 e destes 233 foram excluídos por apresentarem algum tipo de erro, o que representa uma taxa de erro de 5,78 %. Assim, foram avaliados 3.795 autos de infração que produziram um valor total de multas de R$ 583.615.957,00. Entre os tipos de infrações, a maior ocorrência foi de infrações relacionadas a supressão e degradação da vegetação, seguido pela pesca ilegal/irregular/ou em período de defeso e por atividades de caça e coleta de animais silvestres. Infrações relacionadas ao uso do fogo ficaram na 8ª posição com 64 ocorrências. Uma grande quantidade de autos de infração, foram enquadrados como porte de petrechos sem autorização (451), atividades em desacordo com os objetivos da UC, plano de manejo e outros regulamentos (240) e causar danos as unidades de conservação (124). É importante destacar que a quantidade de autos de infração existentes provavelmente é uma subamostragem das infrações que ocorrem nas UCs avaliadas, pois muitos fatores podem influenciar a lavratura dos mesmos, tais como, a quantidade de operações de fiscalização realizadas, facilidade de detecção das infrações, tamanho das UCs, facilidade de acesso, entre outros. Desta forma, o presente trabalho não teve a intenção de trabalhar as infrações de forma quantitativa, mas sim de uma maneira qualitativa. O estudo indica que apesar dos avanços do Brasil no combate ao desmatamento e degradação vegetal muito ainda deve ser feito, considerando que as infrações relativas a este tipo de atividade foram as de maior ocorrência. Este fato, é mais preocupante considerando que as UCs deveriam estar mais imunes a estas atividades que além de promover a perda habitats, é uma grande fonte de emissão de carbono. A grande ocorrência de caça também é muito preocupante, pois, pode prejudicar a manutenção dos ecossistemas florestais a longo prazo e ser mais um fator de incerteza ou potencializador dos efeitos das mudanças climáticas.

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Análise da serrapilheira do solo sob Cerrado Sensu Stricto no Parque Nacional das Nascentes do Rio Parnaíba

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A Serrapilheira é a camada superficial de solos sob florestas, constituída por resíduos vegetais como folhas, restos de ramos, cascas de árvores, raízes finas, excluindo as partes vivas, em diferentes estágios de decomposição, constituindo-se, portanto, numa importante fonte carbono e de nutrientes essenciais para as plantas e para o solo. A deposição dessas serrapilheira sobre o solo corresponde a uma das etapas fundamentais da ciclagem de nutrientes nos biomas. Em ecossistemas florestais a ciclagem de nutrientes consiste em um dos processos mais importantes para a garantia de sua sustentabilidade, e conta com a produção e decomposição da serrapilheira como principal fator. Assim, o estudo da serrapilheira é bastante importante para a compreensão

do funcionamento dos sistemas naturais, principalmente em ambiente com características florestais. Diante do exposto, objetivou-se com este trabalho estimara deposição da serrapilheira sobre o solo na fitofisionomia de cerrado Sensu Stricto e sua importância para a ciclagem de nutrientes no Parque Nacional das Nascentes do Rio Parnaíba. O estudo foi realizado no Parque Nacional das Nascentes do Rio Parnaíba, localizado no bioma Cerrado, em área correspondente ao município de Barreiras do Piauí, na região sul do estado. Para realização da análise sobre a serrapilheira selecionou-se uma área amostral de aproximadamente um hectare. A amostragem se deu no mês de março de 2016, correspondente ao período chuvoso da região. Para tanto, foram coletadas dez amostras na área de estudo, dispostos de forma aleatória. A delimitação de cada ponto amostral foi realizada através da utilização de um quadrante de madeira, com dimensões de0,3 m x 0,3 m correspondente a uma área amostral de 0.09 m^2/ponto. As amostras foram secas em estufa a 70ºC até atingirem peso constante. A quantidade de serrapilheira coletada por ponto amostral variou conforme as características de cada ponto. Os maiores valores observados ocorreram no ponto 7 (0,28kg), 3 (0,24kg)e no ponto 1 (0,21kg) respectivamente, fato que pode ser explicado por se tratarem de pontos localizados em áreas com maior presença de indivíduos vegetais, contribuindo para esta deposição, com variações entre os referidos pontos. Entretanto apesar destes valores apresentarem-se como significativos em relação aos valores totais, estima-se em média a deposição equivalente a 1,55-6kg por hectare, de serrapilheira,verificando a baixa deposição de serrapilheira sobre solo na área de estudo, se comparado com estudos semelhantes. Esta baixa deposição de serrapilheira pode está relacionada ao fato da área de estudo apresentar seus indivíduos vegetais distribuídos espaçadamente uns dos outros, dificultando o acúmulo do material folhoso sobre o solo, como também da rápida decomposição do material presente por influência da precipitação, uma vez que o estudo foi realizado no período chuvoso da região. Apesar da baixa disponibilidade de serrapilheira identificada, ter-se-á como importante para reposição dos nutrientes para o solo e para as plantas, podendo estar sendo pouco favorecido por está baixa deposição de material folhos na área de estudo.

Análise da variação da cobertura florestal ao longo de oito anos em uma área no interior da Floresta Nacional do Jamanxim por meio de técnica de sensoriamento remoto

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Os ecossistemas florestais, principalmente as florestas tropicais, possuem uma grande importância na regulação do clima, devido às contribuições significativas do desmatamento no processo de mudanças climáticas. Portanto conhecer a dinâmica de mudança da cobertura florestal, constitui-se numa ferramenta importante para definições de estratégias no combate ao desmatamento. O objetivo deste trabalho foi avaliar a dinâmica de uso e cobertura do solo em uma área no interior da Floresta Nacional do Jamanxim. A área de estudo compreende uma região alvo de Inquérito Civil no Ministério Público Federal de Santarém – MPF. O primeiro passo do trabalho consistiu na busca por imagens de satélite (2008 e 2016) da série Landsat disponibilizadas gratuitamente serviço web do United States Geological Survey (USGS). Posteriormente foi realizado a reprojeção das imagens para o DATUM/Projeção WGS1984 UTM 21NSul e o pré-processamento das imagens por meio da ferramenta Semi-Automatic Classification Plugin, implementada no software QGIS 2.14.3, que realiza a conversão dos Números Digitais das imagens Landsat para radiância e refletância, a partir das informações dos metadados baixados junto com as imagens, e posteriormente aplica a correção atmosférica dark object subtraction (DOS1), proposto por Chávez Junior (1988).Após a das correção das imagens, foram gerados os Índice de Vegetação por Diferença Normalizada NDVI, definidos por Rouse *et al*. (1974) e que variam de -1 a +1, dos anos de 2008 e 2016. Quanto mais próximo de 1,

maior a densidade da cobertura vegetal. As imagens-NDVI foram fatiadas tomando como valores de referência 0,53 para imagem de 2008 e 0,72 para imagem de 2016. Os resultados desses fatiamentos foram duas imagens classificadas nos quais todo pixel com valor igual a "1" refere-se a Vegetação e valor "0" refere-se a Solo Exposto. Com base nas imagens classificadas foi aplicado a função Land Cover Change implementada no software QGIS 2.14.3.Esta ferramenta permitiu a comparação entre as duas imagens classificadas (2008 e 2016), a fim de avaliar as mudanças de cobertura da terra. O resultado foi um arquivo raster de mudança da cobertura da terra, no qual cada pixel representa uma categoria de comparação entre as duas classificações. Em seguida o arquivo raster foi vetorizadode modo a permitira realização do cálculo de área de cada classe. Ao final foram convencionadas as seguintes classes temáticas: Floresta-F, Regeneração Natural-RN, Incremento de Solo Exposto-ISE e Solo Exposto Permanente-SEP. O resultado nos mostrou que a área total foi de 725,22 hectares, sendo 37,2% de Floresta, 14,4% de Regeneração Natural, ou seja, área que regenerou nos últimos 8 anos, 17,6% de Incremento de Solo Exposto, que são na realidade novas áreas desmatadas entre 2008 e 2016 e 30,8% de Solo Exposto Permanente, áreas que ao longo de 8 anos estão sendo impedidas de regenerar-se, possivelmente por ação antrópica. A Taxa de Regeneração Natural-RN/8 nos últimos 8 anos foi de 1,8%, enquanto que, a Taxa de Desmatamento - ISE/8 foi de 2,2%, e a Taxa de Antropização – ((ISE+SEP)/8) foi de 6,0% um resultado preocupante pois mostra que a capacidade de resiliência da floresta não acompanha a ação antrópica. Nesse contexto, que se justifica a intensificação das ações de controle ao desmatamento na FLONA do Jamanxim, por meio das ações de fiscalização promovida pelo ICMBio nos últimos anos. Essas ações diminuem gradativamente a taxa de desmatamento da floresta nacional e consequentemente ocorre também uma diminuição do lançamento de gases do efeito estufa na atmosfera.

Análise das capturas de elasmobrânquios na plataforma continental e talude superior do sul do Brasil

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Na margem da plataforma continental e talude superior do sul do Brasil, existe toda uma fauna de elasmobrânquios demersais pouco conhecidos para a ciência. Neste caso, há pouquíssima informação sobre as áreas de ocorrência, parâmetros reprodutivos e outros aspectos importantes no ciclo de vida dessas espécies. Assim, estudos desses animais para fornecer novas informações sobre a ocorrência e a biologia reprodutiva são fundamentais para futuras avaliações do estado de conservação dessas espécies. Com esse objetivo, entre os anos de 2009 e 2011 o Navio de Pesquisa "Soloncy Moura" efetuou cruzeiros de monitoramento da biodiversidade marinha demersal (Projeto MOBIO) com redes de arrasto-de-fundo na plataforma continental e talude superior do estado de Santa Catarina entre 160 e 600 m de profundidade. Parâmetros biológicos de determinadas espécies de elasmobrânquios de profundidade foram obtidos durante esses cruzeiros, ou seja, informações sobre a composição de tamanhos, sexos, relações peso-comprimento, estágios reprodutivos, associados aos dados dos locais das capturas, como profundidade do arrasto (m). Inicialmente analisaram-se as capturas do tubarão-serra-do-sul, *Galeus mincaronei* e posteriormente, foram analisados os parâmetros biológicos de mais cinco espécies de elasmobrânquios capturados, sendo elas: *Benthobatis krefti, Heptranchias perlo*, *Schroederichthys saurisqualus, Scyliorhinus haeckeli* e *Gurgesiella dorsalifera*. A identificação dos estágios reprodutivos foi baseada na escala de Stehmann (2002). Durante todos os cruzeiros do projeto MOBIO foram capturados 249 indivíduos dessas espécies. As capturas ocorreram entre as latitudes de 26°06,19'S e 29°07,35'S e longitudes de 46°08,41'W e 48°26,165'W. Apesar do pequeno número de exemplares capturados, os dados obtidos contribuíram para preencher lacunas de conhecimento existentes para estas espécies, sendo que, atualmente, algumas são consideradas pelo ICMBio como espécies com dados deficientes (DD), segundo os critérios da IUCN, para uma avaliação do seu estado de conservação, como é o caso de *G. mincaronei*. A pesca comercial de arrasto, direcionada a outras espécies de peixes demersais, representa uma ameaça à sobrevivência

dessas espécies do Atlântico Sudocidental. O controle efetivo da atividade pesqueira industrial sobre a borda da plataforma continental e talude superior do sudeste e sul do Brasil, são medidas necessárias para mitigar os impactos da pesca de arrasto de fundo sobre essas áreas.

Análise de viabilidade populacional do guigó-da-Caatinga (*Callicebus barbarabrownae*)

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Perda e fragmentação de hábitats são as maiores ameaças à biodiversidade no planeta. Além da extinção e isolamento de populações, ambientes fragmentados podem causar efeitos negativos sobre a persistência das espécies em médio e longo prazo. O guigó-da-caatinga (*Callicebus barbarabrownae*), único primata endêmico do bioma Caatinga, é listado pela IUCN e pelo MMA como Criticamente em Perigo sua população remanescente extremamente pequena e distribuída em hábitats severamente fragmentados. Em situações como esta, as Análises de Viabilidade Populacional (AVP) podem auxiliar na definição de estratégias para a conservação, pois, a partir de dados sobre a espécie em questão ou similares, pode-se simular projeções sobre o futuro de uma dada população, sob certas condições, ao longo de um determinado tempo. O presente trabalho tem como objetivo sumarizar os dados existentes sobre parâmetros demográficos de *Callicebus barbarabrownae* e desenvolver uma AVP para a espécie, em consonância com o proposto no Plano de Ação Nacional para a Conservação dos Primatas do Nordeste. Inicialmente, buscamos informações sobre a biologia da espécie-alvo ou de espécies filogeneticamente próximas; neste caso, espécies do grupo *Callicebus personatus*. Para simular as tendências demográficas, obtivemos, ainda, informações sobre aspectos da paisagem onde as populações estão presentes. As etapas da AVP consistiram na elaboração do modelo-base, testes de sensibilidade de parâmetros incertos, determinação da População Mínima Viável (PMV) e simulação dos cenários reais sempre em projeções para 100 anos e com 500 interações. Para a AVP e caracterização dos fragmentos utilizamos os softwares Vortex e Global Mapper, respectivamente. O modelo-base com tamanho inicial de população de 100 indivíduos, apresentou uma probabilidade de extinção de 2% e manutenção de diversidade genética de 86%. Por se tratar de uma espécie Criticamente em Perigo, adotamos o limiar de viabilidade de 98% de probabilidade de sobrevivência e manutenção mínima de heterozigozidade de 95% em 100 anos. Sendo assim, uma população hipotética de 100 indivíduos em 100 anos é considerada demograficamente viável, mas, o limiar de viabilidade genética é alcançado apenas em populações maiores que 250 indivíduos. Portanto, a PMV de *C. barbarabrownae* pode ser estipulada como 250 indivíduos. Os resultados dos testes de sensibilidade em relação ao parâmetro de idade da primeira cria demonstraram que com a primeira reprodução aos 3 anos a população hipotética do modelo base seria viável e se a reprodução fosse iniciada aos 4 ou 5 anos, a probabilidade de extinção aumentaria consideravelmente. O aumento da proporção de fêmeas reprodutivas, resulta em um leve aumento na diversidade genética, a probabilidade de extinção torna-se nula e o crescimento estocástico aumenta significativamente. Sobre a taxa de mortalidade é possível verificar que nos primeiros anos de vida há uma maior sensibilidade do parâmetro quando aumenta a porcentagem, mas quando esse valor é diminuído os efeitos de variação não são expressivos. Na idade de 3-5 anos aumenta drasticamente a probabilidade de extinção com acréscimo na taxa de mortalidade, o que apresenta certa coerência pelo fato de ser o ano de maturação e dispersão da espécie. Os cenários reais ainda estão sendo desenvolvidos, mas os resultados preliminares já indicam a necessidade de ampliar o conhecimento sobre a espécie, bem como a prioridade de manter as populações que potencialmente abriguem 250 indivíduos ou mais.

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Análise do escoamento da produção de borracha pelas famílias tradicionais – na Reserva Extrativista do Lago Capanã Grande, Manicoré/AM – em relação à área de mercado, por meio de geoprocessamento

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A reserva extrativista é uma unidade de conservação de uso sustentável, que possibilita a presença de comunidades tradicionais. A subsistência destas é por meio da comercialização de produtos madeireiros e não madeireiros, seguindo a sazonalidade de cheias e vazantes dos rios. Uma grande dificuldade de comercialização dos produtos extrativistas está no deslocamento destes ao mercado mais próximo, devido à localização das famílias tradicionais serem distantes das sedes municipais em que estão inseridas. Nesse contexto, o objetivo desse artigo é analisar a distância das áreas de produção de borracha pelas famílias tradicionais da Reserva Extrativista do Lago Capanã Grande, no município de Manicoré do Estado do Amazonas, em relação à área de mercado. Segundo o Plano de Manejo da RESEX (ICMBio, 2013) em 2009, a população das comunidades tradicionais era de 539 habitantes em 99 domicílios, sendo que a borracha é uma das principais fonte de renda, juntamente com a extração da castanha e atividade agrícola (ICMBio, 2013), estas atividades dos moradores mudam conforme as suas necessidades e as estações do ano. A Associação de Moradores Agroextrativistas do Lago Capanã Grande (AMALCG) auxilia no repasse de benefícios e financiamento governamental, quanto aos subsídios de pagamento de valor mínimo aos produtos agroextrativistas. Assim, por ter o preço mínimo estabelecido pelo governo federal, de R$ 3,50 o quilograma da borracha. Acrescentando os subsídios estaduais (R$ 0,70) e municipais (R$ 0,60) de Manicoré, o produtor ganha, no mínimo, R$ 4,80 pelo quilo da borracha. A partir de análises de dados georreferenciados do IBGE e do Instituto Chico Mendes de Conservação da Biodiversidade, esse artigo procura caracterizar e espacializar os resultados obtidos, por meio de geoprocessamento com as ferramentas do software ArcGis 10.2. Com os resultados da classificação Natural Breaks deste software observou-se que a faixa de distância que as famílias tradicionais estão localizadas é de 112,091 km a 121,57 km da sede municipal de Manicoré, no qual o tempo médio com o barco de rabeta é de 6h com uma faixa de velocidade média de 18,681 km/h a 20,26 km/h. Apesar da RESEX Lago Capanã Grande está localizada em uma das mais importantes hidrovias, o Madeira, no qual tem recebido investimentos de infraestrutura, as comunidades tradicionais não foram beneficiadas ainda. A atividade extrativista de produtos florestais não madeireiros busca equilibrar a produção econômica e a conservação da floresta através da qualidade das operações de extração, da preservação e conservação dos recursos naturais ao mesmo tempo manter o trabalho e a renda dos extrativistas, que são na maioria de baixa escolaridade e que não têm nenhuma informação quanto o acesso aos mercados, às tecnologias e aos recursos financeiros. Daí a importância de pesquisas sobre este tipo de atividade econômica que ajudarão a melhorar as tecnologias da extração e comercialização dos produtos extrativistas. Pode-se concluir que a dificuldade de deslocamento é o principal fator que impede o escoamento e a comercialização da borracha, por conseguinte um fraco desenvolvimento econômico. Entretanto, para análise dos fatores econômicos, há a necessidade de aquisição de dados dos pontos específicos da produção da borracha, para assim avaliar a valoração ambiental deste produto, visando criar uma metodologia replicável aos outros produtos extrativistas.

Análise documental e da legislação como contribuição à melhoria da fiscalização e gestão do contrato de concessão de serviços de apoio à visitação no PARNASO

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Em 2010, ICMBio e Hope Recursos Humanos (Concessionária) celebraram Contrato de Concessão 02/2010 para prestação de serviços de apoio à visitação no Parque Nacional da Serra dos Órgãos (PARNASO): operação de sistemas de cobrança/controle de ingressos, estacionamentos, campings, abrigos de montanha e transporte interno. As concessões de serviços em UC no Brasil são relativamente recentes e têm sido elaboradas visando a melhoria e aumento da qualidade dos serviços prestados à sociedade como forma de ampliar a sensibilização da mesma aos objetivos da UC e às propostas de conservação ambiental. As poucas e localizadas experiências, bem como o amplo desconhecimento administrativo e gerencial da ferramenta ainda geram dúvidas sobre sua efetividade. Aqui é apresentada uma análise documental e da legislação visando dar suporte a uma mudança no paradigma da fiscalização do contrato e alcançar melhorias na gestão do mesmo. Após grande debate institucional, em dez/2014 a Concessionária sofreu uma sanção com multa de mais de R$100 mil por falhas na execução contratual. Ao passar por este gargalo administrativo, se tornou imperativo para a equipe do PARNASO tomar medidas que tornassem a fiscalização mais objetiva e ao mesmo tempo eficiente. Além disso, se fez necessário renovar os laços da parceria, pois o mais importante, a qualidade dos serviços prestados, não poderia sofrer ainda mais sob a pena de o Parque não atingir de forma adequada seus objetivos com a concessão. Assim procedeu-se com uma detalhada pesquisa documental e da legislação que abrangeu os seguintes documentos: Contrato de Concessão, Projeto Básico e Edital de Concorrência, leis federais 9985/2000 (SNUC), 8987/95 (Concessões), 8666/93 (Contratos Públicos) e NBR/ABNT 15331 (Sistema de Gestão de Segurança). Como resultado foi criado um conjunto de 160 itens, divididos em de seis planilhas, abrangendo todos os itens contratuais verificáveis contidos nos documentos elencados e que podem ser objetivamente verificados pela fiscalização contratual, assim divididos: Teresópolis (27 itens), Petrópolis (23), Guapimirim (27), Açu (30), Sino (31), Geral (22). Os itens versam sobre todos os objetos do contrato em toda sua extensão. A mudança na fiscalização permitiu inferir que somente 35,7% dos itens contraruais estavam com execução conforme o previsto em jun/2015 e que em dez/2015 a execução estava em 45,7%. Apesar da ainda baixa execução para um contrato de 6 anos, a nova forma de verificar a execução permitiu também perceber que em todos as planilhas/locais houve avanços menos no Abrigo do Açu que ficou mais de um ano interditado mas agora já se encontra aberto. A objetividade da avaliação e as melhorias que podem ainda ser feitas na ferramenta é um dos principais intentos deste projeto de pesquisa e avaliação. Esta análise preliminar permitiu identificar ainda cerca de uma dúzia de outros documentos que estão citados em contrato ou têm pertinência para que as planilhas de fiscalização sejam aprimoradas. Esta tabela vem sendo considerada pela gestão do contrato no ICMBio (UAAF-Rio) como um excelente e inovador instrumento de gestão, tendo propiciado uma avaliação objetiva da execução dos serviços. Não obstante ao sucesso (como subsídios á gestão) de sua implantação, ainda há muitas questões administrativas não solucionadas e dúvidas sobre os papéis complementares de ICMBio e Concessionária na solução de questões contratuais. Futuramente deverá ser investigado também o papel da boa execução da concessão no alcance dos objetivos de conservação do PARNASO, tema ainda completamente inexplorado.

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Análise genética das onças-pintadas do Pantanal: evidência de conectividade entre as porções norte e sul

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A onça-pintada é o maior felídeo das Américas, e atualmente ocorre em cerca de 50% da sua distribuição original. No bioma Pantanal a onça-pintada é considerada uma espécie quase ameaçada, sendo que as principais causas para esta condição são a diminuição de habitat devido à intensificação da utilização de ambientes naturais pelo homem, além da caça ilegal resultante de conflitos com seres humanos. Diante deste cenário, e considerando que uma das atribuições do Instituto Chico Mendes de Conservação da Biodiversidade é o desenvolvimento e a aplicação de estratégias voltadas à conservação da biodiversidade brasileira, em especial às espécies ameaçadas de extinção, o objetivo deste estudo é avaliar a variabilidade genética de duas populações de *Pathera onca* do Pantanal norte e comparar com os dados disponíveis na literatura para o Pantanal sul. Através de 11 locos de microssatélites foram estudados 19 exemplares oriundos da Estação Ecológica de Taiamã, unidade de conservação federal localizada no município de Cáceres/MT, e 20 exemplares da Fazenda São Bento, localizada no município de Corumbá/MS. Além das amostras citadas foram incluídas na análise os dados de 52 exemplares obtidos por Valdez et al. (2015), oriundos de quatro diferentes locais de amostragem no sul do Pantanal, totalizando 91 indivíduos. Os locos analisados neste e no citado estudo foram os mesmos. Para a extração de DNA foi utilizado o QIAamp DNA Mini kit (Qiagen) e os locos selecionados foram amplificados por PCR, sendo os produtos genotipados em sequenciador automático e os alelos identificados através do software Peak Scanner v2.0 (Applied Biosystems). As análises estatísticas foram realizadas com os programas Genepop 4.0.10, GenAlEx 6.5 e STRUCUTRE 2.3.4. Todos os locos foram polimórficos e o número de alelos variou de três a 14, com uma média de 6,63. Quase todos os locos estão em equilíbrio de Hardy-Weinberg, sendo que somente o loco FCA742 em uma população do sul e o loco FCA441 em uma população do norte do Pantanal não se encontram em equilíbrio. Não houve evidência de desequilíbrio de ligação após a correção de Bonferroni. Os valores de heterozigosidade esperada para cada população variaram de 0,627 a 0,679, sendo que não foi possível perceber diferenças entre as populações. Os maiores valores do índice de estruturação (Fst) referem-se às comparações entre populações do norte e do sul, com valor máximo de 0.068, sendo que a maioria dos valores foi significativa. Foi observada correlação positiva de distância genética x distância geográfica entre as populações analisadas (Teste de Mantel, $r = 0.484$, $p = 0.029$). A análise Bayesiana de estruturação identificou $K = 2$ como número de populações mais provável, porém todos os indivíduos analisados estão atribuídos, em diferentes proporções, aos dois clusters. Os resultados descritos indicam que a diferenciação genética entre as populações estudadas é fraca e que possivelmente a distância entre elas seja responsável por parte significativa da estruturação observada. Desta forma, é importante ressaltar a necessidade de implementação de estratégias para a conservação da espécie no sentido da manutenção dos corredores ecológicos existentes, visto que os resultados apresentados indicam a existência de fluxo gênico entre as populações estudadas, representando assim uma única unidade genética no bioma Pantanal.

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Análise histológica confirma a esterilidade em *Pimelodus maculatus* triploides

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A triploidização em peixes vem sendo utilizada como ferramenta na conservação de espécies ameaçadas. Esta técnica é um procedimento importante no transplante de células germinativas exógenas, pois garante a gametogênese heteróloga (xenogênese). Neste estudo, objetiva-se produzir mandis *Pimelodus maculatus* triploides estéreis para atuarem como receptores de células germinativas da espécie ameaçada de extinção *Pseudopimelodus mangurus*, alvo do Plano de Ação Nacional para Conservação das Espécies Ameaçadas da Fauna Aquática do Ecossistema Mogi, Pardo e Grande, categorizada como Vulnerável (VU) pelo Decreto Estadual/SP Nº53.494/2008 categorizado como VU - vulnerável. A triploidização foi induzida em ovos recém-fertilizados, os quais receberam choque térmico a 37°C. A ploidia das larvas resultantes foi confirmada por citometria de fluxo. Aos cinco meses pós-fertilização, foi realizada coleta de gônadas (quatro peixes por ploidia). Análises histológicas das gônadas foram realizadas para determinação do desenvolvimento gonadal. As análises mostraram que as gônadas tanto dos indivíduos diploides quanto dos triploides encontraram-se diferenciadas (machos e fêmeas), porém dos diploides mais desenvolvidas comparadas aos triploides. Nos machos diploides, houve predominância de espermatogônias, alguns cistos de espermatócitos, espermátides e presença de pequena quantidade de espermatozoides na luz, enquanto em machos triploides, somente presença de espermatogônia, indicando esterilidade. Nas fêmeas diploides, verificou-se oócitos primários e oogônias, enquanto nas fêmeas triploides, somente oogônias. O trabalho permite avanços em estudos de conservação de espécies de peixes ameaçados de extinção por meio da produção de quimeras germinativas, visto que a obtenção de receptores estéreis de *P. maculaus* permite o avanço no estabelecimento de técnicas direcionadas à conservação de parentais ameaçados.

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Áreas de conservação ambiental e seu papel na manutenção da atividade pesqueira. Um estudo de caso no entorno da Estação Ecológica de Taiamã, Cáceres, Mato Grosso

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O Pantanal é uma extensa planície periodicamente inundável composta por uma série de unidades de paisagem, sujeita a pulsos de inundação. É caracterizado pela quantidade e diversidade de peixes da região, com aproximadamente 270 espécies descritas. O alto valor comercial de algumas espécies encontradas nesta região favorece o surgimento do grande número de pescadores profissionais em acampamentos circunvizinhos às unidades de conservação, como a Estação Ecológica de Taiamã (ESEC), explorando os recursos naturais ali encontrados. Neste sentido, o objetivo deste trabalho foi verificar a opinião dos pescadores profissionais, que atuam em áreas ao entorno da ESEC, acerca da importância dessa unidade de conservação para a manutenção do

estoque pesqueiro, bem como caracterizar as espécies íctias alvo desta atividade. Para isso foram entrevistados pescadores profissionais, de acordo com a presença dos mesmos nos acampamentos do entorno da ESEC, os quais responderam questões relacionadas às espécies-alvo de captura, sobre a importância da ESEC para atividade de pesca e manutenção do estoque pesqueiro e sobre a atividade de pesca dentro dos limites da UC. A identificação dos entrevistados foi mantida em sigilo de acordo com as recomendações do Comitê de Ética em Pesquisa, conforme parecer nº 1.371.018. Foram entrevistados 21 homens e 5 mulheres. Nas entrevistas, os mesmos citaram 12 espécies como alvo de captura. A frequência observada das etnoespécies citadas pelos pescadores profissionais entrevistados consiste em pacu (100%), pintado (92,6%), piranha (85,2%), peraputanga (77,8%), cachara (70,4%), barbado (63%), piavuçu (55,6%), bagre (40,7%), pacupeva e palmito (ambos 44,4%), piau (37%), jurupoca (29,6%), jaú (7,4%) e curimba (3,7%). Em relação à Estação e o estoque pesqueiro, 100% dos entrevistados deram respostas semelhantes nas quais relataram a importância da ESEC de Taiamã para manutenção das espécies pertencentes à ictiofauna, pois desempenha o papel de berçário aonde os peixes podem se reproduzir. Quando perguntado se já haviam praticado a pesca dentro dos limites da reserva 95% alegaram não terem pescado e 5% que já pescaram, porém antes de se tornar uma unidade de conservação. As etnoespécies citadas estão de acordo com o que foi encontrado na literatura referente à região do pantanal de Cáceres devido ao alto valor comercial destas. Evidencia-se que os pescadores profissionais que atuam próximo a ESEC de Taiamã têm consciência da importância dessa área para reposição do estoque pesqueiro. Assim o conhecimento tradicional deve ser um grande aliado do conhecimento científico para a proteção do habitat aquático e todas as espécies de peixes, sendo elas de interesse econômico ou não. Ainda que os resultados tenham sido satisfatórios no que diz respeito ao entendimento do papel que a ESEC Taiamã desempenha nessa região em relação ao estoque pesqueiro e a diversidade da ictiofauna, é necessária a manutenção do diálogo entre os pescadores profissionais e os gestores da ESEC de Taiamã com o objetivo de intensificar a consciência de que essa área de proteção é essencial para a manutenção da atividade pesqueira na região.

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As capturas da raia-chita (*Atlantoraja castelnaui*) pelo arrasto-de-fundo no sudeste e sul do Brasil

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A raia-chita, *Atlantoraja castelnaui* (Miranda Ribeiro, 1907; Rajidae) é uma espécie endêmica do Atlântico Sul-ocidental, ocorrendo na plataforma continental das regiões sudeste e sul do Brasil. De acordo com a Portaria MMA n° 445, de 17 de dezembro de 2014, foi categorizada como ameaçada de extinção (Em Perigo - EN) segundo os critérios da IUCN. No presente estudo avaliou-se o impacto que as frotas industriais de arrasto-de-fundo duplo e simples, sediadas no porto de Itajaí (SC), exerceram sobre a estrutura de tamanhos e sexos dessa espécie para o período compreendido entre os anos de 2012 e 2013. Foram monitorados os desembarques de *A.castelnaui*, por meio de entrevistas junto aos mestres, bem como amostragens de tamanhos e sexos das carcaças (n = 904). As composições de tamanhos foram obtidas através da medição da largura do disco (LD) em cm e separadas por modalidade de arrasto, sexo, profundidade (m) e áreas de pesca (área 1 – do Cabo de Santa Marta (28,5° S) ao Arroio Chuí (34° S); área 2 – do cabo de São Tomé (23°S) ao Cabo Santa

Marta (28,5°S)). Nas capturas a amplitude de LD variou de 11 cm a 176 cm, com média em 61,7 cm (DP = 17,5 cm). Houve consideráveis capturas de juvenis por ambas as frotas, principalmente no arrasto duplo que operou no ambiente mais raso. A frota de arrasto simples capturou em média, indivíduos de maior tamanho do que a frota de arrasto duplo. Essas diferenças podem ser explicadas pela distribuição batimétrica das frotas, ou seja, o arrasto simples, atuando a maiores profundidades, captura animais de maior tamanho. Nos desembarques os machos apresentaram em média tamanhos maiores do que as fêmeas, sendo essas diferenças mais acentuadas no arrasto duplo. Em especial na área 1, independente da época do ano e da modalidade de arrasto, as fêmeas capturadas, em média foram menores do que os machos. A frota arrasteira como um todo trabalhando na área 1, capturou maiores raias-chita do que na área 2. Todas essas diferenças observadas foram significativas ($P<0,01$) e testadas através de testes "t" de comparações de médias. No caso das comparações de tamanhos entre as duas grandes áreas foi também utilizada a análise de variância e o teste pos-hoc de Tukey. Com relação ao comportamento das proporções sexuais, por áreas de pesca e estações do ano, se observou a predominância de fêmeas. As fêmeas também foram predominantes até os 100 m nas duas áreas consideradas. Os testes chi-quadrado confirmaram a significância nessas proporções ($P<0,01$). A raia-chita é muito vulnerável a pesca de arrasto, haja vista o seu tamanho (é a maior espécie do gênero Atlantoraja), a sua forma deprimida e seus hábitos bentônicos. Pelo fato de serem residentes, depositam os ovos no ambiente bêntico, não efetuando migrações de longa distância, o que aumenta a sua probabilidade de extinção.

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Atualização da ocorrência de *Alouatta belzebul* e *Sapajus flavius* (Mammalia:Primates) em fragmentos florestais na Mata Atlântica da Paraíba e do Rio Grande do Norte

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A perda e a fragmentação de habitats são consideradas as principais ameaças à biodiversidade mundial. Em geral, as espécies da fauna brasileira ameaçadas de extinção ocupam atualmente uma pequena fração de sua distribuição original, seja no quantitativo de fragmentos, seja em área absoluta. Na Mata Atlântica da Paraíba e do Rio Grande do Norte, com menos de 10% de sua cobertura florestal original esparsos em fragmentos, ainda encontra-se o guariba-de-mãos-ruivas (*Alouatta belzebul*) e o macaco-prego-galego (*Sapajus flavius*), listados como Vulnerável (VU) e Em Perigo (EN) (Portaria MMA 444/14), respectivamente, condição que as tornou espécies alvo do Plano de Ação Nacional para a Conservação dos Primatas do Nordeste (PAN PRINE). Através de esforços já envidados pelo ICMBio/CPB, sabia-se que estas espécies ocupavam 25 fragmentos nestes estados, variando entre 40 e 2.350 ha, sendo que em 14 deles ocorre exclusivamente *S. flavius*, cinco somente *A. belzebul* e em seis há ambas as espécies. Considerando um fragmento localizado na divisa de Pernambuco (apenas com *S. flavius*), totalizam-se 26 localidades. O presente estudo tem como objetivo atualizar os registros de ocorrência destas espécies em fragmentos florestais no estado da Paraíba e regiões limítrofes, constituindo a primeira etapa do projeto "Estudo da conectividade de fragmentos florestais de Mata Atlântica prioritários para a conservação de espécies ameaçadas de primatas no estado a Paraíba", que visa implementar ações do objetivo específico prioritário do PAN PRINE que se refere ao desenvolvimento de um programa de conectividade de habitats para ampliar a viabilidade populacional das espécies. A área de estudo vistoriada compreendeu todos

os fragmentos florestais de Mata Atlântica já identificados com a presença de pelo menos uma das espécies, bem como fragmentos adjacentes e aqueles indicados em entrevistas. O levantamento de campo foi realizado entre fevereiro/2015 e julho/2016, durante 23 expedições somando 25 dias de campo. Para este levantamento, foram utilizados os métodos de busca ativa no interior e periferia das matas, busca de indícios diretos (avistamentos) ou indiretos (e.g. fezes, carcaças, vocalizações, restos alimentares) e, eventualmente, levantamentos com o método de play-back. Foram realizadas 13 entrevistas formais com moradores e trabalhadores locais com consistente conhecimento sobre a paisagem e a fauna local baseadas em um questionário semi-estruturado e auxiliado por pranchas com imagens das espécies para indicação de áreas com possível presença atual ou pretérita das mesmas. Pesquisadores que estudam populações de primatas ocorrentes também foram entrevistados informalmente. Todos os fragmentos vistoriados foram georreferenciados. Com os registros obtidos, ampliou-se o número de fragmentos com a presença das espécies de 26 para 35, sendo que destas novas localidades, cinco têm ambas as espécies, três apenas guariba e uma apenas macaco-prego. Dentre os 26 já conhecidos, em dois nos quais somente S. flavius havia sido confirmado, foi registrada a presença de *A. belzebul*. Além de ampliar o número de localidades conhecidas com as espécies-alvo, os resultados indicam a possibilidade de existência de outras pequenas populações, bem como a complexidade de implementar um programa de conectividade para seus habitats.

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Avaliação da efetividade da integração das Unidades de Conservação Federais marinho-costeiras de Santa Catarina

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Os ambientes marinho-costeiros do Brasil são os mais afetados pelo processo de ocupação humana, ocasionando considerável degradação ambiental, sendo necessárias ações que orientem um gerenciamento integrado, visando manter a integridade dos ecossistemas. No Brasil, uma das estratégias utilizadas para conservação do meio ambiente e gestão da zona costeira é a criação de unidades de conservação (UC). A lei que cria o Sistema Nacional de Unidades de Conservação define diretrizes para que unidades de conservação, próximas, justapostas ou sobrepostas, sejam geridas de forma integrada e participativa. Nesse sentido, as UCs marinho-costeiras de Santa Catarina foram objeto de iniciativas visando a integração da gestão das UCs federais no estado que culminaram na criação do Núcleo de Gestão Integrada das Unidades de Conservação Marinho-Costeiras de Santa Catarina. O presente trabalho visou avaliar o quanto essas iniciativas realmente se traduziram em ações práticas hoje estabelecidas, bem como, os motivos do alcance ou não desses resultados. Para tanto realizou-se análise do histórico e dos instrumentos de integração das UCs por meio de documentos oficiais e pesquisa na rede mundial de computadores, da execução de recursos financeiros destinado à integração e dos planos de manejo das UCs. Além disso, foram feitas entrevistas semi-estruturadas da percepção de servidores e gestores do ICMBio sobre a integração e, por fim, uma análise da efetividade atual do NGI-UMC/SC. Nas entrevistas, 82% dos servidores entenderam pela existência de cooperação e compartilhamento de espaço, veículos ou equipamentos, porém, 82% disseram que o planejamento e as tomadas de decisões que envolvem a gestão das UCs não são definidos em conjunto e 64% responderam que o uso dos recursos de compensação ambiental e outras fontes orçamentárias não são discutidos conjuntamente entre as UCs. Quanto à gestão integrada, antes de se apresentar um conceito do que seria uma gestão integrada, 55% disseram que existe na prática uma

gestão integrada entre as UCs, porém, após se conceituar que gestão integrada inclui planejamento e tomadas de decisão em conjunto, com foco em uma gestão territorial ampla, 64% passaram a entender a não existência de uma gestão integrada entre as unidades, o que indica uma deficiência de capacitação entre gestores e servidores. Embora tenham sido observados trabalhos envolvendo o apoio entre as UCs, estes não puderam ser caracterizados como parte de uma gestão integrada, já que a mesma deveria partir da premissa de que o planejamento e as decisões sejam construídos de forma conjunta, visando o território como um todo. Necessária se faz a real integração das UCs federais em análise. Essa integração não deverá se limitar a suprimir as deficiências estruturais do órgão público, mas garantir o atendimento às exigências legais, às normativas institucionais e às decisões coletivas, alcançando uma maior coerência da gestão territorial, assim como uma maior eficiência na conservação dos ecossistemas e na manutenção e ordenamento dos serviços a eles associados.

Avaliação da microbiota cloacal e de orofaringe de cardeais-amarelos (*Gubernatrix cristata*) vinculados ao programa de cativeiro da espécie

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O cardeal-amarelo, *Gubernatrix cristata*, possui distribuição restrita ao Pampa no Brasil, Argentina e Uruguai e está classificado como criticamente em perigo na lista oficial brasileira. A espécie é ameaçada pelo tráfico e fragmentação do habitat, e a maior parte da população existente está nas mãos de criadores amadores. A espécie foi incluída no Plano de Ação Nacional para a Conservação dos Passeriformes Ameaçados dos Campos Sulinos e Espinilho e no Programa de Cativeiro do Cardeal-amarelo. O Programa tem como objetivo garantir as condições sanitárias adequadas para os indivíduos recuperados do tráfico ilícito, possibilitando o aumento da população cativa e a realização de solturas, visando à recuperação das populações naturais. Para avaliar a saúde *ex-situ*, realizou-se a caracterização da microbiota e avaliação da resistência a antibióticos de indivíduos participantes do Programa nos mantenedores Gramado Zoo (Gramado, RS) e Instituto Onça Pintada (Curitiba, PR). Houve predominância de bactérias Gram positivas (65,43%), com crescimento de *Bacillus sp.* (3,70%), *Citrobacter freundii* (8,64%), *Enterobacter aerogenes* (6,17%), *Enterobacter agglomerans*(1,23%), *Enterobacter gergoviae* (3,70%), *Escherichia coli* (7,41%), *Estreptococcus sp.* (2,47%), *Kebsiellaoxytoca sp.* (2,47%), *Serratia liquefaciens* (4,94%) e *Staphylococcus sp.* (59,26%). Constatou-se homogeneidade nas bactérias ao longo do sistema gastrointestinal dos cardeais (Gadj=2,05 gl=1, p=0,15). A resistência a antibióticos foi de 69,88%, não havendo nenhum mantenedor com mais bactérias resistentes (χ^2=0,05, gl=1, p=0,81) ou multi-resistentes (χ^2=1,45, gl=1, p=0,22). Não houve diferenças entre bactérias Gram negativas e positivas quanto à multirresistência (Gadj=2,95, gl=1, p=0,08), nem entre bactérias orais e cloacais quanto à multirresistência (Gadj=5,14 gl=5, p=0,39). Também não houve relação entre bactérias Gram negativas ou positivas (Gadj=2,33, gl=1, p=0,12), diversidade de espécies de bactérias (Gadj=6,42gl=10, p=0,77) e a resistência a antibióticos (Gadj=0,94, gl=1, p=0,33) com a incidência de doenças. O sucesso reprodutivo também não foi influenciado pela diversidade de bactérias (Gadj=5,06, gl=10, p=0,88) e resistência a antibióticos (Gadj=0,86, gl=1, p=0,35). Todas as aves do Gramado Zoo apresentavam histórico de infecção pela sarna knemidocóptica, que pode estar relacionada com baixa imunidade. O comprometimento do sistema imune destas aves pode ter influenciado a predominância de bactérias Gram negativas. Por fim, as baixas taxas reprodutivas da espécie no Programa de Cativeiro podem estar sendo motivadas por fatores externos à microbiota destes animais. Este trabalho apresentou a microbiota predominante em indivíduos cativos desta espécie no Programa de cativeiro e sua relação com a saúde e reprodução.

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Avaliação do método GLORIA para monitoramento de campos de altitude em Unidades de Conservação

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Campos de altitude são formações vegetacionais abertas da Mata Atlântica, com distribuição restrita e disjunta, que ocorrem no topo das montanhas do sudeste brasileiro, particularmente nas serras do Mar e da Mantiqueira. Caracterizam-se pela alta riqueza de espécies vegetais, sendo muitas delas endêmicas restritas e ameaçadas. As principais unidades de conservação (UC) federais que protegem campos de altitude são os Parques Nacionais da Serra dos Órgãos (PARNASO), Itatiaia, Serra da Bocaina e Caparaó e as Áreas de Proteção Ambiental de Petrópolis e da Serra da Mantiqueira. As perspectivas de mudanças climáticas globais ameaçam a conservação a longo prazo dos campos de altitude como formação aberta, bem como de espécies endêmicas com requerimentos climáticos restritos. Desde 2006, o PARNASO vem discutindo a conservação dos campos de altitude com a comunidade científica em seus encontros anuais de pesquisadores. Em 2013, durante o I Workshop sobre campos de altitude, foram discutidas estratégias de monitoramento deste ambiente. Entre elas foi apresentado o protocolo de monitoramento de cumes de montanha usado no projeto GLORIA – Global Observation Research Initiative in Alpine Environments (http://www.gloria.ac.at). Este projeto é uma iniciativa internacional de estudar e monitorar ambientes alpinos e sub-alpinos, que conta hoje com áreas amostrais em todos os continentes, porém ainda sem sítios no Brasil. Em junho de 2014, uma equipe de seis pessoas testou o protocolo GLORIA nos campos de altitude do PARNASO, para verificar adequação às condições dos campos de altitude, custos e facilidade de aplicação por analistas ambientais. Foi escolhida a região da Pedra do Sino para receber este teste, devido à relativa facilidade de acesso (trilha de 10 km a partir da Sede Teresópolis), e à existência de estrutura de apoio (Abrigo 4) e de outras pesquisas em andamento, visando promover a integração entre linhas de pesquisa. Foram realizadas atividades de demarcação e amostragem de parcelas, identificação de espécies vegetais e estimativa de cobertura do solo em um quarto da área total a ser amostrada por cume. Foram encontradas dificuldades logísticas devido ao longo deslocamento e à quantidade de equipamentos a ser transportados. Por outro lado, a declividade elevada do cume impediu a alocação de algumas parcelas e a estrutura da vegetação foi mais complexa do que a vegetação alpina (baixa e pouco densa) para a qual o protocolo foi desenvolvido, pois nos campos de altitude é frequente encontrar plantas de até 2 metros de altura. Finalmente, a necessidade de identificação botânica ao nível de espécie exige a presença de um especialista na equipe ou de uma boa chave de identificação de espécies, que não existe hoje. Com base nos recursos materiais e humanos empregados no teste piloto, foi estimado o custo e esforço de implantação do método, considerando que cada sítio GLORIA deve ter quatro áreas amostrais. O esforço necessário por UC seria de três ou quatro semanas para uma equipe de 6 seis a 8 oito pessoas, com um custo aproximado de material de R$ 40.000,00. Não estão incluídos no cálculo custos com pessoal (diárias ou contratação de equipe). A aplicação do método GLORIA para o monitoramento de campos de altitude em UC requer adaptações do método e contratação de equipe especializada. As vantagens do método são fazer parte de uma rede global de monitoramento de topos de montanha e o custo relativamente baixo de material. Apesar das dificuldades, o monitoramento destas áreas é importante e a adaptação deste ou de outros protocolos continuará sendo uma prioridade.

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Avaliação histológica gonadal de híbridos e triploides de lambaris

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Os peixes híbridos e triploides tem sido alvo constante de estudos, principalmente àqueles relacionados à conservação de espécies e manutenção da diversidade ictiofaunista, pois muitos peixes híbridos e triploides são comprovadamente estéreis, podendo ser utilizados como receptores em técnicas de propagação mediada de espécies ameaçadas de extinção, que tem por finalidade a produção de gametas de uma espécie doadora utilizando outra espécie como receptora. Além disso, estes peixes podem ser utilizados em programas de repovoamento, evitando a probabilidade de introgressão genética, por seu cruzamento com espécies nativas. Deste modo, o presente estudo teve por objetivo a avaliação das características morfológicas gonadais de indivíduos triploides e triploides híbridos provenientes de diferentes espécies de lambari. Para obtenção dos triploides, oocistos de uma única fêmea da espécie *Astyanax altiparanae* foram inseminados com sêmen de 5 diferentes espécies (*A. altiparanae* (Controle), *A. fasciatus*, *A. schubarti*, *Hyphessobrycon anisitsi* e *Oligosarcus pintoi*). Para a triploidização, após a fertilização, os zigotos foram submetidos ao choque de temperatura (40°C), por dois minutos. Aos nove meses de idade, a prole proveniente destes tratamentos foi submetida a avaliação gonadal, com o auxílio das técnicas rotineiras de histologia. Entre os híbridos, a morfologia gonadal variou entre os diferentes cruzamentos e entre os sexos. As fêmeas híbridas normalmente apresentaram ovários repletos de oogônias e raros oocitos em desenvolvimento. Em contrapartida, os machos híbridos apresentaram diferentes morfologias gonadais, variando de acordo com o cruzamento, desde indivíduos com gametogênese normal, apresentando todas as células da linhagem germinativa à indivíduos portando gônadas filiformes repletas de espermatogônias, e até mesmo indivíduos desprovidos de células da linhagem germinativa. Com relação aos híbridos triploides, grande parte dos indivíduos avaliados apresentaram anormalidades no processo gametogênico, seja pela ausência de gametas nas gônadas ou completa ausência de qualquer célula da linhagem germinativa como no cruzamento entre *A. altiparanae* e *A. fasciatus* em que todos os indivíduos eram estéreis. Com a comprovação de híbridos e híbridos triploides estéreis do cruzamento entre *A. altiparanae* e *A. fasciatus*, o presente estudo abre novas perspectivas para a conservação de espécies ameaçadas de extinção, tais como a piracanjuba *Brycon orbignyanus*, que pertence à mesma família dos lambaris estéreis, que deverão ser utilizados como receptores na técnica de barriga de aluguel.

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Avifauna e mastofauna conservados pela Floresta Nacional de Ibirama/SC, um remanescente da Mata Atlântica

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O Bioma Mata Atlântica abriga uma das maiores diversidades biológicas do planeta, destacando-se como um dos cinco hotspots mundiais mais importantes para a conservação. Um dos fatores condicionantes desta biodiversidade é a grande variação de latitude e altitude que ocorre em sua extensão, o que permite que este bioma acumule em suas distintas formações, elevada riqueza de espécies, muitas das quais endêmicas. No entanto, restam na forma de fragmentos florestais apenas 12,5% de sua cobertura original. Além disso, em seu domínio vive a maior parte da população brasileira, o que ameaça esta grande riqueza. Desta forma, este trabalho buscou contribuir com a conservação da biodiversidade de aves e mamíferos da Floresta Nacional (FLONA) de Ibirama-SC a partir do registro, identificação e atualização da lista de espécies presentes no Plano de Manejo da unidade, além de criar um guia prático de identificação, destacando a importância ecológica e grau de ameaça destas espécies. Para tanto, foram utilizados os registros de fauna que constam no Plano de Manejo da unidade como base para a realização de observações oportunísticas (10 horas/mês entre jan/2013 e jul/2016), além da instalação de armadilhas fotográficas (até 18 armadilhas/mês - entre nov/2012 e jul/2016). As câmeras foram instaladas em trilhas e carreiros formados por animais e em plantas com dispersão zoocórica, priorizando as palmeiras: *Euterpe edulis*, *Attalea dubia* e *Geonoma schottiana*. As observações oportunísticas foram realizadas através de caminhadas pela unidade e também durante a instalação e manutenção das armadilhas fotográficas. Foram obtidos 10.765 registros de fauna em 5.943 dias de monitoramento, sendo 18 dias referentes ao somatório das observações oportunísticas e 5.925 dias, ao total de dias monitorados pelo conjunto de armadilhas fotográficas. Registraram-se 159 espécies de aves, das quais 112 apresentam registros fotográficos ou vídeos, sendo oito classificadas como quase ameaçadas e duas como vulneráveis pela IUCN, e cinco como vulneráveis, uma em perigo e duas como criticamente em perigo pela Portaria 444/2014 (IBAMA), onde destacam-se: *Amadonastur lacernulatus*, *Procnias nudicollis*, *Carpornis cucullata*, *Pteroglossus bailloni, Triclaria malachitacea*, *Odontophorus capueira* e *Tangara cyanocephala*, registradas repetidas vezes durante os anos de estudo. Entre os mamíferos foram identificadas 37 espécies, das quais 27 apresentam registros fotográficos ou vídeos, sendo três classificadas como quase ameaçadas e duas como vulneráveis pela IUCN, e seis como vulneráveis pela Portaria 444/2014 (IBAMA), destacando-se os felinos, *Leopardus wiedii*, *Leopardus guttulus*, *Puma yagouaroundi* e *Puma concolor*, frequentemente registrados durante os anos de estudo. Das espécies amostradas, além do grau de ameaça, 30% das aves (47 espécies) e 22% dos mamíferos (8 espécies) são endêmicos do Bioma Mata Atlântica. Tais resultados evidenciam a importância da FLONA de Ibirama para a conservação da fauna brasileira no âmbito da Mata Atlântica. A continuidade dos estudos permitirá ainda empregar outras técnicas de levantamento, como a instalação de redes de neblina para levantamento de aves noturnas (corujas, bacuraus e urutaus) e mamíferos voadores (morcegos), gerando ainda mais conhecimento sobre as espécies presentes na FLONA de Ibirama.

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Banco de dados sobre espécies arbustivas e herbáceas do Cerrado para subsidiar a restauração ecológica

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De acordo com o Novo Código Florestal (Lei Nº 12.651/2012), que visa reforçar seu cumprimento com a criação do Cadastro Ambiental Rural (CAR), milhões de hectares de áreas desmatadas de forma ilegal deverão ser restauradas no país. Sendo o Cerrado o segundo maior bioma brasileiro, entende-se a necessidade de um levantamento de informações que preencham as lacunas de conhecimento e possibilitem uma restauração efetiva, considerando as particularidades do processo de sucessão da formação savânica, muitas vezes confundida com florestas degradadas. No presente trabalho foi produzida uma tabela com informações úteis para a restauração, como distribuição geográfica, floração, fenologia, número de sementes por quilograma, coleta e beneficiamento, condições de armazenamento das sementes, tipos e técnicas de quebra de dormência, porcentagem de germinação e velocidade de germinação de espécies herbáceas e arbustivas. Para a busca serão consultados portais científicos (Web of Science, Portal Capes e Google Acadêmico) para localização de artigos científicos, dissertações, teses e resumos de congresso em português, inglês e/ou espanhol. Foram usadas associações de palavras-chave (em português e inglês) como: 'Cerrado'; 'Neotropical savanna', 'Braziliansavanna'; 'herb*', 'shrub'; 'restoration', 'seed*', 'propagule'; 'propagation'; 'planting', 'fenology', 'fruit*', 'seeddormancy'; 'seedgermination'. Adicionalmente, foram considerados os resultados de experimentos desenvolvidos pelo grupo de pesquisa em que este estudo está inserido. Para o armazenamento, organização e compartilhamento das referências bibliográficas foi utilizado o software livre Mendeley®. Todas as informações sobre história de vida, formas de plantio e resultados de restauração foram sistematizados em uma tabela que contém dados de 68 espécies. As características mais frequentemente encontradas foram as de distribuição geográfica (96% das espécies), seguida da germinabilidade (72%) e informações sobre fenologia - floração (65%) e frutificação (60%). Há informações disponíveis sobre velocidade de germinação para 53% das espécies, para 43% das espécies a síndrome de dispersão de sementes foi identificada e para 37% das espécies há dados publicados sobre fotoblastia das sementes. No que diz respeito ao número de sementes por quilograma e ao armazenamento, informações foram encontradas para cerca de 34% e 32% das espécies, respectivamente. Há menos informações sobre formas de colheita e beneficiamento e dormência (disponíveis para 29% e 10% das espécies). Uma das características mais encontradas corresponde a germinabilidade das espécies (72%), importante fator no qual se basear para escolher as espécies mais adequadas ao processo da restauração. A carência de estudos sobre a dormência de ervas e arbustos nativos tem influência direta na semeadura destas espécies, que podem ser excluídas de plantios pela baixa germinação imediata. A escassez de conhecimento sobre a colheita e beneficiamento das sementes também contribui para a não utilização de ervas e arbustos em projetos de restauração em Cerrado degradado. Apesar de ainda ser grande a carência de informações já existem dados suficientes para possibilitar o uso de mais de cinquenta espécies entre ervas e arbustos nativos das formações savânicas do Cerrado. Essas informações serão incorporadas ao banco de dados aberto e online Webambiente, gerido pela Embrapa, que congrega informações para subsidiar a restauração do passivo ambiental brasileiro.

O projeto Webambiente é uma parceria da Embrapa com o MMA-SEDR (Ministério do Meio Ambiente, por meio da Secretaria de Extrativismo e Desenvolvimento Rural Sustentável).

Caracterização da fauna acompanhante capturada nos experimentos do uso de dispositivos de redução de bycatch (BRD) na APA do Anhatomirim/SC

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O problema dos descartes nas pescarias de arrasto é mundial e vem sendo objeto de estudos para sua minimização há várias décadas. Na APA do Anhatomirim, localizada no litoral de Santa Catarina, o projeto "Rede Viva" – UFPR, visa desenvolver ações para a adoção de artes de pesca mais seletivas na frota artesanal de arrasto, a partir de uma rede de diálogo e aprendizagem com pescadores artesanais, estimulando o uso voluntário de dispositivos tecnológicos para a redução da fauna acompanhante (BRD – Bycatch Reduction Device). A adoção de dispositivos de redução de descarte (BRDs) não só minimiza a captura de indivíduos jovens dos alvos da pesca, como também de espécies que não são comercializadas, incluindo aquelas ameaçadas de extinção, com benefício em prol da conservação e ganho socioeconômico, diminuindo o trabalho a bordo, com aumento da qualidade do pescado. Este trabalho está inserido no projeto "Rede Viva", com o objetivo de analisar o material oriundo do uso de BRDs, em barcos artesanais de arrasto de camarão que operam na APA e suas adjacências, caracterizando a biodiversidade associada a esta atividade e quais modificações poderiam contribuir à construção de boas práticas de pesca, subsidiando medidas de gestão à UC. Foram realizados 18 arrastos duplos nos dias 27 e 28/08/2015, com embarcação de pescador da região, na Zona de Normatização da Pesca de Arrasto, definida no Plano de Manejo da UC. Quatro tipos de redes foram utilizadas, sendo uma delas sem modificação, denominada "Renato" e outras três redes com modificações (BRDs) tanto na malha, como com utilização de grelha, denominadas "Laureci", "Laureci II" e "Grelha". As amostras coletadas foram processadas no CEPSUL, sendo feita a identificação das espécies e as amostragens biológicas dos peixes, crustáceos e cefalópodes. Nas capturas foram identificadas duas espécies de cefalópodes, 15 de crustáceos, quatro de elasmobrânquios e 36 de teleósteos. A principal espécie-alvo de camarão foi o camarão-sete-barbas (*Xiphopenaeus kroyeri*). As espécies consideradas "*byproduct*" (não alvo, mas comercializadas ou consumidas) foram, principalmente, a maria-luiza (*Paralonchurus brasiliensis*), seguida do peixe-espada (*Trichiurus lepturus*) e da corvina (*Micropogonias furnieri*). Das espécies identificadas no "*bycatch*" (descarte), os siris e caranguejos foram os mais abundantes e os teleósteos os mais diversos. Dos siris e caranguejos o siri-azul (*Callinectes ornatos e C. danae*) e siri-baú (*Hepatus pudibundus*) foram os mais abundantes e frequentes. Dos teleósteos a maior representatividade foi de maria-luiza, sardinha-mole (*Pellona harroweri*), mamangá-liso (*Porichthys porosissimus*), cangoá (*Stellifer rastrifer*) e pescadinha (*Macrodon atricauda*). A grande maioria dos exemplares identificados no "*bycatch*" foi de juvenis, o que indica ser o local de estudo uma área de crescimento, especialmente de várias espécies economicamente importantes para a pesca local. No que se refere às modificações, foi encontrada diferença significativa ($p < 0,05$) na proporção da captura do camarão (alvo), do "*bycatch*" e do "*byproduct*", em relação ao peso total capturado em cada rede, sendo a "Grelha" a que apresentou maior proporção de alvo e o menor "bycatch", mas também o menor "*byproduct*", enquanto a rede "Laureci II" apresentou a maior proporção de "byproduct". É importante ressaltar, que a definição de medidas utilizadas na gestão de uma área passa pela necessidade de envolvimento dos usuários dos recursos naturais, na busca conjunta de soluções e do compartilhamento de responsabilidades.

Agradecimentos aos pescadores e servidores da APA do Anhatomirim, por todo processo participativo de pesquisa e ao CNPq pelas bolsas concedidas.

Caracterização das pesquisas realizadas na Floresta Nacional do Tapajós

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A Floresta Nacional do Tapajós é uma Unidade de Conservação - criada pelo Decreto n° 73.684/1974, na região oeste do Pará, com área de 527.319 hectares. Abrange os municípios de Aveiro, Belterra, Placas e Rurópolis. As principais vias de acesso são o Rio Tapajós e Rodovia BR163. Sob a administração do Instituto Chico Mendes de Conservação da Biodiversidade - ICMBio, a unidade é referência, no Brasil e na América latina em gestão socioambiental, uso sustentável e pesquisa científica. Nesta UC são desenvolvidas diversas atividades tais como: o Manejo Florestal Comunitário, operacionalizado pela Cooperativa Mista da FLONA do Tapajós - COOMFLONA, o Turismo de Base Comunitária, Extração do látex (seringueira) e produção do couro ecológico a partir do látex, Extração de óleos de andiroba e copaíba, biojóias (sementes), móveis artesanais a partir dos resíduos (galhos) oriundos do manejo, comercialização de frutas in natura (açaí), produção de polpas de frutas e licores, produção de farinha, produção de mel, criação de peixes e outras. O presente trabalho teve por objetivo quantificar as atividades de pesquisas realizadas na UC com fins didáticos e científicos, no período de janeiro de 2015 a Julho de 2016, bem como identificar as áreas de estudo mais pesquisadas. Para o levantamento dos dados foi utilizado o Sistema de Autorização e Informação em Biodiversidade – SISBio - que é um sistema de atendimento à distância ao qual permite que pesquisadores solicitem autorizações para a realização de pesquisas nas unidades de conservação federais. Por meio da análise dos dados nota-se que Floresta Nacional do Tapajós tem tido um aumento significativo no número de autorizações nos últimos meses. Somente no primeiro semestre de 2016 foram emitidas 71 novas autorizações e 3 renovações de autorizações. Ao se fazer um levantamento da profissão dos pesquisadores que procuram a unidade, verificou-se que na maioria são professores do ensino superior correspondendo a 48% do total, 21% são biólogos e 11% engenheiros florestais. Vale ressaltar que a formação de professor envolve várias áreas de conhecimento, porém não especificado na solicitação. As áreas de estudo que mais foram pesquisadas neste período foram em ecologia, recursos florestais e engenharia florestal, botânica e manejo, respectivamente. Quanto à escolaridade dos pesquisadores verificou-se que 42% do total possuem títulos de doutorado, 35% mestrado e 13% pós-doutorado. Observou-se também que dentre as Instituições com maior número de profissionais vinculados que solicitam a autorização, destaca-se a Universidade Federal do Oeste do Pará – UFOPA, com 40% do total das autorizações, este fato pode ser explicado devido à proximidade de localização entre a instituição e a Unidade. Outras instituições também se destacam como o Instituto Nacional de Pesquisas da Amazônia – INPA, Fundação Universidade do Amazonas – FUA, Instituto Nacional de Pesquisas Espaciais – INPE e Universidade Federal do Pará – UFPA. Das 159 autorizações realizadas entre janeiro de 2015 e julho de 2016, 126 foram com fins científicos e 33 para fins didáticos. A Flona Tapajós é a Floresta Nacional mais procurada para a realização de pesquisas, sendo a primeira no ranking dentro desta categoria. A mesma tem uma vasta riqueza na biodiversidade de fauna e flora, além abrigar populações tradicionais, extrativistas e indígenas ao qual ainda tem muito a oferecer e devem ser exploradas para fins científicos e geração de projetos com temas relevantes para o desenvolvimento e avanço da ciência.

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Caracterização morfológica do solo em áreas do Parque Nacional das Nascentes do Rio Parnaíba

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O Parque Nacional das Nascentes do Rio Parnaíba (PNNRP) está localizado na divisa dos estados do Maranhão, Bahia, Tocantins e Piauí. O presente estudo teve como objetivo analisar a classificação do solo em área do PNNRP, localizado no município de Barreiras do Piauí. A delimitação correspondeu a um hectare. Foram coletadas amostras de solo nas profundidades de 0-20, 20-40 e 40-60 cm seguidas de três repetições, provenientes da abertura de três mini trincheiras, que serviram de base para análise in loco da coloração do solo, segundo a Carta de Munssel e identificação direta dos horizontes. O estudo verificou que os solos da área do PNNRP correspondem a um Latossolo-Amarelo. Verificou-se que na primeira mini trincheira foram identificados os horizontes A com 12 cm de profundidade, B1 de 12 a 37 cm e B2 referente a mais de 37 cm de profundidade. Uma das principais características identificadas nos horizontes foi a presença expressiva de material orgânico com raízes finas e grossas, pertencente ao horizonte A. Entretanto no horizonte B1 constatou-se apenas a presença restrita de algumas raízes médias, não apresentando material orgânico. No horizonte B2 não foram identificadas raízes presentes. A segunda apresentou o horizonte A de 0-20 cm de profundidade do solo, horizonte B1 de 20 – 30 cm e B2 na parte mais profunda do solo referente a 40 cm de profundidade. Estes horizontes identificados apresentam características semelhantes, sendo os horizontes A e B1 extremamente friável e o horizonte B2 com boas condições que favorecem o processo de infiltração natural nestes solos. Além disso, verificou-se a presença de mosqueados, que podem dificultar a dinâmica de retenção ou acúmulo de água neste solo. Essa trincheira localiza-se em área de relevo declivoso, porosidade excelente, cobertura vegetal densa apesar de ser uma área predominantemente arbustiva. Na terceira identificou-se a presença do horizonte A com profundidade referente a 20 cm, horizonte B1 de 20 a 40 cm e horizonte B2 referente a 40 cm de profundidade. Em relação a classificação do solo conforme a Carta de Munssel verificou-se que a primeira mini trincheira apresentou em seus primeiros 20 cm apresentou classificação com os valores Matiz: 7,5 yr, valor 3/2 no horizonte A; No horizonte B1 de 20 a 40 cm a Matiz: 7,5 yr, valor5/3 e em seus 40 a 60 cm a Matiz 7,5 yr, valor 6/3. A mini trincheira 2 apresentou em seu horizonte A a de Matiz: 7,5 yr valor 4/2,horizonte B1 sua classificação em seus 20 a 39 cm apresentou classificação com os valores Matiz: 7,5 yr valor 5/6 e horizonte B2 nos seus40 cm Matiz: (5) yr. Já na terceira mini trincheira identificou-se no horizonte A de profundidade de 20 cm a Matiz: 4 /2 7,5YR, horizonte B1 20-40 cm apresentou classificação com os valores Matiz: 5/6 7,5YR e horizonte B2 aos 40 cm apresentou classificação com os valores Matiz: 5/6 5YR. Conforme a análise do solo pode-se concluir que o solo da área em estudo apresenta-se em proporções significativas uma formação Areno-Argiloso no qual apresenta uma textura friável e com boa infiltração o que favorece a vegetação do local bem como melhores condições possuindo maior quantidade de nutrientes. Além disso, conforme as características do solo analisado verifica-se sua contribuição para conservação dos organismos vivos existentes no parque, principalmente por fornecimento de matéria orgânica e boa condição infiltração do solo, contribuindo para a manutenção de relações ecológicas entre solo, planta e organismos que vivem no e sobre o solo.

Cenários para criação de Unidade de Conservação do Castanhal no município de Parintins, Amazonas, Brasil

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O presente estudo visa elaborar as bases técnicas para propor a criação de uma unidade de conservação municipal na Região dos Castanhais em Parintins, Amazonas, por se tratar de um importante ecossistema, dado como área prioritária para conservação pelo Plano Diretor da cidade. A área em análise contribui para a qualidade ambiental da região, bem como para a conservação de espécies, uso sustentável e prevenção de ameaças ambientais. Os seguintes métodos foram aplicados ao estudo: levantamento e revisão bibliográfica e documental, utilização de ferramentas de geoprocessamento para criação de 2 cenários de delimitação e categorização utilizando-se do método de prospectivas de cenários de Godet, visita a campo para observação direta para levantamento de atributos naturais (integridade, conectividade, fauna e flora) e sociais (ameaças e ocupação humana), levantamento de condicionantes de futuro como a situação fundiária e seleção e indicação de possíveis categorias de UCs para os cenários de delimitação propostos. Parintins possui condições adequadas e necessárias para a criação de unidades de conservação uma vez que já que possui um Sistema Municipal de Meio Ambiente dotada de Secretaria, Fundo, Conselho Municipal de Meio Ambiente e Código Ambiental. Identificou-se que ambos os cenários possuem vegetação com enfâse na presença de castanheiras, mas pode-se citar outras como araçá-pera, goiaba-de-anta e o lacre. O Cenário 1 com apenas 0,245km^2, compreendendo um único castanhal, possui baixa integridade ambiental, não possui moradores no seu interior (até a data de elaboração do relatório final), suas conexões se dão com um bairro, um loteamento em meio a um castanhal e ao Lago do Macurany em aproximadamente 60% do seu perímetro, e que suas ameaças são o uso para atividades ilícitas e deposição inadequada de resíduos sólidos. Para este cenário de área 100% pública sugere-se a Categoria "Parque Natural Municipal". No cenários 2 notou-se que devido ao maior tamanho de área (11,892km^2) possui mais áreas de castanhais, quatro, além de áreas de vegetação secundária e diversos ambientes aquáticos que demonstram maior integridade, suas conexões se estendem por mais áreas com destaque dos 12,80km do perímetro total de 20km de relações diretas com o Lago do Parananema, possui inúmeros moradores no seu interior inclusive dois complexos habitacionais com cerca de 1500 casas, loteamentos, chácaras e moradores tradicionais, suas ameaças são áreas de campo internas e externas e a pressão imobiliária. Sugere-se para este cenário a categoria de Área de Proteção Ambiental devido a abertura para empreendimentos e a presença de moradores. Optou-se ao final elaborar proposta técnica de criação de Unidade de Conservação do Castanhal e projeto de lei que seguem em anexo, segundo os dados apresentados para o que denominados Cenário 1 devido à ausência de moradores e ao fato de ser área público, bem como de se fazer uso do aparato jurídico existente no município, criando um precedente histórico na gestão ambiental.

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Chuva de sementes no Cerrado: precursores de sucessão em áreas degradadas

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A principal forma de regeneração natural de plantas nas savanas do Cerrado é por meio da reprodução vegetativa, especialmente a partir de estruturas subterrâneas. Apesar disso, a produção e dispersão de sementes por espécies savânicas é considerável, e é a única possibilidade de estabelecimento natural em áreas onde o solo foi removido, como em cascalheiras. O objetivo do presente estudo foi amostrar a chuva de sementes em uma área de cascalheira próxima à antiga rodoferroviária do DF. Foram instalados 25 coletores de 1m x 1m de tecido tipo mosqueteiro instalado a 75 cm de altura, paralelo ao solo, próximos à fronteira de cascalheira com um fragmento de Cerrado sentido restrito. As armadilhas foram dispostas em 5 transeções separadas por 20 m com armadilhas fixadas a 15 e 10 m fora do fragmento, fronteira e 5 e 10 m dentro do fragmento. As armadilhas foram monitoradas de novembro/2015 a maio/2016. As coletas foram quinzenais e as sementes foram identificadas e submetidas a teste de germinação. Foram coletadas ao todo 9 espécies, 7 nativas (nat) e duas exóticas (exo), somando 114 sementes. 39% dos propágulos caíram nas armadilhas a 15 metros do fragmento (nat=11%, exo=27%), 4% a 10 metros do fragmento (nat=4%, exo=0%), 11% na fronteira do fragmento (nat=11%, exo=0%), 13% a 5 metros no interior do fragmento (nat=13%, exo=0%) e 33% a 10 metros no interior do fragmento (nat=21%, exo=5%). As espécies coletadas foram: *Andropogon gayanus* (6 sementes), *Aristida* sp. (1), *Baccharis* sp. (15), *Banisteriopsis* sp. (4), *Dalbergia miscolobium* (14, 50% 10 metros dentro do fragmento), *Echinolaena inflexa* (13), *Heteropterys byrsonimifolia* (6), *Melinis minutifloria* (31) e *Struthanthus* sp. (14). As espécies mais coletadas por distância foram, a 15 metros do fragmento, *M. minutifloria* (100%) e *Struthanthus* sp. (75%), a 10 metros do fragmento, *A. Gayanus* (100%), *Aristida* sp. (100%), *Baccharis* sp. (53%), 5 metros dentro do fragmento, *H. byrsonimifolia* (83%) e 10 metros dentro do fragmento *A. gayanus* (100%) e *E. inflexa* (100%). Na fronteira do fragmento não houve predominância de uma espécie, sendo todas as sementes coletadas nestas armadilhas de espécies nativas, entre elas *Baccharis* sp. (47%), *D. miscolobium* (21%) e *H. byrsonimifolia* (17%), com algumas espécies coletadas fora do fragmento, como *D. miscolobium* e *Struthanthus* sp. As sementes levadas a laboratório foram afetadas por fungos, estando provavelmente inviáveis. As espécies herbáceas são *A. gayanus, Aristida* sp., *E. inflexa, M. minutifloria* e *Struthanthus* sp., arbustivas e lianas *H. byrsonimifolia, Banisteriopsis* sp. e *Baccharis* sp. e arbórea *D. miscolobium*. Considerando o hábito das espécies nativas capturadas nas armadilhas de fronteira e externas e o ciclo de vida de algumas espécies, como *Struthanthus* sp., planta hemiparasita (Dettke et al, 2015), e as sementes que alcançaram maior distância, provavelmente as espécies presentes em início de sucessão seriam *H. byrsonimifolia* e *D. miscolobium*. A densidade de propágulos amostrada foi baixa se comparada a chuva de sementes em área de cerradão, (Bocchese et al. 2008), onde foram encontradas 3974 sementes (22 armadilhas por 12 meses).

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Ciência cidadã no Parque Nacional da Serra dos Órgãos: organizando registros de ocorrência de fauna e ampliando a participação social

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A organização, sistematização e divulgação do conhecimento existente são de suma importância para atingir os objetivos da conservação da diversidade biológica. No Parque Nacional da Serra dos Órgãos (PARNASO), os dados de ocorrência de fauna obtidos em projetos de pesquisa e publicações estão armazenados no SISBIO e no SISCON, banco de dados local que armazena dados bibliográficos de publicações das pesquisas realizadas nesta Unidade de Conservação (UC). Informações sobre animais recebidos pelo Setor de Fauna (oriundos do projeto de monitoramento de atropelamento de fauna, de apreensão pela fiscalização ou entrega voluntária) são armazenadas em planilhas eletrônicas e fichas em papel. Até 2015 não existia na UC uma maneira consistente de armazenar registros eventuais de fauna feitos por funcionários, pesquisadores e visitantes. Circulam pelo Parque mais de 217 mil visitantes por ano, em grande parte munidos de câmeras fotográficas ou celulares com câmeras e GPS, que muitas vezes se deparam com animais de interesse para conservação. Na maior parte das vezes esses registros sequer são informados à administração da UC, e assim se perde informação. Este trabalho tem por objetivo desenvolver e testar uma maneira eficiente de armazenar os registros eventuais de fauna no Parque Nacional Serra dos Órgãos, facilitando sua utilização para a gestão da UC. Avaliamos formulários, planilhas e bancos de dados previamente existentes no PARNASO e outras UC. Aplicativos para registro de fauna utilizando celulares disponíveis gratuitamente online (Urubu Mobile e SISS-Geo) foram avaliados com a finalidade de escolher qual melhor se adequaria ao nosso projeto, levando em consideração o funcionamento dos sistemas, a facilidade de uso, o acesso aos dados e aplicações. O aplicativo SISS-Geo foi o que mais se adequou às necessidades do projeto, pois permite o registro de animais em qualquer situação, não apenas de animais atropelados. Além disso, o sistema tem uma versão web que permite o envio de conjuntos maiores de dados de uma vez só, converte informações em tabela Excel, e produz mapas e gráficos, dando um excelente suporte à gestão. O Centro de Informação em Saúde Silvestre (CISS) da Fiocruz e o Laboratório Nacional de Computação Científica (LNCC), desenvolvedores do aplicativo, foram contatados para avaliar possibilidade de cessão de dados registrados no PARNASO e estabelecer parceria. Em 2016 foram realizados pela equipe do SISS-Geo três eventos de treinamento nos meses de março e junho aos servidores, funcionários terceirizados, condutores de visitantes, estagiários e parceiros da UC num total de 129 capacitados, com intuito de estimular o registro de informações e recuperar registros anteriores. Registramos considerável aumento do número de colaboradores cadastrados no aplicativo e de registros enviados, de 02/08/2015 até os dias de hoje, que passou de 21 para 83 colaboradores e de 4 para 33 registros válidos enviados, após as ações de capacitação. Constatamos o grande potencial dessa ferramenta não apenas para organizar registros, mas também para ampliar a participação social na gestão da UC. Pela simplicidade da proposta acreditamos também que depois de testados e indicados os principais gargalos no funcionamento, estes métodos poderão ser aplicados em outras UC e que podem impulsionar grandes melhorias na forma de usar dados para qualificar a gestão e na própria forma de fazer gestão ambiental nas regiões onde estas UC se localizam.

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Composição florística da Reserva Biológica Augusto Ruschi, Santa Teresa/ES, Brasil

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A Mata Atlântica já foi considerada uma das maiores florestas tropicais da América, sua cobertura original era de 150 milhões de hectares estabelecida em condições ambientais altamente heterogêneas, que foram favorecidas principalmente pela amplitude latitudinal e pelos aspectos geográficos. Essa combinação de características criou condições para o surgimento de uma composição florística variada, gerando altos níveis de diversidade e endemismo para plantas e muitos outros grupos, fazendo com que fosse reconhecida como um dos hotspots de biodiversidade no mundo. Visando contribuir para o conhecimento da flora da Mata Atlântica e das unidades de conservação (UCs), o presente trabalho estudou a composição florística da Reserva Biológica Augusto Ruschi (REBIO AR), situada ao norte do município deSanta Teresa, ES. O levantamento da flora da REBIO AR foi realizado através de levantamento de dados secundários, obtidos através dos bancos de dados do herbário do Museu de Biologia Mello Leitão e do projeto speciesLink. Ressalta-se que algumas das identidades taxonômicas obtidas através de banco de dados necessitam de confirmação por especialistas. Os registros do herbário MBML, em sua grande parte, estão identificados pelos especialistas.As espécies foram classificadas em famílias de acordo com o sistema do AngiospermPhylogenyGroup III. Os nomes das espécies, sinonímias, forma de vida e ocorrência foram conferidos por meio de consultas à Lista de Espécies da Flora do Brasil, através do pacote 'flora', versão 0.2.7, programa R. O grau de ameaça foi conferido através da Lista Vermelha do Centro Nacional de Conservação da Flora. Para a REBIO AR foram registradas 1414 espécies, sendo que 115 foram identificadas até o nível de gênero. No total, foram contabilizados 592 gêneros e 168 famílias. As famílias com o maior número de espécies foram: Orchidaceae (178), Myrtaceae (75), Bromeliaceae (59), Melastomataceae (54), Asteraceae (47), Rubiaceae (45) e Fabaceae (40). O grupos das ervas é o que apresenta o maior número de ocorrências na unidade de conservação, com a presença de aproximadamente 501 espécies, seguido das árvores (235 sp.) e lianas/volúveis/trepadeiras (108 sp.), outras formas de vida também foram registradas em menor número e 185 espécies não apresentaram classificação de hábito. Em relação à distribuição geográfica, 65 espécies listadas nesta UC apresentaram registro somente para o estado do Espírito Santo, indicando uma distribuição restrita. E destas espécies que apresentaram distribuição restrita ao estado, duas estão criticamente em perigo, sendo estas: HoehneellaheloisaeRuschi e Myoxanthusruschii Fraga &L.Kollmann, ambas da família Orchidaceae. Ainda deste grupo de espécies restritas ao ES, nove espécies foram consideradas em risco elevado de extinção na natureza e seis espécies foram consideradas vulneráveis. Nestas duas categorias, a família Bromeliaceae predominou em número de espécies com risco de extinção. Este trabalho procurou trazer um panorama geral da composição florística da REBIO AR, ressaltando principalmente a importância desta unidade de conservação em manter parte da biodiversidade da Mata Atlântica localizada na região montanhosa do Espírito Santo, região que abriga espécies com distribuição restrita e que com alto grau de vulnerabilidade, como foi comprovado por este trabalho. As altas taxas de desmatamento conferem ao bioma o título de mais devastado e ameaçado ecossistema do planeta, o que exige ações e medidas urgentes e eficazes de conservação para os remanescentes naturais de vegetação.

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Contaminação do solo por ovos de *Toxocara* spp. em Unidade de Conservação no Pantanal de Mato Grosso, Brasil

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Vários estudos sobre a contaminação do solo por ovos de *Toxocara* spp. em áreas públicas e recreativas no Brasil têm demonstrado o potencial epidemiológico na propagação de infecções humanas, ocasionadas principalmente pela ingestão acidental de ovos larvados presentes no solo. A síndrome da larva migrans visceral (LMV) é uma das manifestações clínicas da toxocaríase humana, sendo geralmente relacionada à alta densidade dos animais domésticos, principalmente cães e gatos, associada às condições educacionais e sanitárias precárias de populações. Neste caso, a avaliação do solo torna-se importante uma vez que a transmissão do agente parasitário e a viabilidade das formas infectantes dependem também das condições ambientais. O objetivo deste estudo foi avaliar a contaminação de solo por ovos de *Toxocara* spp. na Estação Ecológica de Taiamã, unidade de conservação federal localizada no Pantanal de Mato Grosso, em região altamente influenciada pelas flutuações sazonais do nível das águas do rio Paraguai. Adicionalmente, 3 locais com diferentes graus de antropização no seu entorno também foram amostrados. Por se tratar de uma ilha fluvial, a coleta das amostras de solo foi realizada bimestralmente durante o percurso pelo rio através de embarcação por todo o perímetro da unidade de conservação, totalizando 27 locais em seis períodos de coleta entre agosto de 2014 a junho de 2015, sendo que nos meses de cheia poucos locais possibilitaram a coleta de solo devido ao alagamento de grande parte da área de estudo. Foram coletadas amostras de 100 g de solo de dois pontos diferentes em cada local, as quais foram analisadas segundo um método de flutuação com uso de solução de sulfato de zinco (d=1.350g/cm3). Além disso, amostras fecais de onças-pintadas (*Panthera onca*) e jaguatiricas (*Leopardus pardalis*) foram coletadas através dos mesmos transectos, e aleatoriamente quando do achado ocasional no local de estudo. Das amostras de solo recolhidas, 15,5% foram positivas para *Toxocara* spp., frequência similar às encontradas em alguns estudos realizados em centros urbanos no mundo. Vários ovos estavam embrionados, e em 3 ocasiões ovos larvados foram observados, o que indica condições ambientais para manutenção e embrionamento dos mesmos no solo. Apesar de haver apenas um local de coleta com a presença de animais domésticos localizados no entorno e a montante da unidade de conservação, ovos foram recuperados em locais dentro da área protegida e com ausência de seres humanos e seus animais de estimação. Este resultado sugere que há a presença de animais silvestres que podem contaminar o ambiente com ovos de ascarídeos. Como não há registros da presença de canídeos silvestres nesta área de estudo, provavelmente felídeos silvestres podem estar contaminando o ambiente, uma vez que resultados preliminares constataram que algumas das amostras de fezes resultaram positivas para *Toxocara* spp. dentre as coletadas no mesmo período. Diante disso, são necessárias análises moleculares a fim de conhecer as espécies do gênero envolvidas, na busca de um melhor entendimento das inter-relações entre parasitas e hospedeiros neste ambiente altamente influenciado pelas variações sazonais. Os resultados obtidos suscitam as questões relacionadas ao conhecimento das infecções parasitárias que ocorrem em áreas pouco urbanizadas ou próximas a ambientes rurais e silvestres, e suas implicações na sanidade animal e humana.

Desempenho reprodutivo do rivulídeo *Hypsolebias sertanejo* em condições laboratoriais

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Os Rivulídeos compreendem uma família de peixes anuais, amplamente distribuída pelo Brasil, que inclui 201 espécies, das quais 125 encontram-se em risco de extinção, o que enfatiza a implantação de estratégias de conservação. Neste trabalho foi avaliado o desempenho reprodutivo de exemplares do rivulídeo *Hypsolebias sertanejo*, espécie ameaçada de extinção. Dessa forma, peixes coletados em Janaúba e Itacarambi-MG, Brasil, em março/2015 (sete machos e 21 fêmeas) foram distribuídos em aquários de 40 L, na densidade de um macho para três fêmeas, com temperatura da água mantida a 27°C, com fotoperíodo de 12 horas de luz. Em cada aquário foi inserido um recipiente com areia de granulometria menor que 0,42 mm, a qual foi utilizada como substrato para a deposição de ovos. Os ovos coletados entre os meses de maio a julho de 2015 (26 coletas) foram transferidos para microplacas de seis poços, contendo 15 mL de água ultrapura, e mantidos sem iluminação em incubadora BOD a 25°C. Diariamente a água foi renovada, os ovos inviáveis foram retirados, e a eclosão mensurada. Durante o período experimental foram coletados 2.137 ovos, dos quais apenas 3,79% eclodiram. O tempo médio de incubação entre a fertilização e a eclosão foi de 75,84 ± 27,23 dias, variando de 29 a 128 dias. Os resultados aqui apresentados são preliminares e evidenciaram as dificuldades na obtenção de formas jovens da espécie em laboratório. Assim, para o estudo reprodutivo deste rivulídeo ainda é necessário o estabelecimento das condições específicas para a estocagem dos ovos, garantindo assim maior sucesso nos índices de eclosão e sobrevivência.

Agradecimentos ao CEPTA/ICMBio.

Desenvolvimento embrionário de espécies de Rivulidae ameaçadas de extinção

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Os rivulídeos são peixes de pequeno porte, raramente chegando aos dez centímetros de comprimento total, vivem em ambientes aquáticos muito rasos, parcial ou completamente isolados de rios e lagos, como as áreas marginais de riachos ou brejos, que distribuídos em 201 espécies, das quais 125 encontram-se em ameaçadas de extinção devido ao aumento das ações antrópicas e à diminuição de áreas que permitam que seu ciclo se realize. Diante destes problemas estudos que visem à conservação, tais como os estudos reprodutivos básicos em laboratório que permitam fornecer informações essenciais para o delineamento e a execução de estratégias de conservação em ambiente natural, são de extrema necessidade. Com este intuito o presente estudo objetivou avaliar a eclosão de ovos oriundos de ambientes naturais em ambiente laboratorial. O trabalho foi

desenvolvido no Centro Nacional de Pesquisa e Conservação da Biodiversidade Aquática Continental, CEPTA-Pirassununga. As espécies estudadas foram *Nematolebias whitei*, *Ophtamolebias constanciae*, *Hypsolebias magnificus*, *Hypsolebias fulminantes*. Para avaliar a eclosão em ambiente laboratorial ovos foram coletados em ambiente natural no estágio de diapausa e acondicionados em substrato seco de fibra de coco. Das quatro espécies de rivulídeos ameaçadas de extinção foram utilizados 66 ovos para o estudo, sendo 34 (trinta e quatro) ovos da espécie *Nematolebias whitei*, 19 (dezenove) ovos da espécie *Ophtamolebias constanciae*, 12 (doze) ovos da espécie *Hypsolebias magnificus* e apenas um ovo da espécie *Hypsolebias fulminantes*. Os ovos foram distribuídos por espécie em aquários, e foram aferidas medidas, taxa de eclosão, concentração de oxigênio, temperatura e salinidade da água diariamente. Durante os 27 dias de acompanhamento do experimento só houve eclosão de apenas duas larvas de *Hypsolebias magnificus*, do total de 12 ovos incubados da espécie, das outras três espécies não ocorreu eclosão. Com esses resultados podemos concluir que há uma grande dificuldade na obtenção de formas jovens em laboratório, tal fato provavelmente está relacionado com a grande variabilidade de ambientes que estas espécies vivem e de características únicas, sendo necessários mais estudos que proporcionem aos ambientes laboratoriais condições adequadas para seu desenvolvimento e que permitam estratégias para conservação.

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Desmatamento em áreas protegidas no estado do Acre

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O modelo tradicional de ocupação agropecuária no Brasil tem contribuído com o aumento do desmatamento na Amazônia. Em tempos mais recentes e de escassez de terras cultiváveis, as Unidades de Conservação têm se tornado alvos mais frequentes de invasores para exploração de madeira e desmatamento ilegal. Tais pressões antrópicas têm sido observadas em todos os estados que compõem a Amazônia brasileira, implicando em graves prejuízos, como conflitos sociais, empobrecimento da biodiversidade, degradação de solos, comprometimento de bacias hidrográficas, contribuições para a emissão de gases de efeitos estufa e perda de oportunidades econômicas. O presente estudo buscou fazer uma avaliação detalhada da situação do desmatamento e uso da terra no interior das unidades de conservação e terras indígenas no estado do Acre, utilizando dados de sensores remotos e identificando áreas críticas que requerem especial atenção em curto e médio prazo, com base nos parâmetros de desmatamento acumulado, incremento do desmatamento e desmatamento relativo à área de área protegida. Inicialmente foi avaliada a acurácia dos dados do Programa de Cálculo do Desflorestamento da Amazônia – PRODES, comparando-os com inspeções visuais sobre imagens RapidEye de alta resolução espacial. Os resultados deste estudo indicam que os dados do desmatamento produzidos pelo projeto PRODES apresentam uma acurácia global de 96%. Utilizando os dados do PRODES do ano de 2000 até 2015, observou-se que a Terra Indígena no estado do Acre que apresenta situação mais crítica em relação ao desmatamento é a TI Kaxinawa da Colônia Vinte e Sete, por possuir desmatamento relativo à sua área de 80%. Em relação às Unidades de Conservação as que apresentaram situação mais crítica em relação ao desmatamento foram a Reserva Extrativista Chico Mendes, por possuir desmatamento acumulado até 2015 de 49.547 ha; a Reserva Extrativista do Alto Tarauacá, por possuir incremento do desmatamento de 207%; a Área de Relevante Interesse Ecológico Seringal Nova Esperança, por possuir desmatamento relativo à sua área de 37%, e a Floresta Estadual do Antimary, por possuir incremento do desmatamento de 1704%. Nestas áreas protegidas, as áreas desmatadas até 2012 foram em sua maioria ocupadas por pastagens e vegetação secundária, com base na análise feita para o projeto TerraClass para o ano de 2012. O processo de desmatamento aliado ao tipo de uso da terra observado nestas áreas protegidas consideradas mais críticas no estado do Acre revelam uma crescente pressão antrópica nos últimos anos. Esta pressão é uma grande preocupação ambiental e requer medidas urgentes a fim de evitar

a descaracterização ou desvio da finalidade de criação destas áreas. Assim, os resultados do presente estudo podem contribuir para a definição de prioridades e estratégias de conservação ambiental no estado do Acre, evitando o avanço do desmatamento ilegal em área protegidas.

Diagnóstico participativo para o planejamento e ordenamento territorial de Unidades de Conservação: subsídios ao plano de manejo da Estação Ecológica do Taim/RS

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A Estação Ecológica do Taim é uma Unidade de Conservação (UC) localizada na porção Sul da Planície Costeira do estado do Rio Grande do Sul (Brasil). Embora essa UC tenha sido estabelecida há trinta anos, e seja internacionalmente reconhecida como importante área úmida, e proteger espécies ameaçadas, a mesma ainda carece de plano de manejo. Imersa em uma matriz cultural e de atividades produtivas conflitantes com os interesses de conservação, a participação da sociedade na elaboração do plano de gestão é um aspecto fundamental. Neste sentido, foi aplicado um diagnóstico participativo como mecanismo para apreender os modos de relacionamento da população local e seus conhecimentos sobre o meio onde está inserida a unidade, assim como a percepção da comunidade cientifica envolvida com pesquisas na mesma. Foram preparados dois questionários com questões abertas, diferenciados para a comunidade local e para comunidade científica. As questões dirigidas à comunidade local buscavam identificar o conhecimento das mesmas sobre a biodiversidade e habitats, sua percepção sobre o território, e os conflitos com a UC. As questões dirigidas à comunidade científica visavam identificar os habitats mais importantes para a biodiversidade, as principais ameaças e as possíveis soluções de manejo. Foram realizadas setenta e três entrevistas presenciais junto a comunitários no período de fevereiro a abril de 2015. Os pesquisadores foram consultados via correio eletrônico e selecionados via cadastro no Sistema de Informações em Biodiversidade. Um total de oitenta e nove questionários foram respondidos. Adotou-se o método de Análise Textual Discursiva (MORAES E GALIAZZI, 2011) para interpretação das entrevistas. Para elaboração da proposta de zoneamento da UC, foi organizado um banco de dados em Sistema de Informações Geográficas SIG SPRING (CAMARA, G, SOUZA, R. C. M., FREITAS, U. M. G, 1996). Informações sobre cobertura vegetal, hidrografia, usos do território, vias de aceso foram obtida de imagens do satélite RapidEye. As imagens foram processadas digitalmente através de algoritmos estatísticos de classificação automática e semiautomática. As classes de uso e cobertura do solo foram mapeadas e editadas manualmente pós classificação. O estudo fundamentou-se principalmente nos trabalhos de BENSUSAN (2006) e FERREIRA (2010), no que se refere às origens e motivações à criação e ao planejamento de áreas protegidas. No que se refere à participação social, fundamenta-se em D´AMICO (2013), NEIVA (2013). Gênese e evolução Geológica referencia-se em TOMAZELLI e VILLWOCK (2000). Caracterização da flora nos trabalhos de FERRER E SALAZAR (2004), MOTTA MARQUES E VILA NUEVA (2001) e GRINGS (2011). Em relação à fauna nos trabalhos de MÄHLER (1996) avifauna, GARCIA (2006) e CORREA (2011) ictiofauna, GAYER (1986) anfíbios, GOMES E KRAUSE (1982) répteis e AZAMBUJA (2010) e SPONCHIADO (2012) mamíferos. Quanto à caracterização de aspectos antrópicos, nos trabalhos de MOTTA MARQUES E VILANUEVA (2001), HENTSHEL (2009) e BAGER (2003). As informações obtidas por meio do diagnóstico participativo, espacializadas em um Sistema de Informação Geográfica e interpretadas juntamente com dados físicos, biológicos e antrópicos, permitiram caracterizar no território ameaças e oportunidades à conservação na área da unidade. Tal investigação tornou possível propor um esquema de zoneamento de usos, e a identificação de ações de manejo para esta unidade de conservação de forma a subsidiar o planejamento e o ordenamento territorial para a ESEC do Taim.

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Diagnóstico preliminar do conflito entre humanos e carnívoros silvestres no Parque Nacional do Juruena

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O Parque Nacional do Juruena, criado em 2006 e com área de 1.958.203 ha, é uma importante unidade de conservação federal de proteção integral localizada Amazônia Meridional brasileira, englobando partes dos estados do Mato Grosso e Amazonas. A baixa densidade humana na região e o bom estado de conservação de boa parte da área favorecem a ocorrência de conflitos entre moradores locais e mamíferos carnívoros silvestres, tais como prejuízos econômicos decorrentes da predação de criações domésticas e riscos potenciais aos próprios moradores. Esses fatores podem levar a retaliações por parte dos moradores locais à fauna local. Como forma de buscar um maior conhecimento sobre o relacionamento entre os carnívoros silvestres e as populações humanas locais, funcionários do PARNA do Juruena e CENAP realizaram um levantamento preliminar sobre o tema nas comunidades localizadas no parque, com enfoque na Barra de São Manoel, maior comunidade da região, com 43 domicílios. Com base em entrevistas domiciliares conduzidas nos meses de setembro e novembro de 2015, os autores obtiveram dados sobre ataques de mamíferos carnívoros às criações domésticas e a seres humanos, além de informações sobre abates de mamíferos carnívoros silvestres pelos moradores locais e percepções e atitudes dos moradores em relação aos carnívoros. Do total de 39 domicílios amostrados, moradores de 23 domicílios afirmaram ter perdido animais domésticos devido a ataques de animais silvestres. Os animais mais predados foram galinhas (n= 18 domicílios) e cães domésticos (n = 10 domicílios). Em relação à ações de retaliação, moradores de 13 domicílios admitiram já ter abatido onças. Apesar do número relativamente alto de domicílios afetados pelos animais silvestres, os resultados obtidos nas entrevistas não indicaram possuírem os moradores percepções negativas em relação à presença de onças na região. O estudo explicita a importância do monitoramento do impacto de espécies silvestres sobre populações humanas locais como forma de detectar possíveis conflitos entre populações humanas e animais silvestres, buscando com isso minimizar potenciais impactos desses conflitos nas populações humanas e na fauna local.

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Dieta da onça-pintada (*Panthera onca*) através da análise de fezes na Estação Ecológica Maracá-Jipioca, Amazônia Oriental, Amapá, Brasil

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Onças-pintadas são predadores que ocupam os níveis mais altos de cadeias alimentares e são responsáveis por regular os demais níveis tróficos e a correlação de abundância das espécies em sua área de ocorrência. Listada nacionalmente como uma espécie ameaçada de extinção, a fragmentação dos habitats e o consequente isolamento de suas populações são as maiores ameaças para a espécie, assim como as atividades agropecuárias, que é a principal causa da redução de 50% de sua distribuição original, sendo atualmente a Amazônia o maior refúgio para a onça-pintada ao longo de toda a sua distribuição geográfica. Nesse contexto o presente trabalho tem como objetivo analisar

a dieta da onça-pintada, *Panthera onca*, através da análise de fezes na Estação Ecológica Maracá-Jipioca (EEMJ), a única Reserva de Proteção Integral do estado do Amapá totalmente inserida em ambiente costeiro. A EEMJ é constituída por 2 ilhas costeiras: Ilha Maracá (que se subdivide em ilha de Maracá Norte e Maracá do Sul, divididas pelo igarapé do inferno) e pela ilha de Jipioca. Para análise das fezes, o material fecal encontrado foi pesado com auxílio de balança do tipo pesola e coletado em sacos plásticos para conservação e análise. A análise das fezes foi realizada no Laboratório de Zoologia da Universidade Federal do Amapá através de técnicas de lavagem do material com água e sabão. A identificação dos tipos de presas foi feita através de itens encontrados no material coletado e a comparação do material através da utilização das Coleções de vertebrados do Laboratório de Zoologia da Universidade Federal do Amapá e do Instituto de Estudos e Pesquisas do Amapá. Nas amostras de fezes foram identificados os seguintes itens alimentares: dentes (0,23%), cartilagem (0,34%), pele (4,25%), escamas de peixes e répteis (19,98%), espinhas (5,40%), crustáceos (0,57%), unhas (1,15%), pelos (7,35%), conteúdo vegetal (8,61%), penas (10,45%), ossos e vértebras (40,64%), e material não identificado (1,03%), totalizando 1.555 itens alimentares. Os peixes foram os itens mais predados (46,2%), seguido por répteis (24,8%), mamíferos (14,8%) e aves (14,1%). Embora estudos sobre os hábitos alimentares sejam abordados frequentemente com a onça-pintada, os mesmos ainda são insuficientes para caracterizar aspectos ecológicos em ambientes onde a espécie ocorre, destacando que, além de abordar informações sobre a biologia da espécie em uma área de grandes interações entre predadores e presas, o estudo ajuda a compreender como a espécie interage em ambientes tão limitados. Neste contexto, os resultados da pesquisa irão gerar informações fundamentais para traduzir rapidamente o grau de prioridade local, regional e global conferido a Estação Ecológica Maracá-Jipioca em ações locais e representativas de proteção e manejo da Unidade de Conservação e para a conservação e preservação da onça-pintada, *Panthera onca*.

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Diferenciais de riqueza e composição de répteis e anfíbios entre as diferentes fitofisionomias da Floresta Nacional de Ritápolis e entorno e efeitos da fragmentação sobre estas taxocenoses

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O presente estudo objetivou identificar os diferenciais de riqueza e composição da herpetofauna entre as fitofisionomias de áreas mais abertas, como o Campo Cerrado (CC) e o Campo Sujo (CS) com as áreas mais florestadas, como a Matas de Galeria (MG) e a Floresta Estacional Semidecidual (FES) presentes na Floresta Nacional de Ritápolis (FLONA Ritápolis) e na sua Zona de Amortecimento (ZA) Para o alcance destes objetivos, entre outubro de 2015 a junho de 2016, foram registrados encontros ocasionais de espécimes e também instaladas estações de Armadilhas de Funil e de Queda por interceptação com cerca direcionadora em um fragmento de aproximadamente 30 hectares de CC entremeado com CS, na ZA da Unidade de Conservação (UC). Os resultados propiciaram o registro de 220 espécimes da herpetofauna no fragmento amostrado, com uma riqueza de 33 espécies (15 de anfíbios, 12 de serpentes e seis de lagartos) que correspondeu a pouco mais da metade da já registrada anteriormente pelas mesmas metodologias nas áreas de FES e MG no interior da UC, cuja riqueza foi de 60 espécies. Os resultados demonstraram diferenças de composição das taxocenoses entre as fitofisionomias e indicaram que a antropização do fragmento estudado e seu isolamento geográfico em relação

às áreas mais florestadas da UC, devido às barreiras geográficas ao fluxo gênico das populações (principalmente pastagens), geram impactos negativos na riqueza das espécies. Os principais indícios que corroboram esta hipótese são: 1) A alta abundância na amostra obtida no fragmento de Crotalus durissus, que é associada a áreas abertas e antropizadas; 2) a ausência no fragmento de *Enyalius bilineatus*, que foi a espécie mais abundante de lagarto nas áreas florestadas da UC e 3) O registro de ratazanas (*Rattus norvegicus*), espécie exótica que só ocorre em áreas de maior antropização e que não teve nenhum exemplar registrado nas áreas florestadas. Além disso, como já era esperado, no fragmento foram registradas espécies mais típicas de cerrado e áreas abertas, que ainda não tinham sido capturadas nas áreas florestadas, como *Ameiva ameiva* e *Leptodactylus labirintycus.* Estes resultados sugerem que, apesar de sua reduzida área, a FLONA Ritápolis tem uma significativa importância na conservação das espécies mais típicas de áreas florestadas, que na região são raras, pequenas e fragmentadas. Os resultados sugerem ainda que esta extensa fragmentação das áreas de mata nativa nessa região de ecótono entre Cerrado e Mata Atlântica, constitui uma potencial ameaça à conservação de algumas espécies e consequentemente da biodiversidade da herpetofauna. Como possíveis estratégias de manejo para minimizar estas ameaças devem ser incentivadas: a proteção das áreas de preservação permanente que funcionam como corredores ecológicos e promovem o fluxo gênico entre as populações, a formação de mosaicos com outras UCs da região e uma revisão do Plano de Manejo que inclua um estudo de possibilidades de ampliação da FLONA Ritápolis, contemplando a incorporação das áreas contíguas de mata nativa já adjacentes aos seus limites e áreas com potencial de recuperação que poderiam restabelecer o fluxo gênico entre as populações e contemplar a proteção e conservação de mais fitofisionomias e espécies.

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Dinâmica reprodutiva de *Salminus brasiliensis* (Cuvier, 1816) na área de abrangência da Estação Ecológica de Taiamã e do rio Sepotuba, município de Cáceres/MT

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O Pantanal, com 140.000Km^2, está localizado no centro-oeste do Brasil. É caracterizado pela alteração sazonal dos níveis dos rios, sendo este o principal fator que garante a rica diversidade e a sua admirável abundância. *Salminus brasiliensis,* o dourado, é uma espécie reofílica e ictiófaga, que chama atenção tanto pelo valor econômico como em habilidades para a pesca esportiva. Portanto, o objetivo deste trabalho foi descrever a dinâmica reprodutiva de *S. brasiliensis* na área da Estação Ecológica de Taiamã,no seu entorno (área de campo) e no rio Sepotuba, ambos localizados no bioma Pantanal e na bacia do Alto Paraguai. As coletas na Estação foram realizadas entre agosto de 2015 e junho de 2016 (n=38), conforme autorização SISBio nº 51968-1. A captura se deu através de varas com carretilha e isca artificial, e em seguida foram refrigerados em caixa de isopor com gelo para conservação e posterior evisceração. As amostras provenientes do rio Sepotuba (n=74), coletadas entre 2004 e 2011, foram disponibilizadas pelo Laboratório de Ictiologia do Pantanal Norte da Universidade do Estado de Mato Grosso.Em laboratório foram anotadas as medidas biométricas (peso, sexo e o estádio de maturação gonadal). Aplicou-se a metodologia de Vazzoler (1996) para determinar a proporção sexual e o período reprodutivo, observando avariação temporal da frequência de estágios de maturidade e a variação temporal da relação gonadossomática. Foram analisados 122 indivíduos, sendo 69 fêmeas (61,61%) e 43 machos (38,39%). O intervalo de classe por

tamanho predominante foi de 59,54 a 64,63 cm, para machos e fêmeas respectivamente. Para determinar o período reprodutivo foi analisada a frequência mensal para cada estágio reprodutivo classificado macroscopicamente. Dados gonadais para estágio reprodutivo em 'repouso' foi predominante no mês de agosto (17,07% do total de amostras); gônadas 'em maturação' nos meses de outubro e novembro, com 31,25% ambos. Para estágio reprodutivo 'maturo' a maior frequência foi no mês de agosto (40%) e com gônadas 'esvaziadas' nos meses de janeiro e fevereiro com 11,11% e 88,89% respectivamente. Com base no segundo método (considerado mais confiável por avaliar a relação entre o peso da gônada pelo peso total), a média da variação gonadossomática obteve o maior índice da RGS corresponde ao mês de dezembro (ΔRGS: 0,14), indicando ser o mês do pico da atividade reprodutiva (desova).O ápice do período de reprodução para essa espécie ocorre dentro do defesovigente no rio Paraguai.A proporção sexual entre machos e fêmeas também está de acordo com a literatura. Há concordância também que fêmeas são maiores que os machos, dispondo de maior capacidade para desenvolvimento dos ovários. Os resultados apontam para a importância de pesquisas nessa área, que nos remete a implementação de políticas públicas e ao uso sustentável dos recursos naturais, que neste caso é uma espécie de alto valor comercial e cultural.

Agradecimentos ao Instituto Chico Mendes de Conservação da Biodiversidade, por proporcionar a estrutura necessária para a coleta de dados, a Universidade do Estado de Mato Grosso e o Laboratório de Ictiologia do Pantanal Norte pelo aporte necessário para a realização desse trabalho.

Domesticação do Peixe-sapo (*Pseudopimelodus mangurus*) uma espécie ameaçada de extinção

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A domesticação de espécies de peixe ameaçadas de extinção é a primeira etapa para delinear estratégias de conservação como a reprodução e a consolidação de bancos genéticos. A proposta deste trabalho foi estabelecer um pacote de manejo reprodutivo e alimentar para manter peixes coletados em ambiente natural com subsequente domesticação em ambiente de cultivo (tanques) para consolidar um banco genético. Exemplares adultos de bagre-sapo *Pseudopimelodus mangurus* (n = 64, sendo 28 fêmeas e 36 machos) foram coletados nos meses de outubro de 2014 a fevereiro de 2015 no rio Mogi-Guaçu, Pirassununga, Estado de São Paulo, empregando-se vara e linha de mão com anzóis 5/0 e 6/0 e em alguns casos redes de emalhar com abertura de 40 mm. Ao serem capturados, os exemplares foram induzidos à reprodução com Ovopel (6,0 mg.kg-1- Fêmeas e 0,6 mg.kg-1 para machos) e após 160 horas/grau os gametas foram estrusados e a fertilização foi dada pelo método seco. Posteriormente os animais foram separados em tanques de alvenaria onde receberam anti-helmíntico (Cloridrato de Levamisol – 0,1 ml.kg-1) e polivitamínico (Potenay® – 0,2 ml.kg-1) intramuscular. Foi realizada a alimentação forçada semanalmente, utilizando-se ração em pó umedecida com antibiótico (Enrofloxacina – 1 mL kg-1). Quanto às informações etológicas, pode se afirmar que são gregários preferencialmente noturnos e ictiófagos de investida. No tocante aos hábitos reprodutivos, são dioicos com dimorfismo sexual aparente (papila e morfologia externa – abaulamento nas fêmeas), ovíparas que tendem a desova total. Observando as características do local de coleta, são animais que ocupam nichos específicos, próximos a ambientes lóticos ou em locais profundos, tendo nas pedras uma característica comum. O protocolo de indução hormonal apresentou alta taxa

de fertilização (acima de 95%). O tratamento profilático pós-desova foi eficiente, já que a alimentação forçada manteve os animais em melhores condições para serem transferidos para tanques escavados. Considerando os hábitos alimentares, o fornecimento de peixes de comportamento lênticos (ciclídeos) otimizou o consumo e subsequente sobrevivência dos animais.

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Ecologia alimentar e nutricional de *Sapajus flavius* como critério de escolha de áreas para reintrodução da espécie: contribuição da Estação Experimental de Camaratuba, Paraíba

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O Plano de Ação Nacional para a Conservação dos Primatas do Nordeste (PAN PriNE) contempla cinco espécies ameaçadas, dentre as quais Sapajus flavius (macaco-prego-galego), que está Em Perigo de extinção. O presente trabalho faz parte de um estudo amplo em ecologia alimentar e nutricional desta espécie frugívora-insetívora, visando escolher áreas receptoras e aumentar as chances de sucesso de estratégias de reintrodução e realocação de indivíduos, atendendo uma das demandas do PAN PriNE. Teve por objetivo analisar o padrão de oferta alimentar de frutos e artrópodes em área de Floresta Atlântica na Paraíba com presença de *S. flavius*, onde foi realizada a caracterização do estágio sucessional da mata e demarcados 28 pontos amostrais. Nestes foram coletados dados fitossociológicos e instaladas armadilhas para artrópodes. Mensalmente, entre fevereiro de 2015 e julho de 2016, foram registrados dados fenológicos e massa de artrópodes, além de itens da dieta do único grupo de *S. flavius* presente na área, por observações ad libitum. Para as análises fenológicas foram aplicados o Percentual de Intensidade de Fournier e o Índice de Atividade. A área foi considerada floresta secundária, com 15% em estágio médio e 85% em estágio inicial de regeneração. Foram monitoradas 190 árvores, apresentando DAP de 16,96 ± 11,44cm e altura de 12,12 ± 6,89m, pertencentes a 29 táxons, destacando-se *Tapirira guianensis* (18,95%), *Eschweilera ovata* (14,74%), *Schefflera morototoni* (8,95%) e *Bowdichia virgilioides* (5,26%). Treze destes táxons (44,8%) já foram relatados como parte da dieta do macaco-prego-galego, inclusive estes de maior representatividade. As fenofases queda foliar e brotamento estiveram presentes ao longo de todo o período do estudo, com maior intensidade, respectivamente, entre dezembro de 2015 e janeiro de 2016, e entre agosto e setembro de 2015. Floração foi observada a partir de julho de 2015, com maior intensidade em novembro, enquanto frutificação entre março de 2015 e janeiro de 2016, ressurgindo entre maio e julho de 2016, com maior intensidade entre novembro de 2015 e janeiro de 2016. Foram identificadas 13 ordens de artrópodes, quatro já registradas na dieta deste primata (Isoptera, Hymenoptera, Coleoptera, Orthoptera), com maiores capturas em fevereiro, março e setembro de 2015. O grupo foi observado em oito ocasiões, com registros de consumo de embiriba (*E. ovata*) e cana-de-açúcar (*Saccharam sp.*), além de ter sido observado um novo individuo infante nesta população. Os resultados fitossociológicos refletem o estágio de sucessão da área, com razoável diversidade de espécies vegetais em relação àquelas utilizadas por *S. flavius* e alta representatividade de algumas delas. Também foi possível observar que durante o período de estudo sempre houve disponibilidade dos principais recursos da dieta do macaco-prego-galego: frutos e artrópodes. A disponibilidade de recursos na área aparenta subsidiar a manutenção do grupo neste fragmento. Porém, o tamanho do grupo permanece estável há alguns anos e a área é pequena e isolada, o que certamente inviabiliza a reintrodução de novos indivíduos.

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Ela é grande o suficiente? Importância da ampliação da Estação Ecológica Taiamã e efetivação de corredores de dispersão para a manutenção de uma população mínima viável de onças pintadas (*Panthera onca*)

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As Unidades de Proteção Integral são importantes instrumentos de preservação da biodiversidade. Debates acadêmicos não são conclusivos quanto a estrutura e dinâmica das unidades no que diz respeito ao tamanho ou a rede de unidades que seriam necessárias para preservar amostras significativas da diversidade biológica. Enquanto alguns sugerem que maiores unidades são melhores, outros sugerem que redes interconectadas podem resultar em proteção mais efetiva. No entanto, há falta de informação quanto a dinâmica das populações da fauna residentes nessas áreas. Nesse estudo, avaliamos a estrutura e dinâmica de uma população de onças pintadas residentes e não residentes na área da Estação Ecológica Taiamã-MT e seu entorno imediato. Nove animais foram equipados com colares de telemetria GPS-Satélite no período de 09/2013 a 10/2015. Para animais que atenderam o critério de residência (n=7) foram estimadas as áreas de vida utilizando-se o estimador de kernel auto-correlacionado (função akde pacote ctmm em ambiente R). Para animais não residentes (n=2) foram geradas a área de distribuição de utilização (função occurrence pacote ctmm em ambiente R). As áreas estimadas foram convertidas em shapefile e unificadas para estimativa de área total (pacote rgeos em ambiente R). Finalmente, foi realizada a estimativa de área total protegida em função da área total requerida pelos animais monitorados. As áreas de vida estimadas para onças pintadas variaram de 34.8 a 174.3 km2. Os indivíduos não residentes moveram-se em direção Sul seguindo pelas matas ripárias do rio Paraguai. A área total requerida pelas onças pintadas monitoradas é 3.97 maior que o tamanho da unidade de proteção. Considerando 50 indivíduos como população mínima viável para a espécie, como sugerido pela literatura, a unidade deveria ser até 20 vezes maior. A inviabilidade de efetivar áreas com essa dimensão na região sugere a necessidade de atuar em duas frentes: 1) ampliar a unidade para aumentar a proteção de áreas relevantes para a espécie, haja vista que o tamanho atual não garante a preservação de áreas mesmo para os animais monitorados nesse estudo; 2) efetivar a criação de corredores que possam garantir a dispersão de indivíduos para as outras unidades de proteção ao Sul, o Parque Nacional do Pantanal Mato-grossense, o Parque Estadual Encontro das Águas e o Parque Estadual do Guira.

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Emergência potencial de árvores, arbustos e gramíneas nativas do Cerrado: subsídios para a restauração ecológica

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A restauração ecológica busca a recuperação de áreas degradadas ou seu retorno a uma condição ecológica mais próxima da original. O conhecimento das comunidades nativas da área em questão, bem como da autoecologia das espécies que a compõem, são fundamentais para a definição

de metodologias de restauração que abarquem resultados concretos e eficientes. Nesse contexto, faz-se necessário a compreensão da emergência potencial das sementes das espécies utilizadas na restauração. O objetivo desta pesquisa foi determinar o potencial de emergência de espécies nativas utilizadas nas atividades de restauração realizadas no Parque Nacional da Chapada dos Veadeiros (PNCV), GO, em 2015. Foram testadas ao todo 32 espécies, das quais 5 são gramíneas, 6 são arbustos e 21 espécies são árvores. Após a colheita das amostras, realizada no PNCV e entorno, as sementes foram contadas e separadas em lotes divididos em sementes viáveis e inviáveis, por classificação visual. Após a seleção, as sementes foram encaminhadas para a casa da vegetação (coberta com telhas plásticas transparentes) do laboratório de Termobiologia da UnB para realizar teste de emergência potencial. A semeadura foi feita em bandejas plásticas com substrato de subsolo. Foram semeadas 100 sementes para as árvores e arbustos e 4000 sementes para as gramíneas (excepcionalmente *Aristida flaccida* foi testada apenas com 947 sementes). O procedimento de contagem das plântulas emergidas foi realizado semanalmente. O teste de emergência foi realizado entre os meses de fevereiro e junho de 2016. Os resultados indicam espécies com alta taxa de emergência, primordialmente árvores (*Vatairea macrocarpa* 98% de emergência, *Astronium fraxinifolium* 88%), mas também arbustos (*Anacardium humile* 96%); espécies com emergência intermediária, árvores (p. ex. *Hymenaea stignocarpa* 59%, *Myracrodruon urundeuva* 53%, *Magonia pubescens* 53%), arbustos (*Mimosa clausenii* 40%) e gramíneas (*Aristida gibbosa* 33%, *Andropogon fastigiatus* 27% e *Aristida flaccida* 23%); e espécies com emergência muito baixa: árvores (p. ex. *Eremanthus glomerulatus* 7%, *Machaerium opacum* 5%, *Buchenavia tomentosa* 5%), arbustos (*Solanum lycocarpum* 11%, *Eremanthus uniflorus* 3%) e gramíneas (Loudetiopsis chrysothrix 7% e Schyzachirium sanguineum 1%). As espécies de arbusto *Vernonanthura phosphorica*, *Achyrocline satureoides* e *Lepidaploa aurea* não apresentaram emergência durante o experimento, porém em outro estudo semelhante foi encontrada emergência para estas espécies, 10%, 4% e 10% respectivamente (Pellizzaro 2016), indicando possível inviabilidade das sementes aqui testadas. A identificação de espécies com maior taxa de germinação é importante para promover uma rápida cobertura do solo na restauração. Além disso, sabendo-se o potencial de emergência das espécies pode-se calcular a quantidade de sementes necessária para recobrir uma dada área com plantas estabelecidas. Assim, mesmo as espécies com baixa taxa de germinação, ou até dormência, podem ser incluídas nos projetos de restauração para aumentar a diversidade de espécies, desde que se conheça a taxa de emergência e seja possível coletar a quantidade de sementes necessária para a semeadura.

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Estratégias de preservação *ex-situ* de peixes ameaçadas de extinção empregando biotecnologias avançadas

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A introdução de espécies exóticas, a captura e a destruição de habitats estão entre as principais causas de extinção de espécies de peixes. De modo a atenuar esses problemas e garantir

a perpetuação de espécies de peixes, devem ser desenvolvidas estratégias de conservação como a implantação de bancos genéticos ex-situ. Nessa forma de banco genético in vivo, animais selvagens são capturados e transferidos para tanques artificiais(,) e, a partir desses peixes são desenvolvidos protocolos de reprodução para a propagação artificial e possível repovoamento. Contudo, essa forma de banco genético in vivo pode ser perdida por mortalidade (doenças, idade, etc.) ou por simples falta de rastreabilidade (controle dos estoques, cruzamentos sem controle adequado). Portanto, para garantir a manutenção dessas espécies também estão sendo adotados bancos genéticos in vitro, na forma de tecidos, gametas e embriões de peixes congelados em nitrogênio líquido (-196°C) para futura reconstituição. Para essa reconstituição, estão sendo empregadas tecnologias avançadas como a clonagem, quimerismo (barriga de aluguel), androgênese, ginogênese e técnicas moleculares que possam atuar na consolidação de protocolos de preservação para espécies de peixe nativas. Para tanto, foi estruturado o moderno Laboratório de Biotecnologia de Peixes, no Centro Nacional de Pesquisa e Conservação da Biodiversidade Aquática Continental (CEPTA-ICMBio) de Pirassununga - SP, envolvendo alunos de mestrado, doutorado e pós-doutores vinculados a universidades nacionais e internacionais. O referido laboratório possui equipamentos de ponta para gerar pacotes tecnológicos sólidos e capazes não apenas de preservar espécies em extinção, mas também de reconstituir espécies até mesmo em caso de extinção completa.

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Estrutura de população de *Lychnophora ericoides* Mart. (Asteraceae) no Distrito Federal

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Lychnophora ericoides Mart., conhecida popularmente como arnica, é um arbusto endêmico do Brasil e alvo de extrativismo devido ao uso medicinal de seus ramos por comunidades humanas situadas ao longo de sua área de distribuição. Embora suas populações sejam alvo de intenso extrativismo, sofrerem com a fragmentação de seus habitats e exigirem ambientes especializados, ainda são raros os estudos demográficos de suas populações. A estrutura de uma das populações remanescentes de *L. ericoides*, situada em área de campo sujo na Estação Ecológica do Jardim Botânico de Brasília-ESEC-JBB, foi avaliada no período de fevereiro a maio de 2016. Para todos os indivíduos foram tomadas as medidas dos parâmetros altura e diâmetro do caule no nível do solo (DAS), com auxílio de uma fita métrica e um paquímetro, respectivamente. Os resultados de estrutura mostram que a população é formada por 726 indivíduos, os quais foram estruturados em 4 estágios de vida: plântulas, jovens, sub-adultos e adultos, onde 8 eram plântulas, 53 jovens, 555 sub-adultos e 110 adultos. Para a definição dos estágios foram utilizados os seguintes critérios: plântula (até 6,5 mm de diâmetro), jovens (>6,5 até 8,2 mm de diâmetro), sub-adultos (8,3 mm até 20 mm de diâmetro) e adultos (> 20,1 mm de diâmetro, indivíduos reprodutivos). A população é caracterizada por baixa predominância de plântulas e jovens, não formando um modelo de distribuição em forma de J invertido, sendo um indicativo de que a população não está regenerando. Esses resultados corroboram com os de outros estudos desenvolvidos em outras áreas de Cerrado, os quais mostram que em geral a população de *L. ericoides* apresenta baixa taxa de recrutamento e uma tendência de extinção. Entretanto, uma avaliação da dinâmica da população em longo prazo será necessária para se identificar as possíveis mudanças ocorridas nos parâmetros demográficos e se fazer inferência sobre a sobrevivência e o crescimento da população. De qualquer forma as práticas extrativistas existentes no passado e distúrbios como fogo devem estar entre os fatores limitantes de seu recrutamento. As observações realizadas também mostram diferenças significativas na arquitetura aérea das plantas da ESEC-JBB com aquelas de outras áreas já estudadas no Distrito Federal. Os indivíduos de *L. ericoides* apresentaram uma média de 21,05 cm altura, bem inferior àquelas notificadas para outras áreas.

Assim, estudos futuros que avaliem a influência de diferentes habitats no potencial reprodutivo de *L. ericoides* serão muito relevantes para subsidiar as estratégias de manejo de suas populações. Os dados apresentados aqui também consistem em um esforço de monitoramento para a população da espécie, sendo uma base para a realização de futuras comparações relacionadas com o crescimento individual e demográfico da população frente aos diversos impactos as quais ela esteja sujeita. Considerando ainda esses resultados e a tendência de declínio de outras populações, recomenda-se o manejo da população de *L. ericoides* na ESEC-JBB no sentido de implantar um projeto de recuperação da população envolvendo a pesquisa, a adoção de técnicas apropriadas e o seu monitoramento. Por fim, recomenda-se ainda que sejam intensificadas as ações de fiscalização na área de modo a potencializar a proteção da única população remanescente de *L. ericoides* ainda existente nessa área protegida.

Agradecimentos ao ICMBio e ao CNPq pela bolsa PIBIC.

Estudo genético-temporal da espécie *Prochilodus lineatus* frente às ações antrópicas na região de Cachoeira de Emas, Pirassununga, São Paulo (rio Mogi-Guaçu)

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O Curimbatá (*Prochilodus lineatus* Valenciennes, 1836) é uma espécie de peixe migrador de elevado valor econômico e oferece grandes vantagens à piscicultura. Está amplamente distribuída na bacia do Rio Paraná, principalmente nos rios Grande, Pardo e Mogi-Guaçu, envolvendo grande área no Estado de São Paulo. Entretanto, o aumento das ações antrópicas sobre os ambientes ocupados por esta espécie pode levar a alterações do padrão genético de suas populações. Espécies migradoras sofrem com as modificações ambientais, identificadas principalmente por alterações nos regimes pluviais que podem interferir nas rotas migratórias das espécies e que, por sua vez, podem determinar alterações também nos níveis de variabilidade genética e reduzir sua capacidade de adaptação frente a mudanças evolutivas. Dessa forma, o principal objetivo deste estudo foi realizar uma análise genética temporal em populações de *P. lineatus* na região de Cachoeira de Emas (Rio Mogi Guaçu), amostradas durante sua temporada reprodutiva dos anos 2003, 2005, 2006 e 2015, utilizando o marcador nuclear e mitocondrial (Microssatélites e região controladora D-loop). Com base nos resultados parciais é possível constatar uma alta variabilidade genética em todos os grupos, sendo que a heterozigosidade observada (Ho) variou de 0,48 a 0,75 e a diversidade gênica de 0,9436 a 0,9810 para os marcadores Microssatélites e D-loop respectivamente. Este fato também é confirmado pelos valores do Índice de Fixação Intrapopulacional (FIS), uma estimativa da endogamia presente dentro dos grupos, que no geral mostram-se baixos; e nos altos valores de Número de Alelos (Na) que variou de 5,875 a 13,875. A Análise de Variância Molecular (AMOVA) revelou uma baixa estruturação genética populacional entre todos os grupos, sendo que os valores dos Índices de Fixação Interpopulacionais (FST) variaram de -0,0286 a 0,007 para os marcadores Microssatélites e D-loop respectivamente. Nas análises com ambos os marcadores foi constatada que a maior fonte de variabilidade genética está presente dentro de cada população (91,07 % para o marcador Microssatélite e 99,24% para D-loop). A manutenção de uma alta variabilidade genética pode estar relacionada a um grande tamanho efetivo populacional, uma vez que esta espécie é a mais pescada na região. Contudo, embora o grande tamanho populacional e a alta variabilidade genética, a presença de barreiras vicariantes como as barragens hidrelétrica, levam a fragmentação da população efetiva, aumento da endogamia e consequentemente ao aumento da homozigose. Apesar dos resultados iniciais serem favoráveis para as populações de *Prochilodus lineatus* em Cachoeira de Emas, somente com um estudo populacional em diferentes localidades do Ecossistema dos rios Mogi-

Guaçu, Pardo e Grande será possível determinar a real situação das populações desta espécie, assim como determinar um padrão na sua dinâmica migratória. Dessa forma, enfatiza-se a importância da continuidade deste projeto até o final de seus objetivos, com o intuito de gerar informações que irão contribuir na preservação dos estoques de peixes migradores neotropicais, principalmente os ameaçados de extinção.

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Estudos geoecológicos como subsídio ao planejamento e uso das trilhas na Floresta Nacional de Ritápolis – Minas Gerais

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Com a saturação do turismo convencional e o surgimento de novas modalidades de turismo, as áreas naturais protegidas vêm recebendo um fluxo crescente de visitantes para prática do turismo de natureza (atividade turística realizada em ambientes silvestres), tendo como consequência o aumento da pressão sobre os recursos naturais, ampliando a preocupação com os impactos negativos gerados por tal atividade. Para a prática dessa modalidade de turismo, as trilhas, em quase sua totalidade, são utilizadas como ligação e meio de contato entre o homem e a natureza. No entanto, esse contato pode provocar impactos negativos, e as trilhas podem se transformar em vetores de impactos ambientais nas áreas adjacentes ao seu percurso. Sendo assim, o objetivo deste trabalho foi caracterizar o uso das trilhas e avaliar suas condições, bem como propor alternativas de manejo que possam promover o uso sustentável de duas trilhas (Macaúbas e Ferrovia) localizadas na Floresta Nacional de Ritápolis, Minas Gerais. Para realização desse levantamento, as trilhas foram divididas em vários segmentos nos quais foram aplicadas três metodologias: cálculo da AST – Área Seccional Transversal; penetrometria; e tabela de indicadores de sustentabilidade. Os dados obtidos permitiram avaliar os impactos causados pelo uso das referidas trilhas, tais como: compactação do solo; perda/acúmulo de solo no leito das trilhas; danos na vegetação de borda; entre outros indicadores não menos importantes. Por fim, foram propostas algumas alternativas de manejo visando à atenuação e mitigação da degradação ambiental verificada.

Estudos populacionais do Dourado (*Salminus brasiliensis*) na bacia do rio Mogi-Guaçu, Alto Paraná

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O processo de migração em espécies animais vem despertando o interesse de diferentes pesquisadores ao longo de várias décadas. No entanto, várias características genéticas de diferentes espécies permanecem desconhecidas, principalmente quando se tratam de espécies Neotropicais. *Salminus brasiliensis* (Cuvier, 1816) é um excelente peixe migrador, exibindo um corpo grande e

uma ampla distribuição pelo território brasileiro, principalmente na bacia do Prata, constituída pelos rios Paraná, Paraguai e Uruguai. Esta espécie é comumente nomeada de "dourado" e representa um peixe de importância econômica e social para a população humana local, em atividades como a pesca artesanal e esportiva, além do grande interesse para a piscicultura. Devido à importância ecológica do dourado e a intensa interferência humana, como a construção de barragens e os contínuos lançamentos de efluentes industriais em seu habitat, esta espécie vem sofrendo continuamente durante os anos. Nesse sentido, estudos que visem a sua conservação são muito importantes, como aqueles que utilizam ferramentas genéticas para inferir a variabilidade da espécie. Desta forma, considerando as mudanças antropogênicas que afetam esta espécie e a falta de informações que permitam a elaboração de estratégias de manejo e conservação adequadas, o estudo visou à caracterização e um melhor entendimento da dinâmica populacional da espécie *S. brasiliensis* na bacia do rio Mogi-Guaçu utilizando sequências da região controle do DNA mitocondrial (D-loop). A amostragem foi realizada durante períodos de seca (Março a Setembro) e chuvosos (Outubro a Fevereiro) entre os anos de 2007 e 2008 na região de Cachoeira de Emas, Pirassununga – SP. Até o momento, 93 indivíduos foram analisados. Os resultados mostraram uma baixa diversidade haplotípica (0.4591) e a ocorrência de 14 haplótipos distribuídos entre todos os indivíduos. As diversidades genética (residentes: 2007 – 0.529; 2008 – 0.195; migradores: 2007 – 0.590; 2008 – 0.494) e nucleotídica (residentes: 2007 – 0.106; 2008 – 0.044; migradores: 2007 – 0.163; 2008 – 0.061) se mantiveram baixas em ambos os períodos. Através da análise de variância (AMOVA) foi possível identificar que a maior fonte de variação está presente entre indivíduos (100%), o valor do índice de fixação interpopulacional (Fst = -0.004) foi considerado baixo, indicando uma baixa estruturação genética entre os exemplares migradores e residentes desta espécie. Embora estes valores sejam baixos, possivelmente por consequência de seu sucesso reprodutivo, os baixos níveis de diversidade genética e nucleotídica evidenciam os efeitos das ações antrópicas sobre suas populações, o que poderia ocasionar a diminuição da capacidade de adaptação frente às mudanças ambientais. Diante disso, ainda se faz necessário aplicar ações de manejo que visem reduzir os impactos das ações antrópicas sobre seus estoques de peixes naturais, contribuindo assim para a sua conservação.

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Eventos climáticos extremos relacionados ao ENSO e o sucesso reprodutivo da tartaruga-da-amazônia (*Podocnemis expansa*) na Reserva Biológica do Rio Trombetas

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Durante a estação reprodutiva de *Podocnemis expansa* em 2015 foi registrado um dos El niños mais extremos da história, assim como uma alta mortalidade de ovos na Reserva Biológica do Rio Trombetas (REBIO Trombetas). O objetivo deste estudo foi esclarecer uma possível ligação entre anos de La niña ou El ninho (ENSO, Oscilação Sul-El Niño) extremos e o sucesso de eclosão de *Podocnemis expansa* nas praias protegidas da REBIO Trombetas. Utilizamos regressões simples para testar a relação histórica do sucesso de eclosão (número de filhotes vivos dividido pelo número de ovos totais em uma determinada estação reprodutiva) com o nível da água e a temperatura e umidade do ar, entre o período de desova e eclosão. Foram utilizados dados históricos de temperatura e umidade obtidos pela Mina de Saracá (Porto Trombetas), assim como o nível da água e sucesso de eclosão obtidos na REBIO Trombetas entre os anos de 2009 a 2015. Modelos polinomiais foram utilizados em casos nos quais o pressuposto de linearidade para regressões simples não foram atendidos. O sucesso de eclosão é menor em estações reprodutivas cujo nível do rio cai de forma mais pronunciada no

início da estação reprodutiva, pois o nível mínimo no mês de Outubro explica 90% da variação no sucesso de eclosão ($F = 35{,}18$; $R2 = 0{,}90$; $p < 0{,}01$). Períodos de El Niño extremos apresentaram as menores mínimas anuais de altura do rio, além do nível do rio tender a baixar mais precocemente. Este fenômeno possivelmente exacerbou ainda mais o estresse térmico e hídrico nos ninhos devido as alta temperatura e baixa humidade provocada pelo El Niño de 2015. Em períodos de La Niña, o rio tende a descer mais tardiamente, o que também pode afetar a escolha do local de desova pelas fêmeas e diminuir o período de disponibilidade das praias para a desova (período no qual as praias não se encontram submersas). Entretanto, é preciso destacar que os resultados encontrados neste estudo não podem ser generalizados para toda Bacia Amazônica.

Evolução do uso e ocupação do solo no Parque Nacional da Chapada Diamantina, com auxílio das ferramentas de geotecnologia-so

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Com a preocupação em manter o equilíbrio ecológico no meio ambiente, foram criadas áreas legalmente protegidas, regida por uma legislação ambiental com a finalidade de proteger elementos naturais, e assim garantir o que institui a Constituição Federal (CF) de 1988. As Unidades de Conservação (UC) foram criadas como intuito de preservar e proteger os ecossistemas, onde são divididas por grupos de proteção integral e proteção sustentável. Os Parques Nacionais são de uso integral, tendo como objetivo básico a preservação de ecossistemas naturais de grande relevância ecológica e beleza cênica que possam possibilitar realizações de pesquisas cientificas e o desenvolvimento de atividades de educação e interpretação ambiental, de recreação em contato com a natureza e de turismo ecológico. É de posse e domínio público, sendo que as áreas particulares incluídas em seus limites devem ser desapropriadas. Nesse sentido, é necessária a realização de estudos que possibilitem diagnosticar a qualidade da vegetação e o cumprimento efetivo do papel das UC e para facilitar as pesquisas nestas áreas estão sendo utilizadas e com êxito as geotecnologias. As geotecnologias trazem mecanismos fundamentais para o trabalho dos analistas da terra, com utilização dos Sistemas de Informações Geográficas (SIG) como a ferramenta computacional para o processamento e apresentação da informação espacial, permitindo realizar análises complexas, ao integrar dados de diversas fontes em um Banco de Dados Geográficos (BDG). Este estudo tem como área alvo o Parque Nacional da Chapada Diamantina, (PARNA da Chapada Diamantina) que se destaca pela importância em relação à conservação das espécies existentes da flora nativa e da diversidade faunística. Para a realização do presente trabalho foram utilizadas imagens de satélite do LANDSAT 5 e LANDSAT 8, disponibilizadas no site do Instituto Nacional de Pesquisas Espaciais (INPE), onde foram consideradas imagens antes e depois da criação do PARNA da Chapada Diamantina, proporcionando assim a análise em relação as possíveis alterações da vegetação do PARNA da Chapada Diamantina. Para realização de tal análise, foi utilizado o método do Índice de Vegetação por Diferença Normalizada (NDVI) no software Quantum Gis, objetivando quantificar os valores de cobertura vegetal na área do estudo e mostrando o diagnóstico da evolução da qualidade ambiental da vegetação do PARNA da Chapada Diamantina. Com este trabalho foi possível verificar alterações significativas das manchas de vegetação dentro dos limites do Parque após sua criação, dentre estas alterações pôde-se destacar alguns fatores que teve comprometimento com a área avaliada, tendo um vínculo direcionado nas atividades agropecuárias em larga escala, desmatamento por usos diversos e o uso do fogo na região, sendo que a análise aplicada por meio das Geotecnologias, proporcionou um instrumento de suporte a fiscalização e monitoramento em relação ao quantitativo de vegetação existente na área do estudo, principalmente pela dimensão da área estudada.

Exposição das Unidades de Conservação brasileiras às mudanças climáticas globais

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Áreas protegidas são consideradas a principal estratégia para a proteção da biodiversidade. Nos últimos 20 anos houve um aumento substancial de áreas protegidas no mundo e também no Brasil. No entanto, as mudanças climáticas podem alterar a distribuição geográfica das espécies, podendo tornar a rede de unidades de conservação brasileira obsoleta e ineficiente. Este trabalho tem como objetivo avaliar a vulnerabilidade das unidades de conservação do Brasil às mudanças climáticas, focando no componente de "exposição", ou seja, na magnitude e frequência destas mudanças, tendo potencial de fornecer informações que possam ser utilizadas nas Unidades de Conservação (UCs) do Sistema Nacional de Unidades de Conservação (SNUC) frente às mudanças do clima. Utilizamos a base cartográfica das UCs do SNUC, analisando preliminarmente apenas as UCs de Proteção Integral Federais. Para avaliar o clima foram utilizadas as 19 variáveis bioclimáticas disponibilizadas pelo WorldClim, referentes às condições do presente e do futuro (2050) em cenário de mudanças climáticas. O cenário de emissões de gases de efeito estufa utilizado foi o RCP (Representative Concentration Pathway) 8.5 e o GCM (Global Circulation Model) HadGEM2 – AO. Com o auxílio do software ArcGIS foram mapeadas as mudanças do clima no Brasil, através da subtração dos mapas de clima futuro e presente, onde as áreas com a maior diferença são aquelas onde há previsão de maior mudança e, portanto, maior exposição às mudanças climáticas. Foi feita uma média de cada variável para cada UC, e todos os mapas de diferença foram normalizados para valores entre 0 e 1, sendo posteriormente somados, gerando um mapa final com índice de exposição com valores entre 0 a 19. Por fim, foi feita uma classificação de todas as UCs em termos de sua exposição às mudanças climáticas em geral, às mudanças de variáveis de temperatura e às mudanças de variáveis de precipitação. Os resultados apontam uma maior vulnerabilidade na região amazônica, principalmente no estado do Pará. As cinco UCs que apresentaram os maiores índices de exposição (variando entre 10 e 7) foram: Reserva Biológica do Tapirapé (PA); Estação Ecológica da Terra do Meio (PA); Reserva Biológica do Rio Trombetas (PA); Parque Nacional Montanhas do Tumucumaque (PA) e Reserva Biológica do Gurupi (MA). Unidades de Conservação com grande exposição às mudanças climáticas podem não cumprir a função de conservação da biodiversidade no futuro e dependerão de estratégias de manejo voltadas para a redução de outros estressores ambientais para aumentar sua capacidade adaptativa frente às Mudanças Climáticas.

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Fauna associada ao consumo de frutos de *Euterpe edulis* (Martius), uma espécie chave para conservação de aves e mamíferos da Mata Atlântica, na Floresta Nacional de Ibirama/SC (FLONA Ibirama)

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O palmiteiro (*Euterpe edulis* Martius), em função da abundante frutificação, do longo período de oferta de frutos e do grande número de animais associados à frugivoria e dispersão de

sementes, é considerado uma espécie chave para a conservação da fauna na Mata Atlântica. Assim, este trabalho teve como objetivo identificar quais das 59 espécies de aves e 21 espécies de mamíferos associados ao consumo de frutos de *E. edulis*, ocorrem na FLONA de Ibirama, buscando indicativos para a conservação da população deste palmiteiro presente na Unidade. Para a identificação das espécies foram utilizadas as listas que constam no Plano de Manejo da Unidade e a instalação de até 18 armadilhas fotográficas/mês (modo filmagem), entre mar/13 e dez/14 e entre nov/15 e mai/16, monitorando tanto o consumo de frutos nas infrutescências maduras, como no solo. O total de dias monitorados atingiu 5.762 dias (conjunto das armadilhas) e foram realizados 8.616 registros (reg.) de fauna. Destes, 6.956 reg. referem-se ao monitoramento do consumo de frutos nas infrutescências (1.551 dias) e 275 reg. ao monitoramento do consumo de frutos ocorrido no solo (492 dias). Foram identificadas duas novas associações de espécies alimentando-se de frutos de *E. edulis*: *Pionopsitta pileata* e *Chamaeza campanisona*, que somadas às 59 já relatadas pela bibliografia, elevam para 61 o total de aves relacionadas aos de frutos de *E. edulis*. Deste total, 46 espécies apresentam área de ocorrência compatível com a FLONA Ibirama e 44 (96%) foram registradas no presente estudo, sendo quatro classificadas como quase ameaçadas (*Carpornis cucullata*, *Pteroglossus bailloni*, *Triclaria malachitacea, Tinamus solitarius*) e uma como vulnerável (Procnias nudicollis) pela IUCN. Do total de aves registradas, 57% das espécies utilizaram os frutos de *E. edulis* como alimento, sendo as mais frequentes: *Turdus flavipes, Pyrrhura frontalis, Turdus albicollis* e *Selenidera maculirostris* que juntas, somam 75% do total de registros ocorridos nas infrutescências. Das 21 espécies de mamíferos associadas ao consumo de frutos de *E. edulis*, 17 apresentam ocorrência possível na FLONA Ibirama e destas, 14 (82%) foram registradas neste estudo, sendo uma (*Mazama nana*) considerada vulnerável pela IUCN. Do total de mamíferos registrados, 43% das espécies utilizaram os frutos de *E. edulis* como alimento; os mais frequentes no solo foram pequenos roedores da família Cricetidae, seguidos por *Dasyprocta azarae* e *Didelphis aurita*. Entre os mamíferos, uma nova associação relacionada ao consumo de frutos por ratos arborícolas do gênero Phyllomys (19% dos registros nas infrutescências) foi encontrada. Considerando a área de ocorrência das espécies da fauna, a FLONA Ibirama apresenta-se como importante Unidade de Conservação, mantendo 96% das espécies de aves e 82% das espécies de mamíferos relacionados à frugivoria e dispersão de sementes do palmiteiro, inclusive com três associações ainda não descritas na literatura. Destacam-se as espécies de Cotingidae (2), Ramphastidae (3) e Cracidae (3), famílias que reúnem efetivos dispersores de sementes, fato que tem grande relevância para a conservação de *E. edulis*, pois a qualidade da frugivoria/dispersão de sementes exerce impacto direto sobre a continuidade dos processos demográficos e genéticos da espécie. O palmiteiro apresentou-se também como importante recurso para a fauna local, servindo de alimento para 31 espécies.

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Herpetofauna da Estação Ecológica Maracá-Jipioca, Amazônia Oriental, Amapá, Brasil: resultados preliminares

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O Estado do Amapá possui 62% do seu território constituído por áreas protegidas, dos quais 60% estão representados por unidades de proteção integral, apresentando uma biodiversidade muitas vezes pouco estudada ou carente de dados herpetofaunísticos. Objetivando preencher lacunas acerca da biodiversidade existente no estado do Amapá, está sendo realizado um inventário de anfíbios

e répteis na Estação Ecológica de Maracá Jipióca (EEMJ), localizada na costa do município de Amapá, norte do estado. A EEMJ é constituída por 2 ilhas costeiras: Ilha Maracá (que se subdivide em ilha de Maracá Norte e Maracá do Sul, divididas pelo igarapé do inferno) e pela ilha de Jipioca. A EEMJ é a única Reserva de Proteção Integral do estado totalmente inserida em ambiente costeiro, a qual apresenta três tipos de paisagens predominantes: mangue, tabocal e teso. O inventário foi iniciado no mês de dezembro de 2015 e será finalizado em novembro de 2016. Como metodologia nós utilizamos os métodos de busca ativa e auditiva durante o período diurno e noturno, com frequência bimestral de três dias de coleta. As buscas ativas são realizadas em um ponto localizado na ilha Maraca do Norte (boca do igarapé do inferno) e dois pontos na ilha Maraca do Sul (igarapé do Purgatório e Fazenda). No levantamento preliminar identificamos12 espécies de anuros distribuídas em 3 famílias: Bufonidae (*Rhinella major e R. marina*); Hylidae (*Dendropsophus cf. Nanus, Hypsiboas punctatus, H. raniceps, Scinax ruber, Scinax sp1. e Pseudis paradoxa*) e Leptodactylidae (Adenomeraandrea, *A. leptodactyloides*, *Leptodactylus fuscus* e L. *podicipinus*).Para os répteis foram registradas 10 espécies distribuídas em 7 famílias: Alligatoridae (Caimanlatirostris e Melanosuchusniger), Gekkonidae (*Hemidactylus mabouia*), Mabuyidae (*Copeoglossumnigro punctatum*), Dactyloidae (*Norops fuscoauratus*), Iguanidae (*Iguana iguana*),Teiidae (*Ameiva ameiva*, *Cnemidophorus lemniscatus, Kentropyx calcarata e Tupinambis teguixin*), Boidae (*Corallus hortulanus*), Dipsadidae (*Erythrolamprus sp1.e Helicops leopardinus*) e Viperidae (*Bothrops atrox*). Anuros da família Bufonidae apresentaram elevada abundância, registrados principalmente nas bordas do Igarapé do Purgatório. Em relação aos répteis, *Tupinambis teguixin* foi a espécie mais abundante, sendo registrado principalmente na ilha Maraca do Norte. Os resultados preliminares sugerem que a EEMJ apresenta uma baixa riqueza de anfíbios e répteis, com registro de espécies generalistas e que apresentam ampla distribuição geográfica. Em comparação com outras áreas na Amazônia brasileira que registraram uma riqueza de anfíbios e répteis superior a 34 espécies, a baixa riqueza registrada no presente estudo pode estar relacionada com a estrutura dos habitats presentes na EEMJ, o menor esforço amostral e a utilização de apenas um método de coleta para amostragem da herpetofauna. Desta forma, ressaltamos a importância da continuidade de inventários herpetofaunísticos na EEMJ, visto que a real riqueza local ainda está subestimada. O inventário subsidiará informações fundamentais para traduzir rapidamente o grau de prioridade local, regional e global conferido a Estação Ecológica Maracá-Jipioca em ações locais e representativas de proteção e manejo da Unidade de Conservação.

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Identificação botânica e caracterização ecológica e de uso local da flora das trilhas interpretativas do Parque Nacional Cavernas do Peruaçu

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O Parque Nacional Cavernas do Peruaçu está localizado no Norte de Minas Gerais abrangendo os municípios de Januária, Itacarambi e São João das Missões. O presente estudo teve como objetivo caracterizar a vegetação arbórea ao longo das trilhas interpretativas do Parque com a finalidade de fomentar a geração e disponibilização de informações sobre as espécies que ocorrem ao longo das mesmas. O estudo foi realizado nas trilhas de oito atrativos que estão abertos ao público para visitação no Parque, sendo eles: Lapa do Rezar, Janelão, Carlúcio, Cabocla, Índio, Boquete, Bonita e Desenhos. As amostragens foram feitas por transecto, em que a linha central foi o próprio traçado da trilha, e abordando uma faixa de 5 m de cada lado ao longo da trilha. Foi realizado o estudo de fenologia dos indivíduos arbóreos através do acompanhamento mensal das trilhas durante o período de setembro a outubro de 2015, havendo também a coleta de sementes, quando disponíveis, para a confecção de caixas de sementes para exposição aos visitantes e utilização em

atividades de educação ambiental. As espécies foram identificadas in loco através de observações de suas estruturas, inflorescências e frutos. O estudo da caracterização florística ocorreu no período de janeiro a março de 2016. Foram amostrados por meio de inventário florestal todos os indivíduos arbóreos, inclusive os indivíduos mortos que ainda se encontravam eretos, com Diâmetro à Altura do Peito maior ou igual a 10 cm. Com base nos dados obtidos, foram calculados os seguintes parâmetros fitossociológicos: Densidade Relativa (DR), Dominância Relativa (DoR), Frequência Relativa (FR), Índice de Valor de Cobertura (IVC), Índice de Valor de Importância (IVI), Índice de Diversidade de Margalef (IMarg) e Índice de Similaridade de Jaccard (IJ). Durante o estudo de fenologia foram amostrados 291 indivíduos, em setembro, e 211 indivíduos em outubro, ficando constatado que a maioria das espécies florescem e frutificam, assim como dispersam suas sementes, durante o segundo semestre do ano. A família predominante foi a Fabaceae, com 14 espécies amostradas. Com o levantamento florístico foram registrados 2.543 indivíduos arbóreos ao todo, representados por 29 famílias botânicas, 66 gêneros identificados, com 86 espécies identificadas e 43 entre mortas e não identificadas. Dentre as famílias encontradas no levantamento florístico, a Fabaceae também foi a família predominante com 19 gêneros e 23 espécies identificadas. Dentre as espécies amostradas, a espécie *Myracrodruon urundeuva Allemão* (Aroeira), apresentou maior densidade relativa com 20%, estando também entre as espécies com maiores frequências relativas, obtendo o valor de 2,01%. Foi também a espécie com o maior valor de índice de importância com 0,12% e o índice de valor de cobertura com 0,17%. Já a espécie que obteve maior dominância relativa foi a *Ficus adhatodifolia Schott* exSpreng (Gameleira) com 14,4%. A trilha do Carlúcio apresentou a maior diversidade (28,9), seguida por Rezar (27,1) e Desenhos (25,5). Segundo os coeficientes de similaridade obtidos, a maioria das trilhas estudadas foram consideradas floristicamente semelhantes, e as trilhas que obtiveram o maior coeficiente de similaridade foram Rezar e Desenhos, com o valor de 0,5. Durante o estudo foram encontradas duas espécies ameaçadas de extinção, sendo elas *Pilocarpus microphyllus* Stapf ex Wardleworth (Jaborandi) e *Cedrela Fissilis* Vell. (Cedro). Os resultados encontrados servirão de subsídios para a definição da alocação das placas dendrológicas ao longo das trilhas interpretativas.

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Impacto da proteção exercida pelo Parque Nacional da Chapada Diamantina/BA e efeito da sazonalidade sobre a microbiota e qualidade de água do rio Paraguaçú

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Com o intuito de promover a preservação de áreas nativas, o Parque Nacional da Chapada Diamantina (PNCD) possui 152.141 ha e apresenta a Caatinga como bioma oficial. Um dos principais rios do PNCD é o Paraguaçú, sendo que parte de seu curso está contido na Caatinga propiciando o desenvolvimento de atividades agropecuárias, além de participar do abastecimento de água para Salvador. Até o presente não existem estudos que avaliam o efeito de impactos antropogênicos e da sazonalidade no microbioma e da qualidade de água do rio Paraguaçú. O impacto no rio Paraguaçú foi avaliado fora (P1) e dentro(P2 e P3) do PNCD, verificando-se a possível eficácia da proteção exercida pelo PNCD sobre o rio Paraguaçú durante a estação de chuva (novembro/2012) e estação de seca (fevereiro/2013)através da determinação da concentração de parâmetros físico-químicos

relacionados com a qualidade da água (silicato, amônia, nitrito, nitrogênio total, ortofosfato, fósforo total, Carbono Orgânico Particulado (COP) e Carbono Orgânico Dissolvido (COD))e do illumina sequenciamento da microbiota (metagenômica). O ponto P1 apresentou maior concentração de silicato, amônia, nitrito e COP, enquanto que os pontos P2 e P3 apresentaram maior concentração de COD, nitrogênio total, ortofosfato e fósforo total. As amostras de P1 foram segregadas de P2 e P3 pela influência de alta concentração de COP, amônia, silicato e nitrito, sendo que COP e amônia agruparam as amostras da estação de chuva, enquanto silicato e nitrito da estação de seca. O período de chuva pode promover o carreamento de nutrientes de solos fertilizados para a água, o que poderia ser um dos fatores que explica o incremento na concentração de alguns nutrientes em P1 (ponto margeado por plantações). A metagenômica permitiu definir os perfis taxonômico e funcional associados com a saúde do rio Paraguaçu. A microbiota do rio Paraguaçúé composta em sua maioria por Betaproteobacteria (46%), Alfaproteobacteria (8%) e Actinobacteria (8%). O ponto P1 apresentou maior abundância de sequências do gênero Arthrobacter sp. ($p < 0,05$) do que os pontos protegidos pelo PNCD no período de seca. Bactérias pertencentes ao gênero Arthrobacter são capazes de degradar atrazina, pesticida bastante utilizado. A presença destas bactérias poderia, portanto, promover a biorremediação de áreas contaminadas. Em relação ao perfil funcional, a maioria das sequências anotadas (51%) pertencem as categorias i. metabolismo de proteínas, ii. carboidratos, e iii. aminoácido e derivados. Proteínas com função desconhecida totalizaram cerca de 15% das sequências anotadas, resultado que incentiva novas ações voltadas para prospecção biotecnológica, reforçando a importância da conservação dessas áreas com um grande potencial biotecnológico. O ponto P2 apresentou maior abundância de genes relacionados a homeostase de potássio e degradação de benzoato em ambas estações. O potássio é utilizado na agricultura devido a sua importância em processos fisiológicos em plantas. O benzoato está presente no benzoato de emamectina, inseticida utilizado no controle de *Helicoverpa armigera*, e pode persistir no ambiente aquático trazendo diversos impactos à flora e fauna. A metagenômica e a biogeoquímica podem ser uma das ferramentas importantes no monitoramento, manejo e gestão de áreas protegidas. Este trabalho demonstra que atividades antropogênicas no entorno do PNCD podem ser detectadas em sequências metagenômicas. Assim, sugere-se que biossensores ambientais sejam desenvolvidos com o objetivo de monitorarmos precocemente mudanças ambientais em áreas protegidas.

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Importância do mapeamento da cobertura e usos do solo nas Terras Indígenas atendidas pela Política Nacional de Gestão Territorial e Ambiental de Terras Indígenas (PNGATI), tendo as Terras Indígenas Xerente e Funil como áreas de estudo

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Diversos setores públicos responsáveis pelo controle do uso e monitoramento dos recursos naturais do país têm buscado o aperfeiçoamento de suas capacidades nas áreas de sensoriamento remoto e geoprocessamento para o desenvolvimento de ferramentas de planejamento e gestão mais efetivas. Ao mesmo tempo, setores da administração pública federal buscam consolidar entendimento sobre a importância das terras indígenas para a proteção da biodiversidade e seus

imprescindíveis benefícios, principalmente a respeito das mudanças climáticas. Assim, o presente trabalho pretendeu demonstrar a importância do mapeamento ambiental nas áreas atendidas pela Política Nacional de Gestão Territorial e Ambiental de Terras Indígenas (PNGATI), no âmbito do Projeto de Gestão Territorial e Ambiental de Terras Indígenas (Projeto GATI). As áreas de estudo foram as Terras Indígenas Xerente e Funil, ambas da etnia Xerente, que abrangem 183.245,9032 hectares e estão localizadas no município de Tocantínia, Estado do Tocantins, ambas inseridas no bioma Cerrado. Inicialmente, um breve histórico sobre a etnia Xerente, a área de estudo, a PNGATI e o Projeto GATI revelou que a escolha das Terras Xerente e Funil para compor o Projeto GATI concilia o esforço histórico para sobrevivência física e cultural da etnia com a contribuição de suas terras para a conservação do bioma Cerrado. Em seguida, fez-se o estudo de cobertura e usos do solo, com o auxílio de ferramentas de sensoriamento remoto e geoprocessamento. Por incursões a campo foi realizada coleta e descrição dos pontos de controle, que serviram de subsídio para definição de critérios de mapeamento e como realidade de campo para validação dos mapas gerados. O processamento dos dados utilizou o Sistema de Informação Geográfica Quantum GIS. Executou-se uma classificação supervisionada e outra não supervisionada da área de estudo a partir de uma imagem do satélite Landsat 8 de junho de 2015. A classificação supervisionada foi a que resultou no mapeamento com a maior força de concordância entre amostras de treinamento e amostras de validação, atingindo acurácia de 83,19% e índice kappa de 0,78. Com esse resultado foi possível apurar que 81,75% das terras Xerente encontram-se cobertas por vegetação nativa, enquanto 18,25% encontram-se antropizadas. Das áreas antropizadas, tem-se que 10,43% (19.127,24 ha) apresentam solos expostos, 6,77% (12.413,95 ha) estão severamente afetadas por incêndios florestais e 1,04% (1.912,72 ha) estariam ocupadas por pastagens artificiais. Apesar da predominância de áreas nativas, foi possível constatar pelas condições da vegetação que as mesmas têm enfrentado recorrente ação do fogo, que possivelmente é um dos principais fatores de degradação em larga escala. Foi possível concluir que os resultados de mapeamentos ambientais oferecem informações que podem contribuir diretamente para com os planos de gestão das terras indígenas, assim como podem ser utilizados para a avaliação da efetividade de implementação da PNGATI, visando o fortalecimento da conservação da biodiversidade no país e a manutenção sustentável das populações tradicionais em seus territórios. A continuidade do monitoramento é para aprofundar o conhecimento sobre a área e para que os resultados venham a subsidiar o planejamento de ações e projetos mais condizentes com as potencialidades e objetivos de uso e proteção das terras indígenas e em consonância com seus status de áreas protegidas.

Indução de lambari (*Astyanax altiparnae*) triploide: potenciais para conservação e produção

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Um dos grandes desafios da aquicultura é garantir uma atividade sustentável e que não cause impactos ao meio ambiente. A indução de peixes triploides estéreis, com conjuntos extra de cromossomos apresentam menor potencial impactante em caso de escapes. Adicionalmente, podem ser receptores de células germinativas e funcionar como "barriga de aluguel" de espécies ameaçadas de extinção. Deste modo, o objetivou-se com estudo avaliar a esterilidade de peixes triploides de *Astyanax altiparanae* através da análise histológica das gônadas. A triploidização foi induzida por choque de temperatura à 40°C durante 2 minutos, sendo realizada 2 minutos após a fertilização. O grupo controle diploide, vindo dos mesmos parentais, foi realizado separadamente e em condições semelhantes até 175 dias pós-eclosão. Nos resultados obtidos, foram observados que fêmeas triploides

apresentam gônadas imaturas (estéreis). Já os machos triploides exibiram gônadas semelhantes aos diploides. Portanto, fêmeas triploides são interessantes para produção, pois exibem gônadas em estágio imaturo, o que diminui consideravelmente as chances de impacto, no caso de escapes destes peixes ao ambiente. Além disso, podem servir como "barriga de aluguel" em futuros estudos de transplante de células germinativas. Deste modo, serão necessários futuros estudos voltados para a produção em massa de proles 100% fêmeas triploides.

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Influências de áreas antropizadas no movimento do lobo guará (*Chrysocyon brachyurus*)

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Mudanças na cobertura da paisagem são uma realidade em varias partes do mundo. Sendo assim, é fundamental compreender como a paisagem influencia o uso de habitat e recursos, taxas de sobrevivência, riqueza, movimentação e dispersão de espécies. A fragmentação de habitats atua na divisão e redução de áreas naturais, afetando fortemente os processos relacionados à vida selvagem. O lobo guará (*Chrysocyon brachyurus*) é uma espécie de grande interesse, uma vez que é um animal carnívoro que também se alimenta de frutos e que devido à drástica redução de habitat e fragmentação, é considerada uma espécie vulnerável ao risco de extinção. Uma expansão de avistamento de *C. brachyurus* tem sido documentada em áreas antropizadas, levando a conclusão que essa espécie é pouco influenciada pela alteração da paisagem. O objetivo desse estudo é analisar a influência de áreas antropizadas no movimento do lobo guará, verificando a preferência por áreas naturais e matrizes alteradas. Analisamos dados referentes à movimentação de 13 indivíduos de *C. brachyurus*, coletados previamente através de colares com sistema GPS no entorno do Parque Nacional Serra da Canastra (MG). A metodologia utilizada foi o mapeamento dos diferentes tipos de uso do solo e classificação dos mesmos como habitat preferencial e matriz de entorno; e posterior sobreposição dos pontos de movimentação coletados. A partir daí foram calculadas as distâncias euclidianas de todos os pontos registrados em áreas de matriz de entorno em relação às áreas naturais mais próximas. Nossos resultados indicaram que os indivíduos estudados estão sempre próximos à borda de áreas naturais, se afastando em uma média de apenas 50 metros de distância dessas regiões. Apenas dois indivíduos apresentaram registros frequentes a mais de 100 metros de distância das áreas naturais. Esses resultados indicam que C. brachyurus possui uma forte dependência de ambientes conservados. Portanto, a preservação das áreas de campos, cerrados e florestas é fundamental para a manutenção dos processos ecológicos relacionados ao lobo guará (como predação de roedores e dispersão de sementes), assim como a sua sobrevivência e permanência nessas áreas.

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Investigação quali-quantitativa nos trechos do Jardim Serrano e Quebra Frascos inseridos na zona de amortecimento do PARNASO, Teresópolis/RJ

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A expansão territorial desordenada das áreas urbanas e a insuficiência de saneamento básico são alguns dos fatores geradores de conflitos que emergem na zona de amortecimento do Parque Nacional da Serra dos Órgãos (PARNASO). A interação dos atores locais com o meio ambiente vem afetando a qualidade das águas superficiais e a integridade da biodiversidade local. Buscando um caminho frente a este cenário, a Associação dos Moradores e Amigos do Quebra-Frascos apresentou demandas ao Conselho Consultivo do PARNASO e ao Ministério Público Estadual. Para colaborar no entendimento das questões socioambientais e na mobilização dos residentes, surgiu o Projeto Pesquisa-Ação. Parceria entre o PARNASO e o Centro Universitário Serra dos Órgãos, o projeto trata questões socioambientais com os moradores locais, visando gerar conhecimento sobre os problemas e desenvolver ações educativas com vistas à mobilização social e à intervenção qualificada na gestão do território e na conservação da biodiversidade. O presente trabalho é fruto dessas demandas sociais, tendo como objetivo elaborar um pré-diagnóstico socioambiental participativo, com base na investigação quali-quantitativa nos trechos do Jardim Serrano e Quebra Frascos inseridos no entorno imediato do PARNASO, com intuito de compreender e caracterizar os problemas, conflitos e potencialidades ambientais locais que fundamentam a aprendizagem e a ação coletiva. Referenciado pela metodologia da Pesquisa-Ação, este trabalho busca organizar ações diante dos problemas socioambientais e das condições socioeconômicas evidenciadas pelos moradores do Jardim Serrano e Quebra Frascos. Com um conjunto de estratégias metodológicas que promovem o diálogo entre saberes técnicos e empíricos, construíram-se, de maneira participativa e cooperativa, meios para elucidar as ideias e necessidades da comunidade. Tais estratégias vêm tecendo, ainda, a confiança e o comprometimento dos sujeitos que integram a realidade a ser transformada. Na coleta de dados foram elaborados e aplicados questionários aos moradores locais e às instituições locais e supralocais que atuam na região. Os dados primários e secundários auxiliaram na identificação das vulnerabilidades e potencialidades, favorecendo o desenvolvimento do pré-diagnóstico. Os resultados obtidos foram compilados e analisados através de ferramentas estatísticas qualitativas e quantitativas, apresentados em mapas, planilhas, gráficos e nuvem de palavras para compor a base de dados do projeto. Os dados quantitativos foram necessários para elucidar informações estruturais e socioeconômicas, além de articular valores conjuntos aos aspectos qualitativos levantados pelos atores. Foram apontados diversos problemas socioambientais e socioeconômicos vinculados às deficiências de infraestrutura, saneamento básico e saúde pública. Por outro lado, foram também identificadas potencialidades vinculadas ao potencial hidrológico e à gestão comunitária do abastecimento de água. Em síntese, este pré-diagnóstico vem sendo discutido e avaliado pelos moradores durante as oficinas participativas, atuando como elemento-chave na formulação do diagnóstico participativo e do plano de ação comunitário. Tais resultados só foram alcançados devido à participação social ativa dos residentes e poderão alavancar um planejamento territorial sustentável e a implementação de políticas públicas voltadas às necessidades dos atores locais e à conservação do Parque Nacional e das áreas urbanas situadas em sua zona de amortecimento.
Palavras-chaves: Pesquisa-Ação; Quali-Quantitativa; Unidade de Conservação.

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(CNPq). Ao Parque Nacional da Serra dos Órgãos (PARNASO/ICMBio) pela oportunidade de proporcionar a atuação da participação da sociedade em pesquisas de Iniciação Científica, subsidiando o desenvolvimento de ações conjuntas que buscam a proteção e conservação do Meio Ambiente.

Levantamento da comunidade aquática exótica do Rio Sapucaí Mirim

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A introdução de novas espécies pelo homem, também denominada a introdução de espécies exóticas e alóctones, caracterizada pela contaminação biológica, é reconhecida globalmente como a segunda maior causa de perda de biodiversidade no planeta, portanto afeta diretamente a economia e saúde humana. (Conradin& Tortato, 2006). O presente trabalho de iniciação científica tem como objetivo o levantamento da ictiofauna introduzida no rio Sapucaí-Mirim-SP, situado no nordeste do Estado de São Paulo, a fim de propiciar elementos para o estabelecimento de estratégias de manejo para o controle dessas espécies que ameaçam os organismos aquáticos nativos do rio Sapucaí-Mirim-SP. Como metodologia da pesquisa, foi feito um levantamento através de dados secundários de trabalhos de pesquisas já realizados e também de coleta de dados que tiveram como local a bacia hidrográfica do referido rio. Foram levantadas neste breve trabalho as espécies exóticas, alóctones e híbridas da bacia do rio Sapucaí-Mirim, área de atuação do Plano de Ação Nacional Mogi/ Pardo/ Sapucaí-Mirim/Grande. Como resultado da coleta ficou constatado que as espécies coletadas são as descritas nos dados do levantamento secundário, confirmando, assim, a continuidade da constatação daqueles levantamentos. O estudo demonstrou que existem espécies alóctones e exóticas no curso natural do rio Sapucaí-Mirim, o que permite determinar a necessidade de algumas ações descritas no trabalho, quais sejam: a- Promover a Educação Ambiental em vários níveis e dirigida especialmente aos moradores e ribeirinhos das imediações do rio Sapucaí-Mirim; b- Promover a pesquisa sistemática taxonômica para a identificação das espécies atualmente existentes no curso do rio, principalmente para identificação das híbridas e daquelas de conhecimento popular; c- Reduzir as irregularidades nos lançamentos e contenções das pisciculturas de espécies não autóctones, com o cumprimento integral da legislação ambiental, nas imediações do curso natural e tributários do rio Sapucaí-Mirim. d- Estimular programas de valorização do habitat natural dos peixes nativos do rio Sapucaí-Mirim, para iniciativa de fiscalização pelos próprios moradores das imediações. Esse levantamento, associado com os demais já realizados, poderá propiciar o estabelecimento de estratégias de manejo para o controle dessas espécies que ameaçam os organismos aquáticos nativos do rio Sapucaí-Mirim-SP.

Agradeço a primeiramente a Deus, e aos coordenadores do Programa Institucional de Bolsas e Iniciação Científica-PIBIC pela oportunidade deste estudo e aprendizado, também minhas considerações pelos responsáveis do Centro Nacional de Pesquisa e Conservação de Peixes Continentais (CEPTA), pelo conhecimento propiciado pela pesquisa e oportunidade de participação, aos colegas que se esforçaram comigo, aos funcionários que sempre nos atenderam cordialmente, aos familiares que sempre nos incentivaram, e a todos que de qualquer forma se envolveram e compartilharam conhecimento para esse trabalho ser realizado.

Levantamento de macrofungos na região sudoeste da Reserva Biológica do Jaru, Rondônia

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A reserva biológica do Jaru por ser uma área de proteção integral, possui grande diversidade biológica, sendo de grande importância para a preservação das espécies, sobretudo da população de macrofungos. Na região amazônica, existe uma necessidade de estudos sobre a diversidade fúngica a fim de conhecer e preservar esses organismos. Diante disso, este estudo objetivou-se realizar um levantamento sistemático de macrofungos na região sudoeste da reserva biológica do Jaru, enfatizando a importância ecológica desses organismos. As coletas foram realizadas em parcelas previamente demarcadas ao longo de três trilhas na região sudoeste da reserva, durante o período de um ano. Os basidiomas encontrados foram coletados manualmente, acondicionados em sacos de papel e secados em estufa. Após secagem, os organismos foram analisados macro e microscopicamente e a identificação foi baseada em bibliografia especializada. Dados parciais demonstram uma grande diversidade fúngica na área da pesquisa, sendo registradas as famílias Auriculariaceae, Ganodermataceae, Polyporaceae, Meruliaceae, Hymenochaetaceae, Xylariaceae, Marasmiaceae, Meripilaceae, Phanerochaetaceae, Ophiocordycipitaceae e Geastraceae. Essas famílias constituem os primeiros registros para a Reserva Biológica do Jaru e novos registros para o estado de Rondônia.

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Manejo de *Alouatta belzebul* (Primates, Atelidae) na Mata Atlântica da Paraíba

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Primatas do gênero Alouatta são conhecidos por ambos os sexos dispersarem. Com a crescente urbanização e fragmentação de seus habitats, muitas vezes os animais ficam isolados por matrizes agrícolas, pastos e centros urbanos, sem acesso a outros fragmentos de floresta. O guariba-de-mãos-ruivas (*Alouatta belzebul*) é ameaçado de extinção (Vulnerável), e uma das cinco espécies de primatas contempladas pelo Plano de Ação Nacional para a Conservação dos Primatas do Nordeste (PAN PriNE). Possui distribuição disjunta, com populações na região amazônica e outras no Centro de Endemismo Pernambuco (CEP). As populações do CEP foram registradas em apenas 18 fragmentos, sendo 12 no estado da Paraíba. O presente trabalho objetivou analisar as ocorrências notificadas pelo CPB/ICMBio de indivíduos de *A. belzebul* dispersantes no estado da Paraíba no período de outubro de 2011 a julho de 2015. Foram registrados 17 espécimes (três sem procedência) de 11 localidades. As distâncias dos fragmentos mais próximos (com registros comprovados da

espécie) variaram de três a 23 km. Quinze indivíduos foram capturados inadvertidamente por populares ou tiveram de ser resgatados. Os animais foram encaminhados à Reserva Biológica Guaribas (n=5) ou ao CETAS/IBAMA (n=10). Treze foram manejados seguindo protocolo (chave decisória) desenvolvido no âmbito do PAN PriNE: oito machos e cinco fêmeas (quatro jovens ou sub-adultos). Os animais foram medidos e marcados (tatuagem e/ou chip de identificação) e avaliados clinicamente, sendo que alguns deles receberam rádio-colar para acompanhamento pós-soltura. Somente dois indivíduos apresentaram comportamento de domesticação, um deles com marcas de aprisionamento. Após procedimentos, os animais foram mantidos em cativeiro na Rebio Guaribas ou no CETAS, e soltos em áreas apropriadas, individualmente ou em grupos, dependendo de cada caso. A seleção do sítio de liberação levou em consideração: a disponibilidade de recursos alimentares, a continuidade do dossel, a presença de outros grupos e o contexto paisagístico, de acordo com as áreas importantes para a conservação estabelecidas pelo PAN PriNE. O trabalho traz importantes informações com relação à conectividade de paisagem envolvendo os fragmentos de Mata Atlântica do CEP, com a presença de *Sapajus flavius* e *Alouatta belzebul,* além de contribuir com o projeto de repovoamento da Rebio Guaribas pela espécie, que vem sendo coordenado pelo CPB desde 2001. Também reforça a necessidade de um trabalho de educação ambiental, considerando o manejo inadequado por parte da população.

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Mapas de Recorrência de Áreas Atingidas pelo Fogo (AAF) nas Unidades de Conservação Federais – 2010-2015

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Os incêndios florestais em Unidades de Conservação (UC´s) são causadores de grandes prejuízos à biodiversidade, ao ciclo hidrológico/carbono, além de perdas econômicas e demais custos e externalidades negativas (IBAMA, 2009). A recorrência desses incêndios, em uma mesma área, reflete desde condições de natureza física (climática, combustíveis, relevo) e/ou antrópica, passando pela eficiência da gestão nessas áreas protegidas. Segundo Silva (2014), poucos trabalhos tratam sobre a recorrência de incêndios, especialmente em UC´s. Com o objetivo de contribuir nos estudos da dinâmica dos incêndios, bem como as variáveis que influenciam a ocorrência e sua propagação, a Divisão de Monitoramento e Informação - DMIF/CGPRO elaborou o catálogo "Mapas de Recorrência de Áreas Atingidas pelo Fogo (AAF) nas Unidades de Conservação Federais - 2010-2015". Os objetivos específicos foram: 1 - Estimar a área atingida pelo fogo nas áreas protegidas durante o período de estudo; 2 - Identificar as áreas com maior recorrência; e, 3 - Analisar as áreas afetadas segundo fatores como período (severidade) e manejo (nível de gestão). Fundamentada nas pesquisas de Ferraz e Vettorazzi (1998), Miranda (1996), Nascimento (2008), Ribeiro et al. (2008) e outros, a DMIF mapeou as cicatrizes de queima usando imagens do sensor MODIS entre os anos de 2010 e 2015i. A partir dos dados produzidos, com o uso de recursos de geoprocessamento, foram geradas tabelas e mapas temáticos classificados de acordo com o regime de queima. O catálogo conta com 66 Unidades de Conservação Federais, totalizando 6.3 milhões de hectares mapeados. O ano de 2010 obteve o maior valor (valor de que? de hectares mapeados? de total de área queimada?) no período avaliado (1.6 milhão de hectares). Com relação à recorrência de queimadas nessas áreas, cita-se o exemplo do PARNA do Araguaia, onde 78% do território (375.840 ha) foi atingido por algum evento de queima, com 60% de reincidência para as áreas atingidas 3 ou 4 vezes (227.777 ha). Espera-se que o documento possa equipar os gestores das UC´s com informações necessárias (caberia um exemplo de como este estudo contribui com tais "informações necessárias" ao planejamento de ações de combate e de manejo? Fica a impressão de que estas informações ou o desdobramento desta

pesquisa para a gestão fosse óbvio (talvez até seja para o gestor habituado a fazer o manejo do fogo), mas creio que a aplicabilidade aqui sugerida não seja tão intuitiva assim. Considero que cabe uma maior explicitação das "informações necessárias" com as quais este estudo pode suprir os gestores de UCs. Afinal, como a análise de recorrências pode contribuir para a gestão?) para planejamento de ações de combate e controle de incêndios e subsidiar as ações de manejo integrado e adaptativo do fogo. i As "lacunas" de mapeamento são os anos em que a unidade de conservação não foi mapeada por inexistência de área atingida por incêndio naquele ano ou devido a ausência de recursos humanos para fazê-lo.

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Monitoramento de fauna silvestre atropelada no entorno da Estação Ecológica de Carijós

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A Estação Ecológica de Carijós (ESEC Carijós) é uma unidade de conservação (UC) federal localizada no estado de Santa Catarina, no município de Florianópolis, que abriga mais de quinhentas espécies de animais em seus ecossistemas protegidos. É formada por duas glebas, que se constituem em remanescentes dos manguezais do Saco Grande e de Ratones e ecossistemas associados, num total de 760 hectares, representando uma pequena parcela da área original ocupada por esses ecossistemas (apenas 37% no caso do manguezal do Ratones). Apesar disso, a ESEC Carijós abriga considerável biodiversidade, especialmente de fauna. A rica flora e a grande diversidade aquática alimentam animais de níveis tróficos superiores, e levantamento recente da avifauna (VIEIRA *et al*, 2014) revelou a presença de 227 espécies de aves. Quanto aos demais grupos de fauna, não existe levantamento específico, no entanto, sabe-se que a unidade abriga alguns predadores de topo de cadeia, como o jacaré-de-papo amarelo (*Caiman latirostris*), o graxaim (*Cerdocyon thous*), a lontra (*Lontra longicaudis*) e a águia-pescadora (*Pandion haeliaetus*). O presente trabalho tem como objetivo avaliar o impacto dos constantes atropelamentos sobre a biodiversidade faunística da ESEC Carijós. A partir dos resultados totais obtidos serão mapeados os pontos críticos de atropelamentos, com vistas à adoção de medidas mitigadoras adequadas, considerando, inclusive, a mitigação do risco de acidentes em função da presença de animais nas

rodovias. Em função das reduzidas dimensões da unidade e de sua localização em uma capital de Estado, os impactos advindos da urbanização em seu entorno podem representar um sério risco para a preservação da biota ali abrigada, razão pela qual devem ser monitorados e mitigados, na medida do possível. A gleba Ratones representa cerca de 90% da área total da unidade, e abriga ambientes mais conservados do que a gleba Saco Grande, sendo uma gleba importante para fins de monitoramento sistemático de atropelamentos de fauna silvestre, já que é margeada por três rodovias estaduais (SC-400, SC-401 e SC-402), que estabelecem a ligação entre o centro de Florianópolis e bairros do norte da ilha. Portanto, o risco de atropelamento por veículos automotores é constante e diário. Em novembro de 2014 foi iniciado um projeto de monitoramento de caráter sistemático que se estendeu até junho de 2015 e buscou coletar dados confiáveis acerca da mortalidade de fauna silvestre atropelada no entorno da Gleba Ratones da ESSE Carijós. A análise dos resultados mostrou a necessidade da continuidade do trabalho, foi reiniciado em julho de 2015 e finalizado em 30 de junho de 2016, totalizando 47 saídas de campo. Durante este segundo período de monitoramento foram registrados 55 animais atropelados, incluindo 40 mamíferos (72,72%), 10 aves (18,18%), 4 repteis (7,27%), 1 anfíbio (1,83%). Não foram registrados invertebrados. Dentre todas as espécies, a ocorrência mais frequente foi de *Didelphis aurita* (gambá-de-orelha-preta) com registro de 28 indivíduos.

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Monitoramento de quelônios na Reserva Extrativista do Baixo Juruá (2015): retrato e tendências de um ano de cheia histórica

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O Juruá é um rio de águas brancas, regionalmente conhecido por sua alta piscosidade e abundância de quelônios. A Reserva Extrativista (RESEX) do Baixo Juruá está situada a 63 quilômetros do encontro do Juruá com o Rio Solimões, no Estado do Amazonas. Três espécies da Família PODOCNEMIDIDAE ocorrem na RESEX e se reproduzem em praias arenosas fluviais, disponíveis durante o período de seca: o iaçá (*Podocnemis sextuberculata*), o tracajá (*Podocnemis unifilis*) e a tartaruga-da-amazônia (*Podocnemis expansa*). Desde tempos remotos, os índios da região amazônica dependiam dos quelônios e seus ovos para alimentação. No século XIX, os ovos destes animais foram maciçamente utilizados na alimentação e iluminação. Em 1999, a Polícia Militar de Juruá apreendeu uma balsa com 38.000 quelônios, configurando a maior apreensão de quelônios já feita no país até então. Atualmente, as espécies são muito utilizadas na alimentação regional, sendo capturadas para abastecer principalmente as cidades próximas e Manaus. Desde a época dos seringais, diferentes estratégias de conservação dos quelônios têm sido utilizadas na região. Algumas praias foram eleitas como "tabuleiros", sendo vigiadas e conservadas pelos moradores. Na RESEX e seu entorno imediato, quatro comunidades trabalham voluntariamente na vigilância e monitoramento de quatro praias, com apoio do ICMBio e do IBAMA: Botafogo, Antonina, Forte das Graças e Gaivotas. O tabuleiro mais antigo, de Botafogo, é conservado há 18 anos, e dezenas de milhares de filhotes de quelônios, provenientes do tabuleiro, já foram soltos nos lagos da RESEX. Durante a temporada reprodutiva dos quelônios na RESEX em 2015, realizou-se o monitoramento da desova nestas praias, entre os dias 03 de julho e 05 de outubro, com esforço total de 4.573 horas de trabalho e envolvimento direto de 53 moradores. Em cada período do dia (diurno/noturno), uma equipe de monitores capacitados percorreu a praia mais próxima de sua comunidade contabilizando o número de novos ninhos construídos, identificando as espécies a partir dos rastros deixados na areia, e registrando as informações em planilhas padronizadas. No total, foram registrados 560 ninhos de iaçá, 311 ninhos de tracajá e 15 ninhos de tartaruga. A comunidade Botafogo apresentou os maiores números de ninhos de iaçá (336) e tracajá (238), e a comunidade Forte das Graças o maior número de ninhos de tartaruga (8). Nas quatro comunidades, a espécie predominante foi o

iaçá. A produção de ovos e filhotes, estimada a partir do número médio de ovos de cada espécie e das taxas de eclosão, (medidos em estudos anteriores) foi: 9178 ovos e 6496 filhotes de tracajá; 6064 ovos e 5360 filhotes de iaçá; e 2026 ovos e 1823 filhotes de tartaruga. Estimou-se a produção anual da RESEX (2015) em 13.679 filhotes de quelônios, dos quais 47,5% tracajás, 39,2% iaçás e 13,3% tartarugas. A reprodução de iaçás e tracajás teve início em julho e estendeu-se até setembro, com maiores abundâncias de ninhos em agosto (55,9% e 50,5%, respectivamente). As tartarugas desovaram apenas em setembro (93,3%) e outubro. A produção de filhotes da RESEX em 2015, quando comparada a anos anteriores, apresentou diferenças em relação ao número de filhotes gerados, à proporção entre as abundâncias das espécies e ao calendário reprodutivo. Considera-se a possibilidade de que a mudança nos padrões de abundância e sazonalidade das espécies resulte da cheia histórica no Rio Juruá ocorrida em 2015, com efeitos na reprodução de quelônios nesta Unidade de Conservação.

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Monitoramento do Pirarucu (*Arapaima gigas*) manejado na RESEX do Baixo Juruá: subsídios para análise de alterações locais no ambiente

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A Reserva Extrativista (RESEX) do Baixo Juruá, unidade de conservação federal, possui área de 188 mil hectares e está localizada na região do médio Solimões, no estado do Amazonas. Em seu plano de manejo está definido que as atividades produtivas devem ser geridas de forma sustentável. Uma das ações realizadas pelos comunitários da RESEX é o Manejo Comunitário do Pirarucu (Arapaima gigas), que ocorre na unidade desde 2006, seguindo as instruções normativas do IBAMA (Instituto Brasileiro de Meio ambiente e Recursos Naturais Renováveis) e a metodologia de manejo do IDSM (Instituto de Desenvolvimento Sustentável Mamirauá), pioneiro nos trabalhos de manejo com a espécie. O Pirarucu é uma das maiores espécies de peixe de água doce do mundo, de ampla distribuição na bacia amazônica. Possui respiração aquática e aérea, emergindo a superfície a cada vinte minutos em busca de oxigênio, fator que possibilitou o desenvolvimento da metodologia de contagem populacional pelo IDSM. O Pirarucu teve sua captura restringida pelo IBAMA devido à alta pressão de pesca nos rios da Amazônia, estando hoje restrita às áreas de manejo autorizadas pelo órgão. Na RESEX, anualmente, os manejadores realizam as contagens de indivíduos em 102 lagos. Posteriormente, é realizada a pesca da cota autorizada pelo IBAMA, calculada a partir da contagem do ano anterior, com o percentual máximo de 30% dos indivíduos adultos contados. O presente trabalho resume os resultados das contagens e cotas de pirarucu na RESEX entre 2007 e 2015. Analisando a série histórica, verificou-se o aumento do estoque pesqueiro para a espécie nos lagos de manejo da unidade: em 2008, na segunda cota autorizada pelo órgão, foram liberados para a pesca 310 indivíduos; 424 em 2009; 352 em 2010; 327 em 2011; 369 em 2012; 473 em 2013; 516 em 2014; e na última autorização, em 2015, 558 Pirarucus foram autorizados para a pesca, 80% a mais que em 2008. A proporção de adultos, em relação a juvenis (bodecos) contados, variou entre 39,63% em 2010, e 47,92% da população em 2008. Estudos anteriores compilando dados da biometria do Pirarucu manejado na unidade (cumprimento, peso), apontam que os indivíduos pescados na RESEX apresentam boas condições de manejo, quando comparados aos Pirarucus comercializados nos mercados da Amazônia. Nos últimos anos, a região amazônica observa fenômenos climáticos extremos, como cheias e secas acima da média histórica, indícios locais das mudanças no clima. O Pirarucu pode oferecer sinais destas alterações. De acordo com estudos do (INPA) Instituto Nacional de Pesquisas da Amazônia, o estresse do pirarucu a altas temperaturas

surtiu efeito na redução de 20% do tamanho do peixe em cativeiro. As alterações no ambiente podem comprometer o manejo do pirarucu na RESEX do Baixo Juruá. Em condições de cheias acima da média, a espécie tende a deixar os lagos da UC em migração para o leito do rio, dificultando a pesca dos manejadores nas áreas autorizadas e tornando a espécie mais vulnerável à pesca ilegal. Da mesma forma, a contagem de indivíduos é prejudicada, comprometendo a metodologia de contagem e a cota do manejo. Considerando a série histórica de dados do manejo do Pirarucu na RESEX, esta se apresenta como uma ferramenta potencial nos estudos locais de identificação de mudanças climáticas. Outras variáveis podem ser analisadas em conjunto, visando conhecer melhor a correlação entre abundância de indivíduos e as variáveis ambientais associadas ao clima.

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Monitoramento populacional do caranguejo-uçá, *Ucides cordatus* (Linnaeus,1763), como potencial indicador de mudanças climáticas em áreas de maguezal

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Os cenários de mudanças climáticas indicam uma variação do nível médio relativo do mar (NMRM), que poderá influenciar a distribuição do caranguejo-uçá (*Ucides cordatus*). Preconiza-se seu deslocamento para topografias mais elevadas (apicum), que atualmente são ocupadas pelos jovens desta espécie. Posto isto, apresenta-se dados preliminares da aplicabilidade de um protocolo para o monitoramento deste caranguejo, que poderá detectar alterações em sua biologia populacional (densidade e estrutura), em função de mudanças climáticas locais/regionais. Estão sendo registradas variáveis abióticas e bióticas em duas áreas de manguezal (ESEC Juréia-Itatins, SP; e PARNA do Superagui, PR), para o posterior confronto dos dados, e indicação daqueles explicativos e de maior relevância em nível latitudinal (São Paulo vs. Paraná), sazonal (época chuvosa vs. seca), espacial (subáreas: margem vs. apicum) e temporal (2016 a 2018). Até o presente, foram realizadas duas expedições: o treinamento das equipes (outubro e novembro/2015) e Expedição1 (março/2016). Em cada área de manguezal (SP e PR) uma transecção foi posicionada entre as duas subáreas (margem e apicum) e instalados 05 (cinco) quadrados amostrais (5x5m) por subárea. Nelas foram registradas duas variáveis atmosféricas (temperatura e umidade relativa), quatro hídricas (temperatura, pH, oxigênio dissolvido e salinidade) e três edáficas (pH, salinidade da água intersticial e temperatura). Em cada quadrado foi quantificada a densidade dos caranguejos (contagem do número de galerias, assumindo-se um exemplar/galeria) e medido o diâmetro das galerias ativas (DG), para posterior conversão em tamanho dos caranguejos (LC, largura cefalotorácica) e distribuição em classes de tamanho (5mm). Dos fatores atmosféricos registrados, houve uma relação inversa entre a temperatura e a umidade relativa, com tendência da temperatura ser mais elevada na região do apicum ($F=4,11$; $p=0,023$), enquanto a umidade relativa foi maior nas subáreas marginais ($F=5,59$; $p=0,0073$). Até o momento não houve distinção significativa entre as variáveis hídricas, tanto entre as subáreas amostrais como entre as áreas. Para as variáveis edáficas, somente a salinidade da água intersticial apresentou valores contrastantes entre as subáreas ($F=16,56$; $p=0,00015$), com maiores médias para a margem na Juréia e no apicum do Superagui; enquanto o pH contrastou somente na Juréia, sendo maior na margem ($F=3,47$; $p=0,04$), onde foi

mais ácido. Até o momento foram contabilizadas 3.285 galerias para as duas áreas de manguezal (SP+PR), sendo 2.543 abertas ativas (77,4%), 616 fechadas (18,8%) e 126 abandonadas (3,8%). Do quantitativo de galerias ativas, 61,2% estiveram associadas às regiões de apicum (n=1.556) e 38,8% às regiões de margem (n=987). Nas áreas de apicum ocorreram os maiores percentuais de galerias ativas e com mais de duas aberturas (2-4 aberturas), correspondendo a 34,4% nos apicuns e 29,7% nas margens. Evidenciou-se que os caranguejos nas margens foram maiores que no apicum, tanto na Juréia (KW=135,87; p<0,01), como no Superagui (KW=118,82; p<0,01). Contudo, o tamanho do crustáceo nas margens não diferiu nos manguezais avaliados em SP e PR (KS=4,77; p>0,01), o mesmo ocorrendo entre os apicuns (KS=21,82; p>0,01). Estatisticamente, não foi confirmada diferença da densidade do caranguejo-uçá entre a margem e o apicum (F=1,12; p=0,359). Cumpre esclarecer que os dados ora apresentados condizem aos preconizados, alguns ainda figurando como tendências, que poderão ser confirmadas com os dados obtidos nas próximas expedições até 2018.

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Monitores voluntários: um estudo de caso do Parque Nacional da Serra da Bodoquena

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O Programa de voluntariado em unidades de conservação (UC) federais geridas pelo Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) visa a utilizar recursos humanos para auxiliar atividades relacionadas à gestão das UCs, dentre elas podemos destacar a pesquisa, o monitoramento, o uso público e a educação ambiental. O Parque Nacional Serra da Bodoquena (PNSBd), unidade gerida pelo ICMBio e localizada integralmente no estado de Mato Grosso do Sul, protege o maior fragmento florestal contínuo do estado, além de ser um dos maiores remanescentes de Floresta Estacional Decidual do país é uma das unidades que aderiram à implantação e execução do Sistema de Monitoramento *in situ* da Biodiversidade e variáveis climáticas. O voluntariado tem papel fundamental na execução do mesmo, os voluntários são direcionados e selecionados exclusivamente para o Monitoramento, e estão ligados às universidades localizadas no entorno da unidade. A implantação das Unidades Amostrais (UA) de plantas lenhosas, mamíferos de grande e médio porte, aves e borboletas frugívoras ocorreu em 2013 e desde então três vezes ao ano o PNSBd recebe voluntários para realizarem a coleta de dados, referente ao Sistema de Monitoramento. A Unidade de Conservação conta com três servidores efetivos e existem duas UAs, uma em cada fragmento da unidade, para realizar toda amostragem são necessários em média vinte voluntários a cada campanha do programa de Monitoramento. Durante as avaliações, após o fim de cada etapa de amostragem os voluntários apontaram algumas lacunas e deficiências no âmbito de logística, recursos humanos e capacitação. Com o apoio dos voluntários, a gestão da unidade resolveu implantar uma nova categoria de voluntariado, surgindo assim a Monitoria Voluntária (MV) no ano de 2016, que tem como objetivo de apoiar as atividades do voluntariado em seu planejamento e execução. O perfil dos monitores consiste em ex-voluntários atuantes na área de conservação da natureza e envolvidos com atividades pertinentes a gestão de Unidades de Conservação, estes recebem uma capacitação diferenciada antes de cada etapa do monitoramento, inspirada na metodologia do Projeto de Capacitação de Jovens, além de conhecerem mais a fundo as características específicas do PNSBd, como fauna, flora e geomorfologia da região, que apresenta influência de Cerrado, Mata Atlântica

e Pantanal. Os Monitores, também realizam a capacitação dos voluntários na aplicação do Protocolo de Amostragem do Programa de Monitoramento da Biodiversidade, realizam palestras, discussões e dinâmicas antes de cada etapa do monitoramento. Durante a amostragem eles auxiliam os voluntários em campo como manejo, classificação e identificação das borboletas, no reconhecimento dos transectos e na coleta dos dados de fauna e flora. A participação dos Monitores Voluntários em 2016 mostrou-se muito positiva, e avanços durante a amostragem são claramente notados. Um dos avanços é a identificação de borboletas frugívoras em nível de espécie (o protocolo identifica as borboletas até o nível de tribo), os monitores acompanham as amostragens e auxiliam os voluntários na identificação dos indivíduos, a organização e transcrição dos dados coletados também são feitas pelos monitores o que facilita o trabalho dos analistas ambientais da UC. O Parque Nacional Serra da Bodoquena visa inspirar seus voluntários a se tornarem parceiros, e a Monitoria Voluntária tem tornado esse desejo realidade.

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Mudanças climáticas e biodiversidade: desafios para a gestão de áreas naturais

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Estudos mostram que o Sul e o Sudeste do Brasil são altamente vulneráveis à mudança do clima (MC) e que ecossistemas protegidos são essenciais para tornar a biodiversidade e a sociedade mais resilientes aos impactos dessa mudança. Apesar disso, pesquisas sobre clima e biodiversidade ainda são escassas, sobretudo na Mata Atlântica. Esta lacuna de conhecimento dificulta a criação de estratégias de adaptação e, por isso, a Fundação Grupo Boticário lançou em 2010 a iniciativa Bio&Clima Lagamar, que incentiva pesquisas sobre o impacto da MC na biodiversidade para trazer subsídios ao manejo de áreas naturais, com foco no Mosaico de Áreas Protegidas do Lagamar, conjunto de Unidades de Conservação (UCs) localizado no litoral sul de São Paulo e litoral do Paraná. A criação de uma linha de apoio a projetos, que foi lançada em 2011 e já contemplou 11 pesquisas, contou com 30 especialistas de diferentes áreas. Para fomentar a discussão de resultados e subsídios para gestão, anualmente são realizadas reuniões entre pesquisadores, gestores de UCs da região e tomadores de decisão. Como resultados, destacam-se tanto o registro de impactos diretos da MC sobre a biodiversidade como de outras ameaças à região, como, por exemplo, a intensa pressão para uso de recursos naturais e mudança de uso do solo. Tudo isso mostra a urgência de medidas que garantam a integridade ambiental das funções ecológicas do ecossistema, permitindo maior capacidade de resiliência e adaptação aos impactos da MC. Com base nisso, foram apresentadas ao poder público diretrizes que destacam a urgência de sua atuação, sendo que cabe a este manter agências públicas de pesquisa de clima, regulamentar intervenções no ambiente e incentivar o setor privado, mostrando oportunidades de apoio a ações de adaptação à MC. Dentre as diretrizes discutidas, destacam-se: Fortalecer as UCs do Lagamar possibilitando o alcance de seus objetivos e viabilizar o funcionamento do Conselho do Mosaico, bem como dos conselhos das UCs que o compõem, além de fortalecer a relação destes com os tomadores de decisão da região; Priorizar e viabilizar financeiramente estratégias e ações de AbE e conservação para redução da vulnerabilidade à MC no planejamento de gestão, ordenamento territorial e zoneamento das UCs; Elaborar e revisar planos de manejo e outros planos de ordenamento territorial considerando a MC e aprofundar a discussão sobre o tema em órgãos competentes; Atualizar os planos de combate e prevenção de acidentes da região considerando a MC e desenvolver estratégias específicas para bioinvasão; Desenvolver ações com o objetivo de comunicar e sensibilizar a sociedade em relação ao impacto da MC; Sistematizar e espacializar

informações e dados disponíveis sobre em uma plataforma de livre acesso e Definir estratégias integradas de monitoramento da biodiversidade e da MC, seus impactos e relação com outras regiões, especialmente zonas costeiras.

Outro resultado importante foi a formação de um grupo multidisciplinar que passou a incluir a 'lente climática' em suas pesquisas e se aproximar da gestão das UCs. Alguns deles participam de conselhos gestores de UCs e contribuíram com a elaboração de Planos de Manejo e Planos de Ação Nacionais para proteção de espécies.

[1] 1º relatório de avaliação nacional – PBMC 2015

[2] Adaptação baseada em Ecossistemas: Oportunidades para políticas públicas.

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Mudanças climáticas, avaliação de impacto ambiental e biodiversidade: uma análise de empreendimentos costeiros e marinhos no Brasil

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O tema das mudanças climáticas tem sido cada vez mais abordado pela comunidade científica e por políticas públicas, as quais procuram agir seja por mitigação ou adaptação. Neste sentido, existem recomendações de colegiados nacionais e internacionais de incorporar a temática na Avaliação de Impacto Ambiental (AIA), sobretudo em áreas vulneráveis, como zonas costeiras. Nestes locais, a AIA se une a outras ferramentas de gestão, no auxílio da resolução de inúmeros conflitos. A gestão dos recursos naturais neste território enfrenta problemas ambientais globais ignorados até pouco tempo atrás (mudanças climáticas, perda da biodiversidade e mudança no uso da terra) e mudanças sociais globais (globalização econômica, desregulação dos processos de mercado e intensificação contínua na utilização dos recursos mundiais) e, embora estas questões tenham alcance global, nas zonas costeiras, muitos dos problemas, crises e conflitos são experimentados antes, devido à alta densidade populacional e à intensiva exploração dos recursos. É o caso do Brasil, que se destaca devido à sua extensa costa, que possui, além de alta biodiversidade, alta densidade populacional (cinco vezes maior que a média nacional), e à dependência econômica em mercados estrangeiros, o que provoca uma concentração de uma parte considerável da estrutura industrial e logística na região costeira. Um relatório de diagnóstico realizado em 2002 pelo Ministério do Meio Ambiente mostrou que existe um quadro preocupante sobre os impactos ambientais registrados nesta região, e que processos de AIA permissivos contribuíram para este cenário. Desta maneira, o presente trabalho objetivou analisar os processos administrativos de AIA de projetos individuais na busca de abordagens sobre as mudanças climáticas. Foram coletados e analisados 13 processos administrativos referentes a empreendimentos portuários, de produção de energia eletro-nuclear, exploração de petróleo e de calcário marinho, dragagens e gasodutos submarinos. A análise buscou procurar se a temática das mudanças climáticas foi abordada em termos de medidas de adaptação do projeto, na análise de cenários com e sem o empreendimento, incluindo a previsão de impactos sinérgicos do projeto com as possíveis mudanças do clima, e na proposição de medidas mitigatórias e compensatórias aos impactos previstos. Não foram encontradas menções à temática das mudanças climáticas em nenhum dos termos de referência dos processos analisados. Nos estudos de impacto ambiental, em apenas dois a temática foi mencionada, de forma superficial, não havendo seção específica dedicada ao tema, que não foi levado em consideração na análise de cenários futuros com e sem o empreendimento. Em outros dois processos, a pressão da sociedade civil fez com que

algumas ponderações a respeito da temática surgissem, alertando o órgão ambiental para que tais considerações fossem levadas em conta na condução da AIA. Os resultados encontrados demonstram que, apesar de as mudanças climáticas já serem objeto de políticas e planos no Brasil, ainda existe dificuldade de efetivamente incorporar o tema no processo decisório de projetos individuais. Isso demanda uma maior ênfase da AIA como ferramenta para enfrentar os desafios ambientais globais, visto que, se bem realizada, ela pode fornecer uma maneira de analisar questões ambientais chave de forma efetiva e transparente, proporcionando oportunidades de atingir resultados ambientais ambiciosos, em particular aqueles relacionados à biodiversidade e mudanças climáticas.

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O manejo florestal madeireiro na RESEX Tapajós- Arapiuns e a sustentabilidade na execução da atividade por comunidades tradicionais

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Localizada na Amazônia, sudoeste do Pará, a Reserva Extrativista Tapajós Arapiuns (RESEX T.A.) abrange 74 comunidades com aproximadamente 18 mil pessoas. Caracteriza-sepelo modo de vida tradicional que está baseado na prática do extrativismo, na agricultura familiar e na sua luta por território. No entanto, apesar dos moradores da RESEX T.A. apresentarem um modo de vida tradicional, a criação da Unidade de Conservação –UC está intimamente ligada à questão madeireira. Diante desse cenário, o presente estudo tem como objetivo caracterizar o estado de conservação das essências florestais mais exploradas pelas comunidades da RESEX T.A. O método para a coleta de informações foi a aplicação de um questionário semiestruturado com perguntas abertas em cinco comunidades selecionadas, além da análise do banco de dados do inventário amostral e de relatórios, juntamente com a revisão bibliográfica sobre as informações relativas a RESEX T.A. A análise dos dados demonstra que existem 17 espécies que sofrem forte pressão pela exploração realizada nas comunidades, destacando as essências florestais *Mezilaurus itauba* (Itaúba) e *Handroanthus sp*. (Ipê). Vale destacar que os moradores ainda se utilizam de métodos rudimentares para a valorização comercial e mensuração da madeira, na qual ainda é utilizado o palmo para medir pranchões. Além disso identificou-se que os custos para a exploração do recurso florestal madeireiro pelas comunidades em muitos casos são maiores que o lucro. Nesse sentido, o recurso explorado pelas comunidades sofre uma desvalorização, não sendo tão vantajosa a exploração econômica. Com isso conclui-se que há forte pressão sobre um pequeno grupo de espécies florestais madeireiras, o que a longo prazo poderá desfavorecer quem vive da atividade, pois elas ficam cada vez mais distantes, o que inviabiliza algumas etapas do processo de exploração. É notório também que os métodos arcaicos adotados pelas comunidades podem resultar em estimativas errôneas, que acabam subestimando o valor da madeira. Diante deste quadro o ideal seria o incentivo a criação de viveiros florestais e fortalecer parcerias com as universidades da região para trabalhar juntamente com os comunitários a questão do melhoramento de algumas espécies, assim evitando a exploração irregular e predatória. Por fim, a iniciativa do ICMBio, como órgão gestor da RESEX T.A., de colocar em prática o plano de manejo florestal sustentável, que é uma forma de organizar a cadeia produtiva da madeira e beneficiar direta e indiretamente as comunidades dessa UC.

Agradeço pela oportunidade ao CNPq e ICMBio, principalmente a equipe da Unidade de Conservação RESEX Tapajós-Arapiuns, em especial a analista Jackeline Nóbrega que me incentivou e ajudou a participar do Programa PIBIC.

O perfil de guias turísticos e pescadores amadores que utilizam o entorno da Estação Ecológica de Taiamã, município de Cáceres/MT, como área de atividade pesqueira

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A preciosidade do ambiente pantaneiro e a diversidade de peixes da região direcionou o desenvolvimento da pesca esportiva neste local. Paralelo a esta atividade, a Estação Ecológica de Taiamã situada na região de Cáceres – MT apresenta em seu interior uma variedade de ambientes aquáticos, sendo registradas até o momento 131 espécies de peixes. Contígua à ESEC se localiza a região inundável conhecida como "campo", que está inserida no processo de ampliação da Unidade de Conservação – UC, sendo que em parte desta área a pesca é proibida devido à importância para a ictiofauna. O alto valor comercial e social de espécies como o pintado, cachara, pacu e dourado, entre outras, encontradas em regiões próximas da UC, atraem grande número de pescadores amadores em barcos-hotéis explorando seus recursos naturais. O objetivo deste trabalho foi identificar o perfil dos pescadores amadores e guias turísticos que utilizam o entorno da ESEC e verificar a compreensão do papel ecológico desta para a ictiofauna. Sendo assim, foram realizadas entrevistas utilizando-se um formulário estruturado. A identificação dos entrevistados foi sigilosa, de acordo com as recomendações do Comitê de Ética em Pesquisa, conforme parecer n. 1371018. As entrevistas dos guias foram realizadas de acordo com o método Snow-ball e a entrevista dos pescadores foi aleatória. Foram entrevistados 10 guias turísticos e 20 pescadores amadores. Os guias turísticos possuíam entre 38 a 53 anos de idade, todos do sexo masculino, trabalhando neste ramo há pelo menos 9 anos. Todos os guias turísticos afirmaram conhecer a ESEC de Taiamã, sendo que destes 8 atribuíram a importância do local como sendo o "berçário dos peixes" (GT1, GT4... GT10) (Guia Turístico), 1 atribuiu a importância pela "preservação ambiental" (GT3) e 1 entrevistado atribuiu a importância porque os "peixes param lá" (GT2). A idade dos pescadores amadores variou de 30 a 81 anos de idade, todos do sexo masculino, sendo aposentados (5), empresários (6), administradores (4), agricultor, agrônomo, analista de sistemas, contador e servidor público (1 cada). Destes, 26,4% estavam pescando na região pela primeira vez, 31,6% de 2 a 4 e 5 a 7 vezes e 10,5% de 4 a 6 vezes. Quando perguntados sobre a ESEC de Taiamã somente 3 pescadores afirmaram conhecê-la. Sobre a importância da ESEC na conservação da biodiversidade foi relatado que a ESEC "ajuda preservar e é de suma importância que seja mantida" (PT3) (Pescador Turista), "tem importância, a fiscalização impede a pesca" (PT8) e um relatou que "se pudesse entrar lá seria bom" (PT15). Os demais entrevistados não conheciam a ESEC de Taiamã. O papel ecológico desempenhado pela estação, como local de reprodução e berçário para muitas espécies de peixes, torna a área de entorno atrativa para a captura de espécies alvo. Contudo, atividades no entorno de UCs têm recebido atenção especial devido às práticas negativas da população em relação ao meio ambiente, sendo necessária uma ação participativa da comunidade que faz uso do entorno. Neste sentido, nota-se que a compreensão dos guias turísticos acerca da importância da ESEC é reflexo da participação em reuniões promovidas pela ESEC. Por outro lado, a falta de conhecimento pela grande parte dos pescadores entrevistados nos mostra pouco esclarecimento sobre a importância ecológica da ESEC. Assim, para mudar este quadro faz-se necessário instruir os próprios guias turísticos, pois estes possuem maior contato com os pescadores amadores, a informar sobre a ESEC e a importância ecológica da mesma, tornando a gestão participativa mais efetiva.

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O SNUC é um instrumento eficaz para proteção das tartarugas marinhas no Brasil? Um ensaio sobre as tartarugas-de-pente, *Eretmochelys imbricata*, que nidificam no litoral do Rio Grande do Norte

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A tartaruga-de-pente, *Eretmochelys imbricata*, utiliza o litoral do Rio Grande do Norte como uma das mais importantes áreas de desovas no Atlântico Sul. Possuem ciclo de vida complexo, utilizando diferentes ambientes ao longo dos diversos estágios de desenvolvimento. O presente trabalho reuniu informações sobre monitoramento reprodutivo, estudos genéticos e migratórios para esta população e as sobrepõe ao SNUC, discutindo sua efetividade como instrumento legal de proteção. Dados de monitoramento reprodutivo apontam como bolsões de desova as praias da Barreira do Inferno (Parnamirim/RN), Malembá (Senador Georgino Avelino/RN), Pipa (Tibau do Sul/RN) e Olho D'água (Baia Formosa/RN). Destas, as praias de Malembá e Pipa são as únicas que encontra-se dentro dos limites de uma Unidade de Conservação, a APA Estadual de Bonfim – Guaraíras, representando cerca de 48% do total de ninhos. Estudos genéticos indicam que a população de juvenis capturados em Fernando de Noronha e no Atol das Rocas é composta principalmente por animais nascidos em praias brasileiras, sendo a população do Rio Grande do Norte uma das fontes predominantes. Estes juvenis estão atualmente protegidos por três unidades de conservação marinhas: APA e o ParnaMar de Fernando de Noronha e a ReBio do Atol das Rocas. A partir de 2015, com o início dos trabalhos de monitoramento por satélite, começa-se a desvendar as rotas migratórias das fêmeas, até então desconhecidas. Dos 24 animais marcados, 20 alcançaram áreas de alimentação. Análises preliminares dos dados indicaram três padrões de movimentos. Quatro fêmeas realizaram curta migração (entre 15 e 58 km), permanecendo ao largo das praias de desova, fora de Unidades de Conservação. Nove fêmeas migraram para o Norte, percorrendo distâncias maiores, entre 101 e 1515 km. Todas passaram durante a fase migratória pela APA Estadual Recifes de Corais/RN, duas se estabeleceram nos limites desta unidade para a fase de alimentação e outras 5 transitaram durante a migração pelas: Resex Prainha do Canto Verde/CE, Parque Estadual Marinho da Pedra da Risca do Meio/CE e APA das Reentrâncias Maranhenses/MA. Uma fêmea definiu sua área de alimentação dentro dos limites do Parque Estadual Marinho do Parcel Manuel Luis/MA. Sete fêmeas se deslocaram para o Sul, percorrendo distâncias entre 81 e 559 km, das quais 5 cruzaram os limites das APAs da Barra do Rio Mamanguape/PB, de Santa Cruz/PE, de Guadalupe/PE e Costa dos Corais/PE/AL, na fase migratória. Duas fêmeas definiram como área de alimentação a APA Costa dos Corais/PE/AL. Todos os deslocamentos ocorreram sobre a plataforma continental e nenhum alcançou outros países. Dos 20 indivíduos estudados, 25% apresentaram sobreposição entre suas áreas de alimentação e alguma unidade. Apesar de Fernando de Noronha e Atol das Rocas serem importantes áreas de crescimento e estarem sob proteção integral, abrigam apenas uma fração da população do Rio Grande do Norte. No que se refere a área de reprodução, mesmo que cerca de metade das desovas estarem dentro de uma UC, a mesma carece de plano de manejo adequado à proteção da espécie. Com relação às áreas de alimentação das fêmeas adultas, apenas um indivíduo estabeleceu-se em uma Unidade de Proteção Integral. Considerando que a *Eretmochelys imbricata,* classificada como Criticamente Ameaçada possui apenas uma pequena parcela da população sob algum grau de proteção nos diferentes estágios de vida, recomenda-se fortalecimento das existentes e implementação de novas unidades de conservação, visto que apenas 1,57% da zona marinha encontra-se protegida pelo SNUC.

Obtenção de híbridos triploides de *Astyanax altiparanae* como ferramenta para conservação e biotecnologia

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A introdução de espécies exóticas está entre as principais causas da extinção de espécies nativas devido à competição, predação e a introgressão que é causada. A utilização de peixes estéreis é portanto uma alternativa viável para atenuar os efeitos de escapes, e além disso peixes estéreis podem ser usados como receptores de células germinativas e subsequente conservação de espécies ameaçadas de extinção, servindo como "barriga de aluguel". Nesse trabalho foi avaliada a viabilidade da hibridização associada à triploidização de fêmeas do lambari do rabo amarelo *Astyanax altiparanae*, machos de *A. fasciatus*, *A. schubarti*, *Hemigramus caudovittatus* e *Oligosarcus pintoi*. Oócitos de *A. altiparanae* foram fertilizados com sêmen das demais espécies, e a metade da desova foi triploidizada por choque térmico a 40°C, de modo a gerar quatro tipos de híbridos, diploides e triploides. O cruzamento intra-específico (puro) triploide e diploide foi utilizado como controle. Foram verificadas taxa de fertilização, a sobrevivência nos estágios de clivagem, blástula, gástrula, somito, a taxa de eclosão, e a porcentagem de larvas normais e anormais com base em critérios morfológicos. Adicionalmente, foi confirmada a ploidia das larvas obtidas por meio de citometria de fluxo. Não foi verificada diferença significativa (P>0,05) quanto à taxa de fertilização, sobrevivência dos diferentes estágios embrionários, e porcentagem de larvas normais entre todos os cruzamentos e ploidias. Dessa forma, a produção de híbridos triploides de *Astyanax altiparanae* mostrou-se viável, apresentando potencial para a aplicação em estudos de esterilização voltados para a produção sustentável e conservação dos recursos genéticos.

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Ocorrência de fogo na APA Chapada do Araripe como ameaça à conservação do soldadinho-do-araripe (*Antilophia bokermanni*)

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A Área de Proteção Ambiental Chapada do Araripe abriga quinze táxons da fauna silvestre ameaçados de extinção. (Cabe dizer em qual bioma se insere a APA) Destes, somente a *Antilophia bokermanni* (soldadinho-do-araripe) é classificada como Criticamente em Perigo. Sua população é estimada em 277 casais. Sua principal ameaça é o habitat reduzido, estimando-se a Extensão de Ocorrência da espécie em 31 km2, numa porção da **encosta** da chapada do Araripe, nos municípios de Barbalha, Crato e Missão Velha, Ceará. Uma das possíveis causas de redução do habitat é o fogo, tradicionalmente usado na região no sistema de preparo dos solos para agropecuária, e que não raras vezes resulta em **incêndios florestais**. O objetivo deste trabalho foi avaliar o potencial impacto do fogo à conservação da Antilophia bokermanni. O período reprodutivo da espécie pode ser identificado pelo aumento do número de emissões das vocalizações dos indivíduos machos,

acreditando-se que neste período ocorrem mais de 130 vocalizações/minuto, o que foi observado entre outubro a fevereiro nos anos de 2010 a 2014. Neste período há uma maior concentração da população **nas proximidades das nascentes** (independente da espécie, os ambientes que ocorre (por eles mesmos) são ambientes sensíveis/frágeis ao fogo, e num planejamento de manejo de fogo deveriam ser poupados/protegidos) para nidificação o que permite a realização do recenseamento dos machos reprodutivos desde 2013. A comparação dos dados dos censos nos anos de 2013 e 2015 aponta uma redução de 7,5% da população no município do Crato, perdendo-se quase a quinta parte destes devido a um único incêndio florestal que ocorreu em outubro de 2015. Dados de focos de calor dos últimos dez anos (2006 a 2015) disponibilizados no portal eletrônico do Instituto Nacional de Pesquisas Espaciais (INPE) foram organizados resultando na verificação da ocorrência de 72% dos focos de calor na APA Chapada do Araripe nos meses de outubro e novembro. As condições meteorológicas durante setembro a dezembro se caracterizam por baixa pluviosidade, baixa umidade relativa do ar e altas temperaturas o que resulta em longos períodos de situação crítica para ocorrência de incêndios florestais. Somado a isto, dados organizados a partir do portal eletrônico da Fundação Cearense de Meteorologia (Funceme) considerando a precipitação normal confirmou a existência do período chuvoso nos municípios cearenses da APA Chapada do Araripe entre janeiro e abril, concentrando 77,5% da precipitação anual o que resulta na maior disponibilidade de material vegetal seco no último trimestre do ano. O início do período reprodutivo de *Antilophia bokermann*i coincide com a maior concentração de focos de calor detectados na região, com as temperaturas médias mensais mais elevadas e com a maior disponibilidade de material combustível. O fogo representa potencialmente causa de perda de habitat e redução da população, tanto pela destruição dos ninhos quanto pela mortandade de filhotes e, consequentemente, impacto negativo no sucesso reprodutivo. Portanto, pode-se concluir que o emprego de queima controlada (pelo cenário descrito aqui, não está tão controlada assim) neste período impacta, pelo menos potencialmente, de forma negativa a conservação de *Antilophia bokermanni*. Recomenda-se a proibição do emprego desta técnica nos meses de outubro e novembro (incluir/discutir com os usuários um calendário de queima que vede este período seria fazer queima controlada, porem mais ordenada), o aumento da divulgação deste impacto, a criação de brigadas de prevenção e combate a incêndios florestais na região e a intensificação das ações de fiscalização neste período. Parece-me que o problema não é a queima controlada, mas a falta de pensar um manejo do fogo que considere as especificidades já conhecidas desta UC (onde estão seus ambientes mais sensíveis e esta espécie muito sensível (onde e quando)).

Ocorrência do siri-do-Pacífico, *Charybdis hellerii* (A.MILNE-EDWAD,1967), na Área de Proteção Ambiental de Guaraqueçaba: Oportunidade para a participação social na gestão ambiental dos impactos de empreendimentos portuários da região de Paranaguá e Antonina/PR

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No litoral norte do estado do Paraná encontra-se um importante remanescente do bioma Mata-Atlântica, incluindo sistemas estuarinos e manguezais. Associada a esta biodiversidade está a população tradicional Caiçara,que depende de ecossistemas produtivos e saudáveis para a realização da pesca artesanal, sempre em águas interiores e abrigadas (Diegues et al, 2000). A região também abriga os empreendimentos portuários de Paranaguá e Antonina, fontes de alterações ambientais irreversíveis. A gestão ambiental conta com quatro unidades de conservação federais: APA e ESEC de Guaraqueçaba, REBIO Bom Jesus e PARNA do Superagui. A participação dos pescadores artesanais na gestão dos recursos pesqueiros ainda é uma relação de dependência e clientelismo (Haimovici, 2014) sendo que, sob a perspectiva do ecosystemstewardship, a gestão deveria ampliar a noção de

responsabilidade compartilhada, reduzir a vulnerabilidade e transformar trajetórias indesejáveis para a atividade (Medeiros et al. 2014).Nesse cenário a gestão das UC federais busca promover a participação social efetiva na gestão ambiental inclusive em temas complexos como licenciamento ambiental portuário. Para isso foi criado um grupo de trabalho de acompanhamento do licenciamento ambiental do Terminal de Contêineres de Paranaguá – TCP, uma medida condicionante que se soma a outros programas de monitoramento. Foi durante este licenciamento que se identificou a presença do siri-do-Pacífico, *Charybdis hellerii*, na APA de Guaraqueçaba. Os decápodas, especialmente os portunídeos, são um importante recurso pesqueiro da região. A introdução de *C. helleriina* costa brasileira está diretamente relacionada a atividade portuária por meio da água de lastro, associada aos cascos dos navios e correntes marítimas (Lemaitre, 1995; Tavares & Mendonça, 1996). A espécie pode competir com as nativas por habitat e alimento (Tavares & Mendonça, 2004), ameaçar a biodiversidade local e gerar prejuízos para a pesca (Amaral &Jablonski, 2005).Os programas de monitoramento do TCP confirmaram a ocorrência de *C. hellerii* através de entrevistas com os pescadores, que apontaram os locais de ocorrência e as formas de captura. O monitoramento de portunídeos utiliza as armadilhas tradicionais, tipo "gaiolas", instaladas nos locais indicados pelos Caiçaras. Nas coletas trimestrais (De Jul/2014 a out/2015), foram capturados 2.551 portunídeos, sendo *Callinectes danae* a espécie mais abundante (n=2154), seguida de *Callinectes exasperatus* (n=174),*Charybdis hellerii* (n=106) e *Callinectes sapidus* (n=61).A ocorrência de *C. helleri*i foi maior no entorno das Ilhas da Banana e das Cobras, ambas com fundos consolidados, confirmando o relato dos pescadores. De forma adicional foram realizadas coletas ativas nas duas ilhas, capturando mais 132 indivíduos de *C. hellerii*, em três expedições. Foram coletadas todas as classes ontogenéticas, incluindo fêmeas ovígeras na frequência de 40,38%, o que pode indicar um intenso esforço reprodutivo. Na região, *C. helleriipode* ser considerada uma espécie exótica consolidada. As ações futuras incluirão, além dos programas de monitoramento previstos nas condicionantes ambientais, a realização de um inédito Plano de Controle de *C. hellerii*, (condicionante IBAMA), uma vez que espécies exóticas tendem a ser mais tolerantes as alterações ambientais, levando vantagem sobre as espécies nativas. A gestão participativa será estimulada com a apresentação dos resultados ao Conselho Gestor das unidades, promovendo a discussão e construção coletiva de estratégias de mitigação dos impactos socioambientais.

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Padrão de interação de herbivoria e sua relação com as condições microclimáticas e de uso do solo na Reserva Biológica Guaribas, Paraíba, Brasil

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As Unidades de Conservação se propõem a gerenciar as interferências antrópicas sobre os sistemas ecológicos; para isso, estudos sobre herbivoria e microclima tornam-se imprescindíveis para auxiliar na compreensão da dinâmica dos ecossistemas. Diante disto, esta pesquisa apresenta-se com o objetivo de compreender o padrão de interação de herbivoria e sua relação com as condições microclimáticas e de uso do solo na Reserva Biológica Guaribas. Para o desenvolvimento da pesquisa, foi realizado trabalho de campo para definir três amostras experimentais em função do tipo de cobertura do solo. Para a coleta dos dados de temperatura foi utilizado o termo-higrômetro modelo UX-10 Hobos. Os dados foram coletados durante quatro meses (15 de Janeiro a 16 de maio de 2015) ininterruptos que compreendeu o período seco e chuvoso da área de estudo. Quanto ao dano de herbivoria, foram realizadas coletas de 600 folhas ao longo dos quatros meses de estudo. Para a análise dos dados estatísticos foram utilizados o programa R studio 2.0 e os seguintes testes estatísticos: Kruskal-Walls, o teste posteriori de Dunn e o teste qui-quadrado (χ^2). Com a pesquisa, verificou-se

que o número de folhas danificadas nas amostras experimentais não difere significativamente entre as mesmas. Em relação à frequência de guilda, a mesma não diferiu significativamente entre as amostras experimentais. Para a magnitude da área foliar do dano, verificou-se que a área PP (Pouco Perturbada) diferiu significativamente das demais áreas. Para os resultados de temperatura, as áreas não apresentaram oscilações exorbitantes entre os períodos monitorados. Dessa forma, conclui-se que o conhecimento acerca da dinâmica de herbivoria possibilita uma melhor compreensão ecológica da área de estudo.

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Padrões de movimentação da onça pintada (*Pathera onca*) no Parque Nacional da Serra da Capivara/PI

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Ecologia do Movimento é o nome dado aos estudos sobre os padrões de deslocamento do animal onde busca-se compreender quais os aspectos ambientais e processos ecológicos influenciam a movimentação, trazendo informações sobre como a espécie utiliza os recursos disponíveis no ambiente. Este estudo teve por objetivo explorar como a estrutura da paisagem influencia os padrões de deslocamento da onça-pintada (*Panthera onca*) em uma área heterogênea da Caatinga, localizada no Parque Nacional da Serra da Capivara, Piauí. Os mapas foram gerados no ArcGIS 10.2.2 e as análises estatísticas foram realizadas no programa R utilizando os pacotes Adehabitat (adehabitatHR), (adehabitatHS), (adehabitatLT) e Survival. Para analisar as trajetórias do indivíduo monitorado foi utilizada a função de seleção de passos (SSF) que baseia se na análise de distribuição de comprimentos de passos e ângulos de virada na verificação da existência de correlações dessas tomadas de decisão com variáveis da paisagem. A área mapeada para análise de seleção de habitat foi definida a partir do buffer de 6 km de raio em torno de cada ponto de localização obtido com o colar GPS. A área de vida total estimada para o indivíduo monitorado foi de 265,6 km2 (kernel de 95%) e área central com 54,9 km2 (kernel 50%). A análise de seleção foi aplicada para verificar se havia força de seleção para movimentação em diferentes classes de vegetação, as quais foram definidas a partir de análise dos componentes principais (PCA), utilizando imagens do satélite Landsat 8. A vegetação da área foi dividida em quatro classes: Arbustiva baixa, Arbórea densa, Arbustiva alta e Arbórea baixa densa. A classe que possui a maior força de seleção é Arbórea baixa densa. De acordo com tamanho e angulação dos passos, todas as direções foram selecionadas pelo animal tendo uma maior prevalência para direções norte e sul. A maior frequência do tamanho dos passos foi entre 0 á 500 metros e em seguida de 500 á 1000 metros. Ainda há uma escassez de informações sobre a onça pintada na Caatinga, com isso trabalho procura trazer novas informações sobre a escolha de habitat através dos padrões de movimentação.

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Para onde estamos indo? Uma avaliação do plano diretor do município de Florianópolis para o entorno da Estação Ecológica de Carijós

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As zonas costeiras e seus ecossistemas associados sofrem pressões pelos usos e atividades humanas, levando a alterações importantes destes ambientes. Estas alterações levam à perda de serviços ecossistêmicos e seus benefícios, afetando as populações que dependem direta ou indiretamente destes serviços. Sendo assim, a gestão costeira integrada deve ocupar-se em manter e melhorar o bem-estar humano, prevenindo a alteração dos ambientes costeiros com diversos instrumentos operativos e estratégicos. Dentre esses instrumentos, destacam-se os Planos Diretores Municipais, os quais devem absorver os princípios de planejamento urbano que conserve ou recupere as funções dos sistemas ambientais que dão suporte a estes serviços e benefícios. Conforme o plano de manejo da Estação Ecológica de Carijós, as áreas de vegetação de restinga, manguezal e banhado no seu entorno cumprem um importante papel de amortecimento dos impactos causados pela urbanização à biota. Portanto, é importante comparar a atual proposta de plano diretor do município para esta área com as restrições às ocupações previstas na legislação ambiental e quantificar as potenciais perdas ecossistêmicas e dos serviços associados. Este trabalho se baseou em levantamento de vegetação, cursos d'água e ocupação do solo existente, correlacionando as restrições legais. Os resultados foram comparados com dados do plano diretor para o município de Florianópolis. Foram então analisados os ecossistemas possivelmente atingidos e os serviços ecossistêmicos a eles associados, através de sobreposição de imagens e mapas. Com base nos resultados conclui-se que o plano diretor encontra-se em desacordo com a legislação ambiental em vigor, assim como com as legislações que envolvem prevenção às catástrofes naturais. Da análise dos serviços ecossistêmicos relacionados aos diversos ambientes potencialmente impactados é possível vislumbrar a perda destes serviços levando a um cenário impactante não só à biodiversidade, mas também ao bem-estar social.

Persistência de *Sapajus xanthosternos* e *Callicebus barbarabrownae* na Caatinga – projeto piloto

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As transformações nas paisagens promovidas pela ação humana, nos últimos séculos, vêm causando perda, fragmentação, degradação e isolamento de habitats, que acarretam em mudanças na distribuição espacial e temporal de espécies. A persistência de uma espécie, em dada região, está relacionada com a dinâmica de extinções e recolonizações nos remanescentes de habitat em escala local. Sua distribuição e abundância dependem não apenas da paisagem atual, mas também da história, magnitude e trajetória de mudanças em múltiplas escalas espaciais e temporais. Em um contexto de degradação ambiental de quatro séculos, sobrevivem na Caatinga *Sapajus xanthosternos* (macaco-prego-do-peito-amarelo) e o único primata endêmico desse bioma, *Callicebus barbarabrownae* (guigó-da-caatinga). Ambos são considerados ameaçados de extinção, categorizados como "Em Perigo" e "Criticamente em Perigo", respectivamente. As duas espécies estão contempladas pelo Plano de Ação Nacional para a Conservação dos Primatas do Nordeste (PAN PriNE), que tem como objetivo garantir a viabilidade de ao menos cinco populações de cada espécie-alvo, aumentando a área e a conectividade de seus habitats e dirimindo conflitos socioambientais. Para contribuir com o

alcance do objetivo do PAN PriNE, a presente pesquisa visa identificar quais fatores influenciam na persistência destas espécies, em grande parte de sua extensão de ocorrência, com base em dados coletados em campo, modelagem ecológica e informações bibliográficas. A expedição deste projeto piloto foi realizada entre agosto e setembro de 2015, quando foram percorridos 2.400 km em 17 dias, com vistoria de áreas em 12 municípios, incluindo 10 localidades (Campo Formoso, Canudos, Euclides da Cunha, Itiúba, Jacobina, Miguel Calmon, Monte Santo, Morro do Chapéu, Quijingue, Saúde) com registros históricos de C. *barbarabrownae*. Três métodos foram utilizados para detecção das espécies em campo: busca ativa, entrevistas não-diretivas e playback. Foram obtidos treze registros de *C. barbarabrownae,* sendo seis localidades novas e sete em áreas com registros prévios, tendo sido estimados um total de 30 grupos para essa espécie. Destacam-se as localidades de Saúde (seis grupos) e Itiúba e Quijingue (quatro grupos cada). Entre as três áreas sem confirmação atual da espécie, duas parecem manter as condições para sua presença enquanto que, na terceira, pode ser considerado que os guigós estejam extintos localmente, principalmente em decorrência da degradação do habitat. Também foram obtidos sete registros de *S. xanthosternos*, sendo seis em localidades inéditas. Os dados levantados sugerem a existência de uma grande população do macaco-prego-do-peito-amarelo ao longo do complexo de serras entre os municípios de Campo Formoso, Jacobina e Miguel Calmon, denominado Piemonte da Diamantina. Os resultados indicam que, devido à paisagem altamente fragmentada, à perda de habitat e à caça, as espécies estão fortemente sujeitas a efeitos estocásticos, como perda eventual de indivíduos e de diversidade genética, principalmente as populações presentes em áreas muito reduzidas. Em contrapartida, a identificação de novas áreas de ocorrência sugere a existência de mais populações do que previamente registrado, principalmente em agrupamentos, que podem ser tratadas como metapopulações, sujeitas então a estratégias de manejo não invasivas, como a implantação de corredores e reconectividade de habitat, por exemplo.

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Pesquisa-ação com as comunidades do Jardim Serrano e Quebra-Frascos, Teresópolis, RJ: educação ambiental e participação sociopolítica na gestão ambiental pública

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As práticas sociais e os usos do território no entorno do Parque Nacional da Serra dos Órgãos (PARNASO) representam, ao mesmo tempo, ameaças e oportunidades para sua conservação. Expansão urbana desordenada e ocupação de áreas de risco e de preservação permanente, com os decorrentes problemas de saneamento básico, poluição de mananciais, erosão de encostas e ocorrência de incêndios florestais, constituem ameaças ao ambiente e ao bem-viver humano. Por outro lado, as experiências de participação social na gestão do Parque e a governança comunitária dos recursos hídricos apontam novos rumos para a conservação ambiental na região. A Educação Ambiental com comunidades que vivem tais processos é a ação de gestão capaz de qualificar o enfrentamento dos problemas e o fortalecimento das potencialidades socioambientais. Assentado nestes pressupostos, o presente projeto inspira-se nas frequentes manifestações das associações de moradores no Conselho Consultivo do PARNASO, as quais evocam e problematizam o planejamento do uso e ocupação do solo na zona de amortecimento da unidade de conservação como um de seus principais desafios de gestão. Tem-se, portanto, o propósito de investigar, através de técnicas participativas de construção coletiva com os sujeitos envolvidos, moradores das localidades do Jardim Serrano e do Quebra-Frascos, duas dimensões do problema: a primeira refere-se aos processos sociais e históricos que promovem as atuais formas de ocupação do solo na zona de amortecimento, bem

como os problemas e conflitos socioambientais gerados pelas condições de ocupação. A segunda dimensão relaciona-se à construção de soluções no espaço público, a partir do estudo das atribuições dos entes governamentais e da identificação dos fóruns de políticas públicas (Conselhos, Comitês de Bacia Hidrográfica e outros) nos quais as demandas comunitárias adquirem visibilidade, apoios e consequências. Importa ainda investigar os aspectos socioeconômicos e culturais que conferem identidade, territorialidade e potência de atuação aos grupos participantes. A investigação, baseada na metodologia da Pesquisa-Ação, subsidia a construção de estratégias para enfrentamento dos problemas e conflitos e para desenvolvimento das potencialidades nas comunidades envolvidas. Tal construção materializa-se em um plano de ações a serem realizadas pelos moradores com apoio do PARNASO, do Centro Universitário Serra dos Órgãos e outros parceiros. Assim, a geração de conhecimentos se dá na cooperação entre pesquisadores e sujeitos da situação pesquisada, inserida em processos de ensino-aprendizagem sempre associados ao planejamento de ações transformadoras da situação-problema. O levantamento de dados e percepções, bem como a produção de mapas e o desenvolvimento de ações, evidenciaram a coexistência de grupos sociais distintos no território, que vivenciam questões socioambientais de modos diversos, ensejando ações e processos educativos alinhados com seus respectivos contextos. A comunidade do Jardim Serrano, onde predominam famílias de renda e escolaridade reduzidas, moradias sem título de propriedade e moradores nascidos no próprio município ou outros municípios do interior do Estado, contrasta com a população do Quebra-Frascos, em boa parte formada por veranistas e moradores proprietários de grandes lotes, oriundos da capital do Estado e de outros países. Em comum, vivenciam a gestão comunitária das águas e a insuficiência das políticas de saneamento básico. A metodologia adotada neste território poderá ser replicada e inspirar ações em comunidades em situações similares.

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Monitoramento de indicadores tecnológicos e de uso de recursos pesqueiros na APA do Anhatomirim/SC e RESEX Pirajubaé/SC, utilizando protocolo SocMon para o apoio à gestão participativa

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Em 2015, foi iniciado o "Projeto Piloto SocMon Brasil", no qual este trabalho se insere. O Projeto busca promover o monitoramento socioambiental participativo para contribuir na gestão adaptativa de Unidades de Conservação. As atividades deste trabalho foram agregadas às ações do Projeto junto a APA do Anhatomirim (SC) e à RESEX Pirajubaé (SC). A população tradicional da RESEX Pirajubaé enfrenta conflitos de uso do território desde a sua criação, especialmente em função do processo de urbanização de Florianópolis (SC), onde a Unidade de Conservação (UC) está inserida, havendo diferentes demandas para o estabelecimento de acordos de gestão. Entre elas, um grupo de pescadores propôs a alteração do tamanho mínimo da malha da rede para pesca de parati para 6 cm (a INI MPA/MMA 12/2012 determina 7 cm). Então, a equipe da RESEX, em parceria com o CEPSUL, propôs a construção de uma ação de pesquisa para avaliar o uso das malhas 6 e 7. A pesquisa foi concebida como instrumento potencializador de conhecimentos e de saberes direcionados aos setores populares e elaborada em conjunto com os pescadores, autodenominados pescadores-pesquisadores.

De julho de 2015 a junho de 2016 foram realizados 110 lances de pesca com malhas 6 e 7, com redes ligadas entre si. Foram avaliadas a captura de parati, de outros peixes de interesse comercial e da fauna acompanhante sem interesse comercial, descartados na despesca. Com base nos resultados, a construção do acordo de gestão da pesca do parati caminha para a possibilidade do uso da malha 6, de forma associada à boa prática do descarte no momento da despesca. A realização da pesquisa-ação contribuiu para aproximar os pescadores-pesquisadores à gestão da RESEX. Esta aproximação acabou demandando a possibilidade da construção de outros acordos de gestão. Para fundamentar esta construção, foi realizado um diagnóstico participativo do uso dos recursos pesqueiros na RESEX, contemplando a realização de entrevistas semi-estruturadas junto a informantes-chave (utilizando como base o mapa da RESEX) e a elaboração de uma maquete coletiva ou "mapa mental". Este conjunto de atividades constitui a base do projeto "Criando Redes", de três alunos do Curso de Educação Ambiental do ICMBio. Comparando os resultados das entrevistas semiestruturadas com o resultado da maquete, percebe-se que há grande similaridade entre as informações, indicando que o conhecimento sobre o uso dos recursos pesqueiros é relativamente uniforme entre os pescadores, dado o acúmulo de experiência e o grande conhecimento da área e da atividade pelos mesmos. Na APA Anhatomirim, desde 2014 vem sendo desenvolvido, junto a pescadores artesanais de arrasto de camarão, o Projeto Rede Viva, coordenado pelo Centro de Estudos do Mar (CEM)/UFPR e envolvendo as equipes da APA e do CEPSUL. A estrutura metodológica deste projeto orienta-se pela interação dialógica com os pescadores artesanais, de forma a construir de maneira participativa as melhores estratégias para a adoção de dispositivos de redução da fauna acompanhante (*bycatch*) nas redes de arrasto. Em linhas gerais, a metodologia envolve a discussão de adaptações tecnológicas, o teste destas adaptações (pelos próprios pescadores) e a discussão dos resultados, retroalimentando o processo de experimentação. No primeiro semestre de 2016, foram avaliados 74 arrastos, com 3 pescadores, cada um com embarcações e potências de motor, portas e sistemas de rede diferentes entre si. Foram analisados sete dispositivos diferentes. Aparentemente, a Grelha é o dispositivo com maior tendência à redução da fauna acompanhante e ao melhor rendimento da pescaria de camarão sete barbas. não havendo entretanto diferenças estatisticamente significativas entre os dispositivos (Kruskal-Walis, $p<0,05$), o que aponta para a necessidade de um maior número de amostragens, incluindo o controle de novas adaptações, as quais vêm propostas pelos pescadores. Os principais resultados obtidos não são os resultados que venham a indicar esta ou aquela tecnologia adequada, mas sim o envolvimento dos pescadores nas ações de pesquisa e monitoramento, especialmente em função de adaptações da gestão e do ordenamento pesqueiro a partir deste envolvimento.

Polinizadores de *Lychnophora ericoides* Mart . em Unidades de Conservação do Distrito Federal

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A polinização é um mecanismo essencial para a manutenção da biodiversidade e imprescindível para a propagação de muitas espécies. O conhecimento sobre o sistema de polinização de espécies endêmicas é fundamental, especialmente quando as mesmas encontram-se distribuídas em populações fragmentadas. Populações pequenas de espécies polinizadas por animais tendem a ser menos atraentes aos polinizadores, contribuindo para a limitação da produção de frutos e consequente diminuição do tamanho da população. *Lychnophora ericoides* Mart é um arbusto endêmico do Brasil, conhecida popularmente como arnica, e alvo de extrativismo devido ao interesse de populações humanas pelas propriedades medicinais de suas folhas e de seus ramos. Acredita-se que as populações de *L. ericoides* estejam se tornando mais escarssas provavelmente como resultado da fragmentação de seus habitats, de práticas de extrativismo predatório e de distúrbios. O objetivo do estudo foi identificar os visitantes florais de uma população remanescente de *L. ericoides* numa área de campo sujo situada na Estação Ecológica do Jardim Botânico de Brasília- ESEC-JBB. Para

determinar a comunidade de visitantes e a taxa de visitação das flores um censo foi realizado em dezembro, janeiro e fevereiro de 2016, de 9:00–12:00, quando as flores abriram, até as 15:00, quando as atividades dos visitantes florais despareceram. O censo consistiu de 30 minutos para cada ramo de flores onde foram registrados o número de flores abertas observadas e visitadas por cada visitante. Os visitantes foram coletados e inseridos num tubo de ensaio com gel fuchsin para posterior identificação em laboratório. Foram identificados 12 visitantes florais pertencentes às seguintes ordens de insetos: Diptera (*Anthrax pluto* Wiedemann), Lepidoptera (1 sp), Hymenoptera (*Bombus atratus Franklin*, *Centris* sp, *Euglossia* sp, Megachilidae, *Vespula vulgaris* Linnaeus e 5 espécies de formiga). As observações realizadas indicam uma redução no número de visitantes florais quando comparadas com outro trabalho desenvolvido no DF, podendo estar relacionado com o histórico de fragmentação dos seus habitats preferenciais. Assim, estudos futuros que possam avaliar o efeito da fragmentação sobre a rede de polinizadores de *L. ericoides* na ESEC-JBB poderá contribuir para a adoção de estratégias de manejo da espécie. Abelhas do gênero *Bombus atratus* foi o polinizador efetivo de *L. ericoides*, estando de acordo com o indicado em outros estudos. As formigas são visitantes que permanecem nas flores de *L. ericoides* com alta freqüência. Formigas frequentemente visitam flores de várias plantas, mas raramente têm sido documentadas como polinizadores efetivos. Certas plantas possuem barreiras estruturais e repelentes químicos que ajudam a restringir visitas florais por formigas, fornecendo evidências que esses insetos podem reduzir o sucesso reprodutivo. Estudos futuros devem ser desenvolvidos visando ao entendimento da função das formigas e dos polinizadores no sucesso reprodutivo de *L. ericoides*. Esse estudo consiste também numa base para o monitoramento da população de *L. ericoides*, o qual nos permitirá fazer comparações com outras áreas estudadas e identificar os mecanismos responsáveis pelas mudanças ocorridas em longo prazo no sistema reprodutivo de *L. ericoides*. Considerando os resultados apresentados aqui recomendamos também aos gestores da ESEC-JBB que sejam intensificadas as ações de fiscalização no local de ocorrência de *L. ericoides* visando a aumentar a proteção e a redução do risco de extinção de sua população remanescente no DF.

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Potencial de comercialização de créditos de carbono através de projetos de REDD++ das Zonas Primitivas e de Preservação da Floresta Nacional do Amana

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Estima se que a Floresta Amazônica já tenha perdido mais de 20% de sua cobertura florestal original, e mesmo com reconhecida importância para regulação do clima mundial, ela possui um dos maiores ritmos de destruição entre as florestas tropicais do mundo. A queima dessas áreas desmatadas têm sido a principal fonte de emissão de CO2 para atmosfera, atribuída ao Brasil. Uma estratégia utilizada para diminuir o desmatamento e queimadas, tem sido a comercialização dos créditos de carbono, através do Mecanismo de Redução de Emissão de Gases nocivos ao efeito estufa, por meio de projetos de desmatamento evitado, conhecidos como Redução de Emissão pelo Desmatamento e Degradação (REED++). A utilização de mecanismos de REDD++ deve ocorrer atrelada à valorização da floresta em pé, de forma a coibir as atividades ligadas ao desmatamento, proporcionar o desenvolvimento de atividades sustentáveis e a melhoria da qualidade de vida para as populações que dependem diretamente dos recursos da floresta. A Floresta Nacional do Amana (FNA), criada em 2006, está inserida no Distrito Florestal Sustentável BR-163, numa das regiões que mais sofrem pressão de desmatamento da Amazônia e com menor índice de desenvolvimento

humano do Estado do Pará, onde alternativas sustentáveis podem viabilizar a melhoraria na qualidade de vida da região. No zoneamento da FNA, além de áreas destinada ao manejo florestal, existem áreas voltadas à preservação de regiões estratégicas para a conservação e mais bem preservadas, que são as Zonas de Preservação e Primitivas, somando uma área 111.171 ha. Para simular o cálculo do potencial de comercialização de carbono da Flona do Amana, utilizou-se como linha de base, o histórico de desmatamento ocorrido no Estado do Pará no período de 1988 a 2013. Para o cálculo do carbono retido na biomassa da vegetação viva acima do solo, foram utilizados os dados do inventário realizado para a estimativa do volume de madeira, levantados para subsidiar o Plano de Manejo e o Edital de Concessão Florestal. Foram levantadas 88 parcelas de 0,25 hectares, distribuídas de forma inteiramente aleatória, dispostas em cruz de malta no sistema de conglomerado de amostragem da vegetação. Para a estimativa da biomassa fresca foi utilizada equação não linear, de simples entrada PF=a*dap^b; PF: peso fresco; a: 3.049; b: 1.852; dap: diâmetro a altura do peito (cm), cujos parâmetros estatísticos da equação são R2 ajustado:0,82; EPR (%): 5,38. Para o calculo de peso seco foi utilizado o valor de teor de água de 41,6%, para teor de carbono (C) foi utilizado o valor de 48,55, e para transformação em CO2-eq, utilizou a constante de 3,66. Foi encontrado o valor de 486 t.ha-1 de biomassa fresca, que depois de transformado em peso seco, retirado apenas o teor de C da vegetação, resultou em um valor de 138 t.ha-1 de C por hectare. Considerando que as áreas sem desmatamento das Zonas Primitivas e de Preservação juntas somas 111.171 ha e que num cenário sem o projeto as áreas desmatadas nessas áreas somariam 57.330 ha; considerando o cenário de governança do projeto, onde essa área será preservada; considerando uma cotação de US$ 6,00 (seis dólares norte-americanos) por tonelada de CO2 evitado; a área tem potencial de geração de 28.894,32 t de CO2-equivalente evitado, podendo gerar uma receita de U$173.365.920,00. Embora ainda não tenham sido realizados estudos e pesquisas que mensurem/quantifiquem os outros depósitos de carbono importantes do ecossistema florestal que são o solo e a matéria morta acima do solo, a FNA apresentou potencial de carbono para ser inserida em projetos de REDD++.

PIBIC ICMBio INSTITUTO CHICO MENDES MMA

Potencial Ecoturístico da Região Serrana Catarinense para a prática de observação de aves

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A prática de observação de aves vem crescendo no mundo e no Brasil nos últimos anos. É uma prática de baixo impacto ambiental, e que estimula a economia e comércios locais e específicos. Além disso, pode ajudar em uma maior preservação do local, aumentando a frequência de visitação deste, sendo interessante para Parques e áreas naturais. O Parque Nacional de São Joaquim tem sua visitação permitida por portaria do ICMBio, estando aberto à população somente o Morro da Igreja, mediante autorização. Foi aplicado aos visitantes do parque um questionário (n=100) acerca do interesse destes para com as aves do parque, e suas experiências com a prática de observação. A maioria dos entrevistados (67%) visitava o parque pela primeira vez e afirmaram não haverem visto animais no parque (68%). Apesar disso, 79% mostraram-se interessado em conhecer melhor as aves, e 48% estaria interessado em uma trilha especifica para tal atividade. Para os já praticantes da observação de aves, 60% estaria interessado em boas fotografias, sendo este o principal motivo da prática. A região serrana, em especial Urubici, possui forte atrativo turístico, principalmente durante o inverno. A prática de observação de aves mostrou-se um ótimo complemento ao turismo de alta temporada em outras regiões, e poderia ser aplicada da mesma maneira em Urubici, visto que a melhor época para se observar aves é durante a estação reprodutiva, na primavera e verão, baixa temporada turística na serra.

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Potencial impacto das mudanças climáticas sobre a conservação de onze espécies de mamíferos arborícolas ameaçados da Mata Atlântica Central, Brasil

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Mudanças climáticas globais causadas principalmente pelas altas taxas de emissão de gases do efeito estufa (GEE) estão entre as principais ameaças à biodiversidade. Modelos empírico-estatísticos, através de uma abordagem correlativa, permitem prever espacialmente a potencial distribuição e adequabilidade climática presente e futura para uma dada espécie utilizando dados atuais de conhecida ocorrência. No presente trabalho objetivamos estimar a sensibilidade climática e os potenciais impactos que as mudanças climáticas podem exercer sobre a distribuição de 11 espécies de mamíferos arborícolas ameaçados de extinção e endêmicos da porção central da Mata Atlântica (refúgio Bahia), incluindo oito primatas (*Brachyteles hypoxanthus, Callicebus coimbrai, Callicebus melanochir, Callicebus personatus, Callithrix flaviceps, Leontopithecus chrysomelas* e *Sapajus robustus*), três roedores (*Chaetomys subspinosus, Rhagomys rufences, Trinomys paratus*) e um xenarthra (*Bradypus torquatus*). Para as análises foi utilizado o algoritmo MAXENT, 8 oito variáveis climáticas e uma topográfica. Além de modelos de distribuição potencial atual (presente), foram gerados modelos para dois tempos futuros (2050 e 2070) e dois cenários de evolução das taxas de emissão de GEE (RCP4.5; RCP8.5) com base na combinação de 13 modelos climáticos globais. Maior redução foi prevista ocorrer na área climaticamente adequada (potencial área de ocorrência) de *Leontopithecus chrysomelas* (-77 a -94%), seguida de *Rhagomys rufescens* (-52 a -76%), *Brachyteles hypoxanthus* (-43 a -64%), *Callicebus personatus* (-36 a -57%), *Sapajus robustus* (-30 a -50%), e *Callicebus melanochir* (-6 a -11%). A depender do cenário, tanto redução (-18 a -26%) como aumento (+36%) no espaço climaticamente adequado de *Trinomys paratus* foi previsto, refletindo incertezas sobre a direção deste potencial impacto. Para as demais espécies avaliadas (*Callithrix flaviceps, Chaetomys subspinosus, Bradypus torquatus, Callicebus coimbrai*) foi previsto aumento na área climaticamente adequada em todos os cenários, portando sendo esta ameaça menos preocupante. Por outro lado, sobre o pressuposto de nenhuma capacidade de dispersão destas espécies, o impacto pode ser negativo e mais intenso. Nós concluímos que o aquecimento global é uma ameaça que tem potencial de reduzir expressivamente (≥50%) a área de ocorrência de cinco das espécies estudadas e alertamos que esta importante ameaça deve ser considerada durante o planejamento, avaliação e execução de estratégias de conservação para estas.

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Presença de sagui-da-serra-escuro (*Callithrix aurita*) e saguis invasores na Trilha Uricanal, Parque Nacional da Serra dos Órgãos

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O sagui-da-serra-escuro (*Callithrix aurita*) é um pequeno primata ameaçado de extinção. As principais ameaças são a competição e hibridização com os saguis invasores *Callithrix jacchus*

e *C. penicillata*. Pesquisas anteriores indicam que *C. aurita* tem uma distribuição bastante restrita no interior do Parque Nacional da Serra dos Órgãos, localizada em duas trilhas no município de Petrópolis – as trilhas do Açu e Uricanal. Na trilha Uricanal, em 2014, foram identificados dois grupos de saguis: um grupo puro de *C. aurita*, com 3 indivíduos; e um grupo composto por um *C. penicillata*, um *C. aurita* e dois híbridos. A proximidade entre indivíduos aurita puros e espécies invasoras é preocupante para a conservação da espécie ameaçada. Esse trabalho tem como objetivo fazer a observação dos animais na trilha Uricanal, verificando se são dois grupos e se há contato entre eles. Entre maio de 2015 e junho de 2016, 9 pontos fixos na trilha foram monitorados com o uso de playback. Entre maio e novembro de 2015, os saguis foram encontrados em 100% das idas a campo, sempre na extremidade da trilha próxima ao bairro Caxambu, onde há residências próximas. Foram avistados entre 2 e 6 animais, no que aparentava ser um único e grande grupo misto com indivíduos de fenótipo híbrido e *C. jacchus* diferentemente do que havia sido registrado anteriormente. O fato de não terem sido avistados saguis com fenótipo aurita puro; do número máximo de indivíduos avistados ser menor que a soma dos dois grupos; e do fato do grupo misto ter sido avistado em mais pontos na trilha do que em 2015 levam a supor que o grupo misto deslocou o grupo aurita puro para outra região. Em cinco expedições realizadas a partir de abril de 2016 não foram mais avistados saguis em nenhum ponto da trilha. É possível que o grupo tenha deslocado sua área de vida devido a mudanças sazonais na disponibilidade de recursos. Os resultados indicam como a dinâmica dos grupos de saguis é variável ao longo do tempo, sendo importante o monitoramento frequente dos grupos. A continuidade do monitoramento na trilha Uricanal permitirá observar se algum dos grupos volta a ocupar esta área. Ficou clara também a ameaça representada pelos invasores, com a ocupação da área de vida do grupo aurita puro pelo grupo misto.

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Primatas do Parque Nacional da Serra do Pardo – Pará

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São esperados para o Brasil cerca de 150 táxons de primatas, aproximadamente 60% destes são endêmicos e 35 já estão elencados na Lista Nacional Oficial de Espécies da Fauna Ameaçada de Extinção (Portaria MMA 444/2014). Com cerca de 20% das espécies de primatas do mundo, a Amazônia brasileira,em particular, abriga 16 táxons ameaçados de extinção em nível nacional, sete quase ameaçados (NT) e 12 categorizados como dados insuficientes (DD).A crescente pressão sobre a região Amazônica, com números de áreas desmatadas cada vez maiores e inúmeros projetos de infraestrutura (hidrelétricas, rodovias), constitui um risco a sobrevivência das populações de primatas. As unidades de conservação presentes na região são importantes refúgios que poderão garantir a continuidade dessas espécies no espaço e no tempo. Visando contribuir para o conhecimento da distribuição, abundância e identificação de fatores de ameaças na região do Arco do Desmatamento, em especial para com as espécies ameaçadas e com dados insuficientes,em 2015 foi realizada uma expedição ao Parque Nacional (PARNA) da Serra do Pardo. Este PARNA com pouco mais de 10 anos e com 445,4 mil hectares, localiza-se na chamada Terra do Meio, no sul do estado do Pará. O levantamento de dados foi realizado por busca ativa (visualizações) em interior de floresta e em florestas ciliares enquanto embarcados, entrevistas com a população da região e coleta de indivíduos. A unidade apresenta cobertura florestal primitiva em quase sua totalidade, contudo está sujeita ao uso humano não regrado por populações ribeirinhas e indígenas vizinhas.

A coleta de dados ocorreu entre 16/11 a 03/12/2015. No PARNA Serra do Pardo, em 180 homens/hora de campo, foram realizados 18 registros de seis espécies de primatas, a saber, *Sapajus apella*, *Alouatta* cf. *discolor*, *Aotus* cf. *infulatus*, *Saimiri* sp., *Ateles marginatus* e *Callicebus vieirai* ,as duas últimas categorizadas como VU e DD, respectivamente. Indivíduos de Callicebus foram coletados e tombados no MPEG, a fim de confirmar sua identificação, o que resultou na primeira localidade registrada para a *C. vieirai* após a publicação da descrição da espécie. Dentre aos táxons esperados para a região, não foram observados Callitriquídeos, nem o *Chiropotes albinasus*, contudo, algumas poucas entrevistas apontam que estes poderiam ser encontrados no limite oeste do parque. De modo surpreendente Ateles e Alouatta, gêneros notoriamente cinegéticos, são comuns, mesmo nas áreas de fácil acesso, o que leva a supor que a caça voltada a primatas ainda não seja uma atividade preocupante.

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Reservas Extrativistas Marinhas no Pará e oportunidades sociais para comunidades tradicionais

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O estudo faz um cotejo entre os efeitos da mudança climática e a criação de Reservas Extrativistas Marinhas – REMs - no Estado do Pará e a interação entre instituições e atores sociais para viabilizar oportunidades sociais para as comunidades tradicionais. O método da pesquisa foi o estudo de caso múltiplo, via análise interdisciplinar qualitativa dos dados obtidos com pesquisa documental, visitas exploratórias, entrevistas semiestruturadas e grupos focais. Os resultados da análise revelaram que a implementação de políticas públicas de proteção ambiental, tais como a criação das REMs e o reconhecimento e fortalecimento das formas nativas de uso dos recursos naturais geram oportunidades sociais para as comunidades tradicionais inseridas nessas unidades. As comunidades tradicionais reconheceram que impactos ambientais foram minimizados em REMs paraenses. Nos anos de 2013-2014, 87% das lideranças entrevistadas na REM de Curuçá/PA reconheciam que houve benefícios para o município com a criação da REM Mãe Grande de Curuçá em 2002. Os indicadores utilizados para dar objetividade aos resultados da pesquisa foram o Índice de Desenvolvimento Humano – IDH e o Índice de Gini. Este último é o instrumento usado para medir o grau de concentração de renda num determinado grupo, apontando a diferença entre os rendimentos dos mais pobres e dos mais ricos (PNUD, 2013). Nos dez primeiros anos da criação da REM Mãe Grande, o IDH aumentou no Município de Curuçá e a desigualdade social diminuiu. Em dezembro de 2015, lideranças comunitárias na REM em São Caetano de Odivelas estavam otimistas com a recém criação da REM Mocapajuba nesse município, em que pesem as diversas dificuldades estruturais para efetivação das normas ambientais nas duas unidades. Os dois municípios estudados têm a população rural superior à urbana (IBGE, 2012). Nesses municípios o IDHM está abaixo da média nacional. De 2000 a 2010, a desigualdade social em São Caetano de Odivelas continuou aumentando, enquanto houve diminuição em Curuçá. Esse dado agrega informação à análise, se avaliado em conjunto com outros fatores como inserção das comunidades em programas sociais, políticas de incentivo ao empreendedorismo, entre outros. O ICMBIO atestou, em 2014, que em Curuçá eram implementadas as seguintes políticas: o Plano Nacional de Habitação Rural, Bolsa Verde do Plano Brasil sem Miséria, Assistência Técnica e Extensão Rural e Pesqueira para as Populações Tradicionais (ATER) e Projeto Manguezais do Brasil. O INCRA informou, em 2013, que 2000 pessoas em Curuçá foram beneficiadas com a implementação de projeto de reforma agrária. Não existiam, até 2014, beneficiários desse projeto em São Caetano de

Odivelas, área adjacente à Curuçá, ainda estava excluída dessas políticas públicas. Onde há REM a gestão compartilhada, via Conselho Gestor, viabiliza a elaboração e implementação de políticas públicas com a participação da comunidade, o que gera mais oportunidades sociais. Estudos mostram que, para mitigar o risco das alterações climáticas, é imprescindível uma governança reflexiva baseada na comunicação e na percepção do risco, assim como na participação efetiva do público na tomada de decisões (SZLAFSZTEIN, 2014; RICE et al., 2012). As REMs do Pará também constituem espaços de discussão e implementação de cogestão na governança dos ecossistemas manguezais, os quais, além de proporcionar oportunidade significativas para adaptação e mitigação dos efeitos de mudança climáticas, oferecem suporte de meios de subsistência e segurança alimentar para população costeira.

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Respostas inflamatórias e hematológicas de *A. altiparanae*

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O quimerismo é considerado a técnica biotecnológica mais promissora para a preservação de estoques naturais de peixes e manutenção de bancos genéticos, e consiste no transplante de células embrionárias de um embrião doador (de uma espécie ameaçada) e para um embrião receptor (de uma espécie não ameaçada, de fácil manejo reprodutivo e bem adaptada a cativeiro). Isso resulta no desenvolvimento de gônadas produtoras de gametas (espermatozoides e óvulos) do embrião doador no organismo receptor, possibilitando a propagação da espécie doadora sem qualquer contaminação genética. Mas isto de nada se a espécie escolhida como receptora não for capaz de resistir ao estresse e às doenças,podendo levar à perda de anos de trabalho. Apesar de *A. altiparanae* apresentar grande potencial para o quimerismo, do ponto de vista sanitário, pouco se sabe sobre a espécie.A determinação de parâmetros imunológicos e hematológicos caracteriza o primeiro passo em direção ao entendimento da saúde de uma espécie e o presente resumo tem como objetivo apresentar os resultados iniciais de nossa pesquisa sobre a saúde de *A. altiparanae*. Este trabalho, realizado no Centro de Pesquisa e Conservação da Biodiversidade Aquática Continental (CEPTA/ICMBio), avaliou o melhor tempo para a determinação dos parâmetros fagocíticos (englobamento de partículas estranhas realizado por células de defesa) em A. altiparanae, assim como suas respostas hematológicas e hematopoiéticas (produção de células sanguíneas pelo rim cranial) frente a um indutor inflamatório. Para isto, setenta e dois exemplares de *A. altiparanae* foram e injetados na cavidade abdominal com 0,1 mL de solução contendo 2,5 x 106 leveduras. μL-1 com o objetivo de simular uma possível invasão por um patógeno ao organismo do peixe. Após 1, 2, 3 e 6 horas pós-injeção os animais tiveram o sangue colhido para realização do hemograma, e foram avaliados os parâmetros fagocíticos e o ciclo celular do rim cranial por citometria de fluxo. Os dados analisados através de ANOVA sucedido por teste de Tukey. A capacidade fagocítica foi de 14.18% em1hpi, aumentando para 29.45 ± 6.31% em 2 hpi e se mantendo em 20.65 ± 4.07 e 21.60 ± 5.07% em 3 e 6, respectivamente. O oposto foi observado na análise de ciclo celular do rim cranial, com 5.01 ± 0.67% de células com conteúdo de DNA 4C em 1hpi, decaindo para 1.82 ± 0.35% em 2hpi e aumentando novamente para 4.31 ± 0.88 e 4.02 ± 0.83% em 3 e 6

hpi, respectivamente. A média de trombócitos (células responsáveis pela coagulação e fagocitose) diminuiu de acordo com o tempo. O número de pequenos linfócitos foi o mesmo em 1 e 2 hpi mas começou a diminuir em 3 hpi, chegando em seus menores níveis em 6 hpi. O número de grandes linfócitos também foram maiores em 1hpi, declinando em 2, 3 e 6 hpi. Por outro lado, o número de monócitos, assim como o número de monócitos ativados e neutrófilos, também aumentou. Em conclusão, o melhor tempo para estudo da fagocitose em *A. altiparanae* foi em 2hpi, quando os peixes apresentaram a maior capacidade fagocítica. Também em 2hpi detectamos uma aceleração da mitose no rim cranial, o que, junto com o aumento de monócitos e neutrófilos, caracteriza uma aceleração da mitose para inserção de células de defesa na corrente sanguínea. Em adição, o presente estudo apresenta os primeiros dados sobre as repostas inflamatórias desta espécie, e servirá como sustentação para futuras avaliações como desafio experimental frente a patógenos (bactérias e protozoários) e respostas imunológicas de rejeição após transplante embrionário em animais adultos.

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Rios voadores e mudanças climáticas: a importância dos serviços ambientais prestados pela Floresta Amazônica

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Para muitos, falar de fenômenos meteorológicos é algo distante da realidade. Porém, com o aquecimento global e as mudanças climáticas que ameaçam alterar regimes de chuva em escala mundial, é hora de analisarmos melhor os serviços ambientais prestados pela Floresta Amazônica antes que seja tarde demais, principalmente no que diz respeito a crise de água e falta de chuvas que vem ocorrendo no Brasil. Esse estudo refere-se a uma experiência pedagógica socioambiental de divulgação científica dos conceitos do fenômeno meteorológico dos Rios Voadores. Sabe-se que os Rios Voadores são cursos de água atmosféricos, feitos de vapor de água vindo da Amazônia e empurrados pelo vento, que trazem para o Centro-Oeste, Sudeste e Sul a umidade que foi devolvida à atmosfera pelas árvores da floresta. Diante disso, esse estudo uniu o conceito desse fenômeno com o entendimento das interações dos componentes do sistema natural com os sistemas humanos. Dessa forma, por meio do Projeto Rios Voadores, foram utilizadas ações de educação ambiental, oficinas para professores e eventos ambiental, fazendo com que as informações e as descobertas dos pesquisadores sobre o assunto cheguem a população brasileira, utilizando uma linguagem de fácil entendimento e recursos didáticos apropriados. Além da compreensão do fenômeno Rios Voadores, o ser humano foi levado a uma reflexão da sua relação com o seu ambiente natural, percebendo as consequências da ação do homem no mundo e as mudanças ambientais que estão ocorrendo. Foram realizadas nessa experiência pedagógica 17 oficinas de capacitação docente, em 6 cidades distintas, das regiões norte e centro-oeste e 16 eventos socioambientais com a temática Rios Voadores em 09 localidades, das regiões centro-oeste, sul, sudeste e norte. O Projeto Rios Voadores possibilitou a interação das pessoas que moram tanta na zona urbana, como na floresta, perceberem que as árvores fornecem uma grande gama de serviços ambientais gratuitos como: sequestro de carbono, sombra, embelezamento, controle de erosão, fertilidade do solo, alimentação, madeira. Sem árvores a vida humana seria insustentável. Estudos promovidos pelo INPA – Instituto Nacional de Pesquisas Espaciais - já mostraram que uma árvore com copa de 10 metros de diâmetro é capaz de bombear para a atmosfera mais de 300 litros de água, em forma de vapor, em um único dia – ou seja, mais que o dobro da água que um brasileiro usa diariamente. Uma árvore maior, com copa de 20 metros de diâmetro, por exemplo, pode evapotranspirar bem mais de 1.000 litros por dia. Estima-se que haja 600 bilhões de árvores na Amazônia: imagine então quanta água a floresta toda está bombeando a cada 24 horas. Diante disso, as pessoas que tiveram acesso a essas informações tiveram uma maior

aprofundamento de forma mais consciente a relação do fenômeno Rios Voadores e as mudanças ambientais produzidas pelas atividades humanas, e de suas consequências para a vida no planeta, como principais características do mundo moderno.

Agradecimentos à Margi Moss e Gérard Moss que coordenaram o Projeto Rios Voadores e a empresa Brasil das Águas.

Saberes acadêmico e tradicional na identificação e definição de prioridades para conservação de espécies da flora nativa com uso comercial de produtos não madeireiros na Chapada do Araripe, Caatinga, nordeste do Brasil

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A Caatinga e a chapada do Araripe abrigam populações extrativistas que utilizam a flora nativa para consumo próprio e geração de renda. É bastante conhecido o potencial para geração de energia a partir de espécies da flora nativa exploradas para produção de lenha e carvão. No entanto, não existem levantamentos sistemáticos sobre quais espécies florestais oferecem produtos não madeireiros a estas populações e menos ainda sobre quais destas geram produtos comercializáveis. Os principais objetivos deste trabalho foram identificar as plantas nativas que geram produtos não madeireiros de uso comercial (PNMC) para as populações extrativistas da chapada do Araripe e classificá-las segundo o uso e atual estado das suas populações para verificar prioridades de ação para sua conservação. O método empregado baseou-se em princípios da etnobotânica e técnicas de Diagnóstico Rápido Participativo. No ano de 2014 foi elaborada uma lista inicial de plantas nativas geradoras de PNMC que foi aperfeiçoada com revisão bibliográfica e em três (3) reuniões das Câmaras Técnicas Setoriais do Conselho da APA Chapada do Araripe realizadas nos estados do Ceará, Pernambuco e Piauí. Esta lista foi submetida a técnicos, pesquisadores e extrativistas em reuniões denominadas I° e II° Encontro de Saberes do Uso Popular da Flora Nativa da Chapada do Araripe onde foi complementada. Foram indicadas as plantas com necessidade de controle segundo a percepção dos presentes. Todas as plantas indicadas foram classificadas segundo quatro (4) aspectos, dois para identificar pressão de uso e dois para levantar a situação das suas populações. Cada aspecto com três possíveis categorias recebendo uma nota de 1 a 3, de forma que aquelas que atingissem doze (12) pontos teriam a nota máxima para definição de prioridades de ação para conservação. Para classificação da situação nacional das plantas quanto ao estado de conservação foram utilizadas a lista oficial brasileira de espécies da flora ameaçadas de extinção vigente à época e o Livro Vermelho da Flora do Brasil publicado pelo Jardim Botânico do Rio de Janeiro. Convencionou-se que plantas com pontuação necessitariam de ações para conservação. Foram listadas 173 espécies da flora nativa com PNMC, sendo 52 com necessidade de ações para conservação. Segundo os critérios aplicados obteve-se uma lista de 35 espécies com necessidade de aperfeiçoamento no manejo e outra com 25 espécies que necessitam de esforços para recuperação da população, sendo 22 espécies comuns às duas listas. Segundo este método as plantas em situação mais crítica são aroeira (*Myracrodruon urundeuva*, Anacardiaceae), fava-d'anta (*Dimorphandra gardneriana*, Fabaceae), pequi (*Caryocar coriaceum*, Caryocaraceae) e sucupira-branca (*Pterodon emarginatus*, Fabaceae). Este resultado foi incorporado nos processos autorizativos na APA Chapada do Araripe aumentando a restrição do corte das espécies com problemas nas populações e com a exigência de plantio compensatório quando não

é possível evitar o corte. Para as espécies em estado crítico foram criados grupos de trabalho para propor melhoria no manejo. Foi verificado não existir necessidade de controle de origem (emissão de DOF) para os produtos e subprodutos das espécies listadas.

Saberes da floresta e na floresta – narrativas de crianças ribeirinhas

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A pesquisa de onde emergiu esse trabalho é parte de um estágio de pós-doutorado que vem desenvolvendo no Departamento de Ciências Ambientais da Universidade Federal de São Carlos (UFSCar). A investigação tem como foco visibilizar histórias de infâncias vividas às margens de alguns rios amazônicos articulando-as com os princípios da Educação Ambiental e da Educação Popular. Em nosso entendimento, escutar o que nos têm a dizer algumas crianças ribeirinhas, que vivem suas culturas tradicionais com e na floresta, nos remete à oportunidade de espraiar diferentes cosmovisões que podem nos ensinar distintas perspectivas num mundo multicultural e extremamente diverso. Importante ressaltar que falar de Amazônia requer esforços consideráveis para trazer ao diálogo uma multiplicidade de concepções e entendimentos sobre distintos territórios e espaços ocupados por uma imensa diversidade ambiental, social e cultural, cujas reflexões tendem a apresentar em seus recortes muitos lapsos e lacunas. Como diz o geógrafo Carlos Walter Porto Gonçalves (2008), nessa ampla região tudo é plural. Não se pode falar singularmente de uma Amazônia. Considerando, portanto, essa realidade polissêmica, foi escolhido como lócus da pesquisa a Reserva Extrativista Riozinho do Anfrísio, situada na Terra do Meio, estado do Pará. As populações ribeirinhas dessa região, como na maior parte da Amazônia, conformaram-se socialmente principalmente pela miscigenação entre os povos originários e migrantes do nordeste brasileiro. São pessoas que vivem na floresta e criaram uma forma de vida baseada na produção de quase todas as condições para se manter social, econômica e espiritualmente. A pesquisa de campo foi realizada com aproximadamente 30 crianças com quem a pesquisadora conviveu por aproximadamente quinze dias, escutando suas histórias, observando suas rotinas diárias, coletando imagens, filmagens e desenhos. Em linhas gerais, o que foi analisado até o momento é que a Educação Ambiental e a Educação Popular ocorrem organicamente no cotidiano das crianças. Não existe distinção entre o que se aprende de maneira descolada da natureza e das relações sociais. As escolas locais, no período de coleta de dados, não estavam em funcionamento, portanto, a divisão social da Educação não se mostrou mais claramente. O saber das crianças despontou como profícuo conteúdo que pode ser apreendido pela educação escolar, pela Educação Ambiental e pela Educação Popular. Acreditamos que investir em formas de Educação Ambiental e Educação Popular é, de certa forma, encontrar maneiras de contribuir para fortalecer populações que assentam suas formas de vida numa relação mais respeitosa com a natureza. E, ao mesmo tempo, aprender com essas pessoas novas formas de partilha e de comunhão em um planeta que não se sustenta sem a participação e conscientização de todos. Como afirma Berta Becker (2005, p. 83): "Se a Amazônia é efetivamente uma região, então há que se substituir a política de ocupação por uma política de consolidação do desenvolvimento. Uma política de ocupação não tem mais cabimento, porque a região já está ocupada. As florestas que restaram devem permanecer com seus habitantes. É necessário articular os diferentes projetos e os diversos interesses e conflitos que incidem na região". Referências Bibliográficas: BECKER, Bertha. Geopolítica da Amazônia. Estudos Avançados, 19 (53), 2005, p. 71- 86; PORTO GONÇALVES, Carlos Walter. Amazônia, Amazônias. 2a. Ed, 1a. Reimpressão. São Paulo: Contexto Editora, 2008.

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Sazonalidade da comunidade de aves dos campos de Santa Bárbara – Parque Nacional de São Joaquim – Urunici, SC, Brasil. – PIBIC

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O Parque Nacional de São Joaquim é o mais antigo Parque Nacional do Estado de Santa Catarina. Sua lista de aves data da década de 90, buscando neste estudo sua atualização. Como aves podem realizar migrações sazonais e interferir na composição da avifauna de uma localidade, o presente estudo buscou conhecer a dinâmica da comunidade de aves do PNSJ nas diferentes estações do ano. As amostragens foram realizadas entre novembro de 2014 e maio de 2016; o que ocorreu nos Campos de Santa Bárbara, uma área com altas altitudes, em quatro parcelas do Módulo 1 do PPBio Mata Atlântica. Dois métodos foram utilizados: Redes de Neblina e Listas de Mackinnon. Ao total, 152 espécies de aves foram amostradas, e juntamente com os dados da lista de 1990 para o PSNJ, foram 184 espécies para o parque e mais 127 como possíveis ocorrências, levantadas por registros da plataforma *online Wikiaves* para as cidades vizinhas ao parque. Houve diferenças entre as espécies que compõe a comunidade de aves, e a abundância destas ao longo do ano. Espécies como *Knipolegus cyanirostris* e *Elaenia mesoleuca* foram abundantes na estação reprodutiva e depois não foram mais avistadas. Já *Poospiza cabanisi* e *Myiothlypis leucoblephara* estavam presentes o ano todo. De formal geral, houve uma maior similaridade entre a composição da avifauna entre os meses mais quentes (verão e primavera) e entre os meses mais frios (outono e inverno). Dados referentes à reprodução: placas de incubação e protuberância cloacal foram observadas somente na primavera, e dados de mudas principalmente no verão. Concluímos que a comunidade de aves é muito rica e varia ao longo do ano; e outros fatores, como clima, temperatura e detectabilidade também influenciam sua composição.

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Scinax melloi (Peixoto, 1989): desconhecida da ciência, prioritária para a gestão ambiental

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O conhecimento aplicado ao manejo tem importância crescente na gestão de áreas naturais protegidas. Isto se deve ao volume de informações produzidas atualmente, que pode ser aplicado nestas regiões. Selecionar as pesquisas aplicadas é urgente uma vez que as ações humanas promovem impactos diversificados, crescentes e amplamente distribuídos. O Parque Nacional da Serra dos Órgãos/RJ (PARNASO) aparece como área importante para a conservação em diversos instrumentos aplicados à gestão ambiental (ex: Áreas Prioritárias para a Conservação; Key Biodiversity Areas; Hotspots; Alliance for Zero Extinction etc.) e vem sendo, na última década, uma das UC com mais pesquisas científicas no país. A maior parte dos trabalhos produzidos (em volume e qualidade) não está diretamente relacionada a potencial aplicação deste conhecimento. Aqui é apresentada uma revisão e os motivos de *Scinax melloi* (Peixoto, 1989), uma espécie bromelígena de anfíbio endêmica ao PARNASO, ser prioritária para a pesquisa aplicada à gestão. Foram analisados 18 documentos (1989-2015): 9 artigos científicos, 1 TCC, 1 dissertação, o Plano de Manejo do PARNASO (PM), 4 documentos do Plano de Ação Nacional para a Conservação da Herpetofauna Ameaçada da

Mata Atlântica da Região Sudeste do Brasil (PAN) e 2 avaliações do estado de conservação (AEC) da espécie (IUCN e ICMBio). Como resultado, apenas o artigo da descrição original e as AEC trazem informações e são focadas na espécie. O PAN não cita *S. melloi* ou PARNASO. As AEC indicam necessidade de pesquisas sobre história de vida, biologia e distribuição da espécie, que se encontra em categoria DD (dados insuficientes para avaliação) em ambas, e sugerem ligações potenciais com a conservação de bromélias e das matas do entorno do PARNASO. O PM indica como pesquisas prioritárias (potencialmente relacionadas à *S. melloi*): estudos de biologia de espécies raras e endêmicas, identificação de indicadores para monitoramento ambiental, estudos sobre espécies com dados insuficientes, efeitos das captações de água sobre anfíbios, efeitos da visitação sobre a fauna e monitoramento dos impactos da visitação. As ações que a gestão da UC deve executar para conservar espécies e outros aspectos da biodiversidade carecem de instrumentos de priorização. *S. melloi* somente tem sido encontrada nas bromélias do entorno da piscina natural da Sede Teresópolis, atrativo mais visitado do Parque, que teve no último ano 217 mil visitantes no total. Assim, esta espécie pode ser um excelente bioindicador para monitorar a pressão da visitação sobre esta área, pois: é alvo do PAN; tem na região da piscina o único local de ocorrência conhecido desde a década de 1950; é de um grupo taxonômico considerado prioritário pelo PM; e seu habitat (bromélias) é um dos focos de impacto (lixo) da localidade. Desta forma, esta análise eleva *S. melloi* ao foco de ação emergencial da gestão do Parque que pode trazer como resultado: a mudança de seu estado de conservação, a descrição da distribuição, reprodução e demografia da espécie, revisão dos procedimentos e normas de uso público a serem adotados na região da piscina, minimizando os impactos da visitação sobre esta espécie tão pouco conhecida e potencialmente ameaçada de extinção. Com o amplo acesso á informação, maturidade da legislação ambiental, produção científica e gerencial (planejamento, normas etc.) do Brasil é impensável fazer gestão de UC dissociada de sólido conhecimento aplicado, pois tomar decisão carece de conhecimento atual de alta qualidade. Esta priorização de S. melloi pela gestão, pode trazer grandes avanços.

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Seleção de habitat de *Panthera onca* (Linnaeus, 1758) em uma paisagem heterogênea no Pantanal sul Mato-grossense

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O estudo sobre a seleção de habitat por carnívoros em paisagens heterogêneas possui uma grande importância visto que para traçar estratégias de conservação de uma espécie é preciso decifrar seus hábitos e entender como estas se relacionam com o espaço. A determinação de como a estrutura da paisagem pode afetar a permeabilidade para uma espécie auxilia na identificação de corredores e barreiras para a mesma. Neste estudo, foi testada a hipótese de que a seleção de habitat por *Panthera onca* estaria relacionada ao tipo de classe de vegetação, havendo preferência não necessariamente por sua maior disponibilidade e sim para o que esta classe oferece de recursos ao indivíduo. Neste estudo utilizamos dados de movimentação de duas fêmeas, monitoradas através de colares GPS por pesquisadores do projeto Onçafari no Pantanal sul-matogrossense (Refúgio Ecológico Caiman). As duas onças foram monitoradas por quatro meses (de abril a agosto) gerando 2248 pontos de

ocorrência para o indivíduo Esperança e 2301 para o indivíduo Nusa. O mapeamento de uso e cobertura da paisagem, realizado pela equipe do Laboratório de Conservação e Ecologia Espacial – LEEC, foi feito através de imagens RapidEye fornecidas pelo CENAP (ICMBio) e imagem Landsat 5 (INPE), sendo então, estabelecidas as classes de paisagem em 6 categorias: Campo Seco/Pasto com Árvores, Campo Seco/Pasto sem Árvores, Campo Úmido com Árvores, Campo Úmido sem Árvores, Água e Floresta. As análises de seleção de habitat foram baseadas na função de seleção de recurso (RSF) e aplicadas para a região da área de vida de cada indivíduo utilizando os pacotes Adehabitat e Survival do R. O tamanho da área de vida para a fêmea Esperança foi de 116.4 km^2 e para Nusa, de 139.3 km^2 (kernel 95%, com largura ajustada para 2 km) e, em ambos os casos, houve seleção de habitat, visto que a frequência de uso das classes diferiu significativamente da disponibilidade das mesmas em suas áreas de vida. A classe "Floresta" foi a mais utilizada pelas onças e era a classe com maior disponibilidade, entretanto, "Campo Úmido sem Árvores" também foi uma classe de cobertura selecionada pelo indivíduo Nusa. Com essas análises, esperamos auxiliar na priorização de áreas e corredores que sejam de relevante importância para a espécie e sua conservação.

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Serviços Ecossistêmicos de Polinização nas Unidades de Conservação no Brasil

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Unidades de Conservação (UCs) são reconhecidas como importantes provedoras de benefícios ao ambiente por contribuir para a regulação climática e hídrica, conservação da biodiversidade, ciclagem de nutrientes, belezas cênicas, entre outros. Entre os serviços ecossistêmicos providos nestas áreas está também a polinização, essencial não apenas para a vegetação natural como também para a reprodução e manutenção da variabilidade genética das culturas agrícolas adjacentes às áreas protegidas. Um importante agente de polinização são as abelhas sem ferrão nativas, pertencentes a tribo Meliponini (Apidae) e que compreende cerca de 60 gêneros distribuídos pelas regiões tropicais e subtropicais do mundo. No Brasil são aproximadamente 240 espécies agrupadas em 52 gêneros que, além de serem valiosas visitantes florais são também produtoras de mel e produtos medicinais e dispersoras de sementes, auxiliando no processo de revegetação. Levantamos informações sobre a riqueza e distribuição de abelhas sem ferrão nas UCs Federais, Estaduais e Municipais. Para isso foram compilados registros de ocorrência dos meliponíneos disponíveis em bases de dados online (GBIF e CRIA'sSpecies Link http://www.splink.cria.org.br) e literatura cientifica. Estas informações foram cruzadas com a base de dados de UCscadastradas no CNUC/MMA, afim de determinar registros de ocorrência de polinizadores dentro dos limites das UCs. Esta base contém 1186 UCs das três esferas de gestão. Foram reunidos 24562 registros de ocorrência de 235 espécies de abelhas e 31 gêneros. Deste total, 2782 registros (11,32%)de 185 espécies estão presentes em UCs e 50 espécies não foram registradas em nenhuma UC. Ao todo 1060 UCs (89,33 %) não possuem registros de ocorrência de abelhas e entre estas 265 (25%) são UCs Federais. Entre as 126 UCs com registro de ocorrência de abelhas (10,67%) 60 são Federais, 63 Estaduais e três municipais.As UCs com maior número de registros são: Estação Ecológica de Maracá (303), APA Margem Esquerda do Rio Negro Setor Aturiá-Apuazinho (275), APA Sistema Cantareira (161) e APA Marimbus/Iraquara (131). As UCs com mais espécies são Estação Ecológica de Maracá (42), APA Margem Esquerda do Rio Negro Setor Aturiá-Apuazinho (32), Reserva Biológica do Rio Trombetas

(31) e RDS Mamirauá (28). Das 185 espécies que ocorrem em UCs, 42% são registradas nas UCs de Proteção Integral e 58% nas UCs de Uso Sustentável. Considerando somente as UCs Federais, são 1323 registros de 159 espécies, com destaque para a riqueza de espécies da ESEC de Maracá (42), REBIO do Rio Trombetas (31) e REBIO Nascentes da Serra do Cachimbo (27), podendo a diversidade biológica encontrada nas UCs refletir, em parte, a conservação desses ambientes e/ou esforço de pesquisa. Entre as espécies apontas em UCs, duas constam na lista de espécies ameaçadas de extinção: Melipona (Michmelia) *rufiventris* Lepeletier, 1836e Melipona (Michmelia) *scutellaris* Latreille, 1811, ambas classificadas como "Em Perigo". A primeira delas ocorre na APA de Upaon-Açu/Miritiba/Alto Preguiças, APA Margem Direita do Rio Negro Setor Paduari-Solimões, PARNA das Sempre Vivas e REBIO do Rio Trombetas; a segunda ocorre na APA Marimbus/Iraquara, APA Piquiri UNA e a REVIS Mata da Usina São José. Este levantamento servirá como subsidio para análises que envolvam informações sobre a distribuição destes importantes prestadores de serviços ecológicos. Além disso, contribuirá nas análises relacionadas tanto à gestão e manejo das Ucs quanto nas que apontem priorizações para criação de novas áreas protegidas. Futuramente tais informações poderão ainda auxiliar na valoração dos serviços ambientais prestados pelas UCs.

Sincronização do tempo de transplante de células embrionárias em duas espécies de siluriformes

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A biotecnologia pode ser empregada na conservação de peixes ameaçados de extinção, e dentre as tecnologias se destaca o quimerismo, que permite que espécies de fácil reprodução como o *Pimelodus maculatus* (mandi) produzam gametas de espécies ameaçadas de extinção e difícil reprodução como o *Pseudopimelodus mangurus* (bagre sapo). Para isso é necessário realizar o transplante de células de embrião para embrião no estágio de blástula (512 a 1024 células). Neste trabalho, verificou-se o desenvolvimento embrionário em duas espécies de siluriformes que são encontradas na bacia do rio Paraná, que são o mandi e o bagre-sapo, em diferentes temperaturas para sincronizar o período de transplante de células germinativas primordiais (PGC). Foram utilizadas três temperaturas para a incubação de embriões de bagre sapo e mandi amarelo (22°C, 26°C e 30°C). Embriões de bagre sapo e mandi amarelo incubados a 22°C levaram 4 horas e 3 h e 30 min, respectivamente, para atingir o estágio de 512 células. Quando incubados a 26°C os embriões de levaram 2h e 30 min e 2 horas, respectivamente, para chegar ao mesmo estágio de 512 células. Na temperatura de 30°C, os embriões levaram 2 h e 15 min e 1h e 30 min, respectivamente, para alcançar o estágio esse estágio. Os resultados obtidos dos diferentes tempos de desenvolvimento até blástula para as duas espécies, em diferentes temperaturas, serão utilizados para acelerar ou retardar o tempo do desenvolvimento embrionário, podendo assim, sincronizar o período do desenvolvimento entre as duas espécies, para o transplante de PGCs.

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Taxocenose de aves da Estação Ecológica Maracá-Jipioca, Amazônia Oriental, Amapá, Brasil

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Os inventários faunísticos são os melhores recursos para o conhecimento, preservação e conservação da biodiversidade, fornecendo a sustentação para a pesquisa aplicada e servindo de base para o entendimento da composição das comunidades biológicas e da evolução entre os grupos. Novos levantamentos na região amazônica são inadiáveis, sendo imprescindíveis planos estratégicos para a sua execução, incluindo análise de metodologias eficientes. Nesta perspectiva, este trabalho teve como objetivo realizar inventários da avifauna em cinco pontos aleatórios na Estação Ecológica Maracá-Jipioca (EEMJ), Amapá, Brasil. A EEMJ é constituída por 2 ilhas costeiras: Ilha Maracá (que se subdivide em ilha de Maracá Norte e Maracá do Sul, divididas pelo igarapé do inferno) e pela ilha de Jipioca. A EEMJ é a única Reserva de Proteção Integral do estado totalmente inserida em ambiente costeiro, a qual apresenta três tipos de paisagens predominantes: mangue, tabocal e teso. Para tanto, foram realizados inventários durante os meses de dezembro de 2015, março e junho de 2016 em cinco pontos aleatórios, sendo dois pontos na ilha Maracá do Norte (conhecidos localmente como Lago da bibi e Andirobal); dois na ilha Maracá do Sul (Jacitara e Ponta sul); e um no Igarapé do inferno, totalizando um registro de 74 espécies, distribuídas em 32 famílias. O Andirobal (47 sp.) e o Igarapé do Inferno (28 sp.) foram os pontos com maior riqueza de espécies. As famílias mais representativas nos cinco pontos amostrais foram Tyrannidae (12 sp.), Ardeidae (6 sp.) e Psittacidae (5 sp.). Dentre as espécies presentes nos inventários, registramos uma espécie que não ocorre para o estado do Amapá, *Anous minutus*. Esta ocorrência é de grande importância para a avifauna local, já que esta espécie só ocorre em ilhas oceânicas. Neste contexto, ressaltamos a importância de atividades de inventários da avifauna na Estação Ecológica Maracá-Jipioca, visto que a real diversidade local ainda está subestimada. Estes dados irão gerar informações fundamentais para traduzir rapidamente o grau de prioridade local, regional e global conferido a Estação Ecológica Maracá-Jipioca em ações locais e representativas de proteção e manejo da Unidade de Conservação.

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Uso do solo, cobertura vegetal e limites da Área de Relevante Interesse Ecológico Capetinga/Taquara (Fazenda Água Limpa, Universidade de Brasília): Subsídios ao manejo e proposta de recategorização

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O Cerrado é o segundo maior bioma brasileiro ocupando 23% do território nacional (IBGE, 2004). É considerado um dos 34 hotspots da biodiversidade mundial devido à sua riqueza, quantidade de espécies endêmicas e ao elevado grau de ameaça (Myers et al., 2000). O avanço do agronegócio na região reduziu acentuadamente a cobertura vegetal remanescente (Sano et al., 2009), alterando a paisagem natural e colocando em risco a flora e a fauna regional (Klink & Moreira, 2002). Para garantir a conservação de remanescentes naturais especialmente protegidos, foi instituído o

SNUC (Lei nº 9.985), que estabeleceu alguns critérios e normas para a criação, implantação e gestão das unidades de conservação (UC). Dada a relevância ambiental e social da Área de Relevante Interesse Ecológico (ARIE) Capetinga/Taquara na conservação de valores ambientais relevantes para o Cerrado brasileiro e para população do DF, o objetivo do trabalho foi propor uma recategorização e redelimitação dessa UC. Metodologia: A proposta de criação de UC foi dividida em quatro partes: (1) proposta; (2) justificativa da proposta; (3) declaração de significância e (4) memorial descritivo. Obtive os dados a partir de revisões bibliográficas de outros estudos na área e análises de imagens de satélite RapidEye (2013 e 2014). As imagens foram processadas no software ArcGis 10.1 com composição RGB 352, para diferenciar a cobertura vegetal das áreas urbanizadas e degradadas (Datum WGS 1984, UTM Zona 23S). O limite da ARIE Capetinga/Taquara do site do ICMBio foi elaborado sobre imagem-base de qualidade muito inferior à utilizada no presente trabalho. Assim, atualizei o shape usando imagens RapidEye e, a partir desse, delimitei as áreas vizinhas. Resultados: A ARIE Capetinga/Taquara possui área de 2.208,99 ha, sendo que os polígonos Capetinga e Taquara têm 1.601,96 ha e 607,03 ha, respectivamente. A proposta de ampliação é de 519,25 ha, totalizando 2.728,24 ha. A área a ser incorporada à unidade de conservação proposta conecta os dois polígonos. A categoria atual da UC (ARIE) não é efetiva na conservação da biodiversidade (Françoso et al 2015). A proposta de criar um Refúgio de Vida Silvestre (RVS), uma UC de proteção integral, foi baseada na situação fundiária, localização, importância biológica, prioridade de conservação, efetividade da conservação, fiscalização, compensação ambiental e influência da qualidade de vida da população do entorno e reconhecimento da UnB. Assim, o objetivo principal da proposta é tornar essa UC uma área efetivamente preservada, facilitando a elaboração do plano de manejo compatível com as potencialidades do local e sua relevância biológica, gerando uma gestão ativa e uma fiscalização satisfatória. Conclusão: A UnB é uma instituição de renome fortemente respeitada no país e no Exterior. Não é condizente com a reputação da Universidade o fato da Unidade de Conservação gerida pela instituição não possuir Plano de Manejo, um instrumento de gestão obrigatório por Lei (SNUC 2000). Além disso, a Universidade, como instituição que promove a Conservação e a Sustentabilidade, não pode ser conivente com usos conflitantes com os previstos em lei para uma UC com a relevância ecológica da ARIE Capetinga/Taquara. Desta forma, e consciente dessa importância, a proposição de mudança de categoria sinaliza a responsabilidade da UnB com os valores ambientais e sociais, contribuindo de forma relevante para a conservação de um dos hotspots globais de diversidade. A nova categoria representa maior segurança jurídica para a UnB quanto à manutenção da propriedade da terra e representa uma ferramenta para a captação de recursos de compensação ambiental para o investimento em conservação.

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Utilização de mapas temáticos como ferramenta de educação ambiental e participação social em uma pesquisa-ação nas comunidades do Quebra-frascos/Jardim Serrano, entorno do Parque Nacional da Serra dos Órgãos

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A falta de planejamento do uso e ocupação do solo implica em impactos ambientais que podem comprometer seriamente a qualidade dos recursos naturais e a biodiversidade, essenciais ao bem-estar humano, principalmente no entorno das unidades de conservação. A gestão do ambiente nestas áreas requer a participação da sociedade na construção de soluções que minimizem os impactos negativos e promovam os positivos, o que sugere que as instituições gestoras assumam um papel estratégico no apoio à organização social para a gestão ambiental pública. Para tanto, a problemática ambiental deve ser abordada como ela é no mundo real, embutida na complexidade

do meio social e seus diferentes interesses acerca dos usos do ambiente. Assim, o planejamento ambiental deve ter o protagonismo dos grupos sociais envolvidos, prevendo ações que atendam suas expectativas e necessidades e promovam mudanças efetivas na realidade por eles vivida. Para tal, o processo de educação ambiental crítica pode qualificar as ações transformadoras da realidade local. Neste viés, a pesquisa-ação e a cartografia social são metodologias que atendem a tais objetivos, fomentando a participação coletiva, cidadã e ativa na gestão do ambiente. Nestas, os atores sociais participam de forma cooperativa com os pesquisadores na identificação das causas, consequências e possíveis soluções dos problemas e conflitos socioambientais que vivenciam. Assim, este trabalho tem por objetivo a formação de um Sistema de Informações Geográficas (SIG) e a utilização de mapas temáticos no contexto de uma pesquisa-ação em um bairro do entorno do Parque Nacional da Serra dos Órgãos, no município de Teresópolis/RJ. À medida que os sujeitos envolvidos investigam seu ambiente e território para planejar ações transformadoras da realidade, promove-se a alfabetização cartográfica visando à expressão dos problemas, conflitos e potencialidades socioambientais em mapas. Desta forma, busca-se, a partir de técnicas participativas, a enunciação cartográfica dos temas priorizados pelas comunidades, entendendo-se tais mapas socioambientais produzidos como elementos de poder que potencializam as ações e as lutas sociais dos moradores do bairro Quebra-Frascos e da comunidade do Jardim Serrano pela conservação ecológica e a melhoria da qualidade de vida local no contexto da gestão ambiental pública. O SIG formado possui mais de cem informações qualitativas com diferentes temáticas, as quais foram transformadas e organizadas de forma a facilitar sua utilização pelos diversos atores sociais envolvidos. Além disto, dois grupos de moradores foram iniciados na alfabetização cartográfica, os quais apontaram a necessidade de dois mapas temáticos para expressar e qualificar suas demandas por serviços públicos no território. As metodologias, combinadas à educação ambiental crítica, permitiram o encaminhamento de ações para a melhoria do bairro. As técnicas participativas estimularam a participação nas oficinas e permitiram a identificação das prioridades comunitárias para a proposição das ações. O SIG apoiará as ações da unidade de conservação e dos demais atores sociais envolvidos na área de estudo. Os mapas temáticos se mostraram como ferramenta eficaz para a investigação, para o planejamento ambiental, para a educação ambiental e ainda como uma ferramenta de poder na gestão do território.

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Utilização do geoprocessamento para análise do uso e ocupação do solo no Parque Nacional das Nascentes do Rio Parnaíba

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As ações humanas no meio ambiente com o passar do tempo foram se intensificando e pensando na preservação da biodiversidade foram criadas as Unidade de Conservação (UC) que são áreas definida como um espaço territorial e seus recursos ambientais, incluindo as águas jurisdicionais,

com características naturais relevantes, legalmente instituído pelo Poder Público, com objetivos de conservação e limites definidos, sob regime especial de administração, ao qual se aplicam garantias adequadas de proteção. No estado do Piauí temos uma UC do Parque Nacional das Nascentes do Rio Parnaíba (PARNA), sendo localizado nos platôs da Chapada das Mangabeiras/Serra da Tabatinga o Parque Nacional das Nascentes do Rio Parnaíba (PARNA) foi criado pelo decreto s/n de 16.07.2002, com o principal objetivo de proteger as nascentes do Rio Parnaíba, a segunda maior bacia hidrográfica do nordeste, ameaçada pelo processo de ocupação da área e da utilização desordenada dos seus recursos naturais. O PARNA tem grande abrangência, fazendo parte dos Estados do Maranhão, Bahia, Tocantins e Piauí. As áreas de preservação são alvos de exploração ilegal, e para minimizar os usos destas tem sido utilizado com muita frequência as ferramentas das geotecnologias, que além de ser de fácil acesso o custo é relativamente baixo. A geotecnologia, traz mecanismos fundamentais para o trabalho dos analistas da terra, apresenta os Sistemas de Informações Geográficas (SIG), permitindo realizar análises complexas, ao integrar dados de diversas fontes. Este trabalho teve como objetivo analisar o uso e ocupação do solo do Parque Nacional das Nascentes do Rio Parnaíba, considerando os anos de 2000, 2005, 2010 e 2015.Para isso foram utilizadas as imagens do Satélites LANDSAT 5 e do LANDSAT 8,utilizando técnicas de classificação que permite ter a análise do uso e ocupação do solo. Com a realização deste trabalho pôde-se perceber que há uma ocupação bem elevada. O avanço do uso e ocupação e a permanecia desse uso nos anos analisados foi principalmente decorrente da pastagem e de cultivos nas áreas de platô, ou seja, cultivo nas cerras nas partes mais altas, monocultivos principalmente de grãos. Na área do parque essencialmente foi mais voltada para a pastagem de gado, e destaca-se que os platôs faziam parte anteriormente do parque e que se tornou uma área a margem do mesmo após alteração do território. Como consequência da ocupação pelo uso agrícola e pecuário do PARNA pode ter alterado as condições de microclima, condições de qualidade dos solos e principalmente sobre a biodiversidade, afugentando a fauna e alterando a biodiversidade florística. Quanto a ferramenta constatou-se também que o LANDSAT 5 e o LANDSAT 8 foram significativos na extração de informações da área. Considerando que foi analisado uma área de grande extensão, isso facilita para que a ferramenta seja cada vez mais eficiente. Desse modo, espera-se que este trabalho possa contribuir para que haja um monitoramento mais intensivo nas áreas com maior foco de uso e ocupação.

Variação na composição de herbáceas utilizadas em semeadura direta como estratégia para o controle de gramíneas exóticas invasoras em restauração do Cerrado

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A competição com espécies exóticas invasoras é um importante filtro biótico para o estabelecimento de espécies nativas na restauração de comunidades vegetais. No Brasil, o bioma Cerrado é intensamente degradado para a criação de pastos, formados por gramíneas exóticas africanas, que são invasoras nesse ecossistema, devido à sua grande capacidade competitiva. A competição com essas gramíneas é o principal desafio para o estabelecimento de espécies vegetais nativas na restauração de savanas brasileiras. Para evitar o reestabelecimento das exóticas, o recobrimento inicia do solo por outras herbáceas é uma etapa importante das estratégias de restauração. No Cerrado, a semeadura direta tem sido amplamente aplicada na restauração, e utiliza uma grande densidade de sementes, o que intensifica o recobrimento e facilita o plantio de herbáceas. O objetivo deste trabalho é avaliar três técnicas de semeadura, baseadas em diferentes composições de espécies semeadas, no controle de gramíneas exóticas. No Parque Nacional da Chapada dos Veadeiros (GO, Brasil), a restauração de cerrado em uma área utilizada anteriormente para pasto é realizada desde

2012. Anualmente, as gramíneas exóticas são retiradas e espécies nativas são plantadas. Em uma área de restauração iniciada em 2015, foram estabelecidas 27 parcelas de 20x20m, compondo um experimento com dois fatores: tipo de solo (mal drenado, bem drenado e rochoso) e composição de herbáceas plantadas (gramíneas nativas diversas, *Stylosanthes capitata*, ou *Lepidaploa aurea*), com 3 parcelas para cada combinação de tipo de solo e composição de herbácea. 11 espécies de arbustos e uma de árvore também foram plantadas nas parcelas. Uma amostragem da cobertura vegetal foi realizada em abril de 2016 e outra será feita em abril de 2017. No resultado da primeira amostragem, a cobertura média de gramíneas exóticas foi de 92%, a de gramíneas nativas foi de 564%, a de *S. Capitata* foi de 148%, e a de *L. Aurea* foi de 75%. Não houve diferenças significativas de cobertura de exóticas entre os tratamentos de composição de espécies semeadas. A cobertura de exóticas, nativas e *S. Capitata* foi significativamente menor em solo rochoso. A cobertura de *L. Aurea* foi significativamente menor em solo úmido. Os resultados evidenciam que as três composições têm igual impacto sobre o estabelecimento de gramíneas exóticas, mas o tipo de solo é determinante para o sucesso inicial das exóticas e nativas, o que pode alterar o resultado da competição. Resultados futuros permitirão obter conclusões mais precisas.

Viabilidade e potencial germinativo de sementes para restauração de áreas de Cerrado

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A restauração ecológica é um processo que precisa passar por várias etapas para que se consiga um resultado positivo. Em se tratando disso, algumas características do ambiente são importantes para que esse resultado seja alcançado. Uma dessas características é a existência de um banco de sementes para proporcionar ao ambiente as espécies necessárias para restaurá-lo. E a viabilidade das sementes encontradas nesse banco é de grande importância para a restauração de uma determinada área. O objetivo deste trabalho foi analisar a viabilidade e o potencial germinativo de sementes de espécies do Cerrado de interesse para restauração. No experimento foram utilizadas um total de 32 diferentes espécies, sendo 27 arbóreas/arbustivas e 5 gramíneas,cujas sementes foram coletadas do Parque Nacional da Chapada dos Veadeiros, no ano de 2015. Três amostras de cada uma das espécies foram separadas e pesadas; as amostras de arbóreas/arbustivas tinham 100 sementes cada e de gramíneas, 1000. Além disso, durante a separação das amostras, também foram separadas as sementes vistas como viáveis daquelas que apresentavam imperfeições, tidas como inviáveis. As amostras foram colocadas para germinar em bandejas com terra e eram regadas todos os diaspor um período de 15 semanas e em cada semana era contada a quantidade de sementes que germinaram. De todas as espécies de arbóreas/arbustivas, apenas 5 delas não germinaram durante o experimento. Das outras arbóreas/arbustivas, algumas espécies apresentaram germinação em quase todas as semanas no decorrer do experimento, enquanto outras germinaram em blocos de semanas, sendo eles grupos de duas ou mais semanas consecutivas em que se observou germinação. Já as espécies de gramíneas apresentaram germinação apenas durante as 5 primeiras semanas do experimento, sendo que para 4 espécies contou-se germinação em apenas uma semana e a outra apresentou germinação em duas das semanas. Algumas das espécies tiveram uma grande quantidade de sementes germinando de uma vez, sendo que 12 espécies arbóreas/arbustivas apresentaram 10 ou mais germinações contadas em uma única observação. As outras 10 germinaram em quantidade menor, por vezes tendo sido contada apenas uma germinação por semana. No caso das gramíneas, as germinações, mesmo ocorrendo em um pequeno período, foram contadas em maiores números absolutos. Dos dados obtidos ao final das 15 semanas, podemos observar que nem todas as sementes apresentaram uma viabilidade muito extensa visto que algumas das espécies não germinaram mais a partir da metade do experimento, em especial as gramíneas que só germinaram no primeiro terço do experimento. Podemos observar também que as germinações de algumas espécies se mostraram mais concentradas nas semanas iniciais após serem colocadas para germinar, o que poderia indicar

que essas sementes teriam uma viabilidade menor. Para outras espécies, a germinação foi ocorrendo gradualmente durante as 15 semanas de observação do experimento, o que pode demonstrar que essas sementes teriam uma maior viabilidade.

Videotransecto georreferenciado como ferramenta de monitoramento de ecossistemas recifais no Parque Nacional Marinho e APA de Fernando de Noronha

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Os ecossistemas recifais estão enfrentando o terceiro evento global de branqueamento de corais nos últimos 20 anos. Este é o mais severo e difundido branqueamento em massa registrado, e já atingiu cerca de 38% dos corais do planeta até o fim de 2015. Provavelmente será também o mais duradouro: a previsão é que se estenda por pelo menos mais um ano, associando aquecimento global e El Niño. Neste contexto, o monitoramento de ecossistemas recifais é de extrema importância nas UCs que os protegem. Alertas de branqueamento são emitidos pelo programa Coral Reef Watch da NOAA, que monitora a temperatura da superfície dos oceanos via satélite com resolução de 5km e disponibiliza a informação online diária e gratuitamente. Há 4 níveis de alerta, que indicam a probabilidade de ocorrer branqueamento, dependendo da amplitude da anomalia térmica e de sua duração em semanas. Checagens de campo da extensão e severidade do branqueamento são essenciais para subsidiar decisões de manejo. O branqueamento pode ocorrer em poucas horas ou dias, portanto o monitoramento deve ser constante, especialmente em momentos de alerta. Apesar de geralmente ser uma atividade com logística complexa e de alto custo, em 2016 desenvolvemos em Fernando de Noronha (FN) uma metodologia inovadora para o monitoramento, que é realizado pelos servidores do ICMBio. Sua aplicação vem sendo viabilizada através da parceria com as operadoras locais, o que diminui muito o custo. Monitoramentos costumam ser feitos em estações fixas, mas a metodologia foi adaptada aproveitar operações de mergulho dinâmicas, possibilitando o monitoramento intenso dos pontos mais visitados de FN. Os mergulhos são realizados em dupla: uma pessoa faz a filmagem e a outra o georreferenciamento. Para a filmagem, utilizamos uma câmera de vídeo subaquática acoplada a uma estrutura de cano de PVC em formato de "T". O eixo vertical mantém a câmera a uma distância fixa de 0,60m do eixo horizontal, onde há uma fita métrica. O fundo marinho é filmado, e as imagens contém uma escala de 0,84m. Para o georreferenciamento, um GPS é colocado numa caixa estanque em uma boia. O conjunto é ligado a uma carretilha e é conduzido pelo mergulhador marcando o trajeto da filmagem, possibilitando medir a área percorrida e quantificar cobertura de corais, branqueamento, ocorrência de doenças e outras informações. No primeiro semestre de 2016 a metodologia foi usada em 13 mergulhos em 10 pontos diferentes. Neste período, FN teve 132 dias com alerta nível 1 e 26 dias com alerta nível 2, estes últimos todos no mês de abril. Verificamos início de branqueamento em alguns pontos, com extensão reduzida e baixa severidade. O impacto provavelmente foi minimizado por uma ressurgência de água fria no final do mês de maio. Considerando que cerca de 20 pontos de mergulho são abertos ao uso público, a construção deste banco de imagens georreferenciadas permitirá a comparação dos mesmos locais em curto, médio e longo prazo. O ideal é que o monitoramento seja feito também em áreas fechadas à visitação, para avaliar impactos decorrentes do uso público, como efeitos de protetores solares, que são tóxicos para os corais, ou ainda mortalidade devida ao contato de mergulhadores com estes organismos. O monitoramento com videotransecto georreferenciado, associado a iniciativas de monitoramento que incluam outras áreas e grupos taxonômicos como o programa Reef Check proporcionam uma base de dados essencial para acessar o efeito das mudanças climáticas nos ambientes recifais em FN. Essa iniciativa tem potencial de ser replicada em outras UCs marinhas.

Agradecimentos à Atlantis Divers, Noronha Divers e Águas Claras pela parceria na realização do monitoramento.

Seção III – Trabalhos de Iniciação Científica Premiados

Durante o VIII Seminário de Pesquisa e VIII Encontro de Iniciação Científica do ICMBio ocorreu o encerramento do ciclo PIBIC/ICMBio 2015/2016, com a avaliação final dos trabalhos desenvolvidos pelos estudantes de iniciação científica do programa.

Após a avaliação destes trabalhos na forma de painéis, realizada pelos membros dos Comitês Externo e Interno do PIBICI/CMBio, os oito trabalhos com maior pontuação foram selecionados e apresentados oralmente para todo o público do Seminário, os quais são citados abaixo:

Cristiane Tiemi Bezerra Yoshikawa, com o trabalho "**Investigação quali-quantitativa nos trechos do Jardim Serrano e Quebra Frascos inseridos na zona de amortecimento do PARNASO, Teresópolis/RJ**", sob orientação de Marcus Machado Gomes (Parque Nacional da Serra dos Órgãos/RJ).

Larissa Nayara Lima Silva, com o trabalho "**Dinâmica reprodutiva de *Salminus brasiliensis* (Cuvier, 1816) na área de abrangência da Estação Ecológica de Taiamã e do rio Sepotuba, município de Cáceres/MT**", sob a orientação de Daniel Luis Zanella Kantek (Estação Ecológica de Taiamã/MT).

Marcia Virginia Candido dos Santos, com o trabalho "**Ciência cidadã no Parque Nacional da Serra dos Órgãos: organizando registros de ocorrência de fauna e ampliando a participação social**", sob a orientação de Cecília Cronemberger de Faria (Parque Nacional da Serra dos Órgãos/RJ).

Patrícia Kalaf Alves dos Santos, com o trabalho "**Seleção de habitat de *Panthera onca* (Linnaeus, 1758) em uma paisagem heterogênea no Pantanal sul Mato-grossense**", sob orientação de Silvia Nery Godoy e Ronaldo Gonçalves Morato (Centro nacional de Mamíferos carnívoros – CENAP/SP)

Priscila Campos Santos, com o trabalho "**Áreas de conservação ambiental e seu papel na manutenção da atividade pesqueira: um estudo de caso no entorno da Estação Ecológica de Taiamã, Cáceres, Mato Grosso**", sob a orientação de Daniel Luis Zanella Kantek (Estação Ecológica de Taiamã/MT).

Rodrigo Cesário Pereira Silva, com o trabalho "**Monitoramento de indicadores tecnológicos e de uso de recursos pesqueiros na APA do Anhatomirim/SC e RESEX Pirajubaé/SC, utilizando protocolo SocMon para o apoio à gestão participativa**", sob a orientação de Walter Steenbock (Centro Nacional de Pesquisa e Conservação da Biodiversidade Marinha do Sudeste e do Sul – CEPSUL/SC).

Thomas Abbud do Carmo, com o trabalho "**Caracterização da fauna acompanhante capturada nos experimentos do uso de dispositivos de redução de bycatch (BRD) na APA do Anhatomirim/SC**", sob orientação de Roberta Aguiar dos Santos (Centro Nacional de Pesquisa e Conservação da Biodiversidade Marinha do Sudeste e do Sul – CEPSUL/SC)

Vanessa Sousa Gomes, com o trabalho "**O manejo florestal madeireiro na Resex Tapajós-Arapiuns e a sustentabilidade na execução da atividade por comunidades tradicionais**", sob a orientação de Cleiton Adriano Signor (Reserva Extrativista do Tapajós Arapiuns/PA).

A partir da apresentação oral, os trabalhos foram novamente avaliados e classificados, de acordo com sua relevância para conservação e com o desempenho dos estudantes durante as explanações. Assim, após a nova avaliação, os estudantes que tiveram os três melhores trabalhos formam premiados conforme especificado abaixo:

Primeira colocada:

Patrícia Kalaf Alves dos Santos, com o trabalho **"Seleção de habitat de *Panthera onca* (Linnaeus, 1758) em uma paisagem heterogênea no Pantanal sul Mato-grossense"**, sob orientação de Silvia Nery Godoy e Ronaldo Gonçalves Morato (Centro Nacional de Mamíferos Carnívoros – CENAP/SP)

Segunda colocada:

Marcia Virginia Candido dos Santos, com o trabalho **"Ciência cidadã no Parque Nacional da Serra dos Órgãos: organizando registros de ocorrência de fauna e ampliando a participação social"**, sob orientação de Cecília Cronemberger de Faria (Parque Nacional da Serra dos Órgãos/RJ)

Terceiro colocado:

Thomas Abbud do Carmo, com o trabalho **"Caracterização da fauna acompanhante capturada nos experimentos do uso de dispositivos de redução de bycatch (BRD) na APA do Anhatomirim/SC"**, sob orientação de Roberta Aguiar dos Santos (Centro Nacional de Pesquisa e Conservação da Biodiversidade Marinha do Sudeste e do Sul – CEPSUL/SC)

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IMPACTOS DA MODERNIZAÇÃO SOBRE AS ESTRUTURAS SOCIAIS: O EXEMPLO DOS PECUARISTAS DE POCONÉ-MT[1]

Impact of Modernization on Social Structures: The Example of Cattlemen in Poconé-MT

André Luís Ribeiro Lacerda[2]
João Vicente R. B. da Costa Lima[3]

Resumo: Este trabalho parte da constatação de um processo social de transformação, identificado na estrutura do status ocupacional de pecuarista pantaneiro, a partir de entrevistas de *surveys* realizadas entre 2014 e 2015 com pecuaristas pantaneiros que têm propriedades no município de Poconé-MT. Considerando o status ocupacional como variável dependente, identificamos algumas variáveis familiares ao que a literatura sociológica chama de teoria da modernização e que consideramos potenciais variáveis independentes. A hipótese de que o impacto da modernização nas estruturas sociais parece uma boa explicação para as transformações na estrutura ocupacional de pecuarista pantaneiro é defendida a partir do que os trabalhos empíricos sociológicos chamam de padrões de movimento nas estruturas ocupacionais de maneira geral e da relação entre o background dos fazendeiros e o processo de estratificação social.
Palavras-Chave: *status* sócio ocupacional; pecuaristas; modernização.

Abstract: This study starts from the verification of a social transformation process, identified in the structure of occupational status of Pantanal cattlemen and based on survey interviews conducted with Pantanal cattlemen who own properties in the district of Poconé-MT between 2014 and 2015. Considering the occupational status as a dependent variable, we identified some variables that are related to what sociological literature denominates as theory of modernization and we have considered as potential independent variables. The hypothesis according to which the impact of modernization on social structures seems to be a fair explanation for the changes in the occupational status of Pantanal cattlemen is defended on the basis of what empirical sociological studies denominate as movement patterns in occupational structures in general and the relationship between farmers' background and the process of social stratification.
Keywords: sócio-occupational status; cattlemen; modernization.

JEL: A14.

1. INTRODUÇÃO

Surveys aplicados em 2014 e 2015 nos pecuaristas pantaneiros que têm propriedades no município de Poconé-MT revelaram diferenças significativas entre as situações socioeconômicas da velha e da nova geração de pecuaristas pantaneiros. Essas diferenças implicam mudanças na estrutura social que se

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desenha a partir do status e no próprio status ocupacional de pecuarista pantaneiro.

Encarado como uma variável dependente, o status de pecuarista pantaneiro experimenta transformações assim como os outros status sociais do conjunto de status a que pertence o pecuarista pantaneiro que reside em Poconé-MT (TURNER, 2000). O que explica esta mudança? Identificamos algumas variáveis familiares ao que a literatura sociológica chama de teoria da modernização e que consideramos potenciais variáveis independentes. A hipótese de que o impacto da modernização nas estruturas sociais parece uma boa explicação para as transformações na estrutura ocupacional de pecuarista pantaneiro é defendida a partir do que os trabalhos empíricos sociológicos chamam de padrões de movimento nas estruturas ocupacionais de maneira geral e da relação entre o background dos fazendeiros e o processo de estratificação social.

O impacto da modernização sobre a estrutura social formada a partir do conjunto de statuses de pecuaristas pantaneiros pode ser visto como uma dinâmica de mudança social. Gehard Lenski afirma que a história humana não é apenas uma sequência, “uma teia confusa de eventos sem qualquer padrão ou tendência significativa”, mas, ao contrário, apresentava um padrão em que “a presença de tendência de longo prazo é clara e evidente” (LENSKI, 1976, p.554). E segundo ele, a tendência mais evidente é o avanço tecnológico. Ela imprime a direção preponderante da mudança apesar de casos excepcionais de “tecnostase” e “regressão” (SZTOMPKA, 1998, p. 209).

Para Lenski, é possível dizer que todos os demais aspectos da vida social estão fortemente ligados ao caráter da tecnologia, ou seja, as resoluções de uma sociedade para seus problemas tecnológicos “ funcionam como um conjunto de condições determinantes do alcance das soluções que a sociedade pode aplicar a outros problemas (LENSKI & LENSKI,1974, p. 80).

O curso principal da determinação segue a sequência tecnologia-economia-sociedade organizada-sistema distributivo (LENSKI, 1966). Mas, Lenski entende a determinação tecnológica como probabilística, por intermédio de um mecanismo que fornece feedback de outros aspectos da sociedade à tecnologia.

E quais seriam os padrões envolvidos na modernização que produziram mudanças no status de pecuarista pantaneiro? Para identificarmos estes padrões, um caminho produtivo é entender como a modernização se realiza enquanto uma dinâmica social de mudança. Sociologicamente, denominamos à “ interação repetitiva de padrões de comportamento comumente encontrados na vida social” (HORTON & HUNT, 1980, p. 251) de processos sociais. A classificação mais frequente dos principais processos sociais ocorre em termos de cooperação, competição, conflito, acomodação e outros. Tais processos ocorrem tanto no nível individual quanto no nível grupal.

As transformações que identificamos na ocupação de pecuarista pantaneiro podem ser classificadas dentro do que Lenski chama de mudanças cumulativas, ou seja, associadas a sistemas compostos de múltiplas partes inter-relacionadas. Dentro desse sistema, algumas partes mudam enquanto outras permanecem como estavam. Assim, a mudança cumulativa é um processo que

combina elementos de continuidade com elementos de mudança. Muitas partes do sistema são preservadas por extensos períodos enquanto novas parte são adicionadas e outras partes são substituídas e transformadas (LENSKI, 2005).

Durante um tempo, o status de pecuarista pantaneiro gozou de elevado prestígio nas sociedades mato-grossense e poconeana e chegou a imprimir culturalmente um estilo de vida, chamado de pantaneiro, que combinava valores religiosos católicos, estratificação social baseada em grande desigualdade social em que o pecuarista ocupava o topo da hierarquia, grandes propriedades para criação de gado, nas quais viviam a família nuclear do pecuarista e de seus empregados, e baixa produtividade.

Esta estrutura social, aqui entendida como o conjunto de status sociais vinculados ao status de pecuarista pantaneiro e os sistemas de cultura aos quais ele estava e está ligado (MARTIN, 2009; TURNER, 2000) vem sofrendo transformações. As variáveis explicativas que identificamos como possíveis variáveis independentes relacionam-se com o que a literatura sociológica denomina de modernização.

Segundo Sztompka, a noção de modernização pode ser considerada em três sentidos distintos: (1) sinônimo de mudança social "progressiva de qualquer natureza em que a sociedade se move para frente ao largo de alguma escala de aperfeiçoamento aceita" (SZTOMPKA, 1998, p. 227); (2) Invoca a ideia de "modernidade", expressa no complexo de transformações sociais, políticas, econômicas, culturais e mentais que ocorreram no ocidente a partir do século XVI, atingindo seu apogeu nos séculos XIX e XX. Refere-se aos processos de industrialização, urbanização, racionalização, burocratização, democratização, ascensão do capitalismo, disseminação do individualismo e da motivação para as realizações, afirmação da razão e da ciência, entre outros (SZTOMPKA, 1998, p. 227); (3) em um sentido particular, refere-se apenas aos processos sociais de mudança social experimentados por sociedades consideradas "atrasadas" ou "subdesenvolvidas" e "seus esforços para alcançar os países avançados, ou mais desenvolvidos, que com eles coexistem no mesmo período histórico dentro da sociedade global (SZTOMPKA, 1998, p. 228).

No sentido que adotamos aqui, no nível micro e macrossociológico da estrutura ocupacional de pecuarista pantaneiro, significa o fenômeno individual e social pelo qual passam pecuaristas e seus status ocupacionais de uma estrutura social tradicional ou pouco desenvolvida tecnologicamente para atitudes racionais social e economicamente e estruturas sociais fortemente diferenciadas.

Embora disseminada na literatura sociológica e econômica, a ideia de modernização tem sido questionada em sua dimensão empírica como contrária às evidências históricas, e em sua dimensão teórica como baseada em pressupostos não sustentáveis (SZTOMPKA, 1998).

Na verdade, as críticas são mais baseadas em objeções extra científicas do que científicas. Na dimensão empírica, dizia-se que os esforços modernizadores quase nunca produziam os resultados prometidos. Há aqui uma confusão entre a sociologia enquanto ciência e engenharia social. A teoria da modernização tem alguns pressupostos, se eles se realizam ou não entram na

dimensão do seu questionamento enquanto teoria e não seu questionamento enquanto engenharia social. Enquanto teoria que se pretende científica é probabilística.

No plano sócio psicológico, a crítica é que a modernização provoca efeitos colaterais patológicos. A destruição de instituições e modos de vida tradicionais produziram, em diversos casos, a desorganização social e a anomia, conforme aponta Eisenstadt (1968). Neste caso, como na dimensão empírica, a modernização é teorizada como uma transformação exclusivamente positiva, o que é contrário ao que sociologia da mudança social defende, conforme Lenski (2005).

Na dimensão teórica, os pressupostos evolucionistas subjacentes foram considerados inaceitáveis. Aqui estamos, mais uma vez, diante de objeções extra científicas. Uma normatização epistemológica. O que torna um pressuposto aceitável ou não é sua operacionalização e sustentação empírica. Mas, existe também questionamentos relevantes. A crítica de que a estrutura teórica deveria incorporar variáveis do contexto global e de causação endógena. Tal crítica foi considerada por Tiraykian (1985) em meados dos anos 1980, quando assistimos a um renascimento da teoria da modernização.

2. TORNANDO-SE MODERNO OU IMPACTOS DA MODERNIZAÇÃO SOBRE ESTRUTURAS SOCIAIS

Inkeles & Smith (1981) executaram um estudo comparativo que combinou as dimensões micro e macrossociológica e que corrige o que os críticos chamavam de concepção etnocêntrica e ocidentalista dos objetivos da modernização por se basear na ideia de que muitas sociedades e Estados Modernos "ou em processo de modernização se desenvolveram em outra direção que não a dos Estados-Nação europeus" (EISENSTADT *apud* SZTOMPKA,1998).

O enfoque sócio psicológico de Inkeles & Smith considera a modernização basicamente como um processo de mudança "na maneira de perceber, expressar e avaliar. O moderno é definido como um modo de funcionamento individual, um conjunto de disposições para agir de determinada maneira" (INKELES & SMITH, 1981, p. 16). Dessa forma, o que se denomina de moderno não está ligado a uma época ou a um lugar determinado do que qualquer definição de modernidade se pensamos em termos de arranjos estruturais, "se modernidade é definida como um estado de espírito, as mesmas condições devem ter estado presentes na Inglaterra da Rainha Elizabeth, na Grécia de Péricles, e no Japão de Tokugawa" (INKELES & SMITH, 1981, p. 16).

Para que sua concepção de modernidade individual não fosse acusada de ser baseada em padrões de valores europeus, Inkeles & Smith formularam um desenho de pesquisa intercultural, realizado simultaneamente na Ásia, África e América do Sul.

Embora o modelo analítico de Inkeles & Smith (1981) representasse um ponto de vista teórico, ele não ignora o que diversos estudos empíricos

apontavam como proposições sobre as prováveis maneiras com que a modernização está ligada às diversas atitudes em relação "à religião, família, estratificação social e muitas outras" (INKELES & SMITH,1981, p. 24).

Na estrutura social que se desenha a partir do status ocupacional de pecuarista pantaneiro, a religião, a família e a estratificação social tem contornos bem definidos e diferentes daqueles que a modernização traz em seu bojo.

Conforme já mencionamos, o pecuarista pantaneiro era religiosamente católico. Grande patrocinador das festas de santo, cujas realizações envolvia a doação de recursos e gado, momento em que reafirmava seu prestígio e sua posição na hierarquia social.

Em relação à família, vivia quase isolado nas fazendas, com família numerosa e estreita relação com as famílias dos empregados, embora a hierarquia fosse claramente demarcada. A participação feminina majoritariamente estava restrita ao espaço doméstico.

E em relação à estratificação social, viviam em uma sociedade em que eles ocupavam o topo da hierarquia. Os pecuaristas participavam ativamente da vida política no município e no Estado. Uma ilustração de como isto se manifestava na sociedade poconeana, é o fato de que em Poconé existiam clubes reservados aos filhos dos pecuaristas pantaneiros.

Blau & Duncan (1967) nos mostraram, de certa forma, como o impacto da modernização repercute na estratificação social, quando pensamos na mudança das aspirações educacionais e ocupacionais dos membros de estruturas sociais de ocupações vinculadas ao campo, por exemplo, no caso, os fazendeiros. Eles mostram que tende a diminuir o número de pessoas vivendo em fazendas, vivendo a vida na agricultura e buscando ocupações rurais.

Uma das razões que eles apresentam para explicar esta redução de ocupações no campo é que, com a mecanização, o avanço tecnológico, um número bem menor de trabalhadores pode produzir o mesmo volume de produtos que antes era produzido. E isto tende a mudar a dinâmica social de recrutamento para as ocupações no campo de uma geração para outra. Blau & Duncan (1967) mostram que os fazendeiros eram desproporcionalmente recrutados em sua própria classe e de trabalhadores ligados a ocupações rurais. E que em 1962, ¼ dos homens que compunham a força de trabalho de 12 milhões investigada, tinham pais que eram fazendeiros, administradores de fazendas ou trabalhadores de fazendas. Isto nos mostra que o background de fazendeiros se alimentava, basicamente de sua própria classe e atividades afins e, ao mesmo tempo, era uma variável importante para entender a origem e o destino dos indivíduos, quando pensamos processo social de mobilidade social.

Voltando às repercussões da modernização nas várias esferas da vida social, Inkeles & Smith (1981) nos mostram que o impacto da modernização nas três esferas mencionadas acima, caso estejam presente na estrutura da sociedade poconeana, tendem a provocar transformações que provavelmente repercutirão no status de pecuarista pantaneiro.

Religião e família no sentido em que descrevemos na estrutura social da tradicional sociedade poconeana, constituem obstáculos ao processo de modernização, pois, como advertiu Moore, geralmente a estrutura familiar

tradicional constitui uma barreira contra o desenvolvimento industrial, pois encoraja que o indivíduo tenha mais confiança na sua segurança do que nos seus dispositivos (MOORE, 1965).

A literatura sobre modernização indica que, como um fenômeno atrelado ao urbanismo e à industrialização, tende a enfraquecer o vigor das extensas relações familiares. Não pudemos aquilatar a relação destas duas variáveis independentes com a estrutura social dos pecuaristas pantaneiros, considerada variável dependente. Embora possamos falar de um processo de urbanização, não há sinais de industrialização em um município que continua a ser fundamentalmente rural no sentido de suas atividades econômicas fundamentais, agricultura, pecuária, em alguma medida o turismo, mas que não interage com a cidade diretamente, e a mineração que se desenvolve de uma maneira que não podemos considerar significativamente industrial.

A literatura sociológica referente aos impactos da modernização sobre a estrutura social da família indica que as variáveis sociais independentes fundamentais se relacionam com as mudanças nas aspirações educacionais e ocupacionais. Na medida em que atinge a mulher, juntamente com os procedimentos de controle de natalidade, tende a influenciar o tamanho da família. E, na medida em que atingem os filhos, estes não estarão mais dispostos a serem parceiros dos pais no trabalho na fazenda, pois terão outras aspirações educacionais e ocupacionais.

Em relação à religião, como as grandes famílias, ela também se coloca como obstáculo ao desenvolvimento econômico e como tal vítima do processo de modernização. Vários estudos que chegavam a Weber, indicavam que a religião pode ser o principal obstáculo à modernização, por se constituir frequentemente “no baluarte das tradições e no repositório de crenças e valores incompatíveis com a ciência moderna, com a tecnologia e com a ideia de progresso” (INKELES & SMITH,1981, p. 26).

Nos *surveys* que aplicamos, não coletamos dados sobre a religião, embora saibamos da forte religiosidade da geração mais antiga de pecuaristas pantaneiros. Como entrevistamos a maior parte de nossa amostra em suas residências, era frequente nos depararmos com seus símbolos religiosos, geralmente nas salas de estar de suas casas, quando não interrompíamos momentos de oração. Mas não mensuramos o quanto essa religiosidade difere entre as diferentes gerações de pecuaristas, entre os pecuaristas pantaneiros que residem em Poconé e os que não residem, entre aqueles que são nascidos em Poconé e aqueles que são de fora do município, entre aqueles que são de Poconé, mas que estudaram fora de Poconé (curso médio e/ou superior) e aqueles que fizeram toda a sua escolarização no município.

3. MÉTODO

Iniciamos a pesquisa em agosto de 2013. Formulamos 15 questões não estruturadas e aplicamos a 5 pecuaristas de Poconé. A partir de informantes nascidos no município de Poconé, mas que residem na capital do Estado e, por intermédio da Sindicato Rural de Poconé, elegemos estes potenciais entrevistados. As cinco entrevistas não estruturadas nos forneceram informações, como as questões mais importantes no que se referia às

dificuldades da ocupação de pecuarista pantaneiro e algumas categorias importantes, bem como os assuntos delicados e situações a serem evitadas.

Com estas informações, formulamos um questionário estruturado e o testamos em quatro outros pecuaristas. Ao final desse processo, elaboramos finalmente nosso instrumento, um questionário com 40 questões, divididas em 3 blocos. Um primeiro, em que fazíamos uma introdução, abordando questões mais neutras, um segundo em que fizemos as questões que sustentam nossas hipóteses a respeito da ocupação de pecuarista pantaneiro e um terceiro bloco em que coletamos dados sobre seu perfil sócio demográfico.

Em função das dificuldades de acesso ao pantanal, pois existem áreas acessíveis apenas de avião e outras apenas com veículos apropriados, desenhamos nossa amostra pelas vias de acesso, como uma amostra por conglomerados. Estipulamos 4 vias de acesso: Estrada Parque Transpantaneira; Estrada Poconé-Porto Cercado; Estrada do Boqueirão e Rodovia Poconé-Cuiabá. Por estas estradas se alcançam as estradas vicinais.

Entrevistamos 28 pecuaristas. Segundo o posto do Indea em Poconé, existem 2113 propriedades no município, 1556 na terra firme e 557 no pantanal. Sabemos que no baixo pantanal existem muitas propriedades abandonadas e que algumas propriedades têm sido adquiridas por um mesmo proprietário, o que pode indicar que talvez exista um número menor de propriedades, mas nem o Indea, nem a prefeitura nem o Sindicato Rural souberam informar com precisão.

Depois da coleta de dados via entrevistas não estruturadas e de testar o questionário desenhado, iniciamos sua aplicação em 2014 e o finalizamos em março de 2015.

4. RESULTADOS

O status ocupacional de pecuarista pantaneiro continua a ser exclusivamente desempenhado por homens. Não entrevistamos nenhuma mulher e não soubemos de nenhuma pecuarista pantaneira em Poconé.

Em relação à escolaridade:

Tabela 1: Escolaridade dos Pecuaristas de Poconé-MT

Nível escolaridade	Quantidade	Percentagem
Superior	15	53,50%
Ensino Médio	13	46,50%

Fonte: Elaboração própria

Em relação a desenvolver ou não outras atividades econômicas:

Desenvolve outras atividades econômicas?

Tabela 2: Atividades econômicas

Outras atividades econômicas?	Quantidade	Percentagem
Sim	21	75%
Não	7	25%

Fonte: Elaboração própria

Entre aqueles que disseram não desenvolver outra atividade econômica, alguns sublinhavam que não desenvolviam naquele momento. Geralmente eram pecuarista comais de 60 anos que já tinha se aposentado de sua outra atividade. Para conhecer, entre aqueles que desenvolvem outras atividades econômicas, quais as principais atividades por eles desenvolvidas, perguntamos:

Tabela 2a: Pecuaristas Pantaneiros que desenvolvem outra atividade econômica

Qual a outra atividade econômica	Quantidade
Agricultura	1
Turismo	3
Prestador de Serviços	2
Comércio	9
Profissional Liberal	2
Indústria	1
Funcionário Público	3
Total	**21**

Fonte: Elaboração própria

Qual das atividades econômicas é a principal, a pecuária ou a outra?

Tabela 2b: Atividade econômica principal

Atividade econômica	Proporção
Pecuária	23,80%
A outra atividade	76,20%

Fonte: Elaboração própria.

É possível viver exclusivamente da pecuária no pantanal hoje? Muitos que responderam sim e aqueles que também responderam não, estipulavam as condições que tornam a pecuária viável no pantanal hoje: tamanho mínimo da propriedade e a quantidade mínima de cabeças de gado.

Tabela 3: Vivem exclusivamente da pecuária

Exclusivamente	Proporção
Sim	21,50%
Não	78,50%

Fonte: Elaboração própria.

Podemos dizer que entrevistamos quatro pecuaristas da nova geração, embora na fase de coleta de dados inicial e na fase de testes, entrevistamos outros quatro. Eles se destacam por defender claramente que a pecuária no pantanal só é viável enquanto atividade econômica complementar, por defender uma pecuária mais empresarial e por criticarem a insistência da velha geração em acreditar que a pecuária pantaneira extensiva de outrora ainda seja viável.

Tabela 4: Faixa etária dos pecuaristas pantaneiros

Faixa Etária	Quantidade
30-40	2
40-50	2
50-60	14
60-70	5
70-80	5

Fonte: Elaboração própria.

A estrutura de produção da pecuária pantaneira era basicamente familiar, baseada na grande propriedade e na pecuária extensiva. Neste cenário, a ajuda dos filhos era fundamental, que posteriormente assumiam a fazenda.

Filhos ajudam na fazenda?

Tabela 5: Proporção de pecuaristas pantaneiros que contam com a ajuda dos filhos

Contam com a ajuda dos filhos	Proporção
Sim	32,14%
Não	67,85%

Fonte: Elaboração própria.

Deve-se levar em consideração que entre aqueles que disseram não, alguns tem filhos pequenos e, portanto, sem condições ainda de ajudarem na fazenda. E entre aqueles que ajudam, 2 ou 3 são médicos veterinários, ou seja, desempenham ocupações ligadas à pecuária. Mas, se eles ajudam, eles também trabalham fora, ou seja, a ajuda é uma ajuda mesmo.

Tabela 6: Ocupação do Pai

Ocupação do Pai	Proporção
Pecuarista	71,42%
Não Pecuarista	28,58%

Fonte: Elaboração própria.

É importante ressaltar que entre aqueles que não têm pais pecuaristas, alguns tornaram-se pecuaristas porque a esposa é filha de pecuaristas e herdou a terra.

Tabela 7: Distinção de Não-Pecuaristas

Status ocupacionais	Proporção
Status ocupacionais rurais	50%
Status ocupacionais urbanos	50%

Fonte: Elaboração própria.

5. DISCUSSÃO E CONCLUSÃO

É possível visualizar a mudança que experimenta a estrutura social da sociedade poconeana por intermédio de uma visita à cidade. Expressão e símbolo de poder que os pecuaristas pantaneiros não têm mais, a cidade tenta encontrar outras vocações econômicas e, conforme o conceito de mudança cumulativa de Lenski (2005), expressa continuidades e descontinuidades em relação a um tempo em que os pecuaristas pantaneiros eram os atores sociais fundamentais no que se refere ao aspecto econômico, político e social.

Em relação à tabela 1, não controlamos a variável escolaridade e, portanto, não sabemos como ela se relaciona com as mudanças no status de pecuarista pantaneiro. A geração mais nova faz uma distinção entre ser fazendeiro e ser pecuarista no pantanal hoje. Eles dizem que os mais velhos são fazendeiros, ou seja, querem fazer de tudo, mas são pouco especializados e não sabem administrar a fazenda de uma maneira empresarial, condição importante, segundos os mais novos, para que a pecuária pantaneira possa se tornar viável. Apresentam a pecuária na terra firme e o agronegócio como modelos bem-sucedidos a serem seguidos. Nesse sentido, eles tendem a minimizar as críticas às exigências ambientais do poder público e tendem a enfatizar a não viabilidade da pecuária enquanto atividade econômica exclusiva (tabela 3).

Os pecuaristas mais velhos, exemplificados aqui, fundamentalmente, por aqueles que têm quase 60 anos ou mais, tendem a se prender mais ao passado, ao modelo de pecuária extensiva que dava certo e a serem críticos da legislação ambiental e trabalhista que inviabilizam, de certa forma o modelo antigo.

A tabela 2 expressa mudança significativa no status ocupacional de pecuarista pantaneiro. Embora no passado ele participasse da vida pública, em função de seu elevado prestígio, o que o levava a patrocinar festas de santo,

com significativos recursos, e fosse influente na vida política de Poconé e de Mato Grosso, o status ocupacional de pecuarista pantaneiro era seu status principal, todos os outros gravitavam em torno dele. Mas isto mudou e vem mudando, conforme mostra a tabela 2. Sete pecuaristas têm a pecuária como sua única atividade econômica. E, conforme sublinhamos, alguns porque já estão aposentados de sua outra atividade econômica. Nesse sentido, a tabela tende a expressar o pensamento da geração mais nova, que vê na pecuária pantaneira um status ocupacional complementar e não exclusivo.

Podemos dizer que estamos diante de uma consequência da modernização? Parece que sim, mas isto deve ser melhor investigado. A dinâmica social de divisão familiar das grandes propriedades, provavelmente é uma variável importante. Com propriedades menores, a estrutura de produção baseada na família, grande propriedade e pecuária extensiva tornou-se inviável. O tamanho bem menor da propriedade, a redução significativa no tamanho do rebanho e os atrativos em termos de aspirações educacionais e ocupacionais oferecidos pela capital, distante 100 quilômetros de Poconé, fizeram com que a grande maioria dos filhos dos pecuaristas desistisse da vida na fazenda. A tabela 5 nos fornece pistas nesse sentido. Os próprios pecuaristas pantaneiros expressavam suas preocupações, durante as entrevistas, em relação ao futuro das suas propriedades, pois os filhos não se interessam por elas.

Em relação à tabela 2a, é importante destacar a presença de pecuaristas no comércio, enquanto profissionais liberais e no turismo. E necessário mais investigações, mas parece-nos que os pecuaristas antigos também exerciam atividades econômicas no comércio como uma atividade econômica secundária, que provavelmente era exercida por um de seus filhos ou parentes, mas hoje ela passa a ter um peso maior e a ser exercida por ele mesmo ou por ele e sua mulher ou pela mulher. Aliás, o papel da esposa na pecuária pantaneira merece ser melhor investigado. Ela participava ativamente seja diretamente, seja indiretamente, mas sua participação não é reconhecida. Tentei entrevistar algumas mulheres que estavam à frente dos negócios em função do adoecimento de seus maridos, mas elas se recusaram, afirmando que embora fossem parceiras (muitas inclusive opinavam durante as entrevistas), falar de pecuária era assunto dos maridos.

Para aqueles que são profissionais liberais, o status de pecuarista pantaneiro passa a ser uma atividade de fim de semana e um projeto para o futuro, após a aposentadoria.

Para aqueles que trabalham com o turismo, a pecuária constitui-se em uma atividade afim, pois o status de pecuarista está atrelado ao status de proprietário de pousada.

Em relação à tabela 6, os dados sustentam o que Blau & Duncan (1967) apontavam nos anos de1960 nos EUA. Os ocupantes do status de pecuaristas pantaneiros são desproporcionalmente recrutados de sua própria classe e de trabalhadores ligados a ocupações rurais.

Conforme apontamos, entre aqueles que os pais não são pecuaristas, alguns se casaram com mulheres filhas de pecuaristas pantaneiros e herdaram suas terras. Com as dificuldades econômicas enfrentadas pelos pecuaristas

pantaneiros, a nova geração tem buscado status ocupacionais urbanos, conforme atestamos quando perguntávamos o que seus filhos faziam.

Muitas propriedades têm sido adquiridas por empresários de fora de Mato Grosso, que tem uma relação diferente com o status de pecuarista pantaneiro.

As mudanças que identificamos merecem ser melhor investigadas, com uma pesquisa complementar que focalize mais precisamente a estrutura social ocupacional de Poconé e o percurso ocupacional que fez o pecuarista pantaneiro e sua esposa e que estão fazendo seus filhos.

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BIODIVERSITY RESEARCH

Planning for reserve adequacy in dynamic landscapes; maximizing future representation of vegetation communities under flood disturbance in the Pantanal wetland

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ABSTRACT

Aim Using a probabilistic modelling framework, we aimed to incorporate landscape spatiotemporal dynamics into reserve design. We employed a spatially explicit stochastic model, which integrates both hydrological and biological processes, to simulate the wetland's biological succession.

Location Pantanal wetland (with 140,000 km^2) between Brazil, Bolivia and Paraguay.

Methods We used the reserve design software Marxan to optimize the current and future representation (up to 50 years) of 20% of five plant communities with maximum reliability (i.e. smallest uncertainty). The Kappa statistic was used to compare selection frequencies of individual sites through a set of planning timeframes (5, 17, 25 and 50 years) and the likely pattern of biological succession over these periods.

Results Solutions based on static vegetation distributions were significantly dissimilar from solutions based on the expected modelled changes resulting from the flood disturbance and succession dynamics. Increasing the required reliability of biodiversity outcomes resulted in more expensive reserve solutions. We demonstrated the flexibility of probabilistic decision-making methods to illuminate the trade-offs between reliability and efficiency of site selection.

Main conclusions Considering the importance of habitat heterogeneity to the principles and practice of systematic conservation planning, it is notable that landscape dynamics have not been a central theme in conservation planning. In the case of the Pantanal hydrosere, acknowledging and planning for temporal dynamics required an ability to model succession and define acceptable levels of outcome reliability, but ultimately improved the long-term Adequacy of resulting reserve networks.

Keywords
Conservation planning, flood dynamics, Marxan, probabilistic model, succession, wetland.

INTRODUCTION

Recent estimates suggest that half of Earth's wetland systems have already been destroyed (Zedler & Kercher, 2005). Agricultural and industrial demand for water is compromising further the quantity and quality of aquatic habitats all over the globe (Mitsch, 2005a). Hence, flow reduction has become be the major factor threatening wetlands (Klinge *et al.*, 1990; Gopal *et al.*, 2000). To protect such complex systems, we need to consider issues that go beyond the simple representation of species and habitats (typically used as the basis of conservation plans) – we need to consider ecosystem processes.

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Understanding ecological process dynamics and functionality through time constitutes an increasingly central part of wetland conservation planning (Gibbs, 2000; Gopal *et al.*, 2000; CBD, 2004; RAMSAR, 2004).

Disturbance and subsequent biological succession are some of the driving forces that structure processes, species diversity and abundance in plant communities (Clements, 1916; Scanlan & Archer, 1991; Klinger, 1996; Amarasekare & Possingham, 2001; Mark & Wilson, 2005; Rammig *et al.*, 2006). Successional processes are often incorporated into management plans to restore wetland functionality (Lamb, 1998; Wan *et al.*, 2001; Ward *et al.*, 2001; Zedler & Kercher, 2005; Rammig *et al.*, 2006), however, are rarely considered in systematic conservation plans (Turner *et al.*, 1999; Mitsch, 2005b; Chan, 2006; Franklin, 2010).

Many models of successional dynamics in wetlands have used Markov chains to describe the stochastic processes behind community behaviour, because they use probabilistic methods to account for the likelihood of transition between seral stages. However, succession is dictated by the hydroperiodic signature of each wetland (i.e. the most frequent combination of flood intensity, frequency, extent and duration). Combined, such understanding allowed humans to develop management strategies and restoration plans for wetland ecosystems (Tutin, 1941; Van Hulst, 1979; Li, 1995; Klinger, 1996; Logofet *et al.*, 1997; Toner & Keddy, 1997; Wu *et al.*, 1997; Childress *et al.*, 1998; Balzter, 2000; Klein *et al.*, 2005). We used our knowledge of the Pantanal's hydroperiodic signature to develop a model that can help us predict the effect of floods on succession dynamics (Gopal *et al.*, 2000).

The spatial distribution of wetland communities, present in a dynamic equilibrium state, is largely determined by the life history traits of their constituents (Connell & Slatyer, 1977). This effect called *systems' memory* and defined by how long the past influences the future state of the system can vary from just a few years in aquatic hydrosere (Walker, 1970) to hundreds of years in forest succession (Hall *et al.*, 1991). These forces are considered to be responsible for the patchy structure of wetlands and have been described using Markovian models (Johst & Huth, 2005). This is because, under the influence of biogeographical forces and temporal stochasticity (DeAngelis *et al.*, 1998; Johnson, 2004), these systems have a propensity to reach stable distribution, where several habitats or seral stages can coexist (Burgman *et al.*, 1992).

In recent years, disturbance models have been considered in systematic reserve selection to incorporate the effect of catastrophic events such as fires, hurricanes and coral bleaching, and their impact on biodiversity and on the success of protected areas (Platt & Connell, 2003; Keane *et al.*, 2004; Leroux *et al.*, 2007a; Game *et al.*, 2008). While catastrophes can cause massive jumps in biological succession (e.g. hurricanes destroying old growth forest and coral reefs), flood disturbances in wetlands are less dramatic, their effects are bi-directional considering that the absence of floods also result in successional changes (Richards *et al.*, 1999; Johst & Drechsler, 2003; Leroux *et al.*, 2007b; Drechsler *et al.*, 2009). In the case of the flood/drought cycle, seral stages can be independently pushed back and forward along the terrestrialization-paludification gradient instead of jumping unidirectionaly to the earliest stage of succession (Junk, 1989; Mitsch & Gosselink, 1993; Klinger, 1996).

Several studies have tried to incorporate the probabilistic occurrence of species and communities into systematic conservation planning decisions (Margules & Nicholls, 1987; Polasky *et al.*, 2000; Cabeza *et al.*, 2004; Sakar *et al.*, 2004; Nicholson & Possingham, 2006; Game *et al.*, 2008; Becker *et al.*, 2010; Carroll *et al.*, 2010). For stochastic systems, the use of a probabilistic framework provides predictive models with a natural currency that can help explicitly define the uncertainty around solutions (Sakar *et al.*, 2004). Markov chains are considered particularly helpful in predicting future states of systems that rely on past transitional conditions (Balzter, 2000; Polasky & Solow, 2001; Cabeza *et al.*, 2004; Wilson *et al.*, 2005). However, coupling of flood and vegetation models under temporal stochasticity for the purpose of designing representative and adequate reserve systems is still a frontier in systematic conservation planning (Kiester *et al.*, 1996; Margules & Pressey, 2000; Arthur *et al.*, 2002; Leroux *et al.*, 2007b).

METHODS

The study region

The Pantanal is the biggest contiguous freshwater wetland ecosystem in the world (Mittermeier *et al.*, 2005). Nested in the Upper Paraguay River basin (365,000 km^2), the floodplain is shared by Brazil, Bolivia and Paraguay, with, *c.* 70% (140,000 km^2) of the wetland ecosystem lying within Brazilian territory (Fig. 1). Like the floodplains of central Amazon, the Pantanal has been characterized as a pulsing system with markedly wet and dry phases (Junk, 1992; Junk & da Silva, 1999). The temporal dynamics of flood disturbances are a recognized driver of the Pantanal biodiversity's spatial heterogeneity, and environmental services (Ab'Saber 1988; Assine & Soares, 2004; Harris *et al.* 2005; Junk & Nunes da Cunha, 2005).

The Pantanal floodplains are among most biodiverse wetlands in the world (Zedler & Kercher, 2005), with healthy populations of threatened species such as Hyacinth macaws (*Anodorhynchus hyacintinus*), marsh deer (*Blastocerus dichotomus*), giant river otters (*Pteronura brasiliensis*) and jaguars (*Panthera onca palustris*). These species are particularly dependent on the wet and dry phases of the ecosystem for water, food and shelter (Crawshaw & Quigley, 1991; Quigley & Crawshaw, 1992; Mourão & Campos, 1995; Rosas *et al.*, 1999; Guedes, 2004; Fonseca *et al.*, 2005).

In recent years, human activities have become a major force in shaping the ecology of the Pantanal. Deforestation, river damming and wildfires are disrupting plant community dynamics (Padovani *et al.*, 2004; Junk & Nunes da Cunha, 2005). Such interventions may compromise ecosystem func-

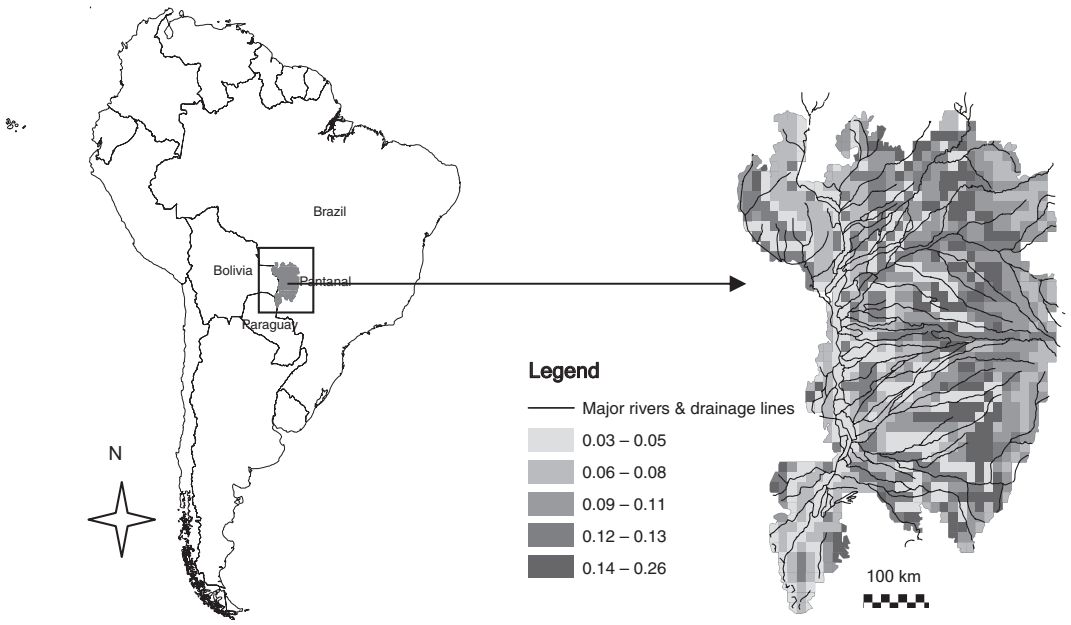

Figure 1 Map of South America and its country borders with an insert showing the Pantanal flood probability map (1:100,000). The grey scale provides the flood probabilities over the last century for each site, which was interpolated from Hamilton's (1996) model as the probability of flooding of site *i*, based on topography and distance from rivers.

tions and jeopardize environmental services estimated at US$ 15.5 billion (Seidl & Moraes, 2000).

Despite its economic importance and the abundance of rare and threatened species, recent reviews showed severe shortcomings in the protected areas system for the Pantanal (Rylands & Brandon, 2005), with < 5% of its surface covered by public and private reserves. Even the expansions of priority areas proposed for the Brazilian Pantanal (Ministério do Meio Ambiente, 2007) failed to deliver on two of the four basic principles of conservation planning, representation and efficiency (Possingham *et al.*, 2006; Lourival *et al.*, 2009).

Wetland dynamics and conservation

The aim of this paper is to develop an ecologically relevant picture of conservation needs in the Pantanal, by incorporating hydrological disturbance and ensuing successional ecosystem dynamics into systematic conservation. We present a conservation planning method that can better deliver on the conservation principle of adequacy, whereby the resulting reserve systems presumably superior in their long-term conservation performance (Possingham *et al.*, 2006). We illustrate our study with an example of the Pantanal wetland in South America (Por, 1995; Mittermeier *et al.*, 2005; Drechsler *et al.*, 2009). Our objective is to select a set of sites which represents 20% of the occurrences of vegetation succession stages, while also maximizing the chance of retaining such targets 50 years into the future, because they are assumed to represent the breadth of regional biodiversity. We implement our approach with the decision support system Marxan (Ball & Possingham, 2000; Game *et al.*, 2008) and compare the reserve selection outcomes (variance of site selection frequency scores) under static and dynamic conditions.

Vegetation classification

Because we were interested in successional stage dynamics, we clustered the 17 vegetation classes of Da Silva *et al.* (2000), into five functional clusters. We added a fifth class to Naiman's classification system to account for a climax seral stage, which in the Pantanal represents the influence of upland mesic vegetation occurring in higher topographic regions of the floodplain (Naiman & Decamps, 1997). These clusters represent a set of recognizable successional stages distributed in 1126 grid cells, each of about 10,000 ha, defined as our individual planning units, mapped at 1:100,000 scale. The resilience of each stage to flood disturbance was used as our clustering criterion (Table 1 and Appendix S1). We simplified the original dominance-based vegetation distribution from Da Silva *et al.* (2000) into presence/absence information, using a transformation script for ArcView 3.3-ESRI (Redlands, CA, USA). In cases of equal contributions of stages, we set a neighbourhood criterion (based on 'majority rule') so that each planning unit contained just one of the five seral stages at one time, which were used as the starting points for the simulations.

Hydrology and flood dynamics

Wetlands can be classified according to their hydrological, physico-chemical or biological characteristics (Heckman

Table 1 Percentage of the Pantanal covered by different plant communities classified according to their resilience to flooding. Their corresponding spatial distributions are summarized in (Fig. 3).

Classification*	No. planning units	Seral stage	Features clustered†	Resilience	% Area	No. features
Invader	169	Aquatic community	Aquatic habitats	Very high	15	1
Endurer	272	Hydrophytes community	Swampland Floating mats Flooded grasslands *Cyperus* & *Thalia* swamps	High	24	4
Resister	93	Wet savanna	*Mauritia* palm woodland *Vochysia* forest *Copernicia* palm woodland Wet Chaco Gallery forest	Medium	8	5
Avoider	360	Dry savanna	Dry grasslands *Byrsonima* scrublands Savanna scrublands *Tabebuia* woodlands	Low	32	4
Climax	232	Climax	*Orbignya* palm woodland Savanna woodland Semideciduous forest	Very low	21	3

*Based on Naiman & Decamps (1997).
†Based on Da Silva *et al.* (2000).

1994a; Lytle and Poff 2004; Robertson and Fitzsimons 2004). Despite several phytosociological studies in the Pantanal which attempt to elucidate some aspects of vegetation and community structure (Prance & Schaller, 1982; Dubs, 1994; Heckman, 1994b, 1998; Pott & Pott, 1994; Pinder & Rosso, 1998; Junk, 1999; Schessl, 1999; Damasceno-Junior *et al.*, 2005), there is scarce information describing the association between vegetation communities and the flood dynamics for this wetland (Heckman, 1994b, 1998; Nunes da Cunha & Junk, 2004). Our succession model based on available floristic information and phytosociological studies attempts to illustrate the relationship between floods and phyto-physiognomies (Adámoli, 1982; Da Silva & Abdon, 1998). The seral stage distribution maps were produced by the aggregation of vegetation maps produced by the Center for Pantanal Research of the Brazilian Agricultural Research Corporation-EMBRAPA (Da Silva *et al.*, 2000), with support from the literature (Pott & Pott, 1994, 2000). Areas converted for pasture within each planning unit were on average smaller than the natural vegetation and therefore were not masked out.

A hundred years of flood data have been recorded for the Pantanal (Hamilton *et al.*, 1996). The pattern found in the Pantanal hydroperiod signature shows fluctuations between short- and long-term flood cycles (Hamilton *et al.*, 2002) that were accredited to stochastic climatic forces (Collischonn *et al.*, 2001; Barros *et al.*, 2004). Based on the correlation found by Hamilton *et al.*, (1996) between river height in Ladário Navy station in Brazil and the flooded area in the floodplain, we spatially interpolated the probabilities of a site being flooded using a geographical information system ARCMAP 9.2 – ESRI (2006). We used the frequency of past flood events, topography and distance to rivers to determine the probability of particular sites being flooded (Fig. 1). We used 394 equidistantly distributed control points in the interpolation and 'spline with tension' was the method chosen to generate the flood probabilities for all 1126 sites, because it deals with surfaces, points and topographic features, in a robust manner. We also tested the method for its spatial independency in generating the probability surface used to parameterize our Markovian probabilistic model as prescribed in Drechsler *et al.* (2009).

The biological succession model

We constructed the diagrammatic model of succession for the Pantanal (Fig. 2) considering the relationship between flood regimes, topography (Hamilton *et al.*, 1996), and the probability of vegetation change. The Markovian model of vegetation dynamics underpins the simulations of the probability distribution dynamics through time and its outcome drove the reserve selection process in Marxan (Game *et al.*, 2008). We developed a set of rules used to describe the transitions between the different seral stages. These assumptions based on decades of field observations (Pott & Pott, 1994, 2000) were gathered from a set of sites in the Pantanal floodplain. Those rules describe on average, how many years of disturbance (flood/drought) it would take for a particular seral stage to change to another stage (Fig. 2). The model considers flooding disturbance as an instantaneous event. The maximum level of flooding in a calendar year was used to determine the flood frequency along the time series. For simplification, we overlooked the influence of the duration of flood events on biological succession. However, duration is implicitly considered by the assumption that flood-based biological succession is stochastic rather than deterministic as discussed by the model explanation in Drechsler *et al.* (2009).

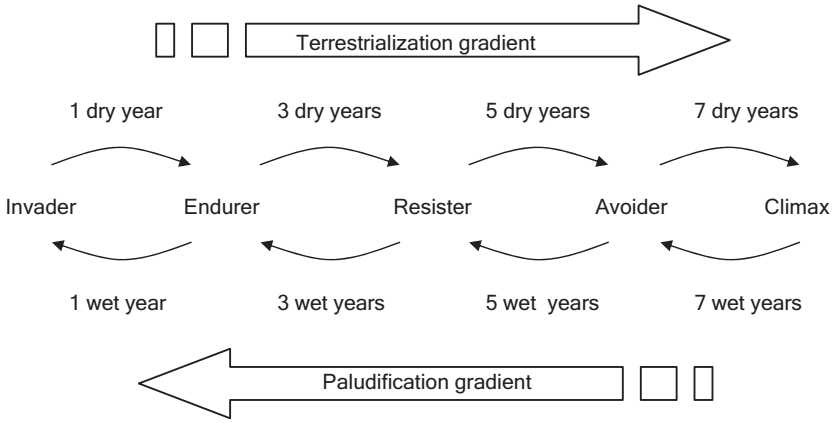

Figure 2 Logical model for the transition rules between the different succession stages and the transition time necessary for a community to change between stages measured in years (Drechsler *et al.*, 2009).

Predictions were based on the flood probability of individual planning units. To implement the model, we assumed a 'flooding as usual scenario' whereby flood events will be stochastic but flood frequencies will remain relatively unaltered. This approach assumes that a climate similar to that of the last century will be influencing the Pantanal over the coming 50 years. Therefore, each site has a certain probability of being flooded (q) in a particular year. Estimates of these probabilities were based on 100 years of records of past floods (Hamilton *et al.*, 1996). We constrained the problem by assuming that each site may be occupied by just a single community at the beginning of the simulation (Drechsler *et al.*, 2009). Then we constructed a Markov chain model of vegetation succession to determine the probability pij of observing a particular state j at a given site i in the future, under the assumption that flood frequencies in the future would remain the same as they have been between 1900 and the present.

We used distribution maps of the presence or absence of our five seral stages (Fig. 3) as seeds for the Markov chain simulation routine in MATLAB (MathWorks, Natick, MA, USA), with the purpose of predicting the future state of the system (i.e. spatial distribution of our successional stages) (Balzter, 2000). Our objective for the Pantanal reserve system was to spatially capture a fixed fraction of each existing seral stage with maximum reliability (i.e. minimum uncertainty) of

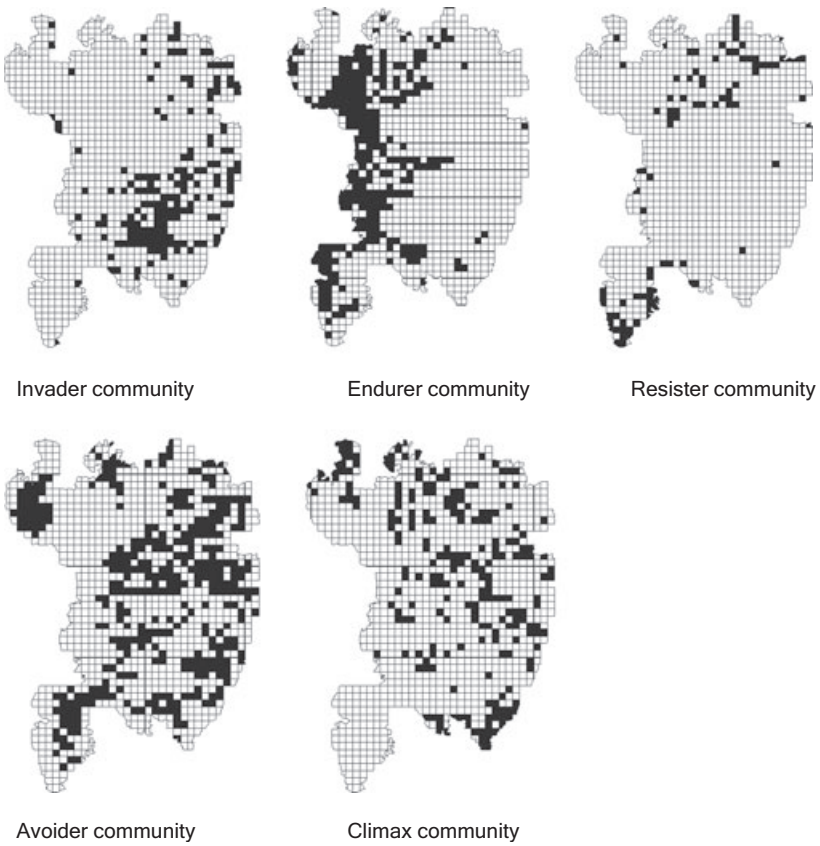

Figure 3 Maps of the distribution of the five succession stages in the Pantanal floodplain, re-sampled from Da Silva *et al.* (2000) as described in Table 1.

retaining representation in the future. We assume that our Markovian probabilistic model adequately describes (Drechsler *et al.*, 2009), and is able to simulate, the successional processes that will occur in planning units spread across the floodplain (Appendix S2). After the data pre-processing, the outcomes of simulations consisted of a probability matrix where each planning unit has a certain likelihood of being at each seral stage 50 years later, based on flood history.

Simulated time to reach stationary distribution of seral stages in the Pantanal

To understand the applicability of the Markovian simulations to conservation planning, it is necessary to understand the behaviour of the model through time. Markov chains are known to reach a stationary distribution, which is an essential assumption and could limit the viability of the model predictions for conservation purposes (Facelli & Pickett, 1990; Junk *et al.*, 2006). We used sensitivity analysis to elucidate the effect of time on the hydroseral model. We simulated the succession behaviour 200 years into the future to evaluate the stabilization point and its appropriateness for conservation planning. Running simulations, we found that each seral stage stabilized at slightly different timeframes; however, results indicated that the 50-year stabilization point is appropriate and realistic for long-term conservation planning (Fig. 4). This supports the use of the model (Drechsler *et al.*, 2009) in real-world planning, while still consistent with assumptions of spatial independency for the hydroseral model (Burgman, 2005).

The problem of site selection in dynamic systems

We investigated the capacity of our disturbance model to predict the future distribution of seral stages, evaluating the effects of succession dynamics on the selection frequency of planning units across a series of planning horizons, from now to 50 years. We set targets for each of the five seral stages under the minimum set coverage problem (Possingham *et al.*, 2000; Moore *et al.*, 2003). Solutions are expected to maximize the likelihood of target representation at a minimum cost.

Flood probabilities for each planning unit were derived from topographic maps and the major hydrological network and divided into 10 intervals, according to the flood frequency chart thresholds for community change (Fig. 2). This decision limited the scale of analysis to planning units of 10,000 ha, what can be considered a coarse scale for habitat mapping but enough to represent average property size, and therefore a management unit.

We evaluated these matrices over four simulated timeframes: 5, 17, 25 and 50 years. Nevertheless, to conform to the assumption of spatial independence, just two scenarios were used to evaluate adequacy: the present conditions (5 years) and the end of our planning horizon (50 years). Marxan software was used to select planning units that maximized the probability of representing 20% of the extent of each of the five seral stages over the entire planning timeframe, based on current and projected distributions. The cost considered was described in Drechsler *et al.* (2009), a programming method that provided an exact solution to the problem of selecting sites under stochastic disturbance. Despite being initially complex and computationally demanding the parameterization and implementation of the method, a probabilistic approximation proposed by the same authors, based on spatial independence between sites (Appendix S3), allowed the efficient exploration of solutions using the existing Marxan software represented by the number of planning units recruited in each solution (http://www.uq.edu.au/marxan/) (Game *et al.*, 2008).

Sensitivity analysis

As our aim was to verify the effect of spatiotemporal heterogeneity on planning unit selection, we used a modified version of the Marxan decision support system (Ball & Possingham, 2000; Drechsler *et al.*, 2009) to incorporate disturbance risk into the site selection problem using the Pantanal wetland flood probability surface. The sensitivity of site selection to simulated changes in community dynamics was tested over four planning timeframes with the aim of adequately meeting our targets for representation, both in the present and at the end of a 50-year planning horizon. We use the term 'reliability' to refer to the probability of achieving our targets.

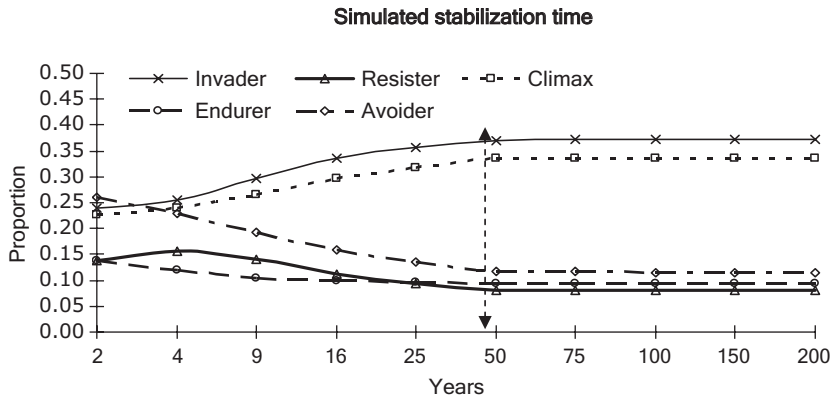

Figure 4 Sensitivity analysis of Pantanal hydrosere simulated through time using the proposed Markovian model of transition probabilities. The arrow marks the point in time where the probability distribution of each seral stage reaches its stationary distribution.

To investigate the effect of reliability requirements on the efficiency of solutions, we tested interval between 50% and 100% reliability, here the least number of planning units in a solution the more efficient the solution was (Pressey & Nicholls, 1989). Each Marxan solution was the average of 100 runs of 1,000,000 iterations each. The 'summed solution' output was assumed to be a measure of the irreplaceability of each planning unit (Carwardine *et al.*, 2007). We then verified the reliability level of such solutions for each planning timeframe (Fig. 5). We used the Kappa statistic to conduct pairwise comparisons between solutions to evaluate how dissimilar solutions were after the removal of overlaps because of chance, between different planning timeframes (Monserud & Leemans, 1992; Richardson *et al.*, 2006).

RESULTS

Hydroperiod and flood dynamics in the Pantanal

Considering the extent of the Pantanal wetland (140,000 km^2), the annual probability of a flood larger than 100,000 km^2 (80% of the floodplain size) is 7% over the last century (Fig. 1). Flood events, spanning more than 80,000 km^2 (i.e. 60% of the total floodplain area), were the most frequent, occurring 26% of the time, while the average flood size, covering 53,000 km^2 occurred only 5% of the time (Hamilton *et al.*, 1996). These results point to a frequently disturbed ecosystem, where processes and functions are often determined by climatic stochasticity as described in the literature (Assine & Soares, 2004; Junk *et al.*, 2006).

Trade-offs between reliability of predictions and the efficiency of reserve systems

Considering that we were not interested in solutions that have low probability of securing future representation, we constrained our search to the 50% and 100% reliability intervals and over the 50 years planning horizon. We explored this interval to achieve target representation in the most efficient/reliable way possible using Marxan's annealing algorithm.

The behaviour of selection frequency (i.e. irreplaceability score) for individual planning units was quite intriguing (see Fig. 5a–g). At a lower reliability requirement, the irreplaceability of each site is ambiguous with the majority of planning units selected with almost equal (low) frequency. As the penalty for missing targets in the future was increased, the solutions become more focused, with some planning units showing a markedly higher irreplaceability score (Fig. 5f).

However, if we wish to achieve conservation goals with very high reliability (i.e. > 90%), most planning units became highly irreplaceable, and solutions became costly and inefficient. In summary, as reliability requirements increase, the number of planning units necessary to meet targets in the

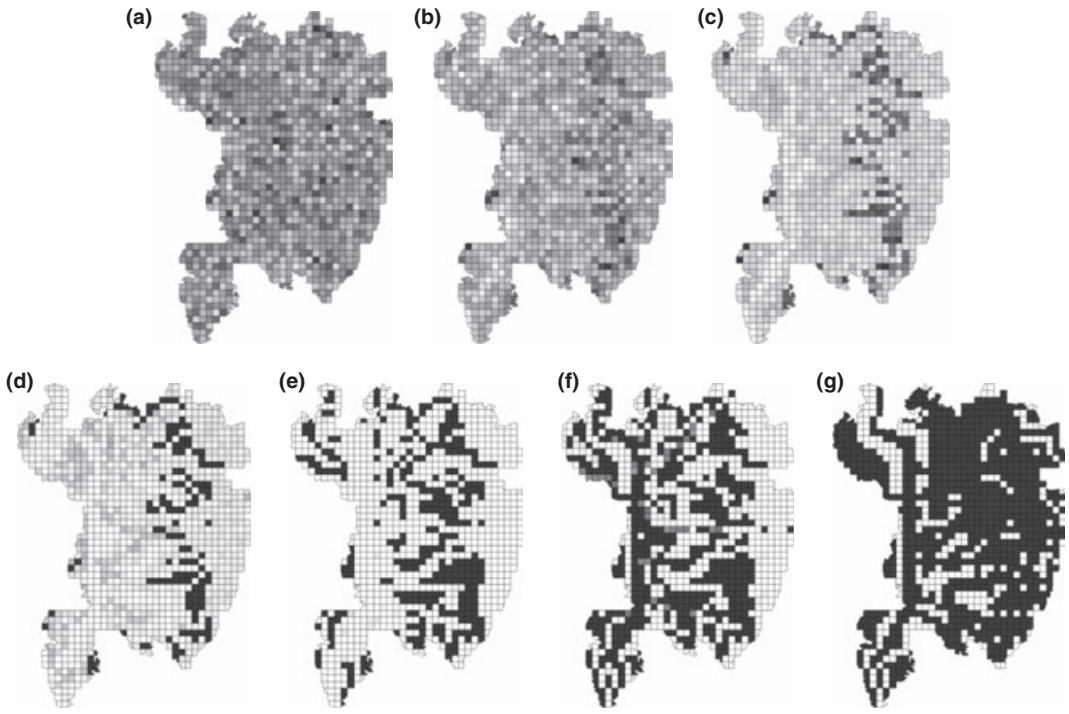

Figure 5 Sensitivity analysis of planning unit selection frequency (irreplaceability) according to demand for reliability for the 50-year planning timeframe. Here, figures (a–g) represent an automatic calibration of exponential increases in weights, to explore the solution space between 50% and 100% of expected reliability of achieving the 20% target for all successional stages in a 50-year timeframe.

Figure 6 Changes in the spatial distribution of selection frequencies of planning units (darker grey represents higher irreplaceability) to represent the 20% of all five seral stages in the Pantanal. For (a–c) achieved 95% reliability, respectively, for 5, 17, 25 years, whereas 50 years into the future, a very efficient solution (d) has a reliability of 88%.

future (i.e. cost) grew exponentially (Fig. 7). In our case study, a solution with 90% reliability required 850 planning units, however, we still found at 88% reliability highly efficient solutions (225 planning units).

Analysis of selection frequency through time

The Kappa statistic indicated that there was little spatial similarity between solutions for any of the four time steps considered so planning for different times in the future requires quite different plans. Spatial similarity is a metric that ranges from 1 to −1 (Table 2), where one equals a 100% similarity between solutions while a value of 0 means that similarities were no bigger than what would be expected by chance alone. If the value approaches −1, the results are considered highly dissimilar (Fielding & Bell, 1997). All values were very close to 0 (i.e. from −0.0675 to 0.253) indicating that similarities between solutions are not statistically different than those because of chance (Table 2). The results strongly suggest that the dissimilarity between selection frequency maps was driven by two factors. For short-term plans of < 5 years (Fig. 6a), selection frequency scores respond to the spatial distribution of features alone, because the state of the vegetation in each planning unit does not change significantly in such a short time period. Beyond 5 years, the effect of simulated transitions starts to operate (Fig. 6b,c). However, at 50 years when the stationary distribution is reached, the effects of spatial autocorrelation become negligible, as predicted by the model. Site selection then becomes driven by the biological succession dynamics, which is heavily influenced by the flood history of the site (Fig. 6d), and the majority of highly irreplaceable planning units are found in regions where the highest frequency of historical disturbance occur.

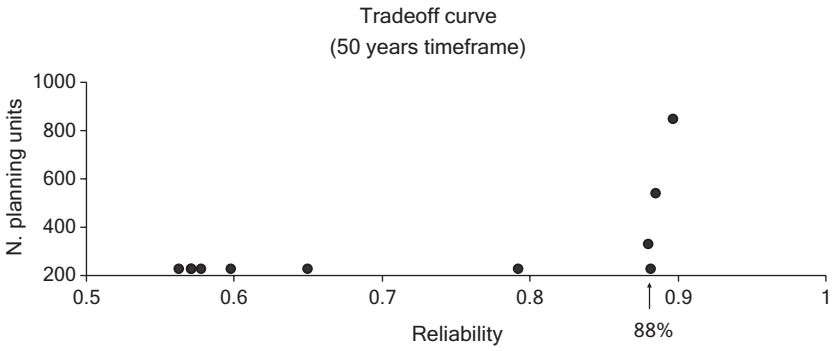

Figure 7 Trade-off curve for the 50-year planning horizon. The plot shows the reliability of each solution on (*x*) axis and cost (measured in number of planning units taken by each solution) on the (*y*) axis. The arrow shows the solution with the best trade-off between reliability and efficiency.

Table 2 Pairwise comparison of planning timeframes, using the Kappa statistics values for Marxan's summed solution outcomes (Monserud & Leemans, 1992).

Timeframe (in years)	5	17	25	50
5	1	0.0695	−0.0675	0.0121
17		1	0.208	0.0897
25			1	0.253
50				1

DISCUSSION

Systematic conservation planning aims for comprehensive, adequate, representative and efficient protection of the Earth's biodiversity (Possingham *et al.*, 2006). Very few conservation plans, however, explicitly consider the natural temporal dynamics that most ecological communities experience. This is despite an extensive and well-documented knowledge about the importance of temporal heterogeneity in shaping biotic communities (Clements, 1936; Odum, 1983). Designing reserve systems that adequately represent biodiversity now and in the future under such dynamic conditions is a challenge for three reasons: the unpredictability of climate into the future; the lack of understanding of succession pathways; and the uncertainty around the ability of models to predict changes (Leroux *et al.*, 2007a).

Here, we addressed the problem of incorporating disturbance dynamics in conservation planning to better enable reserves to meet both current and future conservation goals. This was achieved by allowing the treatment of disturbance dynamics, based on Markov probability chains, to be used in a spatial optimization method. This treatment enabled us to deal with the uncertainties associated with predictive modelling, while also providing statistical robustness and flexibility for the decision-making process.

The results presented here demonstrate that the spatial distributions of conservation priority can be markedly different when different planning timeframes are considered (Fig. 6). Our results suggest that short-term plans based entirely on current distribution of features can lead to inadequate conservation outcomes. Given this is true for a simple 'flooding as usual' scenario, the adequacy of existing reserves under the potential effects of climate change and water diversion may be even further compromised.

The design of reserve networks that consider temporal dynamics depends not only on our ability to predict future changes, but perhaps more importantly, on the level of reliability demanded of these predictions and our subsequent decisions. The easiest way to achieve greater reliability is through the acquisition of more planning units (see Fig. 7) such that demanding more reliable outcomes is likely to result in more expensive reserve systems. In the Pantanal case, where plans that are based on stewardship mechanisms (i.e. little budget restrictions) and concerned with the future adequacy, we might choose highly reliable but spatially inefficient solutions. If however, there are limited resources (e.g. when there are true acquisition costs involved), planners might choose the least expensive systems, compromising somewhat on the reliability with which they meet conservation targets.

Considering temporal dynamics in conservation planning requires appropriate planning horizons, this will require finding the balance between practicality and predictive reliability. We can predict with a good degree of reliability what the distribution of the vegetation types will be in 1 year's time. However, no one would suggest that it is practical or desirable to re-design a reserve network every year as successional changes occur. On the other hand, a 100-year plan may be politically appealing; most scientists will feel uncomfortable making environmental predictions over that timeframe.

Our ability to reasonably predict the future in dynamic systems and thus find good indicators of an appropriate planning horizon will depend on the type and speed of expected ecosystem changes and the amount of information available on such dynamics. The corollary of accepting the outcomes of such predictive exercises is that the best solutions are reliant on the resources needed to implement them and how confident stakeholders need to be.

Implications for conservation planning

To date, the literature has not offered a convincing solution to the problem of incorporating freshwater dynamics as part of the reserve selection process, and how it affects the principle of Adequacy. Post hoc approaches such as the one suggested by Leroux *et al.* (2007a) definitely help to design adequate reserve

systems and to adjust them to cope with an ever changing environment. However, using a new problem formulation coupled with a stochastic vegetation succession models enabled us to find reserve systems that meet both current and future conservation objectives in an optimal, defensible and transparent way. This is one of our method's advantages when compared to niche-based modelling and scenario building (Carroll *et al.*, 2010). The adaptations introduced in the reserve selection software Marxan enabled it to deal with probabilistic datasets in a robust manner, therefore, generating solutions that are reliable and realistic. However, the greatest advantage of our method is that it offers the opportunity to make decisions today that will, under acceptable levels of uncertainty, give a high probability of achieving targets into the future.

Model limitations

The results presented here are based on a highly simplified view of the Pantanal succession dynamics, including the use of discrete time, which forces the model to behave in a stepwise fashion rather than a continuous process. Nevertheless, animal and plant communities often respond to seasonality in a stepwise fashion, buffering effects caused by the hydroperiod dynamics (Clarke, 2005). Transitions between seral stages are then determined by the cumulative effect of subsequent years of floods or droughts and can occur for early stages of succession based on one seasonal cycle, or several years for the later stages. As a consequence, flood history has good explanatory and predictive power on how succession is pushed through these transition thresholds. More complex succession trajectories are not uncommon (Van Hulst, 1979) and the model could be adapted to simulate such trajectories.

For simplicity, we also ignored the influence of other factors that may affect succession such as soil composition, biogeography, damming, intensive grazing and fire. Some of these factors can be simultaneously approached in Markovian submodels. Nevertheless, the advantages of using Markovian approaches to handle temporal stochasticity in reserve design applications greatly surpass their limitations. First of all, Markovian models use probability as their currency, allowing uncertainty to be explicitly considered. Also because of their computational simplicity, they allow direct tests of the length of a system's memory and determination of the stationary distribution. Finally, they can handle a large number of variables and have a diverse apparatus for robust statistical inferences (Horn, 1975). In combination, these features allow straightforward integration of both spatial and temporal heterogeneity into systematic conservation planning.

Implications for conservation in the Pantanal wetland

The existence of carryover effects from subsequent floods has clear effects on species diversity and abundance (Clarke, 2005). Empirical data suggest that these effects are particularly important for recruitment and survival in fishes and reptiles in the Pantanal (Coutinho & Campos, 1996; Catella *et al.*, 1999). Our simulations indicate they are also essential for plant communities and should be considered in any effort to protect biodiversity in the Pantanal.

The results of this study indicate that designing reserve systems to simply represent present-day vegetation classes in wetlands such as the Pantanal without incorporating the likelihood of change because of flooding and succession is inadequate. Conservation priority maps that do incorporate successional dynamics differ dramatically from those based only on the current distribution or their likely succession of vegetation through time. Some emergent rules-of-thumb are as follows: (1) planning timeframes should reflect the timeframe of ecosystem process under study; (2) if the system is subject to disturbances, understanding its frequency improves the adequacy of conservation plans; and (3) when spatial autocorrelation is not present, protecting the areas frequently disturbed apparently increases the likelihood of reserve system adequacy in the Pantanal.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Appendix S1 The characteristics of the five seral stages which described the starting points of simulation as shown in Fig. 3.

Appendix S2 Mathematical formulation and the description of the model properties.

Appendix S3 Statistical formulation and model properties behind the adaptations of the Decision support software Marxan.

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BIOSKETCH

Reinaldo Lourival has a background in ecology and wildlife management, more recently focused his research into systematic conservation planning, with interest in the dynamics of habitats and tropical wetland ecology. His aim is to expand the capabilities of decision support software as a tool to investigate how conservation decisions can be improved in the Tropics. Reinaldo is currently working in the identification of partial contribution of biodiversity in different land use types into systematic zoning, aiming to improve the UNESCO's Biosphere reserve concept and accountability, through further developments of Marxan decision support software.

Author contributions: R.L. conceived the idea for the paper, gathered and analysed the data, and led the writing; M.D. formulated the mathematical problem and tested a simplification method to handle the issues of spatial autocorrelation. M.W. and E.G. developed the Marxan algorithm to manage probabilistic dataset. H.P. in the capacity of supervisor guided the collaboration process and provided insights and with E.G. reviewed the manuscript helping increase the paper focus.

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Predicting ranchers' intention to kill jaguars: Case studies in Amazonia and Pantanal

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ABSTRACT

The killing of jaguars by ranchers in Amazonia and the Pantanal is a major threat to the species. We used the Theory of Planned Behavior to examine the role of ranchers' perceptions, norms, attitudes and intentions concerning jaguar killing, in determining their jaguar-killing behavior. We also investigated the influence of: (1) descriptive norm and social identity on ranchers' intention to kill jaguars on their properties; and (2) the effect of perceptions of jaguar impact on human livelihoods (livestock and human safety), and of property size, on the variables that influence intention to kill. Results based on interviews with 268 cattle ranchers indicated that the impact of jaguars on livestock is not the only predictor of a rancher's intention to kill jaguars. Fear, personal and social motivations, and internal and external barriers (e.g. lack of skills and force of law, respectively) to killing jaguars can also influence jaguar killing. The relative importance of these factors in determining intention to kill varies with region and affluence. We recommend ways of deterring jaguar killing behavior through communication interventions. In addition to the economic and legal incentives that have already been considered by conservationists, effective strategies to protect jaguars on privately owned land will need to address the social and psychological factors that determine the killing of jaguars by ranchers. Conservationists need to find and support ways to make jaguar killing not only unprofitable and illegal, but also socially and personally unacceptable.

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1. Introduction

The most urgent issue in jaguar (*Panthera onca*) conservation is the killing of jaguars by humans (Zeller, 2007). Because jaguars are renowned for preying on livestock (Hoogesteijn, 2000), one might assume that people kill jaguars in an effort to reduce economic losses associated with livestock predation. Conservationists have approached jaguar killing within the framework of human–wildlife conflicts (Rabinowitz, 2005) and to date research and conservation efforts have focused on the ecological (Azevedo and Murray, 2007; Cavalcanti, 2008; Michalski et al., 2006) and economic (Silveira et al., 2006) dimensions of the conflict. Little has been done to understand the link between jaguars killing livestock and people killing jaguars. The killing of jaguars may not be strictly retaliatory and might have motivations besides the economic. If we are to curb the killing of jaguars, first we have to understand the underlying causes of this behavior. We used an approach that went beyond the usual human–wildlife conflict framework to examine the reasons – both related and not related to conflict – for ranchers killing jaguars in Amazonia and Pantanal.

The few studies that have attempted to address human–jaguar conflict from the human side have assessed attitudes towards jaguars among people that were directly involved in conflict with jaguars over livestock (Conforti and Azevedo, 2003; Palmeira and Barrella, 2007; Santos et al., 2008; Zimmermann et al., 2005). Unfortunately, the relationship between attitudes and behaviors may not always be strong or direct. Moreover, by limiting the study of attitudes to the context of human–wildlife conflict, factors involved in the decision to kill a certain species, but not directly related to the impact of that species on human livelihood, may be overlooked. Theoretical frameworks have been developed by social scientists to predict human behavior from attitudes (Ajzen, 1985; Fazio, 1986), and these could provide a useful structure for studying the killing of jaguars. Key aspects of such an approach are the proper measurement of attitudes and inclusion of additional explanatory variables. In this study, we develop a framework based on the Theory of Planned Behavior (TPB) (Ajzen, 1985) to explore the relationships between landowners' perceptions of jaguar impact on human livelihood and their own jaguar killing behavior on the Amazon deforestation frontier and in northern Pantanal. We incorporate factors not related directly to the impact of jaguars on human livelihood, such as social motives for killing jaguars and perceived barriers to doing so.

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1.1. Theoretical framework

The TPB proposes that human behaviors are governed not only by personal attitudes, but also by social pressures and perceived control over one's own behavior. According to the TPB, the most proximal determinant of a person's behavior is their intention to engage in that behavior (Fig. 1). In turn, behavioral intentions are influenced by three main factors: attitudes towards the behavior, subjective norms and perceived behavioral control (PBC). Attitude scores reflect an individual's overall positive or negative evaluation of performing the behavior. Subjective norms represent an individual's perception of whether people important to them would approve of them performing the behavior. Perceived behavioral control reflects the extent to which an individual perceives the behavior to be under their volitional control. Thus, according to TPB, people who have positive attitudes towards killing jaguars, think that there is normative support for killing jaguars, and perceive that they can easily kill jaguars (or pay someone else to do it for them), should have strong intentions to kill jaguars. In addition, to the extent that PBC is a proxy for the actual control (accurately accounts for both the internal factors [e.g. knowledge, skills, courage] and external factors [e.g. legal barriers, money, equipment, help from others]) needed to perform the behavior, it may also have a direct impact on behavior.

While the great majority of attitudinal studies conducted in wildlife or conservation research have assessed attitudes about the species in question (Bruskotter et al., 2007; Kaczensky et al., 2004; Lindsey et al., 2005), the TPB recognizes that attitudes will not predict behavior unless they are measured with corresponding levels of specificity: attitudes about objects (such as jaguars) will not necessarily predict behaviors (such as killing jaguars). In order for attitudes to predict behavior, the attitude and behavior must correspond on four levels of specificity: action, target, context and time. In this study, we could have had four different attitude objects: (1) killing (action), (2) killing a jaguar (action and target), (3) killing a jaguar on own property (action, target and context), and (4) killing a jaguar on own property in the near future, or the next jaguar that appears (action, target, context and time). Questions about attitude objects 1 and 2 should predict general intentions to kill jaguars in the future or indices of killing jaguars in the past, but would be poor predictors of the behavior described in attitude objects 3 and 4. Questions about attitude objects 3 and 4 are specific and would be expected to predict the behaviors described in the statements (Manfredo, 2008). We therefore assessed attitudes (and other TPB variables) related to the specific rancher's behavior of "killing (action) the next (time) jaguar (target) that appears on his property (context)".

A multitude of variables can be related to or influence attitude, subjective norm and PBC: age, gender, education, socioeconomic status, personality, emotions, general attitudes, religion, knowledge, past experience and so forth (Fig. 1). The TPB recognizes the potential significance of such background factors. Although reviews and meta-analyses have demonstrated broad support for the basic TPB (e.g., Ajzen and Cote, 2008; Armitage and Conner, 2001), it is acknowledged that for some behaviors and contexts, the inclusion of other variables may increase the predictive utility of the model. Descriptive norms and social identity are examples of such variables. Descriptive norms reflect an individual's perception of whether other people perform the behavior in question (Cialdini et al., 1990). Descriptive norms describe what is typical or normal, and motivate action by indicating what is likely to be effective, adaptive and appropriate action (White et al., 2009). For instance, a rancher who believes that all his neighbors kill jaguars will feel motivated to do the same. Social identity is that component of an individual's concept of himself that is derived from his knowledge of group membership, and the value and emotion attached to that membership (Tajfel, 1981). According to the social identity theory, people define and evaluate themselves in terms of distinct social categories [e.g. rancher, *pantaneiro* (i.e. native to the Pantanal)]. By allocating himself a particular social identity an individual is encouraged to accentuate both the similarities between himself and other group members, and the differences between himself and people outside the group (Fielding et al., 2009). A social identity approach assumes that if a certain behavior, for example killing a jaguar, is centrally linked to a social identity, then that behavior will be influenced by the norms of that social group rather than by the expectations and desires of generalized others.

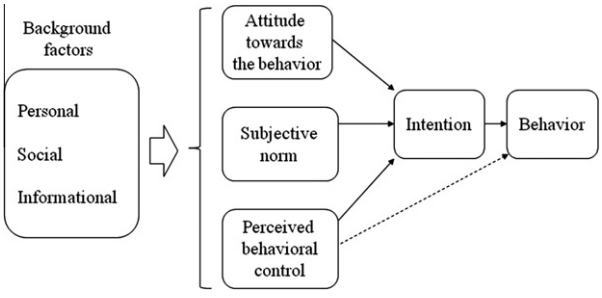

Fig. 1. Diagrammatical representation of the Theory of Planned Behavior.

1.2. Hypotheses

Perceptions of conflict with jaguars (more specifically, perception of jaguar impact on livestock and on human safety) were expected to affect intention: people who perceive that their livestock, or safety, is threatened by jaguars are more likely to intend to kill jaguars (Hypothesis 1). However, we hypothesized that the killing of jaguars by ranchers is not strictly retaliatory, and that by taking into account factors that are not related directly to livestock depredation, or threat to human safety (i.e. subjective norm and PBC), the TPB would offer a more predictive model of intention to kill jaguars (Hypothesis 2).

During the preliminary stages of this study we gathered anecdotal evidence of a social dimension to jaguar killing, especially in the Pantanal surveyed site. Evidence included photographs of hunted jaguars and jaguar paw trophies displayed prominently in ranchers' living rooms, boastful stories told by ranchers about their bravery in hunting jaguars, and repeated mention that killing jaguars is something that everybody does, or have done for generations, as an important element of the local tradition. Therefore, including descriptive norm and group identity in the model was expected to increase significantly the predictive utility of the TPB model (Hypothesis 3): ranchers who believe that other ranchers kill jaguars and identify themselves with those ranchers will have stronger intentions to kill jaguars themselves.

Attitude towards a particular behavior is measured using experiential items (i.e. how it feels to perform the behavior e.g. unpleasant–pleasant) and instrumental items (i.e. whether the behavior achieves something e.g. detrimental–beneficial and worthless–useful) (Ajzen and Fishbein, 1980). Retaliatory killing of jaguars is instrumental in nature: it is expected to bring the benefit of decreased livestock loss or increased human safety. Therefore, we predicted that attitudes towards killing jaguars would be affected by perceptions of jaguar impact on livestock and on human safety. Indeed, in the TPB, background factors are assumed to influence intentions and behavior indirectly by affecting attitude, norms and PBC: we predicted therefore that perceptions of conflict with jaguars would influence jaguar persecution indirectly by affecting attitude towards the killing of jaguars (Hypothesis 4).

Commercial, sport, and recreational hunting are prohibited in Brazil. Nonetheless, in remote areas of rural Amazonia and

Pantanal people do not expect to be penalized for breaking the law. Expectation of law enforcement and perceived risk associated with breaking the law are probably lower among large, affluent, and consequently, more influential ranchers. Furthermore, jaguars are more likely to be present on larger properties and their landowners more likely to have the resources for killing jaguars. In summary, the larger the property the more volitional control its owner should have over killing jaguars. Therefore, we hypothesized that perceived behavioral control increases with property size (Hypothesis 5).

While hosting relatively large populations of both cattle and jaguars (Cavalcanti et al., 2010), the two study areas differ distinctly in some socioeconomic aspects. The Amazon frontier was colonized recently by people from different parts of Brazil, including areas where jaguars had long been extirpated. Small family-owned farms coexist with large commercial cattle ranches on the Amazon frontier. In contrast, Northern Pantanal is home to a few traditional families that own large ranches and have been raising cattle in the region for generations. In communities where residents come from different parts of a country, for example, in frontier areas, there may be no consensus on what are acceptable or unacceptable behaviors towards wildlife. In other words, descriptive norms are unclear. Even if there is some agreement, many people may not care about the opinions of others, and so the subjective norm and group identity are less likely to influence behavior. In contrast, where traditional communities are intact and there is collective thinking and articulation about what constitutes acceptable practice, subjective norms and group identity may be sufficiently powerful to maintain practices that are illegal but socially encouraged. Therefore, we hypothesized that the relative importance of the social determinants of jaguar killing and perceived control over this behavior would differ between the Amazon deforestation frontier and northern Pantanal (Hypothesis 6).

2. Materials and methods

2.1. Study areas and participants

The Amazonia survey was carried out in the district of Alta Floresta, in the north of the State of Mato Grosso. Alta Floresta was founded in 1976 and colonized by migrant farmers from other parts of Brazil. Alta Floresta has approximately 49 000 urban inhabitants, and overall the district rears over 748 000 head of cattle (Brazilian Institute of Geography and Statistics, 2007). Cattle depredation by jaguars is regarded as a severe problem in Alta Floresta (Michalski et al., 2006), and persecution and habitat loss are major threats to jaguars there (Michalski and Peres, 2005). The Pantanal study was conducted in the districts of Cáceres and Poconé, also in the State of Mato Grosso. Cáceres and Poconé have approximately 84 000 and 31 000 inhabitants respectively, and cattle ranching is their main economic activity (Brazilian Institute of Geography and Statistics, 2007). As with the Amazon frontier, northern Pantanal rears large cattle herds (around 832 000 and 347 000 head in Cáceres and Poconé, respectively) (Brazilian Institute of Geography and Statistics, 2007) and livestock depredation by jaguars is a major complaint among ranchers (Marchini, 2003; Zimmermann et al., 2005).

The sample unit was the property, with either owner – but preferably the husband – from each surveyed (in a few large ranches, the ranch manager was interviewed when neither of the owners was available). We used a combination of sample selection techniques to maximize randomness and representativeness. Google Earth imagery (Google Inc., 2009) was used to map all roads within the study areas (available road maps do not include minor roads). Then we used a systematic sampling strategy, selecting every other property along randomly chosen roads. In Amazonia, ranches were easily accessible by land and all interviews were carried out on site. In the Pantanal some properties near the *Transpantaneira* highway could be visited but many others were inaccessible overland and so some ranchers, randomly selected from a list of members provided by the association of rural workers of Cáceres and Poconé, were interviewed in their second residences in town.

2.2. Procedures and measures

Interviews were conducted between March and October 2007 in Amazonia and between February and May 2008 in the Pantanal. The killing of jaguars is illegal and can be a sensitive issue for some ranchers. Therefore, some measures were taken to avoid response and interviewer biases. All interviews were conducted by SM, who is Brazilian and acquainted with the local culture and parlance in both study areas. SM was always accompanied by a male local field assistant during the interviews. SM was as objective and neutral in appearance and behavior as possible.

We conducted a pilot study using qualitative, semi-structured interviews (Oppenheim, 1998) with 130 people (90 rural and urban residents in Amazonia, and 10 ranchers and 30 urban residents in the Pantanal). By listening to people talk freely, we were able to identify salient beliefs, perceptions, and peculiarities of the local parlance, which were then used in the design of the questionnaire, and in adjusting our language to the target groups. During the piloting process, open-ended questions were replaced incrementally by clear, quantitative questions that would produce data suitable for statistical analysis. We used Cronbach's alpha to improve the internal coherence of the scales by discarding items to maximize the alpha value (Vaske, 2008).

We anticipated that some ranchers would feel inclined to omit their negative perceptions, attitudes, intentions and behaviors towards jaguars. Given that people attempt to provide answers consistent with the ones they have already given in the survey (Sudman et al., 1996; Tanur, 1992), questions were asked in the order in which we expected the likelihood of a deceiving answer to increase: questions of perceptions and attitudes first, then intention and, finally, behavior. All TPB components were measured according to the recommendations of Ajzen and Fishbein (1980) and Ajzen (1985). Where a TPB component was assessed using multiple questions, we created average scales to summarize that component. The variables used in the analyses and the items used to construct the variable scales are shown in Table 1. The variables are described in more detail below.

Perceptions of jaguar impact on livestock and on human safety were recorded on a 6-point scale coded 0–5 (no impact to high impact) according to the size of the impact. Respondents' attitudes towards killing jaguars were assessed by asking them to indicate their attitude towards killing the next jaguar that appeared on their properties, using five-point evaluative semantic differential scales. The attitude to jaguar killing scale ranged from −2 (most unfavorable) to 2 (most favorable). Subjective norms, descriptive norms, group identification, perceived behavioral control and intention to kill were recorded on a 5-point scale ranging from 1 (minimum) to 5 (maximum). We explained clearly to the respondents that by killing jaguars we meant using any of the methods and approaches used to kill jaguars in Amazonia and Pantanal (e.g. finding and pursuing a jaguar using dogs, creating a baiting station at which to shoot a jaguar, poisoning, and acting either alone or with others including hired professional hunters).

Three approaches were used to assess jaguar-killing behavior: (i) respondents were asked if they had ever killed a jaguar and, if so, when they had last done this; (ii) respondents were asked to say which of their neighbors had killed jaguars within the previous 5 years; and (iii) in Amazonia, two independent local

Table 1
Items used to measure each variable, Cronbach's coefficient alpha (α), and comparison of variables between the Amazon and Pantanal surveyed sites in the State of Mato Grosso, Brazil; means, standard deviations (SDs) and GLM results.

Variable/item	α	Amazonia		Pantanal		*F*	SE	*p*
		Mean	SD	Mean	SD			
Property size[a]		298.8	1581.1	5524.0	5342.4	209.30	368.63	<0.001
Perceived impact on livestock[b] Damage associated with depredation ever caused to you Damage associated with depredation ever caused to your neighbors Risk of any damage associated with depredation to you in the next 12 months Risk of any damage associated with depredation to your neighbors in the next 12 months	0.80	0.63	0.65	1.89	0.72	127.79	0.43	<0.001
Perceived impact on human safety[b] Number of people ever hurt by a jaguar in the neighborhood Number of family members ever hurt by a jaguar Risk of you being hurt by a jaguar in the next 12 months Risk of a family member being hurt by a jaguar in the next 12 month	0.76	2.95	0.59	2.57	0.89	13.54	0.42	<0.001
Attitude to jaguar killing[c] Killing the next jaguar the appears in your property would be: Bad – good Useless – useful Exciting –boring Beneficial – harmful Unenjoyable – enjoyable	0.90	0.25	0.91	0.42	1.24	1.10	0.16	0.296
Subjective norm[d] How many of the people important to you would disapprove of you killing jaguars? Most people important to me think that killing jaguars is admirable Among your neighbors, how much agreement would there be that it is a good thing to kill jaguars? In your family, how much agreement would there be that it is a good thing to kill jaguars?	0.85	1.85	0.71	2.70	0.91	50.30	0.12	<0.001
Perceived behavioral control[d] Whether I kill the next jaguar that appears on my property is up to me For me, to kill the next jaguar that appears on my property would be: The number of factors outside my control which could prevent me from killing the next jaguar that appears on my property are:	0.88	2.26	1.13	4.09	0.73	116.22	0.17	<0.001
Descriptive norm[d] How many of your neighbors do you think kill jaguars? Think of the landowners in (location) – what percentage of them do you think kill jaguars?	0.90	2.17	0.78	3.98	0.67	223.57	0.12	<0.001
Group identity[d] How much do you identify with the landowners in (location)? How much do you feel strong ties with the other landowners in (location)? In general, how well do you feel you fit into the group of landowners in (location)?	0.76	1.88	0.96	3.50	0.95	130.93	0.15	<0.001
Intention[d] I intend to kill the next jaguar that appears on my property If a jaguar appears on my property, I will try to kill it	0.92	2.40	1.13	3.47	1.25	33.92	0.18	<0.001

[a] Size in ha.
[b] Scale ranging from 0 to 5.
[c] Scale ranging from −2 to +2.
[d] Scale ranging from 1 to 5.

informants – a professional hunter and a veterinarian – indicated ranchers who were supposed to have killed jaguars in the previous 5 years. One year after the main survey we conducted a follow-up survey in Amazonia; we: (1) revisited a randomly-selected sub-sample of 40 respondents to ask them whether they had killed any jaguar since our last visit; and (2) asked the informants whether any of the study participants were supposed to have killed jaguars during the year since the survey. We used three different approaches (self-reporting, neighbor reporting and informant reporting) to guard against the likelihood that some respondents would fail to report their own killing behavior and, to a lesser degree, that of their neighbors.

2.3. Data analysis

All analyses were conducted in SPSS, version 14 (2005). For each study area separately we used χ^2 tests to test for a relationship between recent jaguar killing and intention to kill jaguars in the future (intention was recoded as a binary variable for this analysis, using 0 for no intention to kill jaguars and 1 for any level of intention). This provided a way of validating the measurement of intention. Pearson correlation coefficients were used to examine correlations between predictor variables. The internal consistency of scales was examined using Cronbach's alpha reliability coefficients (Vaske, 2008). Two sets of GLMs were performed to develop a predictive model of jaguar persecution for each study area. The first GLM analysis examined the prediction of intention to kill jaguars. Instead of an automated stepwise procedure, we carried out a structured comparison of specific models defined *a priori* based on different explanations of jaguar persecution. Because the models included multiple predictors that were somewhat correlated, we used sequential sum of squares (type I) models so that each effect in an individual model adjusted only for preceding effects in the model. The following models were assessed: (Model 1) perceptions of jaguar impact on livestock and on human safety; (Model 2) TPB variables; (Model 3) significant predictors of the TPB plus descriptive norm and group identity; and (Model 4) significant predictors of the extended TPB plus perceptions of jaguar impact on livestock and on human safety. We compared Models 1 and 2 to test the hypothesis that the TBP offers a more predictive model for jaguar persecution than the usual approach that assumes strictly retaliatory killing. By comparing Models 2 and 3 we examined whether adding descriptive norm and group identity to the TPB resulted in an increase in the predictive utility of the model. Finally, by contrasting Models 3 and 4 we assessed the contribution of the perceptions of conflict to the extended TPB. The second GLM analysis examined the effect of certain background factors ((i) perceived impact of jaguars on livestock, (ii) perceived impact of jaguars on human safety and (iii) property size) on those variables from the extended TPB that significantly affected intention to kill jaguars in the first GLM analysis.

3. Results

3.1. Characteristics of sample

On average, respondents in the Pantanal ($n = 48$) were older (mean = 54.8 years, SD = 11.8, range = 27–77) than those in Amazonia ($n = 220$, mean 42.4 years, SD = 13.1, range = 17–82). In the Pantanal, all respondents were male, whereas 26.7% of Amazonian respondents were female. This sample properly reflects relevant characteristics of the study populations: young landowners are more common in the small family-owned farms of the Amazon agricultural frontier and women are rare in the large, remote ranches of the Pantanal, and less likely to take part in the decision making process regarding jaguar management in the property. Table 1 presents additional information about the variables used in the analyses and comparisons between Amazonia and Pantanal.

3.2. Predicting intention to kill jaguars in the Amazon deforestation frontier

Both perceived impact of jaguars on livestock and on human safety were significant predictors of behavioral intention (Model 1) (Table 2). In support for Hypothesis 1, landowners who perceived a greater impact of jaguars on their livestock or their safety were more likely to intend to kill jaguars. However, in support for Hypothesis 2, the TPB model (Model 2) explained over twice as much of the variation in intention ($R^2 = 0.22$ compared with 0.10), even though subjective norm did not emerge as a significant predictor in the analysis. Landowners with more positive attitudes towards killing jaguars and a greater sense of control were more likely to intend to kill jaguars on their properties. In support of Hypothesis 3, the addition of descriptive norm (Model 3) accounted for a further 4.5% of the variation in intention to kill jaguars, over and above that explained by attitude, subjective norm and PBC. Respondents who perceived that other landowners killed jaguars had stronger intentions to kill jaguars.

Neither perceived impact on livestock nor perceived impact on human safety had a significant impact on intention to kill jaguars in the extended TPB model (Model 4), and inclusion of these variables accounted for only 1% of the variation in intention. Nonetheless, both perceived impact on livestock and on human safety had a significant effect on attitude ($\beta = 0.101$ and 0.126, respectively, both with $p < 0.001$), and therefore an indirect effect on intention to kill jaguars. These two findings provide support for Hypothesis 4: the perceived impact of jaguars on livestock and on human safety determine intentions indirectly by affecting attitude towards the killing of jaguars.

Property size was a significant predictor of perceived behavioral control ($\beta = 0.001$, $p = 0.015$). In support of Hypothesis 5, ranchers who owned large properties had a stronger sense of control over killing jaguars on their land. The main barriers to killing jaguars pointed out by the small landowners who perceived that killing jaguars was not under their volitional control were: fear of jaguars (43%); lack of skills (31%); lack of equipment (15%); and illegality (10%).

The above findings are summarized in Fig. 2. Landowners within the Amazon deforestation frontier were more likely to intend to kill the next jaguar that appeared on their property if they: (1) had more positive attitudes towards killing jaguars; (2) had a greater

Table 2
Results of GLM predicting intention to kill jaguars in the Amazon surveyed site in the State of Mato Grosso, Brazil.

Model	Predictor included	R^2	*B*	SE	*p*
1	Perceived impact on livestock	0.105	0.083	0.027	0.002
	Perceived impact on safety		0.110	0.031	<0.001
2	Attitude	0.222	0.510	0.076	<0.001
	Subjective norm		0.016	0.096	0.865
	Perceived behavioral control		0.178	0.061	0.004
3	Attitude	0.267	0.458	0.075	<0.001
	Perceived behavioral control		0.139	0.062	0.027
	Descriptive norm		0.322	0.088	<0.001
	Group identity		0.008	0.075	0.911
4	Attitude	0.278	0.458	0.084	<0.001
	Perceived behavioral control		0.139	0.060	0.027
	Descriptive norm		0.322	0.088	<0.001
	Perceived impact on livestock		0.033	0.026	0.207
	Perceived impact on human safety		0.039	0.030	0.198

sense of control over their jaguar-killing behavior; and (3) perceived that other landowners killed jaguars. Landowners with stronger perceptions of jaguar impact on livestock, or on human safety, had more positive attitudes towards killing jaguars. Larger landowners had a greater sense of control over their own jaguar-killing behavior.

3.3. Predicting intention to kill jaguars in the Pantanal site

Perceived impact of jaguars on livestock was a significant predictor of intention to kill jaguars (Model 1) (Table 3). Perceived jaguar impact on human safety had no significant impact on intention. In partial support for Hypothesis 1, landowners who perceived a greater impact of jaguars on livestock had stronger intentions to kill jaguars. The TPB (Model 2) offered a more predictive model, in support of Hypothesis 2. Even without a significant effect of perceived behavioral control, the TPB accounted for 55% of the variation in intention to kill jaguars. Ranchers with more positive attitudes towards killing jaguars and a greater perception of others' approval of jaguar-killing behavior had a stronger intention to kill the next jaguar that appeared on their properties. Descriptive norm and group identity (Model 3) emerged as significant predictors of intention, in support for Hypothesis 3. Ranchers who perceived that other ranchers killed jaguars and identified themselves with the other ranchers were more likely to engage in jaguar killing. Descriptive norm and group identity accounted for an additional 17% of the variation (over and above attitude and subjective norm), providing support for the inclusion of these variables in the model (Model 3). Including perceived impact on livestock and perceived impact on human safety in the extended TPB model (Model 4) did not improve the model significantly further (accounting for just 0.8% more of the variation in intention), and their effect on intention was not statistically significant. However, perceived impact of jaguars on livestock did have a significant effect on both attitude ($\beta = 0.172$, $p = 0.005$) and subjective norms ($\beta = 0.129$, $p = 0.006$), and therefore an indirect effect on intention to kill jaguars. Perceived impact of jaguars on livestock seems indirectly to determine intention by affecting attitude (and subjective norms), which supports Hypothesis 4.

Fig. 3 summarizes the above findings. Intention to kill jaguars in the Pantanal was greater among ranchers who: (1) had more positive attitudes towards killing jaguars; (2) believed there was normative support for performing such behavior; (3) perceived that other ranchers killed jaguars; and (4) identified themselves with the other ranchers. Ranchers who had a stronger perception of the impact of jaguars on livestock also had more positive attitudes towards killing jaguars and a stronger sense of social pressure to kill them.

Table 3
Results of GLM predicting intention to kill jaguars in the Pantanal surveyed site in the State of Mato Grosso, Brazil.

Model	Predictor included	R^2	*B*	SE	*p*
1	Perceived impact on livestock	0.200	0.193	0.061	0.003
	Perceived impact on safety		0.063	0.047	0.187
2	Attitude	0.552	0.323	0.115	0.007
	Subjective norm		0.734	0.152	0.000
	Perceived behavioral control		0.98	0.181	0.593
3	Attitude	0.722	0.345	0.089	<0.001
	Subjective norm		0.341	0.147	0.025
	Descriptive norm		0.550	0.162	0.001
	Group identity		0.431	0.132	0.002
4	Attitude	0.730	0.328	0.096	0.002
	Subjective norm		0.309	0.153	0.002
	Descriptive norm		0.530	0.165	0.003
	Group identity		0.448	0.134	0.002
	Perceived impact on livestock		0.039	0.042	0.359
	Perceived impact on safety		-0.014	0.031	0.645

The contrast between Figs. 2 and 3 supports Hypothesis 6: the relative importance of the social determinants of jaguar killing and perceived control over this behavior differs between the Amazon deforestation frontier and northern Pantanal.

3.4. Relationship between intention and behavior

The proportion of respondents intending to kill the next jaguar that appeared on their property was greater in the Pantanal (46%) than Amazonia (15%). No jaguar kills were observed or reported during the 12 months following the survey. However, by cross-referencing information provided by landowners and by independent informants, we identified 11 landowners in the Amazonia sample who had killed at least one jaguar on their property in the previous 5 years (six of these landowners had not reported these kills). This information was used to examine the relationship between landowners' declared intention to kill jaguars and their past jaguar-killing behavior. Most (82%) of the landowners that were confirmed to have killed jaguars in the previous 5 years said that they intended to kill the next jaguar that appeared on their property, whereas most (89%) of those that had not killed jaguars recently did not intend to do so in future ($\chi^2 = 40.5$, df: 1, $p < 0.001$). This relationship between measured behavioral intention and actual past behavior suggests that intention to kill jaguars may be a valid proxy for future killing behavior in Amazonia.

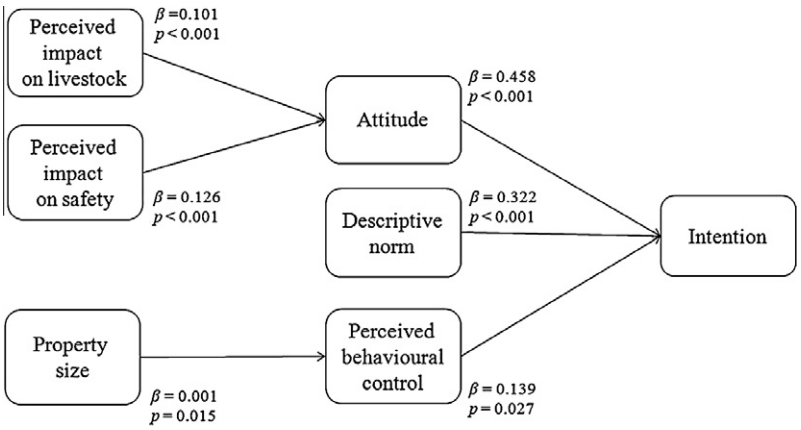

Fig. 2. Final model showing intention to kill jaguars in the Amazonia deforestation frontier, State of Mato Grosso, Brazil.

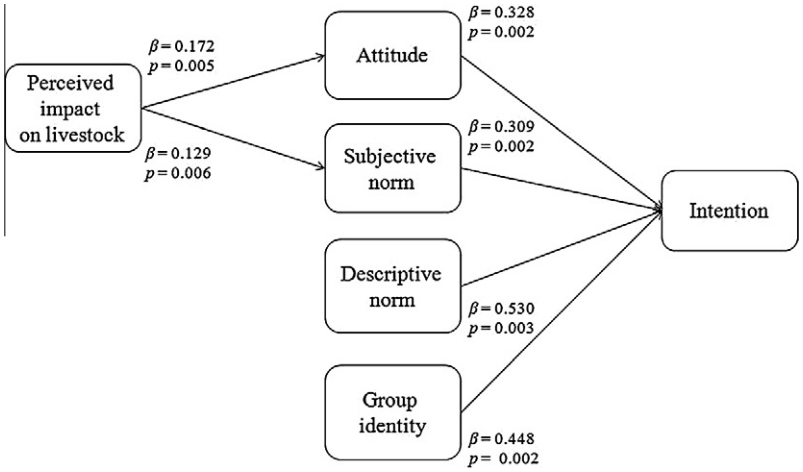

Fig. 3. Final model showing intention to kill jaguars in the Pantanal surveyed site, State of Mato Grosso, Brasil.

All seven ranchers in the Pantanal that reported killing at least one jaguar on their property in the previous 5 years said that they intended to kill the next jaguar that presented a similar opportunity. In contrast most (64%) of those that had not killed jaguars did not intend to do so in future (χ^2 = 8.9, df: 1, p = 0.003).

4. Discussion and conclusions

This study shows that the impact of jaguars on livestock is not the only predictor of a cattle rancher's intention to kill jaguars. Intention to kill jaguars is also determined by fear, personal and social motivations, and internal and external barriers to killing jaguars. The relative importance of these factors in determining intention varies with region and affluence. Conservation measures that aim to decrease jaguar persecution by ranchers will be more effective if these factors are taken into account.

Fear is an important factor in determining Amazonian landowners' intentions to kill jaguars. Fear affects intention through two distinct and opposing mechanisms. On one hand, fear of jaguar impact on human safety can increase the likelihood of a positive attitude towards killing jaguars, while, on the other, fear arising from landowners' own inability to kill jaguars (poor perceived behavioral control) may act as an internal barrier that limits their intention to engage in jaguar killing. A fear of jaguars is indeed common among the Amazonian frontiersmen (Cavalcanti et al., 2010), who are largely immigrants with little experience of jaguars and the forest, but fear of jaguars was also reported by some ranchers in the Pantanal. Jaguars are potentially dangerous to people, and a phobic response to the species might be instinctive. However, fear of jaguars varies with knowledge. The better informed people are about jaguars, the less they fear them (Cavalcanti et al., 2010.). After all, the strong fear of jaguars among Amazonian ranchers is not grounded in fact. Attacks on people by jaguars are extremely rare and have occurred almost invariably either when hunted jaguars are cornered or injured, or when jaguars are defending cubs or carcasses. The only documented, unprovoked, fatal attack by a jaguar on a human in Brazil occurred on 24 June 2008, when a young fisherman was believed to have been killed by a jaguar while sleeping in his tent on a bank of the Paraguay River in the district of Cáceres, northern Pantanal. This unique incident may have occurred as a result of jaguars becoming habituated to people around baits used to attract them to be photographed by tourists.

Attitude towards killing jaguars predicts landowners' intention to kill them in both Amazonia and the Pantanal. This attitude is shaped by both instrumental and experiential expectations. For example, landowners may favor killing jaguars because they consider such behavior beneficial and useful, as well as exciting and enjoyable. The thrill of the hunt may be an important additional motivation for retaliatory killing and may in some situations be the only reason for killing jaguars. Ranch hands that do not own livestock are known to kill jaguars on other people's ranches in the Pantanal, where absent owners have specifically banned the practice by (Cavalcanti, 2008). This provides further evidence that jaguar killing may be explained by personal motivations unrelated to the impact of jaguars on human livelihoods.

Social motivations are important determinants of the intention to kill jaguars in both Amazonia and the Pantanal. In the Pantanal, some ranchers justified their perception of the social approval of jaguar killing on the grounds of tradition. Ranchers and cowboys in the region often refer, with apparent pride, to the '*Pantaneiro* culture' and the conviction that jaguar hunting has been passed from generation to generation as an element of that culture. The subjective norm among Pantanal landowners is affected by their perception of jaguar impact on livestock; ranchers who perceive a strong impact of jaguars on livestock also perceive a strong peer pressure to kill jaguars. The economic and cultural centrality of cattle ranching in the region doubtless accounts for this correlation. It is widely perceived that jaguar killing is common in both Amazonia and the Pantanal, and the perception that neighbors often kill jaguars encourages landowners to intend to do the same. Despite it being an illegal practice, jaguar killing is not something people strive to keep secret. On the contrary, some perpetrators talk openly with other ranchers, about killing jaguars. Stories of jaguar hunting spread quickly among the community, are told repeatedly, and are often remembered vividly as a consequence. The ease with which stories of jaguar hunting are brought to mind among landowners could account for the strong descriptive norm concerning jaguar killing (Tversky and Kahneman, 1974). A vicious circle may exist in which hunts are readily remembered and repeated, often reaching other landowners, and creating the perception that jaguar killing is common and acceptable, which in turn causes more jaguars to be killed. Finally, social identity (group identity) also influences jaguar killing in the Pantanal. In our Amazon sample, many small landowners were settlers belonging to small, organized communities. Although group identity was greater among smaller settlers than among large landowners in the region, jaguar killing was not perceived to be an in-group behavior, and so group identity did not affect their intention to kill jaguars in Amazonia. In contrast, ranchers in the Pantanal have a strong group identity and perceive that jaguar killing is part of *Pantaneiro* culture. If perceived association of jaguar killing with in-group members is coupled with a perceived

association of jaguar conservation with out-group members, conservation efforts considered to emanate from outside the group may be poorly accepted and conflicts between ranchers and jaguars may be replaced by conflict, about jaguars, between ranchers and conservationists. The role of conflicts between human groups in resolving human–jaguar conflicts (Herda-Rapp and Goedeke, 2005) deserves further investigation.

Current behavior could not be measured. Consequently, the utility of the model to predict future behavior could not be verified. Jaguar killing is a particularly difficult behavior to measure for two reasons: (i) it is illegal and therefore some respondents might fail to report it; and (ii) it depends upon a contextual factor that is highly variable in time and space: an encounter with a jaguar. While most behaviors that have been addressed in TPB studies can be observed on a daily basis (e.g. exercising, recycling) or every month at most (e.g. reducing energy use) (Armitage and Conner, 2001), killing jaguars is something a rancher typically does when the opportunity arises, i.e. when a jaguar appears, e.g. a few times in 1 year and then not for several more years. Robust validation of the intention–behavior relationship would require the measurement of behavior either over several years for individual ranchers, or over larger areas encompassing a larger number of ranches than surveyed in this study. However this study provides some evidence that our measurement of intention to kill jaguars was valid: (i) observed relationships between intention and its predictors were consistent with expectations based on theory (Vaske, 2008); and (ii) there was a significant relationship between intention to kill jaguars and recent past killing behavior.

4.1. Further implications for conservation

Our model is not only useful to the extent that it can predict jaguar killing. It can also be used to assess the relative importance of the different factors that motivate or deter such behavior. Efforts to increase people's tolerance of jaguars and discourage jaguar killing have focused largely on economic incentives (e.g., monetary compensation for livestock loss; Silveira et al., 2006) and legal prohibitions and sanctions (e.g. establishment of protected areas). The role and importance of social and psychological factors have been far less considered. This study proposes a broader approach for understanding and preventing the killing of jaguars, an approach that goes beyond the usual framework of human–jaguar conflicts, and considers all the motivations and barriers – social and psychological as well as legal and economic – concerning jaguar killing.

Human behavior is partly determined by external, contextual factors (Clayton and Myers, 2009). The measures mentioned above aim to prevent jaguar killing behavior by changing the economic and legal contexts. Our findings, however, highlight the importance of social context. Social norms and social identity also affect jaguar killing and should be taken into account by conservationists. A number of techniques can be used to change social context. For instance, a persuasive communication campaign using models (i.e. conspicuous and respected group members or community institutions) might help to create or redefine a social norm by explaining that the community condemns rather than accepts the killing of jaguars.

Human behavior is also determined by internal, psychological factors (Clayton and Myers, 2009). This study revealed the importance of perceptions, knowledge, skills, attitudes and emotions such as fear and excitement in inciting the killing of jaguars. Education and information-intensive campaigns might be used to influence these factors in order to deter jaguar killing. The role of information in changing behavior is complex. While researchers agree that information alone will not necessarily motivate someone to adopt a new behavior (e.g. to tolerate jaguars) (Stern, 2000), it is equally clear that a lack of information can be a barrier to changing behavior (Schultz, 2002). Information interventions addressing livestock predation by jaguars might help ranchers correctly to identify a depredation event, implement preventive measures, and adjust exaggerated perceptions of jaguar impact on livestock and human safety to reality.

The behavioral approach explored in this study is relevant to the mitigation of the conflicts between people and other wildlife species, especially when the conflict involves deep rooted prejudices and feelings towards the species, which is often the case in the conflicts with large carnivores (Dickman et al., in press). As humans are the constant in the highly variable realm of human–wildlife conflict, and the course and resolution of conflict is determined by the thoughts and actions of the people involved, understanding the human behavior is the most crucial pre-requisite for developing effective mitigation (Manfredo and Dayer, 2004).

4.2. Conclusion

In neither Amazonia nor Pantanal would it be possible to construct an effective jaguar protection strategy based on a single field of influence. Jaguar killing results from the interplay between external incentives and internal influences, and effective strategies to prevent jaguar killing should therefore be based on the social and psychological aspects of human–jaguar relationships as well as on legal and economic considerations. We need to find and support ways to make jaguar killing not only unprofitable and illegal, but also socially and personally unacceptable.

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RESEARCH ARTICLE

Dynamics of Cattle Production in Brazil

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Abstract

Movement of livestock production within a country or region has implications for genetics, adaptation, well-being, nutrition, and production logistics, particularly in continental-sized countries, such as Brazil. Cattle production in Brazil from 1977 to 2011 was spatialized, and the annual midpoint of production was calculated. Changes in the relative production and acceleration of production were calculated and spatialized using ARCGIS®. Cluster and canonical discriminant analyses were performed to further highlight differences between regions in terms of cattle production. The mean production point has moved from the Center of Minas Gerais State (in the southeast region) to the North of Goiás State (in the Midwest region). This reflects changes in environmental factors, such as pasture type, temperature and humidity. Acceleration in production in the northern region of Brazil has remained strong over the years. More recently, "traditional" cattle-rearing regions, such as the south and southeast, showed a reduction in growth rates as well as a reduction in herd size or internal migration over the period studied. These maps showed that this movement tends to be gradual, with few regions showing high acceleration or deceleration rates.

Introduction

The occupation of geographic space and territory has been a constant concern of agribusiness and society and, consequently, of public policies. However, beef demand is growing worldwide [1] and stimulates increased productivity and production. This has occurred mainly in countries with areas for expansion of beef cattle, such as Brazil. Only between 1990 and 2009, the Brazilian cattle herd has grown by 33%, mainly through expansion in the Midwest region, due to the presence of several favorable elements, such as the presence of external drivers, including socioeconomic factors [2].

However, livestock development within a country or region has implications on several fronts (genetics, adaptation, well-being, nutrition), particularly in continental-sized countries such as Brazil. This movement in production is also accompanied by the need for adequate infrastructure (abattoirs, transport, energy, inputs industries), commercialization and marketing, as well as technical support. It also fuels the need for credit programs as well as research and development activities to support intensification goals [3].

Furthermore, statistical analyses have shown only quantitative changes in herd productivity indicators and associated regions and do not enable a more detailed temporal interpretation to understand the different phenomena and dynamic trends of an activity in the territory. Thus, the use of Geographical Information Systems (GIS) has resulted in a better and more timely visualization of production systems and can aid in the identification of problematic areas [4]. GIS can aid in the identification of areas that are suitable for the expansion of production [5], as well as identification of genetic resources for conservation [6]. Thus, the objective of this article is to study the dynamics of cattle production in Brazil on a municipal scale and to identify potential areas of strangulation for continued growth and variables that could limit the increase in production and productivity of the cattle in Brazil.

Methods

This study considered all municipalities (5561 in total) in five regions of Brazil. Data on cattle production in Brazil were obtained from the website of the Brazilian Institute for Geography and Statistics [7] from 1977 to 2011.

Maps were generated using the number of animals/head of cattle (production) for each year, which was then converted into a raster format (GRID) and processed using ENVI 4.5 software.To analyze the dynamics of production growth, maps were drawn for the relative growth rate (GR %) of production by municipality by dividing the time interval analyzed into seven equal periods, using the sum of 5 years of production in each period examined (1977 to 1981 1982 to 1986, 1987 to 1991, 1992 to 1996, 1997 to 2001, 2002 to 2006, and 2007 to 2011). The relative growth rate was calculated using the following equation (Eq 1):

$$\mathrm{GR} = \frac{[(\text{Production in present period} - \text{Production in previous period}) \times 100]}{\text{Production in previous period}} \quad \text{Eq 1}$$

The relative growth rate resulted in seven maps. Data were classified as high growth (growth $\geq$ 50%), low growth (between 10 and 49.9%), stagnation (between +9.9 and -9.9%), low reduction (between -10 and– 49.9%) and high reduction ($\leq$ -50%). The acceleration of growth rate was obtained by the relative differences in the images, which resulted in six maps calculated as GRPsP – GRPvP, where GRPsP is the Growth Rate in the Present Period and GRPvP is the Growth Rate in the Previous Period. These maps were generated on a continuous scale, as these represent differences between two periods, presented as the beginning of one period until the end of the next period (p.ex 1977 to 1986).

The spatial midpoint of production in the country was calculated for each year to assess the direction of production in the country. The latitude (Eq 2) and longitude (Eq 3) midpoint were obtained by multiplying the sum of the geographic coordinates of the municipality and their production divided by the number of municipalities for each year.

$$\frac{\sum(\text{latitude} \times \text{production})}{\text{Number of municipalities}} \quad \text{Eq 2}$$

$$\frac{\sum(\text{longitude} \times \text{production})}{\text{Number of municipalities}} \quad \text{Eq 3}$$

Cluster (PROC CLUSTER) and canonical discriminant (PROC CANDISC) analyses were performed to further highlight differences between regions in terms of cattle production using SAS® v.9.3 (SAS Institute, Cary, North Carolina). Two groups of clusters of municipalities were formed according to the relative growth and acceleration calculated above. Cluster means for acceleration and relative growth were compared using an analysis of variance and mean

separation using Tukey test ($P<0.05$) after standardization. Discriminant canonical analyses were used to identify regions and municipalities that behaved in a different manner.

Results

Several different movements have been observed over the years: North (1977–1991; 2003–2011) Midwest (1978–1981; 1991–1995) and Northwest (1995–2003). Cattle numbers grew in all regions over the period studied (Table 1). The most expressive growth was initially observed in the Northeast and Midwest regions, which sustained this growth over the period; however, this growth has been slower in recent years (Table 2).

This indicated that the mean production point has moved from the Center of Minas Gerais State (in the southeast region) to the North of Goiás State (in the Midwest region) (Fig 1). This change also reflected a strong change in environmental factors such as NDVI (Normalized Difference Vegetation Index), temperature and humidity. The northeastern region underwent a deceleration in the 1990s similar to the southeast at the end of this period. The southeastern and southern regions showed the slowest growth during these periods.

In recent years, strong growth was observed in the northern region of Brazil (Fig 2G) with a reduction in the south of the Midwest region and along the northern border with Colombia. This growth in the north can be observed from the early 2000s (Fig 2E–2G); however, this reduction is a more recent phenomenon. Growth in the Midwest was observed in earlier years (Fig 2A–2C). While the Pantanal region of Brazil showed strong growth in cattle numbers in the 1970s (Fig 2A), the growth has recently been reduced (Fig 2G).

The acceleration in production in the northern region of Brazil has remained strong over the years (Fig 3), but the southern part of this region and Midwest showed stagnation in the early years of this study. More recently, these regions have shown a reduction in growth rates and "traditional" cattle-rearing regions, such as the south and southeast, which, in general, have demonstrated a reduction in growth rates as well as a reduction in herd size or internal migration over the period studied. The maps showed that this movement tends to be gradual, with few regions showing high acceleration or deceleration rates.

Table 1. Relative growth of cattle numbers and percentage (standard error) in Brazil from 1977 to 2011 in 5-year periods by region.

Regions	Year Interval													
	77–81		82–86		87–91		92–96		97–01		02/06		07/11	
	N°head	%	N°head	%	N°head	%	N°head	%	N°head	%	N°head	%	N°head	%
MW	298,900a	43.31b	388,884a	17.13b	969,797a	25.22a	564,002a	14.58b	621,752a	14.45b	749,685a	8.83c	757,887a	9.04b
	(5582)	(7.91)	(5821)	(3.24)	(6156)	(4.75)	(6833)	(3.48)	(7076)	(1.51)	(8470)	(1.54)	(8362)	(0.8)
N	66,973cd	375.64a	101,116b	78.58a	144,380b	27.91a	196,092b	32.84a	255,299b	43.67a	415,802b	39.83a	451,584b	19.1a
	(1691)	(146.53)	(2102)	(24.19)	(2901)	(5.89)	(3026)	(7.71)	(3193)	(3.95)	(5766)	(4.48)	(6691)	(3.2)
NE	580,62d	30.41b	61,998c	13.38b	71,232d	8.59b	66,548d	-1.81c	63,395d	0.10c	72,338c	22.76b	80,417c	8.76b
	(442)	(1.45)	(452)	(1.25)	(465)	(0.77)	(475)	(1.22)	(465)	(2.05)	(492)	(1.18)	(549)	(1.44)
S	95,551bc	18.76b	103,429b	5.77b	106,362cd	-0.34c	109,898c	6.14bc	111,485c	1.62c	116,694c	2.79c	115,926c	9.53b
	(1421)	(0.96)	(1450)	(1.17)	(1421)	(0.90)	(1348)	(1.34)	(1220)	(0.95)	(1302)	(1.3)	(1262)	(0.94)
SE	106,246b	2.35c	105,098b	5.83b	108,424bc	5.23bc	111,719c	3.27c	110,930c	2.78c	116,476c	8.24c	115,183c	5.73b
	(772)	(2.91)	(816)	(1.42)	(864)	(0.84)	(819)	(0.90)	(765)	(1.29)	(822)	(0.77)	(807)	(0.89)
Average	229,658	94.09	152,105	24.13	280,039	13.32	209,652	11.00	232,572	12.52	294,199	16.49	304,1994	10.43
Total	1,148.29		760,525		1,400.20		1,048.26		1,162.86		1,470.995		1,520.997	

MW–Midwest; N–north; S–South, SE–Southeast, NE–Northeast. Means in the same column with different letters indicate a difference according to the Tukey test ($P<0.05$).

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Table 2. Cattle production in Brazil from 1977 to 2011 in 5-year periods per region with regard to the number of head and percentage acceleration (standard error).

Regions	Year Interval													
	77–81		82–86		87–91		92–96		97–01		02/06		07/11	
	N°head[1]	%	N°head	%	N°head	%	N°head	%	N°head	%	N°head	%	Nºhead	%
MW	59,780a	-5.27a	77,777a	-31.3a	93,959a	-5.19b	112,800a	-14.35b	124,350a	-3.42a	149,937a	-7.62c	151,577a	0.22a
	(5582)	(7.70)	(5821)	(7.84)	(6156)	(3.11)	(6833)	(5.63)	(7076)	(3.67)	(8470)	(1.68)	(8362)	(1.60)
N	13,395b	352.82a	20,223b	-308.67b	28,876b	-52.94a	39,218b	-3.24ab	51,060b	2.46a	83,160b	-3.94c	90,317b	-20.69b
	(1691)	(146.71)	(2102)	(150)	(2901)	(24.90)	(3026)	(10.25)	(3193)	(8.63)	(5766)	(5.91)	(6691)	(5.52)
NE	11,612b	11.34a	12,400b	-16.95a	14,246c	-5.35b	13,310c	-10.86b	12,679c	1.00a	14,468c	22.52a	16,083c	-14.12b
	(442)	(2.06)	(452)	(2.05)	(475)	(1.54)	(465)	(1.66)	(378)	(1.69)	(492)	(1.66)	(549)	(1.63)
S	19,110b	6.60a	20,686b	-13.1a	21,272c	-5.8b	21,980c	5.19a	22,297c	-6.24a	23,339c	1.20b	23,185c	6.74a
	(1421)	(1.38)	(1450)	(1.59)	(1421)	(1.43)	(1348)	(1.75)	(1220)	(1.83)	(1302)	(1.47)	(1262)	(1.16)
SE	21,249b	-26.47a	21,020b	2.64a	21,685c	-0.68b	22,344c	-2.23ab	22,186c	-1.16a	23,295c	4.39b	151,577a	-2.45a
	(772)	(3.34)	(816)	(3.22)	(864)	(1.70)	(819)	(2.82)	(765)	(1.69)	(822)	(2.43)	(8362)	(1.88)
Average	25,029	67.80	30,421.20	-73.47	36,007.60	-13.99	41,930.40	-5.09	46,514.40	-1.47	58,839.80	3.31	86,547.80	-6.06
Total	125,146		152,106		180,038		209,652		232,572		294,199		432,739	

[1] Number of animals per municipality per year; MW–Midwest; N–north; S–South, SE–Southeast, NE–Northeast.

Means in the same column with different letters indicate a difference according to the Tukey test (P<0.05).

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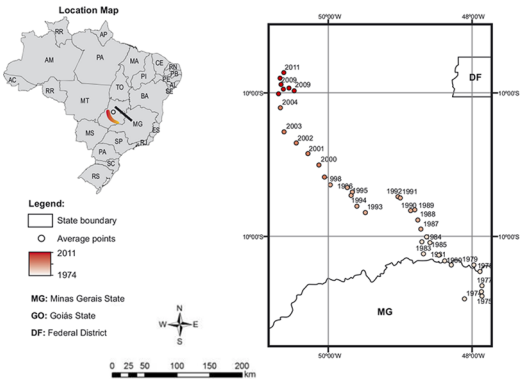

Fig 1. Midpoint of cattle production in Brazil by year.

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The relative increase in production in the Midwest and northern regions is evident in Fig 4, which is considerably higher compared to other regions. In the northern region, because the original herd was small, the initial acceleration (1980–1990) was high with the migration of cattle production from other regions, but in numeric terms, the herd size has only become expressive within the last 10 years. Although there was a high acceleration in production in the region since the 1980s, this growth has decreased significantly in recent years.

The Midwest and northern regions are highlighted for their increase in cattle production over the period studied, in particular, the states of Mato Grosso do Sul, Goias, Mato Grosso (Midwest region) and Roraima (northern region). These two regions are also important for acceleration in production, which is specifically highlighted in the Northern states of Para, Roraima and Acre (Northern region) as well as the Midwestern state of Mato Grosso.

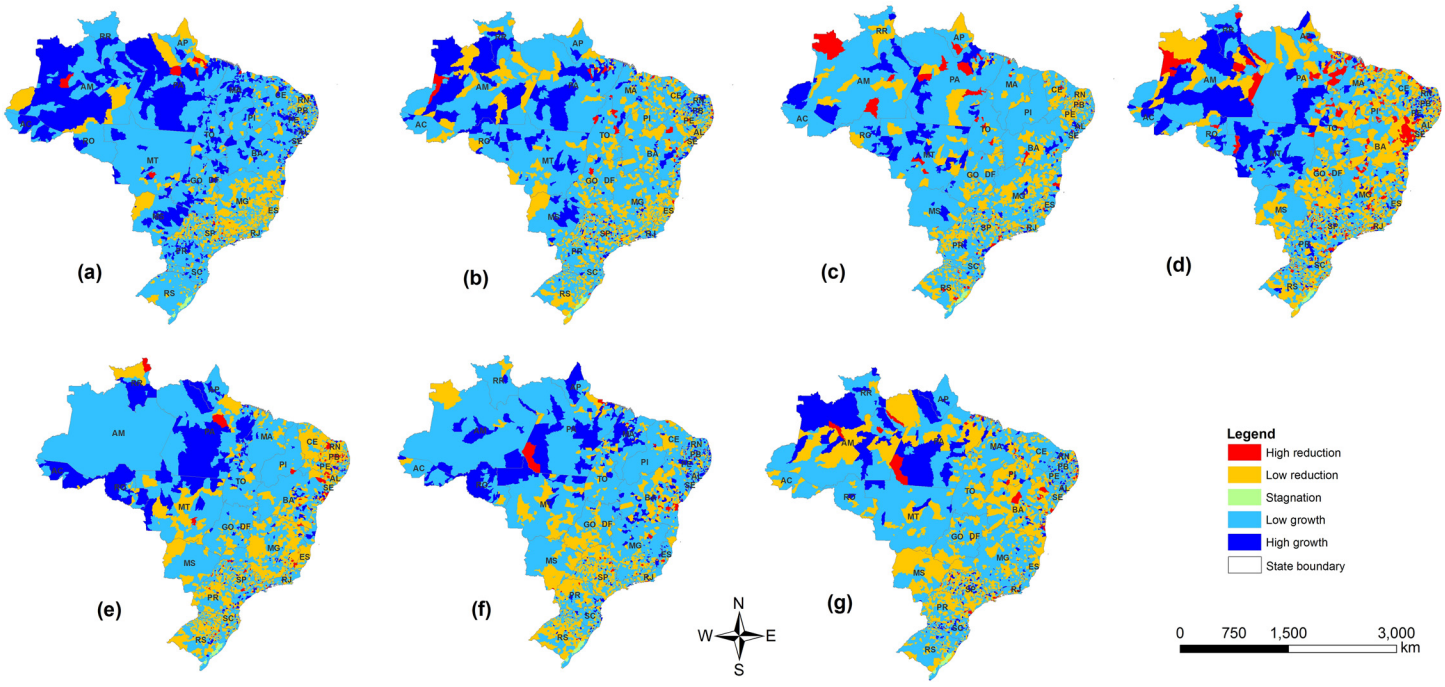

Fig 2. Growth of cattle production in Brazil by municipality by period: (A) 1977–1981; (B) 1982–1986; (C) 1987–1991; (D) 1992–1996; (E) 1997–2001; (F) 2002–2006; and (G) 2007–2011.

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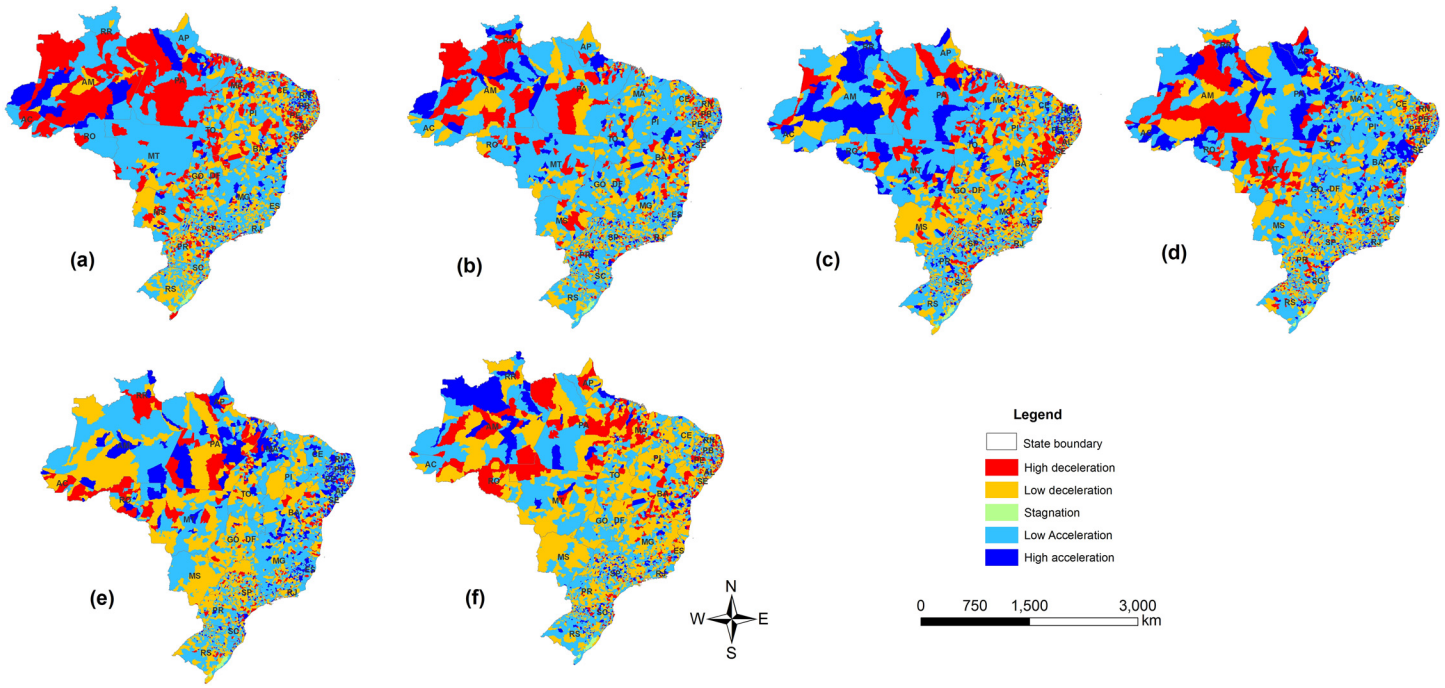

Fig 3. Acceleration of Cattle Production in Brazil by period: (A) 1977–1986; (B) 1982–1991; (C) 1987–1996; (D) 1992–2001; (E) 1997–2006; and (F) 2002–2011.

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Clusters formed according to relative growth and acceleration data showed that a small part of the municipalities is responsible for the largest relative growth (Table 3, cluster 4) and acceleration in growth (Table 4, cluster 3). Importantly, these clusters do not indicate the same group of municipalities in the two analyses.

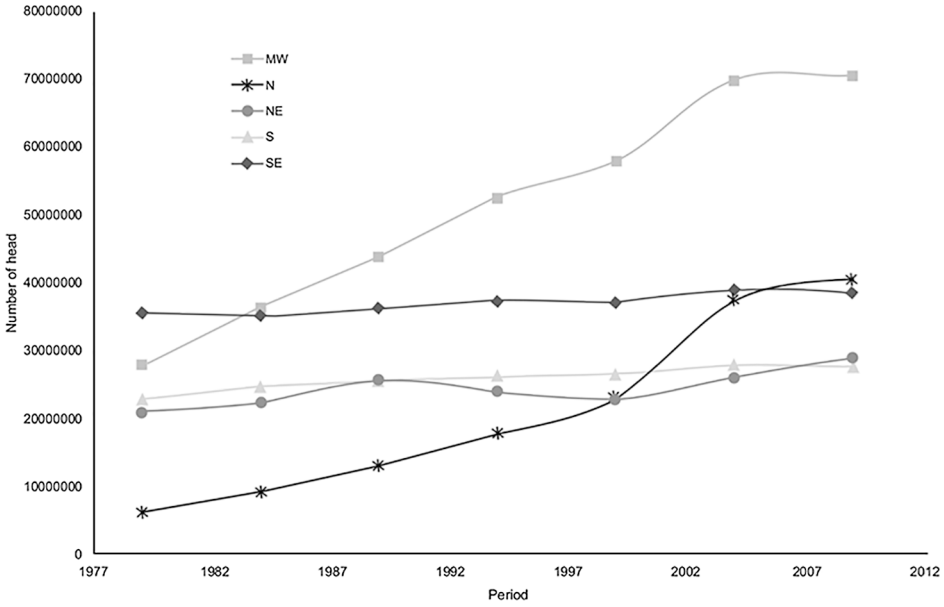

Fig 4. Cattle numbers by region in Brazil (1977–2012) with error bars.

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Table 3. Clusters of Brazilian municipalities according to the relative growth in the number of cattle (standard error) and the percentage of the total herd from 1977 to 2011 in 5-year periods.

Cluster	N° of municipalities	Cluster totals													
		77–81		82–86		87–91		92–96		97–01		02–06		07–11	
		N° head	%	N° head	%	N° head	%	N° head	%	N° head	%	N° head	%	N° head	%
1	4586	112,079,170^{a}(781)	99.33^{a}	12,339,5441^{a}(830)	97.01^{a}	13,363,0443^{a}(886)	92.97^{a}	13,531,0694^{a}(932)	85.95^{a}	13,331,7659^{a}(919)	79.79^{a}	15,176,3196 (1086)	76.00^{a}	15,592,9590^{a}(1078)	75.72^{a}
2	37	9,514^{c}(256)	0.01^{b}	53,324^{c}(958)	0.04^{b}	106,343^{c}(1507)	0.07^{c}	510,618^{c}(4368)	0.32^{d}	2,020,695^{bc}(17107)	1.21^{c}	4,938,362 (41844)	2.47^{c}	61,44,112^{b}(53428)	2.98^{c}
3	472	622,510^{b}(334)	0.55^{b}	3,508,974^{b}(1237)	2.76^{b}	7,745,821^{b}(2067)	5.39^{b}	14,258,079^{b}(2964)	9.06^{b}	19,506,141^{b}(3504)	11.67^{b}	27,747,408 (5022)	13.90^{b}	27,881,597^{b}(5159)	13.54^{b}
4	441	76^{c}(1)	0.00^{b}	134,185^{c}(204)	0.10^{b}	2,135,892^{b}(1006)	1.49^{bc}	7,213,948^{b}(1748)	4.58^{c}	11,880,724^{b}(2370)	7.11^{b}	14,225,586 (3220)	7.12^{b}	14,594,619^{b}(3556)	7.09^{c}
5	22	123,352^{bc}(3846)	0.11^{b}	102,609^{c}(3195)	0.08^{b}	124,963^{c}(3616)	0.09^{c}	131,216^{c}(2937)	0.08^{d}	365,547^{c}(5487)	0.22^{c}	1,016,667 (16864)	0.51^{c}	1,389,080^{b}(25859)	0.68^{d}

Means in the same column with different letters indicate a difference according to the Tukey test (P<0.05).

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Table 4. Cluster of Brazilian municipalities according to the acceleration of growth in the number of cattle (Standard error) and the percentage of the total herd over the 5-year period.

Cluster	Number of municipalities	Cluster totals													
		77–81		82–86		87–91		92–96		97–01		02–06		07–11	
		N° head	%	N° head	%	N° head	%	N° head	%	N° head	%	N° head	%	N° head	%
1	416	475,276^{b}(362)	0.42	2,136,630^{b}(1,000)	1.68	4,902,490^{b}(1,627)	3.41	8,995,882^{b}(2,242)	5.71	13,554,254^{b}(2,766)	8.11	23,221,157^{b}(4,572)	11.64	26,225,864^{b}(5,249)	12.75
2	48	9,513^{c}(197)	0.01	231,130^{c}(3,643)	0.18	359,335^{c}(5,313)	0.25	621,111^{c}(6,783)	0.39	1,651,891^{c}(12,985)	0.99	3,943,384^{c}(33,012)	1.98	4,687,262^{c}(42,007)	2.28
3	689	4,665^{c}(6)	0.00	422,420^{c}(242)	0.33	3,638,908^{b}(900)	2.53	11,707,855^{b}(1629)	7.44	18,046,189^{b}(1,849)	10.80	22,352,493^{b}(2,452)	11.20	22,956,642^{b}(2,558)	11.16
4	34	171,927^{b}(2,541)	0.15	166,131^{c}(2,172)	0.13	200,419^{c}(2,434)	0.14	303,915^{c}(3,544)	0.19	641,732^{c}(7,961)	0.38	1,136,294^{c}(12,952)	0.57	1,229,481^{c}(14,206)	0.60
5	4364	112,173,230^{a}(816)	99.41	124,238,215^{a}(870)	97.68	134,642,308^{a}(932)	93.67	135,795,385^{a}(986)	86.26	133,196,461^{a}(990)	79.72	148,910,406^{a}(1,171)	74.62	150,607,922^{a}(1,151)	73.21
Total		112,834,613		127,194,528		143,743,461		157,424,150		167,090,528		199,563,736		205,707,173	

Means in the same column with different letters indicate a difference according to the Tukey test (P<0.05).

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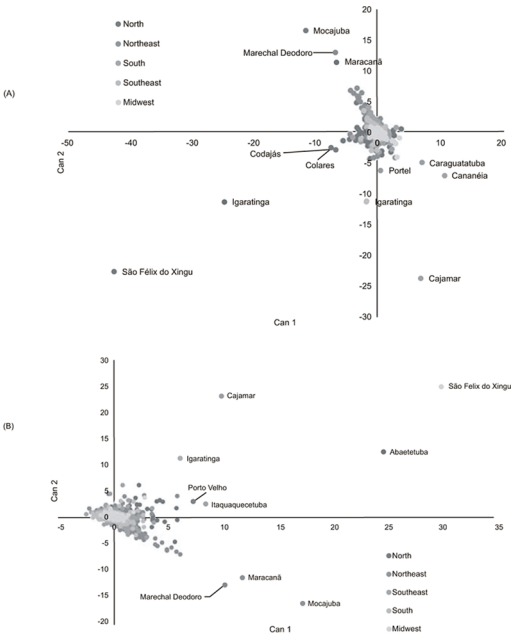

Fig 5. Canonical analysis of relative production) in cattle production in Brazil (N–North, NE–Northeast, SE–Southeast, S–South, and MW–Midwest). (Can 1 and Can 2 are the first tow canonical scores for each municipality). Each point on the graph represents a municipality, with those that are named showing highest discriminatory values.

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The canonical score plot of the first two canonical functions (Can1 and Can2) for each municipality are plotted in Figs 5–7. These reflect the highest variance in the discriminant model and provide a summary of the separation of the municipalities. Both increase and relative increases as well as acceleration of production are observed in the Midwest, Southeast and Northern regions, with only a few municipalities in each of these regions are responsible for these changes. These municipalities showed both marked growth and retraction in given periods. For example São Félix do Xingu in the Northern State of Pará went from less than 10,000 head to more than 1.9 million in the period studied, while Ribas do Rio Pardo, Corumbá, Juara and Cáceres, all in the Midwest, also saw significant increases in cattle numbers. Municipalities in the South (Alegrete, Bagé, São Gabriel), although showing reasonably high numbers of animals (approx 0.5 million), did not show significant changes in these numbers in the period shown, which may reflect the small variation in the herd of this region.

Fig 6. Canonical analysis of acceleration in cattle production in Brazil (N–North, NE–Northeast, SE–Southeast, S–South, and MW–Midwest). (Can 1 and Can 2 are the first tow canonical scores for each municipality). Each point on the graph represents a municipality, with those that are named showing highest discriminatory values.

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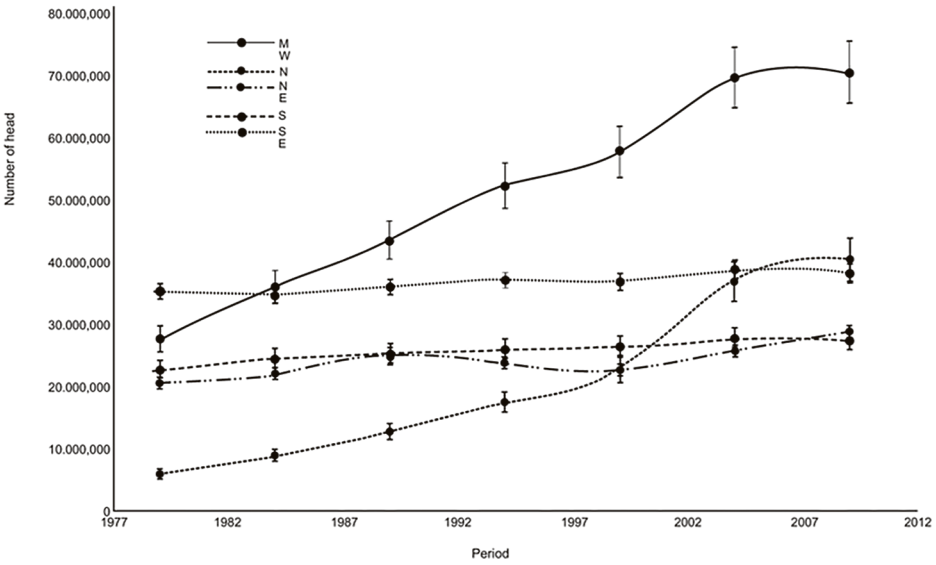

Fig 7. Total cattle numbers (periods of 5 years) in cattle production in Brazil (N–North, NE–Northeast, SE–Southeast, S–South, and MW–Midwest).

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Discussion

The causes of the geographical dynamics of the Brazilian cattle herd were originally associated with the need to meet the internal demand for beef, particularly in the 1970s and 1980s. The needs to expand the agricultural frontier in Brazil, the entry of foreign abattoir industries and the opening of markets to export processed beef to the United States have been motivated by the livestock sector and their migration to land areas at lower costs. The existence of a secure market stimulated investments in animal production and expansion to areas that were further from production centers. In this period, the driver was the existence of cheap land, which facilitated the increase in activity [8]. Subsequently, at the end of the 1990s, there was a greater increase in productivity rather than herd numbers, including a reduction in the area occupied by the activity.

Moreover, the need for Brazilian cattle growth in this decade was approximately 20%, however, the increase in productivity (weight kg/head/year) was around 30%, demonstrating a considerable gain in efficiency.

The adoption of technologies changed beef cattle production and productivity, particularly by increasing the weaning rate and weaning weight and reducing the age at slaughter and first mating. Between the years 2000–2010, weaning rate increased from 57 to 68%, with slaughter at 33 months of age, while weaning weight increased from 167 kg to 190 kg, and the age at first breeding of heifers went from 36 to 30 months. Technological developments in beef cattle production enabled Brazil to achieve an outstanding position in the international beef market. Between 1960 and 2010, the Brazilian cattle herd increased by 251%, and the stocking rate evolved from 0.47 head/hectare to 1.2 head/ha with an offtake rate of approximately 20% [9]. During this decade, the high prices of agricultural commodities, environmental restrictions and the high price of land in the Midwest region of Brazil, produced a new wave of cattle migration toward to the North, constituting 22% of the total effective of the country.

Intensification has been suggested as the means for the cattle industry [10] to reduce pressure on forest margins and free-up land for soybean or sugarcane production. The sugarcane expansion resulted in a significant reduction of pastures and number of cattle and higher

economic growth compared to neighboring areas [11]. However, it could not be established to what extent the discontinuation of cattle production induced the expansion of pastures in other areas, thereby potentially resulting in indirect deforestation. However, these results indicate that the potential migration of cattle production reached further than the neighboring expansion regions. Therefore, a positive correlation between pasture, deforestation and cattle growth rate had existed in these Amazonian regions.

This is also the mainstay of Brazil's plan for the mitigation of greenhouse gas emissions [3], the environmental effect of animal production was crucial in the promotion of sustainability of agriculture production [12]. In the livestock sector, the animal productivity is related to food intake and weight gain efficiency, thereby generating methane emissions. Thus, the low beef cattle productivity index becomes the big problem of emission of greenhouse gases. This can be exacerbated by increased temperature in the region that can reduce up to 25% carrying capacity of pastures. All of these factors reinforce the need for seeking more efficient systems of land use with constant monitoring of its dynamics. Furthermore, the major drivers of sustainability in agriculture were the demands of the food market.

The original mid-point of cattle production was the so-called "Triângulo Mineiro or Mineiro Triangle" in the Minas Gerais State, which was the main region of cattle production in Brazil up to the turn of the millennium in terms of the number of animals as well as the history and culture of cattle ranchers. The Mato Grosso and Goias States constitute as a physiographic continuation of the north and northwest of the state of Minas Gerais, with no physical barriers that facilitated the displaced of cattle to similar geographical environment areas. In this region, the main zebu breeding centers are localized on the limits of the Midwest, where there is cheap land and perspectives for the expansion of zebu breeds, particularly the Nelore breed. The migration in cattle production was different from the migration in sheep production in Brazil during the same period [13], which followed a steady Northeastern route but has stabilized in recent years. This reflects the differences in production aims and market opportunities in the two production chains.

It is estimated that there is a decrease in beef cattle productivity due to the increase in air temperature and vulnerability of pasture capacity in the cerrado (savannah) Midwest, north and northeast regions of Brazil [14]. This may explain some of the results found in the present study. The increase in cattle production and expansion of pastures for cattle ranching in the North is accompanied by deforestation [15]. Recently, soy production has also moved into the Amazonian forest [16]. This occurred despite allegations of a widespread marketplace transition within the beef and soy industries, the main drivers of deforestation, to exclude Amazon deforesters from their supply chains [17]. Nevertheless, the expansion through the incorporation of forest areas, particularly in the northern regions, meets with barriers that did not occur in the past. Questions related to the new Brazilian Forest code, the lack of logistics (slaughterhouses, roads) for a more intensive production, as well as the difficulty in obtaining credit for investments in the region, caused serious restrictions for the accelerated migration of cattle to this region. This was reflected in a slow movement of cattle production into new regions (Figs 2 and 3) and the need to increase productivity. When examining the aptitude of the cattle herd for the region (beef and milk), 90% of the herd in the north and Midwest was for beef production. With better lands and climatic conditions in the south and southwest, milk production systems can account for up to 30% of all cattle production systems [18]. On the other hand, although do not occur growth in the North region, with the current flock and the structure of agro-industrial complex linked to the beef chain, there will be a demand for increased production in the livestock sector, which can be achieved by increasing productivity. It is noteworthy that this region weaning rate and head for productivity are 43 and 37% lower than the average of the Midwest, respectively.

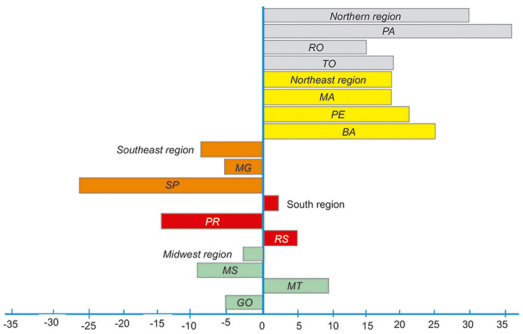

Fig 8. Variation in the rate of growth (%) of the cattle herd from 2005–2012 by region in Brazil and their main states (PA-Para, RO-Roraima, TO-Tocantins, MA-Maranhão, PE-Pernambuco, BA-Bahia, MG-Minas Gerais, SP-São Paulo, PR-Parana, RS-Rio Grande do Sul, MS-Mato Grosso, MT-Mato Grosso, and GO-Goiás.

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Production does not mean competitiveness, and studies have shown a lack of competitiveness within Brazilian beef production [19, 20]. The total productivity factor show that technological growth in the agribusiness sector in Brazil was 4.5% per year, particularly in the southern region [21]. Nevertheless, productivity grew by only 2.6%. Thus, there was a gap between technological innovation and productivity. Restrictions to growth are due to the lack of credit, public policies directed to education, infrastructure and logistics. This may explain the deceleration in cattle production in regions that have problems with slaughterhouse logistics, such as transport and production flow, but may also be due to an increased productivity in the region, the production systems in the Amazon region still present low technology use [22].

However, it must be considered that the Brazilian cattle industry still has its production base in volume and scale in the Midwest and northern regions, as the price of land and the conditions of the biome limit more rapid expansion of agricultural crops. However, with the technological improvements in the agricultural sector and soils that are currently of limited use for farming should, in the future, present economic viability and expel livestock to new frontiers or would change the existing production systems for a more intensive processes by the semi-confinement and confinement systems which may maintain the current herd situation. This explains the movement of the cattle herd to the northern states of Brazil, as the land that had been previously occupied by livestock now produces soybeans and corn. Thus, production systems previously based on the complete cycle now lack conditions for fattening cattle, due to limitations of the pasture, a reduction in available physical space and logistics for the new region. However, this can affect the price of land for cattle ranching in Brazil, which increases in the same proportion as lands for agriculture.

The pro-intensification policies such as credit provision for recover degraded pastures and improved pasture management and investment in more intensive production systems must be accompanied by an implementation and enforcement of such policies [3]. These should alter the incentives to clear forest for pasture, discourage land speculation, and increase the accountability for land management practices if intensification of the cattle sector is to avoid new deforestation and displace production from low-yield, extensive cattle production systems in frontier regions of the Brazilian Amazon [1,23, 24].

Further analysis showed that during the period of greatest participation of Brazil in the international beef market and the valorization of agricultural produce (2005–2012), there was a relative commodity growth of 6%. However, this growth was higher in regions where land prices were lower (North and Northeast) (Fig 8). In these regions, there was an incentive to rear beef cattle, particularly for the installation of large meat processors and the

implementation of large projects producing meat for export. However, due to environmental issues and port logistics and infrastructure, these regions failed to facilitate the sale of meat abroad. As an economic alternative, the state of Pará, the main producing state of these two regions, redirected its strategy for the export of live animals to countries such as Venezuela and Arab nations. Scenario studies have showed that Pará, 4th Brazilian herd, would have a low growth over the next 10 years, resulting in a stagnation of the regional herd. On the other hand, would improve productivity, especially in fattening due to adequacy of ranchers environmental legislation that enables the properties to provide animals for slaughter. Regardless of the slowing growth and significant reduction in herd numbers, the states of São Paulo, Goiás, Minas Gerais, Mato Grosso do Sul and Mato Grosso still represent the majority of beef exports in Brazil. These states are where the main structure for export of slaughtered animals is located, and they are also the main centers for completing feed-lots, which explains the fact that even with a reduction of the herd, they remain the leading exporters of meat.

Moving beef cattle production from one region to another requires skills and expertise as it passes through a redefinition of farming objectives, as well as strategies and processes to achieve better results. Nevertheless, there is always a risk that it will not work. Thus, there is a need to know the main vectors that will be employed in this migration. They may relate to the technological or organizational aspects of the main processes involved in the production cycle. This demonstrates that the change in land use for livestock immediately repositions other agricultural activities. In these areas, the farmer either sells land or remains with a reduction in herd size or may enhance productivity. Moreover, the emergence of integrated production systems called Crop-Livestock Integration and Crop-Livestock-Forest Integration can create new conditions for ranchers to avoid the migratory cycles for livestock production. These systems are based on sharing and maximizing the use of resources and the synergism between them, ensuring environmental balance and reducing trading risks by diversifying farm activities model. In addition, there might be a stabilization of farmers in their regions to acquire efficiency and sustainability.

Conclusions

The acceleration of the cattle herd growth in Brazil has been increasing from 1977 to 2011. Thus, agricultural productivity must keep pushing cattle ranching to occupy new frontiers. However, the opening of new areas for livestock requires infrastructure, logistics, availability of credit/loans, public policies and adaptation to environmental issues that practically restrict this migratory phenomenon. These results confirm the reduction forecast in livestock productivity in the Cerrado, Midwest, North and Northeast due to the increase in air temperature and vulnerability of pastures.

Thus, it is clear that the expansion of the Brazilian herd is through migration, and if it finds no geoeconomical support, it should stabilize or even undergo a slight decrease as shown by the relative stagnation of this migration in recent years (Fig 1). In addition, there are possibilities of productivity gains in the beef cattle sector because there are still regions with low efficiency indicators. Therefore, the beef chain will be conducted by the market obligations. Thus, future studies should incorporate variables related to the expansion of crops, income from plant products, average area of farms, different specializations in cow-calf, growth and completion of production systems and density of cattle in different regions of Brazil.

Author Contributions

Conceived and designed the experiments: CM JOJB VL. Performed the experiments: DZ BF OCJ MG EAD VL JBN. Analyzed the data: CM PH OCJ JBN. Contributed reagents/materials/

analysis tools: CM PH OCJ JBN. Wrote the paper: DZ BF OCJ MG EAD VL JBN RFG. Wrote the paper: DZ EAD MG.

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Year-to-year changes in water level drive the invasion of *Vochysia divergens* in Pantanal grasslands

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Abstract. In recent decades, cattle ranchers of the Pantanal of Mato Grosso, Brazil, have pointed to the accelerated spread of several herbaceous and woody plant species that invade natural and artificial pastures (*campos*). It has been speculated that overgrazing by an increasing number of cattle, lack of grazing in abandoned areas, or large-scale changes in environmental conditions may be the reason for this invasion. This study focuses on ecological and ecophysiological aspects of *Vochysia divergens* (*cambará*), a flood-tolerant tree that began spreading in the Pantanal during the last 30 years and is considered a very aggressive invasive plant. The study shows that the spread of *cambará* can be related to natural multi-years wet periods. During multi-years dry periods the species is reduced by the increasing impact of fires in the Pantanal. This points to the great importance of multi-years climatic events on the vegetation cover of the Pantanal and indicates a very dynamic development in plant communities.

Keywords: Brazil; Floodplain; Flood pulse; Invasive tree; *Vochysia divergens*.

Nomenclature: Pott & Pott (1994).

Introduction

The Pantanal of Mato Grosso is a 140 000 km^2 floodplain in the southwestern part of Brazil bordering Bolivia and Paraguay. Since the beginning of the 18th century, the area has been used for cattle ranching. In 1970 about 30% of the beef produced in the states of Mato Grosso and Mato Grosso do Sul came from the Pantanal (Allen & Valls 1987). The existence of large pasture areas, locally called *campos,* is the economic basis for cattle ranching. These *campos* are covered with a large variety of herbaceous plants, with the frequent occurrence of *Paspalum almum* and *P. plicatulum*, which are considered valuable forage for cattle. Increasing competition with cattle ranches on non-flooded artificial *cerrado* pastures forces ranchers in the Pantanal to increase beef production. Quality, size, and availability of the pastures during the hydrological cycle are becoming limiting factors for the economy of the ranches. Ranchers increase pasture area by clearing periodically flooded shrubland (*campos sujos)* by means of fire, machetes and axes.

According to observations of the ranchers the spread of invasive plants started since the large floods of the early seventies including *Vochysia divergens, Licania parvifolia, Combretum lanceolatum, C. laxum, Byrsonima orbignyana* and *Ipomoea fistulosa*. Although they are native, these species are called invasive species (Anon. 1974; Pott 1982; Allen & Valls 1987). Of special importance is *Vochysia divergens*, *Vochysiaceae* (*cambará*), which vigorously spreads into pastures and can form monospecific stands locally called *cambarazais*.

Several authors mention the occurrence of *Vochysia* in the Pantanal (Veloso 1947, 1972; Almeida & Lima 1959; Prance & Schaller 1982; Rizzini 1979). According to Anon. (1982) *Vochysia* spreads from the riverine forests of the upper Cuiabá and São Lourenço rivers into the periodically flooded areas of the Pantanal. The first study about floristic composition and structure of a *cambarazal* was made by Nascimento & Nunes da Cunha (1989). Haase & Haase (1995) present data on litter production. Faßnacht (1995) used Landsat-TM-data to make maps of the distribution of *Vochysia* in the area near Poconé.

The unexpected spread of plants may point to large-scale changes in environmental conditions in this wetland of international importance with multiple far-reaching consequences for the ecosystem and its management. The following paper presents data on biology and ecology of *Vochysia* and offers explanations for its spread.

Study area

The study was undertaken in the Pirizal ecoregion in the northeast of the Pantanal of Poconé (Adámoli 1982) (Fig. 1) (16°15' 24" S, 56°36' 24" W). The climate is characterized by a pronounced dry season from May to September and a rainy season from October to April.

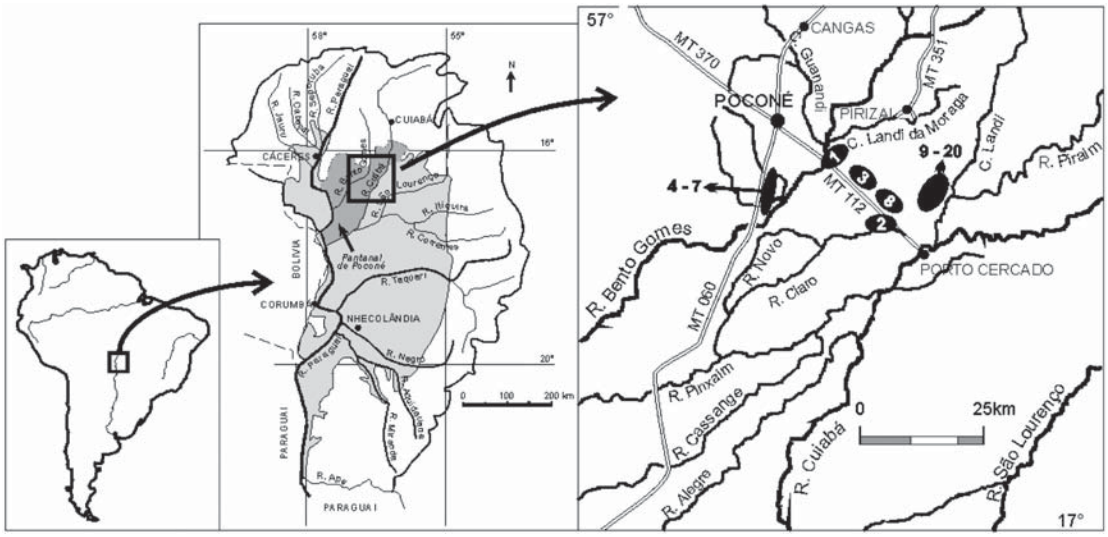

Fig. 1. Map of the study area. The numbers indicate the position of the studied *Vochysia divergens* plots.

Mean annual precipitation is ca. 1400 mm with maximum rainfall in January and minimum rainfall in July (Fig. 2). Mean annual temperature is 25.8 °C, with October being the hottest and July the coldest months (Almeida 1998).

Flooding follows the rainy season, as shown by the gauge of the Cuiabá River (Fig. 2). However, because of the flat landscape, the flood pattern inside the Pantanal is strongly influenced by local precipitation. The Pantanal of Poconé is in the upper Pantanal, where floods are rather shallow up to about 2 m depth. During the low water period, the Pantanal and many of the floodplain lakes are disconnected from the river channel. In addition to annual flood cycles, the Pantanal is subject to multi-years periods of high floods and pronounced droughts as shown by the hydrograph of the Paraguay River at Ladário at the outlet of the Pantanal (Fig. 3).

Soils are of fluvio-lacustric origin of Pleistocene age and mineralogically partly modified (Zeilhofer 1996). They are sandy, slightly acidic, with high aluminium content, and of low fertility (Radam 1982; Anon. 1997; Couto et al. 2002; Zeilhofer & Schessl 1999). Sediments deposited along the major rivers are of Holocene age.

Vegetation cover

According to Loureiro et al. (1982), the vegetation of the northeast of the Pantanal of Poconé belongs in its majority to the subformation *Savana Parque* without gallery forest. The heterogeneity of the Pantanal landscape results from a variety of small-scale geomorphological units (Sánchez 1978; Nunes da Cunha et al. in press, a, b), which in combination with the annual floods create a large diversity of habitats.

Major geomorphological units are *Campos* that are

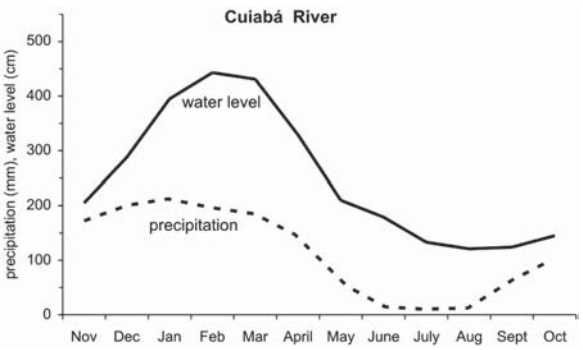

Fig. 2. Mean annual water level fluctuation of the Cuiabá River (1933-1993) and mean precipitation near Cuiabá, northern Pantanal (1971-1988). Rainfall data from INEMET, river level data from DNAEE.

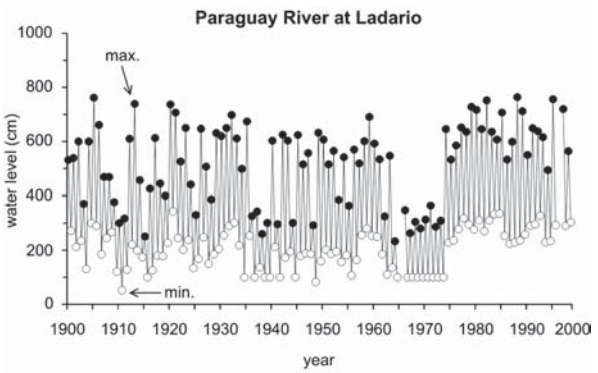

Fig. 3. Annual water level fluctuations of the Paraguay River at Ladário from 1900 to 2000 (full circles = annual maxima, empty circles = annual minima). Data from DNAEE.

seasonally flooded flat savanna areas called hyperseasonal by Eiten (1982), with three subtypes: *Campos limpos* and *campos sujos* are savannas without and with shrubs and trees, respectively, and *campos de murunduns* are savannas with termite mounds, covered with trees (termite savannas). *Cordilheiras* and *capões* are remnants of palaeo-levees covered with forest, reaching ca. 1 m above the mean flood level. Levees and terraces are depositions of recent sediments covered with forest, found along the Piraim, Cuiabá, and Bento Gomes River. Shallow seasonal channels in the *campos de murunduns* with a close connection to the groundwater table covered with forest are called *landis,* without forest *vazantes* (Ribeiro et al. 1999). Other specific habitats of the Pantanal are permanent lakes (*baías),* perennial river channels, permanent small drainage channels inside the flood-plain (*corixos*), and permanent swamps (*brejos)* covered by aquatic and semi-aquatic herbaceous plants. For detailed characterization and species lists see Nunes da Cunha (1990, 1998), Nunes da Cunha & Junk (1999, 2001) and Schessl (1999).

Material and Methods

Morphology

Vochysia is a tree 7-25 m tall, with a dense leafy crown. The stem is cylindrical with 30-50 cm diameter at breast height, shedding bark in irregular pieces. The leaves are simple, in whorls of three to four, coriaceous, glabrous, brilliant on the upper side and opaque on the underside, 7-13 cm long and 3 cm broad; petiols are 2-3 cm long. Inflorescence is racemose, terminal, subpyramidal, 20-28 cm long with pedicelled yellow flowers. Fruit capsules are oblong, trigonous, glabrous, with 4-5 seeds (Lorenzi 1998).

Phenology

Phenology of 15 selected *Vochysia* individuals was observed during the study period of 1998. The period of flowering was determined by the appearance of the first buds until the disappearance of the last flower and that of fruiting from the appearance of the first young fruit until the end of seed dispersal (Maia 1997). For quantification of phenological observations 30 litter samplers with a total surface area of 7.54 m^2 were distributed under *cambará* trees. Litter was collected monthly and separated according to leaves, flowers, fruits, and miscellaneous. For the determination of seed weight, seeds were collected separately.

Seedling establishment

Seedling establishment was studied in five different environments: soil covered and not covered with organic litter layer inside the *cambarazal*, soil below the mother tree with little litter, soil in the open *campo* with high radiation rates at the border of the *cambarazal*, and a *cambarazal* previously burned. The areas were fenced for protection against disturbance by humans and cattle. In every area 16 plots of 1 m^2 were selected and the seedlings were labeled. From November 1998 to June 1999, every 15 days growth, mortality and the occurrence of new seedlings were recorded before, during and after the flood period.

Grazing effect

To study the impact of cattle grazing on plant species composition in *campo limpo,* in 1993 three plots of 20 m × 20 m were fenced with barbed wire to prevent the entry of animals. In 1999 the occurrence of woody species was recorded in the fenced plots.

Population structure

Areas ($n = 20$) of different physiognomy dominated by *Vochysia* (*cambarazais*) were selected in the Pirizal region for community analysis. In the centre of each of these areas a plot of 50 m × 5 m was established and divided in 10 subunits of 5 m × 5 m to characterize the vegetation. Tree species were determined, height was estimated and circumference at breast height of all individuals with more than 1 cm, corresponding to 0.3 cm DBH, was measured. This paper refers only to *Vochysia*. Length of the flood period was registered by visiting the plots at monthly intervals during the flood period that lasted in 1997/1998 from January to May. Plant samples were deposited in the herbarium (HC-UFMT) of the University of Mato Grosso in Cuiabá. The basal area of the species per unit area was calculated. A raw-data matrix of tree mean diameter data was established for cluster analysis using mean Euclidian distance coefficient and average linkage clustering (UPGMA).

Impact of fire

In 1999, a wild fire affected part of the study area. In 2000, the impact of the fire on the *Vochysia* stands was analysed in four plots of 15 m × 5 m in size, counting number and determining DBH of dead and living trees. The percentage of dead trees in adjacent plots not affected by fire was also determined.

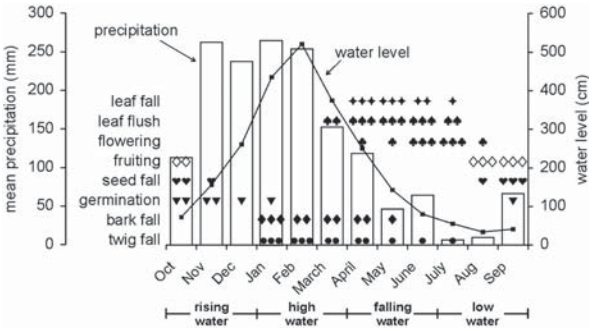

Fig. 4. Phenological aspects of *Vochysia divergens* in relation to water level and precipitation during the study period 1998 - 1999. Bark fall: The apical parts of the twigs shed the outer layer of the bark from January to May. Intensity of the respective event is indicated by the number of symbols: 3 = high, 2 = medium, 1 = low intensity.

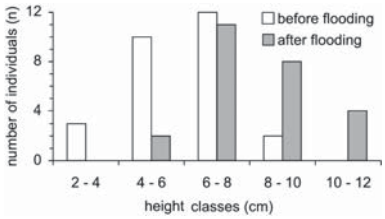

Fig. 5. Number of individuals and height classes of *Vochysia divergens* saplings before and after 5 months of flooding. Before flooding $n = 28$, after flooding $n = 26$.

Results

Phenology

The main leaf shedding period is April to June at the end of the aquatic phase (Fig. 4). At the same time the flush of new leaves occurs, so that the tree always bears leaves. Flowering begins with decreasing water level and continues until July. During that period the trees dominate the landscape of the Pantanal with their beautiful yellow flowers. Seed production reaches the maximum during the dry period and continues until the beginning of the rainy season in November (Fig. 4). Winged seeds have a mean weight of 0.053 g (0.015-0.070 g; $n = 50$). The weight without wings is 0.045 g (0.013 - 0.067 g; $n = 50$). Viability is maintained for about 6 mo.

Seedling establishment

Seed germination starts with the first light rains in September/October. In November 1998, at the end of the dry season, 179 seedlings were registered in the total area of 80 m^2. The largest number of seedlings was observed in the area without a litter layer followed by the area in the *campo* at the border of the *cambarazal*. When the water reached the experimental plots in the beginning of January, the seedlings had a mean height of 6-8 cm. The development of 28 saplings was observed during the flood period. Plants slightly increased in size (Fig. 5). Mortality reached ca. 7% after 150 d of flooding. About half of the time the saplings were totally flooded, but did not shed leaves under water.

Grazing effect

Two of the fenced *campo limpo* plots that were inundated during about 3-4 mo per year, showed strong growth of woody species (Table 1, Fig. 6). *Vochysia* was found in these plots. In the third plot, which was subjected to flooding for about 5-6 mo, only one woody plant specimen established.

Diameter class structure

The cluster analysis based on mean stem diameters (cophenetic relation = 0.95) shows (Fig. 7) three well-defined groups: (1) plots 8 and 7 with a high mean stem diameter value of 27 cm, high basal areas and few individuals; (2) plots 9, 11, 1 and 3 with stem diameter values of 9-15 cm; (3) large group with low mean stem diameter values of 6.6-12 cm, low basal areas and many

Table 1. Species composition and growth of woody species in three plots of 400 m^2 each in the *campos limpos* of the Ipiranga Farm after 7 yr of protection against cattle grazing.

	n	Mean height (m).	Total basal area (cm^2)	Height min. (m)	Height max. (m)
Plot 1					
Vochysia divergens	12	2.50	4.016	1.50	2.50
Eugenia florida	2	0.98	0.589	0.80	1.15
Combretum laxum	3	0.43	0.730	0.40	0.57
Byrsonima orbigniana	6	1.80	5.637	1.60	2.00
Plot 2					
Licania parvifolia	21	1.80	11.740	0.50	2.50
Byrsonima orbigniana	1		0.675		1.80
Combretum laxum	9	0.50	0.150	0.33	0.37
Coccoloba spec.	2	0.55	0.020	0.49	0.49
Vochysia divergens	1		0.115		1.33
Plot 3					
Combretum laxum	1		0.020		1.41

Fig. 6. Fenced plot in a man-made *campo limpo* after 7 yr of protection against grazing. Several tree species have successfully established, including *Vochysia divergens* (cambará).

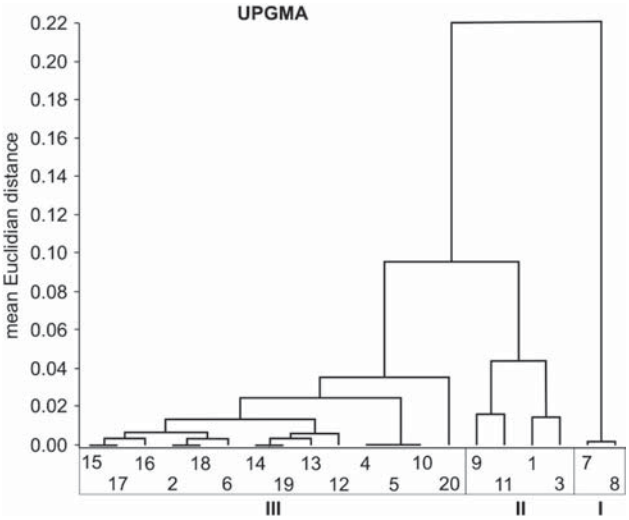

Fig. 7. Dendrogram of multivariate analysis showing the different groups of 20 plots of *Vochysia divergens* communities based on stem diameter (Cophenetic relation 0.95%).

individuals (Fig. 8). Group one represents *cambarazais* with several old and large specimens with diameters of up to 63, respectively 51 cm. The second group contains many medium sized species with diameters of 21 to 41 cm. The third group corresponds to early stages of community development, including monotypical and mixed stands. Specimens with diameters larger than 18 cm are rare or absent (Fig. 8).

Impact of fire

One year after the wild fire of 1999 in some *cambará* stands mortality was very high (Fig. 9) and varied between 57% and 86% of larger trees (mean mortality of all trees 75%). Small size classes are not represented in this inventory, because they were burned completely. Fire affected trees of all large size classes. In neighbouring old stands not affected by the fire, dead trees comprised < 5%, in young stands < 2%, therefore the number of individuals that were already dead before the fire affected the stands can be neglected.

Discussion

Allen & Valls (1987) explain the spread of invasive plants into pastures of the Pantanal as due to inadequate pasture management, mainly overgrazing in the early 1970s. This will not hold for *Vochysia divergens* as shown by the exclosure experiments on the Ipiranga Farm. After 7 yr, two of three plots of 400 m^2 protected against grazing cattle contained woody species including *Vochysia* (Table 1), whereas the surrounding pasture was free of them (Fig. 6). Animal density was about one cattle per 2 ha pasture. Since the rancher did not apply other weed control methods, this points to efficient control of the woody vegetation by grazing animals in this case.

Why *Vochysia* has been spreading recently may be answered by the analysis of the environmental requirements of the species and major changes in environmental conditions during this period. *Vochysia* occurs from Paraguay to Mexico, colonizing tropical and subtropical humid riparian forests (Thiele 1997), i.a. in Goiás, Mato Grosso (Brazil) and Bolivia (Stafleu 1948). Nunes da Cunha collected *Vochysia* along the Teles Pires River

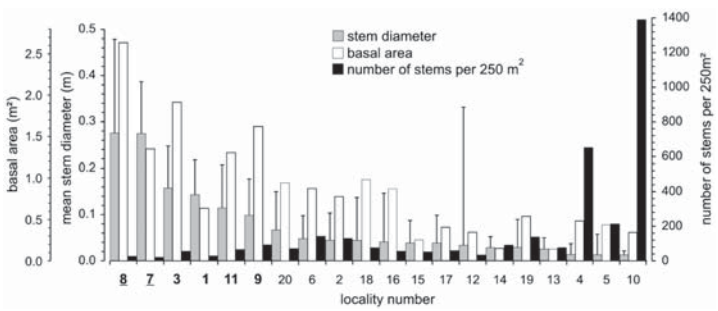

Fig. 8. Mean stem diameter + standard deviation, basal area and number of stems per plot of 20 stands of *Vochysia divergens*. The numbers 8 and 7 correspond to old *Vochysia divergens* stands, the numbers 3, 1, 11 and 9 to stands of intermediate age and the remaining plots to young stands separated by the multivariate analysis on stem diameter (Fig. 7).

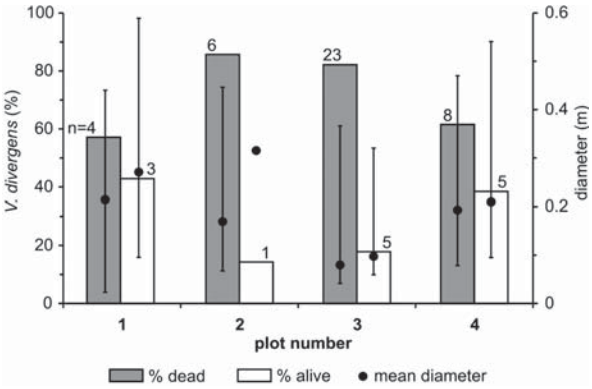

Fig. 9. Total number and percentage of dead and living trees of *Vochysia divergens*, and mean, maximum and minimum DBH of the stems in four plots one year after a wild fire.

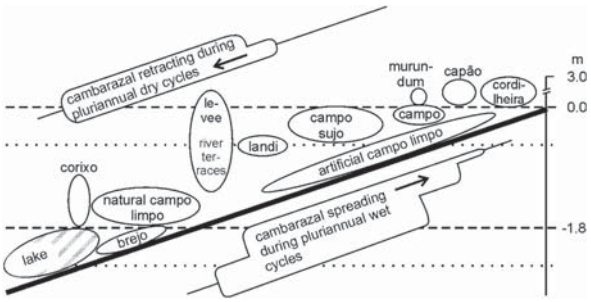

Fig. 10. Distribution and abundance of *Vochysia divergens* in different landscape units of the Pantanal of Poconé along the flood gradient and its shift during multi-years wet and dry periods. Mean annual water level fluctuations ===== during multi-years wet cycles and :::::: dry cycles. The diameter of the figures around the distribution of the *cambarazais* indicates their relative abundance.

near the Pará border. It also occurs in the Araguaia National Park (Ratter 1987). *Vochysia* colonizes the gallery forests of the rivers from central Amazonia to Paraguay and spreads from the São Lourenço and Cuiabá Rivers into the Pantanal (Anon. 1982).

Seedling establishment

Vochysia is a flood-tolerant species with relatively small and numerous seeds. In dry years, seed production is low. Observations in the dry summer of 1999 indicate increased abscission rates and very high predation by parrots and insect larvae. Seeds are spread at the beginning of the rainy season by wind and water. Distribution by water currents results in a patchy accumulation of seeds and high seedling density. The highest rate of seedling establishment was found on bare soil, pointing to the ability of the plant to colonize disturbed areas, for example recently-exposed sedimentation areas along rivers. Instead of seed banks, *Vochysia* forms sapling banks in the understorey which grow very slowly in the shade, but replace dead trees as soon as light conditions on the forest floor indicate gaps in the canopy. This leads to the maintenance of *Vochysia* dominated communities (*cambarazais*), despite the fact that the species has many characteristics of a pioneer species or a species of early successional stages.

The observations of seedling establishment show a strong resistance of seedlings and saplings to long-term flooding. The capacity to maintain leaves intact below the water surface for several months can be considered a competitive advantage, because it enables the sapling to photosynthesize and grow slowly even below the water surface, or at least immediately after emergence of the leaves. Similar adaptations have been reported from flood-adapted trees of the Amazon floodplain (Waldhoff et al. 1998).

Occurrence

Vochysia occurs naturally, within the study area, mainly in communities subjected to periodical flooding or waterlogging of the soils, e.g. (1) the *campos de murunduns*, where the areas between the termite mounds are colonized, (2) the flooded forests of the *landis,* (3) the flooded riverine forests and (4) the *campos sujos*. In these areas *Vochysia* can form nearly monospecific stands covering 5 - 7% of the total area of the Pantanal of Poconé, as shown by 1994 satellite images (Faßnacht 1995). All the plots we investigated were flooded in 1997/1998 for 4-5 months and to a depth of 0.4-0.8 m. In non-flooded habitats and communities, *Vochysia* is rare or absent. Invasion also occurs only into periodically flooded or waterlogged pastures and not into upland pastures (Fig. 10). This points to the hydrological regime as driving factor for the expansion of *Vochysia*. The hydrological regime in the individual sites is very complex, because it is affected during high water by the connected rivers but also by local rains that inundate depressions even in periods of relatively low river levels. Changes in soil structure and soil nutrient content can be excluded as reason for the spread of *Vochysia* because soil analyses (not shown in this paper) show similarity in grain size distribution, mineral type, and nutrient status of the top soil layer of the investigated plots.

Diameter class and age structure

The analysis of stem diameter by multivariate analysis in the different *Vochysia* plots shows three different mean diameter classes corresponding to different age classes. According to Ishima (1998), *Vochysia* shows, in the southern Pantanal, a mean diameter increment of about 0.7 cm.yr^{-1}. For the first five years growth is quicker, but large trees have small increment rates. Growth is more retarded by drought stress than by

flooding. If this increment rate is also assumed for the Pantanal of Poconé, a mean tree diameter of 27.5 and 27.3 cm in the plots of diameter class one corresponds to a mean age of ca. 39 yr. In this class maximum age is ca. 90 and 73 yr respectively, and there are many individuals > 45 yr. In these plots there are few young specimens. A mean diameter of 9.9-15.7 cm in the plots of diameter class two corresponds to a mean age of 14.1-22.4 yr. All plots of this class contain several individuals with an estimated age of > 35 yr. Young specimens are frequent. The third diameter class comprises plots with a mean diameter of 1.3-6.7 cm, corresponding to a mean age of ca. 3-9.6 yr. In this class, the overwhelming majority of the trees have a DBH < 18 cm, corresponding to an age < 25 yr. Only in some plots are there a few specimens older than 25 yr, as for instance plot 12 with one specimen of 54 cm diameter, corresponding to ca. 77 yr. This points to a catastrophic event that affected *Vochysia* stands ca. 25 yr ago.

Impact of fire

During 1962-1972 Paraguay River shows a multi-years period of low floods (Fig. 3). In this period, vegetation of the Pantanal suffered severe drought stress. Many swamps and shallow lakes dried out completely during the dry season and fire spread over large areas of the Pantanal. Fire-resistant trees of the *cerrado* vegetation were scarcely affected (Coutinho 1982) but the flood-adapted and fire-intolerant *Vochysia* was strongly reduced because the bark is easily damaged. In *Vochysia* stands one year after the wild fire in the study area, 75% of all *cambará* trees in the four investigated plots were killed (Fig. 9). Dead trees provide additional fuel for repeated wild fires that, during multi-years dry periods, can eliminate entire *cambarazais* excepting a few individuals, as shown in plot 12 where a single tree of 54 cm diameter occurred in the middle of young trees with a diameter less than 18 cm (Fig. 8). Only in areas not or little affected by the fires, have entire stands survived as represented by the plots of diameter class one and to a smaller extent by the plots of diameter class two.

In the following multi-annual period of high floods and high rainfall, starting in 1974 and continuing until present, flood-tolerant species were favoured and *Vochysia* spread into all periodically-flooded areas, being limited only by long-term and high flooding as happens in the natural *campos limpos*. The communities described by the third diameter class are early successional stages in a very dynamic successional development. The observed invasion of *campos limpos* by *Vochysia* represents the occupation of its natural habitats under favourable hydrologic and climatic conditions (Fig. 10). Cattle grazing eliminates seedlings and saplings growing in small numbers in open areas as shown by the fenced plots (Fig. 6), but it does not effectively control spread of the plants along the edges of existing stands where seedling density is very high. However, long-term survival is possible only in areas not affected by fire. In these areas community development continues and reaches advanced seral stages with many old and a few young specimens of *Vochysia*.

With respect to the overall dynamics of the plant community development in the Pantanal, the periodical spread and retreat of native plant species such as *Vochysia* points to the great importance of changes over several years in the flood regime as driving factor as indicated by the flood pulse concept (Junk et al. 1989). This statement is of specific importance for populations of long-living plants, which need more time than populations of annual plants to reestablish after strong setbacks by multi-years extreme droughts and floods.

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Aves ameaçadas ocorrentes no Pantanal

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Apresentação

O Pantanal é um ecossistema de relevante importância para várias espécies de aves, muitas delas, ameaçadas de extinção em âmbito global e nacional. Entretanto, algumas espécies ainda possuem populações vigorosas na planície pantaneira, tais como a arara-azul-grande (*Anodorhynchus hyacinthinus*). Porém, pouco se conhece a respeito das espécies de aves ameaçadas de extinção que ocorrem neste ecossistema.

Neste trabalho é apresentada uma listagem das espécies de aves ameaçadas ocorrentes no Pantanal.

José Aníbal Comastri Filho
Chefe-Geral da Embrapa Pantanal

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Aves ameaçadas ocorrentes no Pantanal

Alessandro Pacheco Nunes
Fernando Augusto Tambelini Tizianel
Walfrido Moraes Tomas

Introdução

O uso intensivo e não sustentado dos recursos biológicos tem provocado uma perda crescente da biodiversidade mundial. Nos fóruns científicos e de deliberação política, o processo de erosão dos recursos naturais vem sendo alardeado como um dos problemas mais sérios a ser enfrentado pelo homem. Dentre as principais causas da diminuição das populações de animais silvestres, estão a redução de seus habitats devido à destruição da cobertura vegetal primária; a crescente ocupação humana; a exploração econômica de áreas de florestas, áreas úmidas, o cerrado e campos naturais; e o tráfico de animais silvestres, caça predatória e indiscriminada. A adoção de estratégias para reverter este processo constitui o grande desafio atual (Lins et al., 1997, Marini e Garcia, 2005). Para Straube et al. (2004), as aves destacam-se dentre os demais organismos por se tratarem de autênticos "indicadores biológicos de conservação".

As aves estão entre os vertebrados mais ameaçados pelo desmatamento, comércio ilegal de animais silvestres e a caça predatória (IBAMA, 2006; RENCTAS, 2006). No entanto, a maior parte das espécies ameaçadas não ocorre ou está inadequadamente protegida em unidades de conservação, e as prioridades de criação destas áreas pelo governo não estão associadas às regiões onde espécies ameaçadas estão concentradas (Olmos, 2005).

O tráfico de animais silvestres é a terceira maior atividade ilícita no mundo, e é apontado como o fator que mais ameaça a sobrevivência de muitas espécies ameaçadas de extinção. O Brasil lidera como 2º. lugar no ranking mundial de espécies de aves ameaçadas. Na planície do Pantanal, vários municípios são apontados como regiões de coleta (Coimbra, Rio Negro, Coxim, Miranda e Dourados) e venda (Cuiabá, Cáceres, São Gabriel do Oeste, Porto Murtinho e Corumbá) de animais silvestres (RENCTAS, 2006).

O Pantanal é um ecossistema extraordinário e importante para muitas espécies de aves, principalmente as aquáticas, que ocorrem em abundância, e as migrantes em larga escala que utilizam a planície de inundação como sítio de forrageio e descanso, durante seus deslocamentos entre o Sul do continente Americano e o Hemisfério Norte (Sick, 1997; Nunes e Tomas, 2004b; Nunes e Tomas, no prelo). Brown Jr. (1986) relaciona cerca de 657 espécies de aves para a planície e áreas limítrofes e Mittermeier et al. (2003) 463 espécies. No entanto Tubelis e Tomas (2003), listam 465 espécies de aves na planície, e citam outras 50 que podem ocorrer. Publicações mais recentes revelam a ocorrência de 17 novas espécies para a planície do Pantanal (Antas e Palo Jr., 2004; Cestari, 2006). Tubelis e Tomas (2003) ressaltam a necessidade de inventários mais consistentes, especialmente em áreas pouco ou nunca amostradas. Este trabalho objetivou apresentar uma listagem das espécies de aves ameaçadas ocorrentes no Pantanal.

Área de estudo

A planície de inundação do Pantanal está localizada na porção central da América do Sul, na bacia do Alto Paraguai onde ocupa cerca 140.000 km^2 nos estados de Mato Grosso do Sul e Mato Grosso. O Pantanal apresenta algumas características marcantes, como baixa altitude, pouca declividade, alternância de períodos de cheias e de secas, grandes amplitudes térmicas anuais, um padrão de precipitação marcadamente sazonal e uma variação pluri-anual das cheias, resultados da ocorrência de anos consecutivos com altas precipitações interrompidos por seqüências de anos com precipitação mais moderada (Adámoli, 1982). Cheias, fatores topográficos e edáficos influenciam a vegetação, que ocorre como mosaicos diversificados contendo florestas (matas semidecíduas, cerradão, cerrado e cerrado de murundu), ambientes aquáticos (rios, corixos, vazantes, baías, salinas, brejos e campos inundados) e habitats abertos (campos de pastagens nativas e/ou introduzidas e campos inundáveis). A composição da fauna e da flora do Pantanal é influenciada pelos biomas vizinhos, Chaco, Cerrado, Floresta Amazônica de Transição e Floresta Estacional Semidecidual Atlântica, que convergem para a planície (Brown Jr., 1986; Nunes e Tomas, 2004a).

Material e Métodos

Para a elaboração desta nova listagem das espécies de aves ameaçadas ocorrentes na planície e regiões adjacentes, foram compiladas listas de aves ameaçadas num âmbito global (IUCN, 2006; CITES, 2006), ou seja, em países vizinhos como Bolívia (Ergueta e Morales, 1996; BirdLife International, 2006) e Argentina (Aves Argentinas - Associacion Ornitologica del Plata, 2006) e no Brasil (IBAMA, 2006), nos estados de Minas Gerais (Biodiversitas, 2006), São Paulo (CEO, 2006), Rio Grande do Sul (Marques et al., 2002) e Paraná (Straube et al., 2004). As espécies contidas nestas listas foram comparadas com a avifauna listada para o Pantanal (Tubelis e Tomas, 2003; Antas e Palo Jr., 2004; Cestari 2006).

As espécies foram classificadas quanto ao hábitat (dados de campo e observações pessoais dos autores), dieta (Sick, 1997), atividade migratória (Nunes e Tomas, 2004b; Nunes e Tomas, no prelo) e grau de ameaça (Tomas et al., 2004; CMS, 2006; GROMS, 2006; IUCN, 2006). Entretanto, as espécies listadas pela IUCN (2006), na categoria Lc, não foram consideradas, uma vez que o grau de ameaça não é significativo. Quando disponíveis nas listagens, os tipos de ameaças foram acrescentados. Com base nos dados compilados e publicados por Tubelis e Tomas (2003) foram inclusas as áreas de distribuição das espécies na planície. A classificação qualitativa da abundância das espécies para o Pantanal foi baseada em Tomas et al. (2004). As categorias consideradas são:

Categoria migratória: A (migrante em larga escala); B (migrante intracontinental, ou seja, dentro da região sul do continente Sul Americano), C (migrante local ou regional), Ø (espécie inclusa nos anexos do Conservation on Migratory Species).
Categoria trófica: Ca (carnívoro), Fr (frugívoro); Gr (granívoro); In (insetívoro); Ma (malacófago); Ne (nectarívoro); On (onívoro); Pi (piscívoro).
Categorias de ameaça – IUCN: Cr (criticamente ameaçada), D (dados insuficientes), En (ameaçada de extinção), Ex (extinta), Nt (quase ameaçada), Pa (Provavelmente ameaçada), Pe (provavelmente extinta), Re (Recentemente ameaçada), Vu (vulnerável). CITES: Anexo I - espécies ameaçadas que são ou podem ser afetadas pelo tráfico de animais; Anexo II - espécies que atualmente não estão ameaçadas, mas necessitam de controle do comércio ilegal; Anexo III - inclui espécies que freqüentemente estão ameaçadas em âmbito global e que necessitam de regularização parcial ou mais ampla do tráfico, bem como espécies que necessitam da cooperação de outros países para prevenir sua exploração ilegal. P = **Pantanal:** 1 - área de ocorrência muito restrita, 2 - rara, 3 - pouco abundante, 4 - abundante, 5 - situação desconhecida, † – extinta segundo Tomás et al. (2004).

Resultados e discussão

Espécies ameaçadas

Nesta nova análise, estão listadas 188 espécies de aves ameaçadas, vulneráveis, em perigo ou mesmo extintas em outras regiões e/ou em âmbito nacional e global que ocorrem no Pantanal (Tabela 1). Estas espécies representam 25% da avifauna listada para o Pantanal. Foram excluídas 6 espécies da listagem publicada por Tomas et al. (2004), pois as mesmas não se encontram inclusas nas listas mais recentes e, outras 77, foram incluídas, muitas delas, recentemente registradas na planície, como os papa-capim *Sporophila palustris, Sporophila nigrorufa* e *Sporophila hypochroma* (Cestari, 2006).

No Brasil, de acordo com a CITES (2006), 681 espécies de aves estão ameaçadas. As espécies ameaçadas ocorrentes na planície e áreas adjacentes representam 27% destas aves. Para países próximos à planície do Pantanal, como Argentina, Bolívia, e Paraguai, a CITES (2006), cita 441, 410 e 238 espécies de aves ameaçadas, respectivamente. Com base em dados de 2003, o IBAMA (2006), estabeleceu uma lista com 147 espécies ameaçadas para o Brasil. Entretanto, ressalta-se que estes dados, já defasados, possivelmente não refletem a situação atual.

Aproximadamente 52% (98 espécies) das aves ameaçadas estão inclusas nos anexos da Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2006) e 18 na International Union for Conservation of Nature and Natural Resources (IUCN, 2006). Verifica-se, no entanto, uma grande contradição nas listagens de espécies globalmente ameaçadas, pois várias das espécies citadas pela IUNC não constam nos anexos da CITES, como os jacus (*Penelope superciliaris* e *Penelope ochrogaster*), o maçarico-acanelado (*Tryngites subruficollis*) e seis caboclinhos (*Sporophila nigrorufa, S. ruficollis, S. palustris, S. hypochroma, S. cinnamomea* e *S. maximiliani*). A pressão do comércio ilegal de animais silvestres é o principal critério utilizado pela CITES para incluí-las em suas listas, o que explica a presença de todas as araras, periquitos e papagaios (Psittacidae), do tucanuçu (*Ramphasto toco*), do cardeal (*Paroaria coronata*) *e* da cavalaria (*Paroaria capitata*), no Anexo II. No entanto chama-se a atenção para as demais espécies, tais como os membros das famílias Anatidae (marrecas e patos), Accipitridae (gaviões), Falconidae (falcões), Strigidae (corujas) e Trochilidae (beija-flores), os quais usualmente não são alvos do tráfico ilegal de animais silvestres. Estas aves, notadamente beija-flores, corujas e gaviões, são ligadas a ambientes florestais, muitas delas, extremamente sensíveis às alterações no hábitat.

Tabela 1. Lista das aves ameaçadas de extinção ocorrentes no Pantanal e regiões adjacentes. A ordem taxonômica, assim como a nomenclatura científica e os nomes vernáculos seguem o Comitê Brasileiro de Registros Ornitológicos (CBRO, 2006).

Família/Espécie	Habitat	CT	Categorias de ameaça/Lista das espécies									
			IUCN	CITES	IBAMA	P	Arg	Bol	SP	MG	RS	PR
Rheidae												
Rhea americana ema (PN, PC, PS)	Ce, Cp	On	Nt[a,c]	II, III		4	Nt	Nt[a,c]	Cr[a,c]	Vu		Cr[a,c]
Tinamidae												
Crypturellus undulatus jaó (PN, PC, PS)	Ce, Cp	Fr				4			Vu			Cr b
Rynchotus rufescens perdiz (PN, PS)	Ce, Cp	In		II		4						
Anhimidae												
Anhima cornuta anhuma (PN, PS)	Aq	On				2			Cr			En[e]
Anatidae												
Dendrocygna bicolor [B, ,Ø] marreca-caneleira (PS)*	Aq	On		III		3						
Dendrocygna viduata [B, Ø] irerê (PN, PC, PS)	Aq	On		III		4						
Dendrocygna autumnalis [B, Ø] asa-branca (PN, PC, PS)	Aq	On		III		4						
Coscoroba coscoroba [B, Ø] capororoca (PS)*	Aq	On		II		2						
Neochen jubata [B, Ø] pato-corredor (PN, PS)*	Aq	On	Nt[a]	II		2	Nt	Nt	Pe			

continua...

... continuação da tabela 1.

Família/Espécie	Habitat	CT	Categorias de ameaça/Lista das espécies									
			IUCN	CITES	IBAMA	P	Arg	Bol	SP	MG	RS	PR
Cairina moschata [C, Ø] pato-do-mato (PN, PC, PS)	Aq	On		III		4		Vu[a]			En	
Sarkidiornis sylvicola [B, Ø] pato-de-crista (PN, PS)	Aq	On		II		2		Vu[a]			Vu	
Amazonetta brasiliensis [C, Ø] pé-vermelho (PC, PS)	Aq	On				4						En
Cracidae												
Penelope superciliaris jacupemba (PN, PS)*	Fl	Fr	Nt[a,b]			3					Pa	
Penelope ochrogaster jacu-de-barriga-castanha (PN, PS)	Fl	Fr	Vu[a,b]		Vu	1				En		
Crax fasciolata mutum-de-penacho (PS) *	Fl	Fr				4			Cr	Vu		Cr[a,b]
Ardeidae												
Cochlearius cochlearius arapapá (PN, PC,PS)	Fl, Aq	Pi				3			En			D[b]
Ixobrychus exilis socoí-vermelho (PS) *	Aq	Pi				2						D[c]
Bubulcus ibis [B] garça-vaqueira (PN, PC, PS)	Ce, Cp	In		III		4						
Ardea alba [C, Ø] garça-branca-grande (PN, PC, PS)	Aq	Pi		III		4						
Pilherodius pileatus [B] garça-real (PN, PC, PS)	Aq	Pi				3						Nt[f]
Threskiornithidae												

continua...

... continuação da tabela 1.

Família/Espécie	Habitat	CT	Categorias de ameaça/Lista das espécies									
			IUCN	CITES	IBAMA	P	Arg	Bol	SP	MG	RS	PR
Plegadis chihi [B] caraúna-de-cara-branca (PS)	Aq	In				4						Nt[b,c]
Mesembrinibis cayennensis coró-coró (PN, PC, PS)	Fl, Aq	In				3					En	Nt[b]
Platalea ajaja [B] colhereiro (PN, PC, PS)	Aq	In				4				Vu		
Ciconiidae												
Ciconia maguari [B] maguari (PN, PC, PS)	Aq	Pi				3			Vu			
Jabiru mycteria [B, Ø] tuiuiú (PN, PC, PS)	Aq	Pi		I		4			Cr	En		
Mycteria americana [B, Ø] cabeça-seca (PN, PC, PS)	Aq	Pi				4			Vu[a]	Vu		
Cathartidae												
Cathartes burrovianus urubu-de-cabeça-amarela (PC, PS)	Fl, Ce, Cp	Ca				3			Pa[a]		Cr	
Sarcoramphus papa (Linnaeus, 1758) urubu-rei (PN, PC, PS)	Fl, Ce, Cp	Ca		III		2			En			
Pandionidae												
Pandion haliaetus [A, Ø] águia-pescadora (PN, PS)	Aq	Pi		II, III		3			Pa			

continua...

... continuação da tabela 1.

Família/Espécie	Habitat	CT	Categorias de ameaça/Lista das espécies									
			IUCN	CITES	IBAMA	P	Arg	Bol	SP	MG	RS	PR
Accipitridae												
Leptodon cayanensis gavião-de-cabeça-cinza (PN, PS)	Fl	Ca		II, III		3			Pa		Cr	
Chondrohierax uncinatus caracoleiro (PN, PS)*	Fl, Aq	Ma		I		2			Vu			Vu[b]
Elanoides forficatus [A, Ø] gavião-tesoura (PN, PS)	Fl, Ce	Ca		II, III		2						
Gampsonyx swainsonii gaviãozinho (PN, PC, PS)	Fl, Ce, Cp	Ca		II		3						
Elanus leucurus [B, Ø] gavião-peneira (PN, PS)	Fl, Ce, Cp	Ca		II, III		3						
Rostrhamus sociabilis [B, Ø] gavião-caramujeiro (PN, PC, PS)	Aq	Ma		II, III		5						
Ictinia mississippiensis [A, Ø] sauveiro-do-norte (PN, PS)	Fl	Ca		II, III		2						
Ictinia plumbea [B, Ø] sovi (PN, PS)	Fl, Ce	Ca		II, III		4						
Circus buffoni [C, Ø] gavião-do-banhado (PS) *	Fl	Ca		II		3			Pa			
Acipiter bicolor [C, Ø] gavião-bombachinha-grande (PC, PS)	Fl	Ca		II, III		3						D[b]
Geranospiza caerulescens gavião-pernilongo (PN, PC, PS)	Fl, Ce	Ca		II, III		4						

continua...

... continuação da tabela 1.

Família/Espécie	Habitat	CT	Categorias de ameaça/Lista das espécies									
			IUCN	CITES	IBAMA	P	Arg	Bol	SP	MG	RS	PR
Leucopternis albicollis gavião-pombo (PN)*	Fl, Ce, Cp	Ca		II, III		2						
Buteogallus urubitinga gavião-preto (PN, PC, PS)	Ce, Cp	Ca		II, III		4						
Heterospizias meridionalis gavião-caboclo (PN, PC, PS)	Ce, Cp	Ca		II, III		4						
Harpyhaliaetus coronatus águia-cinzenta (PS)*	Fl, Ce, Cp	Ca	En [a,b]	II	Vu	2	En	Nt[a,b]	Cr[b]	En	Cr	Vu[b]
Busarellus nigricollis gavião-belo (PN, PC, PS)	Aq	Ca		II, III		4			Vu		Vu	
Rupornis magnirostris gavião-carijó (PN, PC, PS)	Fl, Ce	Ca		II, III		4						
Buteo albicaudatus [C, Ø] gavião-de-rabo-branco (PN, PC, PS)	Ce, Cp	Ca		II, III		2						
Buteo melanoleucus [B] águia-chilena (PN, PS)*	Cp	Ca		II, III		3					Vu	En[b]
Buteo nitidus [C, Ø] gavião-pedrês (PN) *	Cp	Ca		II, III		3						
Buteo albonotatus [C] gavião-de-rabo-barrado (PS)*	Ce, Cp	Ca		II, III		3						D[b,c]
Spizastur melanoleucus gavião-pato (PN, PS)*	Fl	Ca		II		2			En	En	Cr	
Spizaetus ornatus gavião-de-penacho (PS)*	Fl	Ca		II		2			Cr[a,b]	En	Cr	En[b]

continua...

... continuação da tabela 1.

Família/Espécie	Habitat	CT	Categorias de ameaça/Lista das espécies									
			IUCN	CITES	IBAMA	P	Arg	Bol	SP	MG	RS	PR
Falconidae												
Caracara plancus caracará (PN, PC, PS)	Ce, Cp	Ca		II		4						
Milvago chimachima carrapateiro (PN, PC, PS)	Ce, Cp	Ca		II		4						
Micrastur ruficollis falcão-caburé (PN)*	Fl	Ca		II		3						
Micrastur semitorquatus falcão-relógio (PN, PS)	Fl	Ca		II		4						
Herpetotheres cachinnans acauã (PN, PC, PS)	Fl	Ca		II		4						Vu
Falco sparverius quiriquiri (PN, PC, PS)	Ce, Cp	Ca		II		4						
Falco rufigularis cauré (PN, PC, PS)	Fl, Ce, Cp	Ca		II		3						En
Falco deiroleucus falcão-de-peito-laranja (PS)*	Ce, Cp	Ca		II		2			En	Cr		Pe
Falco femoralis [C, Ø] falcão-de-coleira (PN, PC, PS)	Fl, Ce, Cp	Ca		II		4						
Rallidae												
Neocrex erythrops [B] tutu-tutu (PS)*	Fl, Aq	In				3						D[c]
Porphyrio flavirostris [C] frango-d'água-pequeno (PN, PS)	Aq	In				2			Vu			D[a,f]

continua...

... continuação da tabela 1.

Família/Espécie	Habitat	CT	Categorias de ameaça/Lista das espécies									
			IUCN	CITES	IBAMA	P	Arg	Bol	SP	MG	RS	PR
Heliornithidae												
Heliornis fulica (Boddaert, 1783) picaparra (PN, PS)	Aq	In				2			Vu			D[b,f]
Cariamidae												
Cariama cristata seriema (PN, PC, PS)	Ce, Cp	On				4						Nt[a,c]
Charadriidae												
Vanellus cayanus [B] batuíra-de-esporão (PN, PS)	Aq	In				4			Vu			D[c,f]
Scolopacidae												
Limosa haemastica [A, Ø] *maçarico-de-bico-virado (PN)**	Aq	In				5			Vu			D[c]
Numenius borealis [A, Ø] maçarico-esquimó (PN)*****	Aq	In	Cr[a,c]	I	Ex	+	Pe		Pe			
Tryngites subruficollis [A, Ø] maçarico-acanelado (PN)*****	Aq	In	Nt[c]			5	Nt				Vu	D[b,f]
Columbidae												
Columbina minuta rolinha-de-asa-canela (PN, PS)	Ce, Cp	Gr				4						D[e,f]
Claravis pretiosa [C] pararu-azul (PN, PS)	Fl, Ce	Fr				3					En	
Patagionenas speciosa pomba-trocal (PN)*****	Fl	Fr				3			Vu			D[a,b]
Patagioenas cayennensis pomba-galega (PN, PS)	Fl, Ce, Cp	Fr				4					Vu	

continua...

... continuação da tabela 1.

Família/Espécie	Habitat	CT	Categorias de ameaça/Lista das espécies									
			IUCN	CITES	IBAMA	P	Arg	Bol	SP	MG	RS	PR
Psittacidae												
Anodorhynchus hyacinthinus arara-azul-grande (PN, PC, PS)	Fl, Ce	Fr	En[b,c,d]	I	Vu	3		En b		Cr		
Ara ararauna arara-canindé (PC, PS)	Fl, Ce	Fr		II		4			Cr	Vu		Cr[a,e]
Ara chloropterus arara-vermelha-grande (PN, PC, PS)	Fl, Ce	Fr		II		4			Cr	En		Cr[a,e]
Primolius auricollis maracanã-de-colar (PN, PC, PS)	Fl	Fr		II		4						
Diopsittaca nobilis maracanã-pequena (PN, PS)	Fl, Ce	Fr		II		3			Pe			
Aratinga acuticaudata aratinga-de-testa-azul (PC, PS)	Ce, Cp	Fr		II		3						
Aratinga leucophthalma periquitão-maracanã (PN, PC, PS)	Fl, Ce	Fr		II		4						
Aratinga aurea periquito-rei (PN, PS)	Fl, Ce, Cp	Fr		II		3						
Nandayus nenday periquito-de-cabeça-preta (PN, PS)	Ce, Cp	Fr		II		4						
Pyrrhura devillei tiriba-fogo (PS)*	Fl	Fr		II		1						
Pyrrhura molinae tiriba-de-cara-suja (PS)*	Fl	Fr		II		1						
Myiopsitta monachus caturrita (PN, PC, PS)	Ce, Cp	Fr		II		4						

continua...

... continuação da tabela 1.

Família/Espécie	Habitat	CT	Categorias de ameaça/Lista das espécies									
			IUCN	CITES	IBAMA	P	Arg	Bol	SP	MG	RS	PR
Forpus xanthopterygius tuim (PN, PS)	Fl, Ce	Fr		II		3						
Brotogeris chiriri periquito-de-encontro-amarelo (PN, PS)	Fl, Ce, Cp	Fr		II		4						
Salvatoria xanthops papagaio-galego (PN, PS)	Ce	Fr	Nt[b,d]	II		3		Vu	Pe	Vu		
Pionus menstruus maitaca-de-cabeça-azul (PN, PS)	Fl, Ce	Fr		II		2						
Pionus maximiliani maitaca-verde (PN, PC, PS)	Fl, Ce	Fr		II		4						
Amazona aestiva papagaio-verdadeiro (PN, PC, PS)	Fl, Ce	Fr		II		4			Vu			
Amazona amazonica curica (PN, PS)	Fl	Fr		II		3			Pa			
Cuculidae												
Coccyzus euleri [B] papa-lagarta-de-euler (PN)*	Fl, Ce	In				3			En			D
Crotophaga major [C] anu-coroaca (PN, PC, PS)	Fl, Aq	In				3					Vu	
Dromococcyx phasianellus peixe-frito-verdadeiro (PN, PS)	Fl, Ce	In				3					En	
Tytonidae												
Tyto alba coruja-da-igreja (PN, PS)	Fl, Ce, Cp	Ca		II		4						

continua...

... continuação da tabela 1.

Família/Espécie	Habitat	CT	Categorias de ameaça/Lista das espécies									
			IUCN	CITES	IBAMA	P	Arg	Bol	SP	MG	RS	PR
Strigidae												
Otus choliba corujinha-do-mato (PN, PS)	Fl, Ce	Ca		II		4						
Pulsatrix perspicillata murucuturu (PS)*	Fl	Ca		II		5			En		En	D[a,b]
Asio stygius mocho-diabo (PS)*	Ce	Ca		II		2						D[a,c]
Bubo virginianus jacurutu (PN, PC, PS)	Fl	Ca		II		4						
Glaucidium brasilianum caburé (PN, PC, PS)	Fl, Ce	Ca		II		4						
Athene cunicularia coruja-buraqueira (PN, PC, PS)	Cp	Ca		II		4						
Rhinoptynx clamator coruja-orelhuda (PS)*	Ce, Cp	Ca		II		3						
Nyctibiidae												
Nyctibius grandis mãe-da-lua-gigante (PN, PS)	Fl, Ce	In				3			En			
Caprimulgidae												
Nyctiphrynus ocellatus bacurau-ocelado (PN)*	Fl	In				5						En[b]
Apodidae												
Tachornis squamata [c] tesourinha (PN)*	Ce, Cp	In				3			Cr			D[b]

continua...

... continuação da tabela 1.

Família/Espécie	Habitat	CT	Categorias de ameaça/Lista das espécies									
			IUCN	CITES	IBAMA	P	Arg	Bol	SP	MG	RS	PR
Trochiliae												
Glaucis hirsutus balança-rabo-de-bico-torto (PN, PS)	Fl, Ce	Ne		II		3						
Phaethornis nattereri besourão-de-sobre-amarelo (PN)*	Ce	Ne		II		2						
Phaethornis ruber rabo-branco-rubro (PS)*	Fl, Ce	Ne		II		2						
Phaethornis subochraceus rabo-branco-de-barriga-fulva (PN, PS)	Ce	ne		II		3						
Phaethornis pretrei rabo-branco-acanelado (PN, PC, PS)	Ce	Ne		II		4						
Phaethornis eurynome rabo-branco-de-garganta-rajada (PS)*	Fl, Ce	Ne		II		5						Vu
Anthracothorax nigricollis [B] beija-flor-de-veste-preta (PN, PC, PS)	Fl	Ne		II		3						
Chrysolampis mosquitus [C] beija-flor-vermelho (PS)*	Ce, Cp	Ne		II		3						
Chlorostilbon lucidus besourinho-de-bico-vermelho (PN, PS)	Ce, Cp	Ne		II		4						
Thalurania furcata beija-flor-tesoura-verde (PN, PS)	Fl	Ne		II		3			Vu			
Hylocharis sapphirina beija-flor-safira (PS)*	Fl	Ne		II		3			En			
Hylocharis chrysura beija-flor-dourado (PN, Pc, PS)	Fl, Ce	Ne		II		4						

continua...

... continuação da tabela 1.

Família/Espécie	Habitat	CT	Categorias de ameaça/Lista das espécies									
			IUCN	CITES	IBAMA	P	Arg	Bol	SP	MG	RS	PR
Polytmus guainumbi beija-flor-de-bico-curvo (PN, PC, PS)	Cp	Ne		II		4						
Amazilia versicolor beija-flor-de-banda-branca (PN, PS)	Fl	Ne		II		4						
Heliomaster longirostris bico-reto-cinzento (PN, PS)	Ce	Ne		II		3						
Heliomaster furcifer bico-reto-azul (PN, PS)	Fl, Ce	Ne		II		3						
Calliphlox amethystina [c] estrelinha-amestista (PN, PS)	Fl	Ne		II		3						
Alcedinidae												
Chloroceryle inda martim-pescador-da-mata (PS)*	Fl, Aq	Pi				3						Nt[b]
Chloroceryle aenea martinho (PN, PS)	Aq	Pi				1			Pa			
Momotidae												
Momotus momota udu-de-coroa-azul (PN, PS)	Fl	In				4						Nt[b,g]
Galbulidae												
Brachygalba lugubris ariramba-preta (PN, PS)*	Fl	In				3			Cr			
Galbula ruficauda ariramba-de-cauda-ruiva (PN, PC, PS)	Fl	In				4						Nt[b]

continua...

... continuação da tabela 1.

Família/Espécie	Habitat	CT	Categorias de ameaça/Lista das espécies									
			IUCN	CITES	IBAMA	P	Arg	Bol	SP	MG	RS	PR
Bucconidae												
Monasa nigrifrons chora-chuva-preto (PN, PS)	Fl	In				3			Pa			
Ramphastidae												
Ramphastos toco tucanuçu (PN, PC, PS)	Fl, Ce	Fr		II		4					Vu	
Ramphastos vitellinus tucano-de-bico-preto (PN)*	Fl	Fr		II		3			Pe			Nt[a,b]
Selenidera maculirostris araçari-poca (PS)*	Fl	Fr		III		3					Cr	
Pteroglossus castanotis araçari-castanho (PN, PS)	Fl	Fr		III		4					Cr	
Picidae												
Picoides mixtus pica-pau-chorão (PS)*	Fl, Ce	In				5			Cr		Cr	
Dryocopus lineatus pica-pau-de-banda-branca (PN, PC, PS)	Fl, Ce	In				4					Vu	
Thamnophilidae												
Herpsilochmus longirostris chorozinho-de-bico-comprido (PN, PS)	Fl	In				3			Vu			
Formicivora melanogaster formigueiro-de-barriga-preta (PS)*	Fl	In				5			Vu			
Formicivora rufa papa-formiga-vermelho (PN, PC, PS)	Fl, Ce	In				4						Nt[b]

continua...

... continuação da tabela 1.

Família/Espécie	Habitat	CT	Categorias de ameaça/Lista das espécies									
			IUCN	CITES	IBAMA	P	Arg	Bol	SP	MG	RS	PR
Dendrocolaptidae												
Lepidocolaptes angustirostris arapaçu-de-cerrado (PN, PC, PS)	Fl, Ce	In				4						Nt[b,c]
Campylorhamphus trochilirostris arapaçu-beija-flor (PN, PC, PS)	Fl, Ce	In				3			Vu			
Furnariidae												
Synallaxis albescens uí-pi (PN, PS)	Fl, Ce	In				5					Vu	
Synallaxis hypospodia joão-grilo (PS)	Fl, Ce	In				3						D[e,g]
Synallaxis scutata Estrelinha-preta (PS)*	Fl	In				3			Pa			
Philydor dimidiatus limpa-folha-do-brejo (PS)*	Fl, Ce	In				5						Cr[b]
Tyrannidae												
Myiopagis gaimardii maria-pechi (PN, PS)*	Fl	In				5			Vu			
Corythopis delalandi estalador (PN, PS)*	Fl	In				5					En	
Elaenia cristata [B] chibum (PN)*	Fl	In				3			Vu			
Suiriri suiriri [B] siuriri-cinzento (PC, PS)	Ce, Cp	In				4						Nt[b,c]
Polystictus pectoralis [B, Ø] papa-mosca-canela (PS)*	Ce	In	Nt[b,c]		Vu	5	Nt	Nt	Cr			D[b]

continua...

... continuação da tabela 1.

Família/Espécie	Habitat	CT	Categorias de ameaça/Lista das espécies									
			IUCN	CITES	IBAMA	P	Arg	Bol	SP	MG	RS	PR
Cnemotriccus fuscatus guaracavuçu (PN, PC, PS)	Fl	In				4					Vu	
Contopus cinereus [B] papa-moscas-cinzento (PS)*	Fl	In				5					En	
Xolmis irupero [B] noivinha (PS)	Cp	In				3						En[c]
Alectrurus risora [B, Ø] tesoura-do-campo (PS)*	Ce, Cp	In	Vu[c]			5	Nt					
Colonia colonus [B] viuvinha (PS)*	Ce, Cp	In				3					Vu	
Cotingidae												
Cephalopterus ornatus anambé-preto (PN, PS)	Fl	Fr		III		3						
Pipridae												
Antilophia galeata soldadinho (PN, PS)*	Fl	Fr				3			En			Cr[b]
Pipra fasciicauda uirapuru-laranja (PN)	Fl	Fr				5			Vu			
Corvidae												
Cyanocorax cyanomelas gralha-do-pantanal (PN, PC, PS)	Fl, Ce	On				4						Nt[b]
Cyanocorax cristatellus gralha-do-campo (PS)*	Ce, Cp	On				3						
Thraupidae												

continua...

... continuação da tabela 1.

Família/Espécie	Habitat	CT	Categorias de ameaça/Lista das espécies									
			IUCN	CITES	IBAMA	P	Arg	Bol	SP	MG	RS	PR
Cypsnagra hirundinacea bandoleta (PS)*	Ce, Cp	In				5			En			En[b]
Piranga flava tié-do-mato-grosso (PS)*	Fl, Ce	Fr				4						Nt[b]
Tangara cayana saíra-amarela (PN, PS)*	Fl, Ce	Fr				4						Nt[b]
Emberizidae												
Porphyrospiza caerulescens campainha-azul (PS)*	Ce, Cp	Gr	Nt[b,c]			5		Nt				
Sicalis citrina [B] canário-do-amazonas (PS)*	Ce, Cp	Gr				2			Pa			
Sicalis flaveola canário-da-terra-verdadeiro (PN, PC, PS)	Cp	Gr				4				Vu		
Sporophila plumbea [B] patativa (PS)*	Ce, Cp	Gr				3			En			Vu[a,c]
Sporophila collaris [C] coleiro-do-brejo (PN, PC, PS)	Cp	Gr				4					Vu	
Sporophila leucoptera [B] chorão (PN, PS)	Cp	Gr				4						Nt[c,d]
Sporophila nigrorufa [B] caboclinho-do-sertão (PS)*	Cp	Gr	Vu[c,d]		Vu	2		En				
Sporophila bouvreuil [B] caboclinho (PS)*	Cp	Gr				3			Cr[a]			Nt[c,d]
Sporophila hypoxantha B caboclinho-de-barriga-vermelha (PN, PS)	Cp	Gr				3					Cr	Ntc,d

... continuação da tabela 1.

Família/Espécie	Habitat	CT	Categorias de ameaça/Lista das espécies									
			IUCN	CITES	IBAMA	P	Arg	Bol	SP	MG	RS	PR
Sporophila ruficollis [B] caboclinho-de-papo-escuro (PS)*	Cp	Gr	Nt[c]			3	Nt	Nt	Cr[a,c]	Vu		
Sporophila palustris [B] caboclinho-de-papo-branco (PS)*	Cp	Gr	En[c,d]		En	2	En		Cr[a,c]	En	En	En[a,c]
Sporophila hypochroma [B] caboclinho-de-sobre-ferrugem (PS)	Cp	Gr	Nt[c,d]			3	Nt	Vu				
Sporophila cinnamomea [B] caboclinho-de-cahpéu-cinzento (PS)*	Cp	Gr	Vu[c,d]		En	1	Vu		Cr[a]		En	En[a,c]
Sporophila angolensis [B] curió (PN, PS)	Ce, Cp	Gr				1			Vu[a]	En	En	Vu[a]
Sporophila maximiliani [B] bicudo (PS)*	Ce, Cp	Gr	Nt[c,d]		Cr	1			Pe	Cr		
Paroaria coronata (Miller, 1776) cardeal (PN, PS)	Cp	Gr		II		4			Pe			
Paroaria capitata cavalaria (PN, PC, PS)	Cp	Gr		II		4						
Cardinalidae												
Saltator atricollis bico-de-pimenta (PS)	Ce	In				4			Vu			D[b]
Cyanocompsa brissonii azulão (PN, PS)	Ce	Gr				5			Vu			
Parulidae												
Basileuterus flaveolus *canário-do-mato (PN, PC, PS)*	Fl	In				4						Vub

continua...

... continuação da tabela 1.

Família/Espécie	Habitat	CT	Categorias de ameaça/Lista das espécies									
			IUCN	CITES	IBAMA	P	Arg	Bol	SP	MG	RS	PR
Basileuterus leucophrys pula-pula-de-sombrancelha (PN)*	Fl	In				3						Vu[b]
Icteridae												
Psarocolius decumanus japu (PN, PC, PS)	Fl, Ce	Fr				4			Vu			Cr[b]
Cacicus solitarius iraúna-de-bico-branco (PN, PC, PS)	Fl	Fr				4			Vu		Vu	D[b]
Agelasticus cyanopus [c] carretão (PN, PC, PS)	Aq	In				3					En	
Molothrus oryzivorus iraúna-grande (PN, PS)	Cp	In				3			Pa			En
Fringilidae												
Euphonia violacea guaturamo-verdadeiro (PS)*	Fl	Fr				5					Vu	

Distribuição na planície: PN (Pantanal Norte: Cáceres, Poconé, Barão de Melgaço), PC (Pantanal Central: Paiaguás, Norte da Nhecolândia), PS (Pantanal Sul: Sul da Nhecolândia, Abobral, Aquidauana, Miranda, Nabileque, Porto Murtinho); *Espécies com distribuição muito restrita na planície do Pantanal.

Categoria migratória: A (migrante em larga escala); B (migrante intracontinental, ou seja, dentro da região sul do continente Sul Americano), C (migrante local ou regional), Ø (espécie inclusa nos anexos do Conservation on Migratory Species).

Habitat: Aq (campos inundados, baías, salinas, vazantes, brejos, rios e corixos); Ce (cerrado e cerrado de murundu); Cp (campo sujo, caronal e campos inundáveis); Fl (floresta semidecídua, mata ciliar e cerradão).

CT = Categorias tróficas: Ca (carnívoro), Fr (frugívoro); Gr (granívoro); In (insetívoro); Ma (malacófago); Ne (nectarívoro); On (onívoro); Pi (piscívoro).

Categorias de ameaça – IUCN: Cr (criticamente ameaçada), D (dados insuficientes), En (ameaçada de extinção), Ex (extinta), Nt (quase ameaçada), Pa (Provavelmente ameaçada), Pe (provavelmente extinta), Re (Recentemente ameaçada), Vu (vulnerável). CITES: Anexo I - espécies ameaçadas que são ou podem ser afetadas pelo tráfico de animais; Anexo II - espécies que atualmente não estão ameaçadas, mas necessitam de controle do comércio ilegal; Anexo III - inclui espécies que freqüentemente estão ameaçadas em âmbito global e que necessitam de regularização parcial ou mais ampla do tráfico, bem como espécies que necessitam da cooperação de outros países para prevenir sua exploração ilegal. P = **Pantanal:** 1 - área de ocorrência muito restrita, 2 - rara, 3 - pouco abundante, 4 - abundante, 5 - situação desconhecida, † – extinta segundo Tomás et al. (2004).

Lista das espécies: P (Pantanal), **Arg** (Argentina), **Bol** (Bolívia), **SP** (São Paulo), **MG** (Minas Gerais), **RS** (Rio Grande do Sul), **PR** (Paraná).

Pressão de ameaça: a (caça), b (desmatamento), c (agricultura e pecuária), d (tráfico ilegal de animais silvestres), e (população reduzida devido à área de ocorrência coincidir com limite de distribuição do táxon), f (poluentes), g (usinas hidrelétricas)..

Na listagem nacional de aves ameaçadas elaborada pelo Ministério do Meio Ambiente (IBAMA, 2006) constam apenas 9 espécies ocorrentes Pantanal. Espécies como o papagaio-galego (*Salvatoria xanthops*) e da tesora-do-campo (*Alectrurus risora*) e a maioria das aves listadas pela CITES (2006), estão fora da lista nacional. As aves Não-Passeriformes são as mais representativas, com 135 espécies (72% da avifauna ameaçada), sendo os Accipitridae (gaviões), a família mais representativa, com 23 espécies (17% da avifauna), sendo seguida dos Psittacidae (araras, periquitos e papagaios) e Trochilidae (beija-flores), com 19 espécies (14%) e 17 espécies (12,6%), respectivamente, como pode ser visto na Figura 1.

Os gaviões, sendo aves do topo da cadeia alimentar, são na maioria dependentes de ambientes florestais e requerem extensas áreas para estabelecer seus territórios e se reproduzir. A principal ameaça a este grupo é o desmatamento (Sick, 1997). Araras, periquitos e papagaios (Psittacidae) e tucanos (Ramphastidae) destacam-se como as aves mais cobiçadas pelo comércio ilegal de animais silvestres (IBAMA, 2006; RENCTAS, 2006). Galettti et al. (2002), alertam para os efeitos do processo de destruição de habitats naturais pelo homem, que muito provavelmente colocará em risco as espécies do gênero *Ara* e *Amazona* no Pantanal.

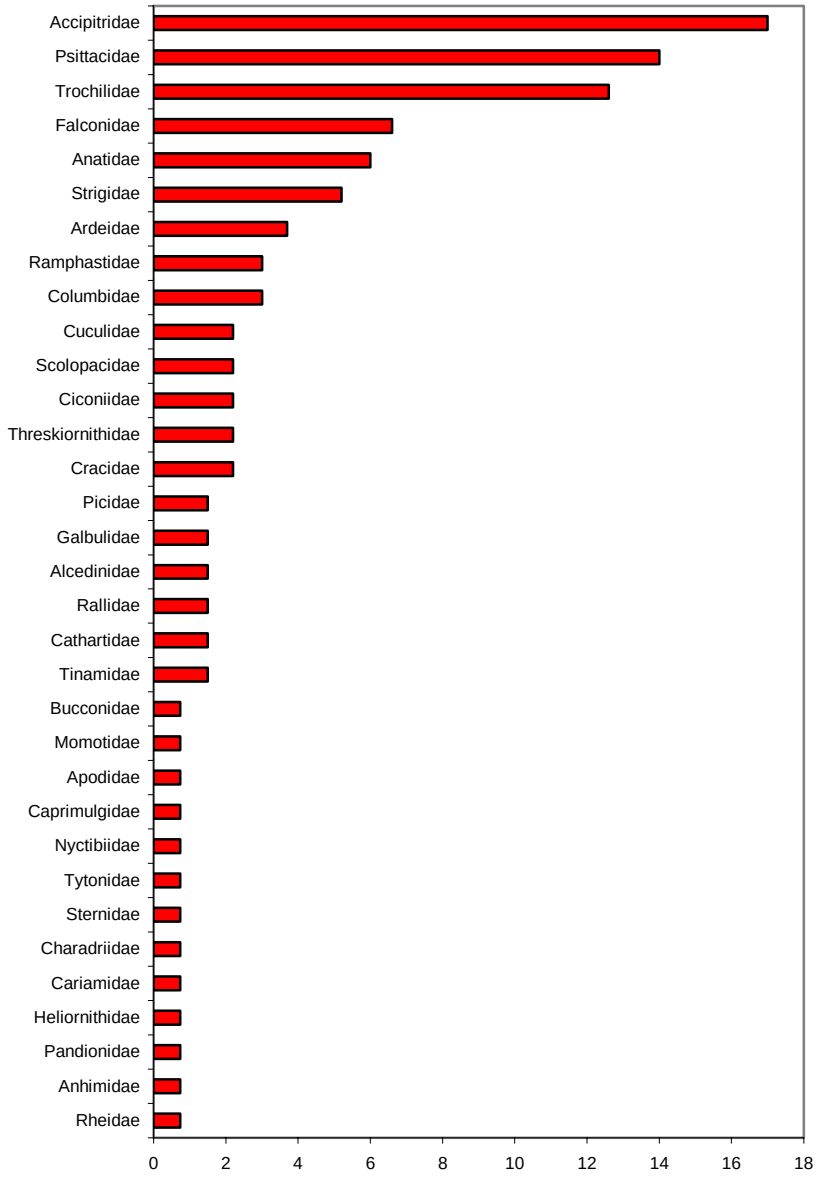

Figura 1. Freqüência relativa (%) de espécies de aves Não-Passeriformes ameaçadas de extinção ocorrentes no Pantanal, agrupadas por famílias.

Os coleirinhos e caboclinhos (Emberizidae), assim como papa-moscas (Tyrannidae) estão entre as aves mais ameaçadas da Ordem Passeriformes ocorrentes no Pantanal, com 17 espécies (32%) e 10 espécies (19%), respectivamente (Figura 2). Das espécies ameaçadas na Bolívia, 12 também ocorrem na planície do Pantanal. Estas espécies, na sua maioria, são as mesmas citadas como globalmente ameaçadas uma vez que suas listagens são elaboradas com dados da IUCN (Ergueta e Morales, 1996).

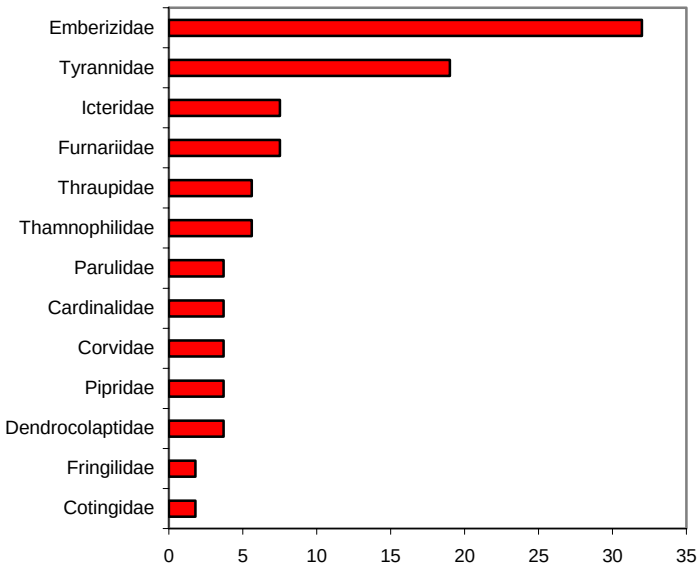

Figura 2. Freqüência relativa de espécies de aves Passeriformes ameaçadas de extinção ocorrente no Pantanal, agrupadas por famílias.

Próximos à fronteira com o Brasil, a Área Natural de Manejo Integrado San Matías e o Parque Noel Kempff Mercado, ambos em Santa Cruz, Bolívia, se destacam como regiões similares ao Pantanal e áreas de relevante importância para a conservação de várias espécies de aves (BirdLife International, 2006). Muitas delas também ocorrem na planície do Pantanal.

Em 2002 o canário-da-terra-verdadeiro (*Sicalis flaveola*), a patativa (*Sporophila plumbea*) e o curió (*Sporophila angolensis*), estiveram entre as dez espécies mais capturadas por traficantes de animais silvestres no Brasil (IBAMA, 2006). De acordo com o IBAMA (2006) e, Marini e Garcia (2005), o Pantanal possui menor número de espécies de aves ameaçadas, comparado à Mata Atlântica e ao Cerrado.

Os estados com maior número de aves ameaçadas foram São Paulo e Paraná, com 67 e 66 espécies, respectivamente. Nestas regiões, a avifauna é fortemente associada com a Mata Atlântica, bioma considerado o mais ameaçado do Brasil (IBAMA, 2006). Várias das espécies ameaçadas de extinção nestes estados não estão inclusas na listagem do IBAMA, como a ema (*Rhea americana*), o gavião-pato (*Spizaetus melanoleucus*), o gavião-de-penacho (*Spizastur ornatus*), o falcão-de-peito-laranja (*Falco diroleucus*) e a arara-canindé (*Ara chloropterus*).

As informações sobre as aves ameaçadas nos estados que abrangem o Pantanal são muito escassas e desatualizadas, uma vez que nem mesmo possuem uma listagem das espécies que ocorrem em seus territórios, ao contrário do que ocorre em outros estados, como São Paulo (Willis e Oniki, 2003), Paraná (Scherer-Neto e Straube, 1995), Rio Grande do Sul (Belton, 1984; 1985; 2004) e Minas Gerais (Andrade, 1997).

Várias espécies inclusas nos anexos II da CITES (2006), são comuns e apresentam ampla distribuição na planície do Pantanal, tais como a ema (*Rhea americana*), algumas marrecas e patos (Anatidae), o tuiuiú (*Jabiru mycteria*), o cabeça-seca (*Mycteria americana*), alguns gaviões e falcões (Accipitridae e Falconidae, respectivamente), corujas (Strigidae), beija-flores (Trochilidae), o tucanuçu (*Ramphasto toco*), o cardeal (*Paroaria coronata*) e a cavalaria (*Paroaria capitata*). Tais aves, ainda mantém populações vigorosas no Pantanal, o que torna o Pantanal, um grande e importante refúgio para populações de espécies ameaçadas. A arara-azul-grande (*A. hyacinthinus*) é um exemplo disso. De acordo com Guedes e Harper (1995), a população de araras-azuis ocorrente na planície é tida como a mais importante em toda sua área de distribuição.

Entretanto, chama a atenção, algumas espécies restritas a determinada parte da planície, de acordo com os dados disponíveis em Tubelis e Tomas (2003), como o capororoca (*Coscoroba coscoroba*), o pato-corredor (*Neochen jubata*), o pato-de-crista (*Sarkidiornis sylvicola*), o jacu-de-barriga-castanha (*Penelope ochrogaster*), o caracoleiro (*Chondrohierax uncinatus*), a águia-cinzenta (*Harpyhaliaetus coronatus*), o tucano-de-bico-preto (*Ramphastos vitellinus*), o papa-moscas-canela (*Polystictus pectoralis*), a tesoura-do-campo (*Alectrurus risora*) e a campainha-azul (*Porphyrospiza caerulescens*).

Harris et al. (2005) ressaltam que apenas 2,5% da Bacia do Alto Paraguai estão oficialmente protegidas sob forma de unidades de conservação federais, estaduais e reservas privadas, protegendo apenas uma pequena fração da diversidade de fauna e flora. Para Tomas et al. (2004), o monitoramento da situação das aves raras e ameaçadas é importante, uma vez que o Pantanal é considerado ainda pouco alterado por atividades humanas, e que, portanto, pode se constituir no último grande refúgio que abriga populações vigorosas destas espécies.

Várias espécies ocorrentes no Pantanal encontram-se ameaçadas em estados e ecossistemas vizinhos, mas na planície, ainda possuem populações vigorosas, o

que sustenta ainda mais o "status" da planície como um refúgio ecológico para estas espécies. No entanto, ressalta-se que grandes áreas dentro da planície foram pouco ou nunca amostradas, o que pode ampliar as áreas de distribuição destas taxa à medida que estudos ornitológicos sejam desenvolvidos na região. Os tipos de ameaças às aves aqui consideradas, citados por Ergueta e Morales (1996), Straube et al. (2004) e IUCN (2006), são em grande parte relacionados à caça e ao comércio ilegal de animais silvestres, mas também, aos desmatamentos e às atividades agropecuárias. Tais ameaças poderiam ser minimizadas através de leis ambientais mais rigorosas, maior fiscalização por parte dos órgãos federais como IBAMA e Polícia Ambiental, bem como estratégias de conservação efetivas.

Migrantes

Dentre as aves ameaçadas ocorrentes no Pantanal (Nunes e Tomas, no prelo), 63 espécies, ou seja, 33% da comunidade realizam deslocamentos migratórios em maior ou menor escala. Destacam-se aquelas que migram dentro do continente Sul Americano, principalmente entre as regiões mais meridionais, com 40 espécies (64%). Estas aves são representadas principalmente pelos papa-capim (Emberizidae, 12 espécies), seguidas dos papa-mosca (Tyrannidae, 7 espécies), marrecas (Anatidae, 6 espécies). As que realizam deslocamentos mais regionais somam 16 espécies, sendo dois anatídeos (*Cairina moschata* e *Amazonetta brasiliensis*), cinco gaviões (*Circus buffoni, Accipiter bicolor, Buteo albicaudatus, B. nitidus* e *B. albonotatus*), o falcão-de-coleira (*Falco femoralis*), o frango-d'água-pequeno (*Porphyrio flavirostris*), a pararu-azul (*Claravis pretiosa*), o anu-coroca (*Crotophaga major*), o andorinhão (*Tachornis squamata*), os beija-flores (*Chrysolampis mosquitus* e *Calliphlox amethystina*), o coleiro-do-brejo (*Sporophila collaris*) e o carretão (*Agelaioides cyanopus*). Ressalta-se a ocorrência de 7 espécies migratórias em larga escala, todas oriundas do Hemisfério Norte, como a águia-pescadora (*Pandion haliaetus*), o gavião-tesoura (*Elanoides forficatus*), o sauveiro-do-norte (*Ictinia mississippiensis*), o maçarico-de-bico-virado (*Limosa hemastica*), o maçarico-esquimó (*Numenius borealis*), o maçarico-acanelado (*Tringites subruficollis*) e o trinta-réis (*Sterna hirundo*).

Ainda com relação as aves migratórias ameaçadas Nunes e Tomas (2006) citam a ocorrência de várias espécies para o Pantanal. Entretanto, a IUCN (2006 e a CITES (2006) não consideram muitas delas. Portanto, tais espécies não foram incluídas na listagem, sendo apenas citadas no texto. Dentre elas estão: as marrecas (*Callonetta leucophrys, Anas versicolor, A. cyanoptera* e *Nomonyx dominica*), o urubu (*Cathartes aura*), os gaviões (*Accipiter poliogaster, A. striatus, Buteo brachyurus*), o pernilongo (*Himantopus melanurus*), as batuíras (*Pluvialis dominica, P. squatarola* e *Charadrius semipalmatus*), os maçaricos (*Gallinago paraguaiae, Bartramia longicauda, Tringa melanoleuca, T. flavipes, T. solitaria, Actitis macularia, Calidris canutus, C. alba, C. pusilla, C. minutilla, C. fuscicollis,*

C. melanotos e *Phalaropus tricolor*), trinta-réis (*Sterna hirundo*), e os sabiás (*Catharus fuscescens* e *Turdus amaurochalinus*). Estes migrantes ameaçados também merecem especial atenção, uma vez que a maioria, 15 espécies são oriundas do Hemisfério Norte, visitando anualmente os mesmos sítios de invernada na planície. Estes sítios de invernada, tais como baías, salinas, campos inundáveis e cordilheiras são extremamente importantes ao fornecer abrigo, ponto de descanso e alimento a estas espécies (Nunes e Tomas, 2004b; Nunes e Tomas no prelo). Para tanto a conservação destas áreas faz-se extremamente necessária à sobrevivência e manutenção do ciclo migratório das espécies migrantes, tanto em larga escala, quanto a nível local.

Habitats

As aves de habitats florestais respondem por 26% (47 espécies) da avifauna ameaçada que ocorre no Pantanal, seguidas por aquelas que exploram ambiente florestal/cerrado (Fl,Ce) e aquático (Aq), com 38 (20%) e 28 espécies (15%), respectivamente, como pode ser visto na Figura 3.

Agrupando as aves que, de alguma forma, exploram o hábitat florestal (incluindo o cerrado) verifica-se, que elas representam uma parcela considerável da avifauna (50%, 94 espécies). Embora incluso como vulnerável pela IUCN (2006) e no anexo II da CITES (2006), o estado de conservação do papagaio-galego (*Salvatoria xanthops*) em âmbito nacional é ignorado pelo IBAMA (2006). A situação deste papagaio é preocupante devido o crescente aumento na degradação do cerrado (Cavalcanti, 2000), ambiente no qual é considerado endêmico (Sick, 1997). Alterações nos pulsos de inundação e drenagem de várzeas e áreas úmidas podem afetar drasticamente espécies ameaçadas dependentes dos ambientes aquáticos, principalmente patos e marrecas (Anatidae), garças (Ardeidae), maguari, cabeça-seca e tuiuiú (Ciconiidae).

As espécies campestres como os papa-capim (Emberizidae), podem ser afetados pela alteração do hábitat. A atual tendência de modificação de áreas campestres pela substituição de espécies nativas por gramíneas, como a brachiaria, pode causar impactos nestas espécies, mas nada se sabe sobre isso. Ressalta-se que estes estudos são essenciais e que a definição das práticas de manejo do ecossistema precisam ser cautelosas e firmemente apoiadas por estudos científicos.

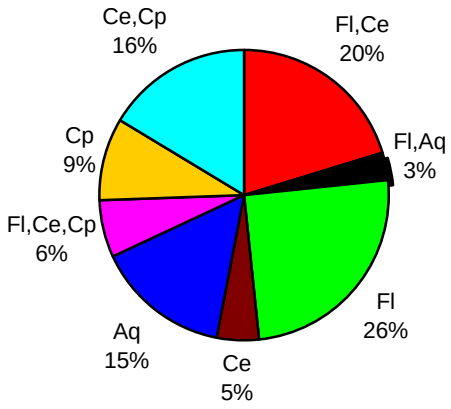

Figura 3. Preferência de habitat (%), das espécies de aves ameaçadas que ocorrem no Pantanal. Aq (Aquático), Ce (Cerrado), Cp (Campos), Fl (Florestal).

Entre as aves florestais ameaçadas destacam-se os gaviões (Accipitridae) e os beija-flores (Trochilidae), que formam a maioria na comunidade, jacus e mutuns (Cracidae), pica-paus (Picidae) e arapaçus (Dendrocolaptidae), também são exemplos de espécies estritamente relacionadas e dependentes deste ambientes. Nas últimas décadas a intensificação na produção pecuária no Pantanal tem levado à substituição dos habitats naturais por áreas de pastagens exóticas, e tais alterações podem causar impactos significativos a avifauna (Tubelis e Tomas, 1999). A ação das carvoarias também tem relevante contribuição ao desmatamento na planície.

Guildas tróficas

Analisando as preferências alimentares das aves ameaçadas que ocorrem na planície e regiões adjacentes, observou-se o predomínio da insetivoria, com 49 espécies (27%), seguida dos carnívoros (40 espécies, 21%) e frugívoros (38 espécies, 20%), como pode ser visto na Figura 4. Dentre as famílias de insetívoros, destacam-se os bacuraus (Caprimulgidae), pica-paus (Picidae), joão-grilo, limpa-folhas, barranqueiros (Furnariidae), arapaçus (Dendrocolaptidae) e principalmente os papa-moscas (Tyrannidae). As aves ameaçadas predadoras de

topo de cadeia, ou seja, as carnívoras, estão representadas principalmente pelos gaviões (Accipitridae, com 23 espécies), bem como pelos falcões (Falconidae, 9 espécies) e as corujas (Tytonidae e Strigidae, 8 espécies). Os papagaios, araras e periquitos, juntamente como os tucanos, araçaris e saíras, somam grande percentagem de aves frugívoras ameaçadas ocorrentes na planície do Pantanal. Espécies carnívoras, frugívoras e nectarívoras são muito sensíveis às perturbações no ambiente, pois necessitam de grandes áreas naturais pouco alteradas que lhes forneçam alimento suficiente durante épocas diferentes do ano (Sick, 1997).

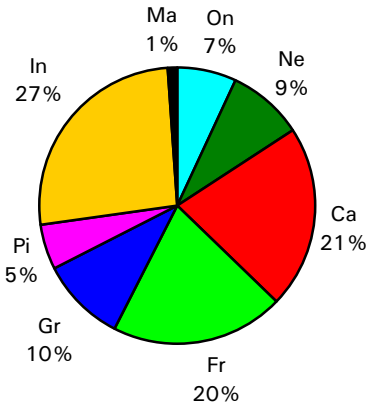

Figura 4. Guildas tróficas (%) exploradas pelas aves ameaçadas que ocorrem no Pantanal. Ca (carnívoros), Fr (frugívoros), Gr (granívoros), In (insetívoros), Ma (malacófagos), Ne (nectarívoros), On (onívoros), Pi (piscívoros).

Aves ameaçadas ocorrentes no Pantanal: conhecimento sobre as espécies de alguns grupos

Anatidae

Neochen jubata (pato-corredor): consta como quase ameaçado (IUCN, 2006) e no anexo II da (CITES, 2006). Esta espécie, segundo dados de Tubelis e Tomas (2003), possui apenas dois registros dentro da planície, Caiçara (MT) e em Porto Quebracho (MS), sendo considerada rara. Dentre as possíveis ameaças, estão alterações no habitat, pois tende a desaparecer em rios muito navegáveis (Sick, 1997).

Coscoroba coscoroba (capororoca ou pato-arminho): espécie presente nos anexos II da CITES (2006), ocorrendo na planície em locais como Fazenda Alegria e região da Nhecolândia, no Pantanal Sul (Tubelis e Tomas, 2003). O capororoca se distribui pela Argentina, Chile, Bolívia e Terra do Fogo, tendo, no Brasil, grande concentração no Rio Grande do Sul (Nascimento et al., 2001). Alterações no seu habitat, como banhados e rios, são as possíveis ameaças à espécie na região.

Cracidae

Penelope ochrogaster (jacu-de-barriga-castanha): ave de distribuição mais restrita à região norte da planície e é tida como quase ameaçada (IUCN, 2006) e vulnerável (IBAMA, 2006). Esta espécie é florestal e a pressão gerada pelo desmatamento na região, possivelmente, é a ameaça mais proeminente, visto que não é caçada na planície.

Accipitridae

Chondrohierax uncinatus (caracoleiro): consta no anexo I da CITES (2006). Ocorre segundo os dados de Tubelis e Tomas (2003), em áreas muito restritas, como a Fazenda Santo Antônio das Lendas (MT), sendo considerada uma espécie rara. As possíveis ameaças a esta espécie, na planície, são desconhecidas.

Harpyhaliaetus coronatus (águia-cinzenta): espécie considerada vulnerável (IUNC, 2006; IBAMA, 2006) e rara na planície, segundo Tubelis e Tomas (2003). Registros da espécie estão restritos à região sul (Fazenda Fazendinha, Pantanal da Nhecolândia). A descaracterização de seu habitat, através da substituição dos

campos naturais por pastagens introduzidas, pode ser uma ameaça potencial a esta espécie.

Spizaetus ornatus (gavião-de-penacho): consta como criticamente ameaçada e ameaçada nos estados de São Paulo (CEO, 2006) e Paraná (Straube et al., 2004), respectivamente. Seus registros na planície do Pantanal restringem-se a Porto Murtinho, ao Vale do Bugio (Corguinho), nas proximidades do Rio Paraguai na Serra do Amolar, ambos no Estado de Mato Grosso do Sul, e a Rota da Transpantaneira, em Poconé/MT (Tubelis e Tomas, 2003; W.M. Tomas, obs. pessoal; A. Melo, com. pessoal). Dentre as possíveis ameaças, podemos destacar o desmatamento.

Scolopacidae

Numenius borealis (maçarico-esquimó): espécie migrante setentrional e tida como criticamente ameaçada, segundo a IUCN (2006), e presente no anexo I da CITES (2006), embora o IBAMA (2006) a considere atualmente extinta no Brasil. A atual situação desta espécie expressa bem como alterações no habitat podem causar danos irreversíveis às populações naturais.

Psittacidae

Anodorhynchus hyacinthinus (arara-azul-grande): considerada ameaçada pela IUNC (2006) e vulnerável (IBAMA, 2006). A população da planície é considerada muito importante para a conservação da espécie (Guedes e Harper, 1995; Galetti et al. 2002). Embora esta população seja vigorosa e os esforços do Projeto Arara Azul tenham mantido e aumentado o número de indivíduos desta deme na região, esta espécie ainda é perseguida por traficantes de animais silvestres. Outra ameaça à espécie é o desmatamento e práticas de manejo inadequadas, que escasseiam o manduvi (*Sterculia apetala*) na região, árvore da qual dependem para nidificar.

Pyrrhura devillei (tiriba-fogo): espécie inclusa no anexo II da CITES (2006), no Brasil ocorre apenas em Mato Grosso do Sul, sendo neste estado, restrita às Serras da Bodoquena e Maracaju, além das áreas de tensão ecológica entre o planalto e a planície do Pantanal, como as matas ciliares do Rio Taboco, no município de Aquidauana. Como ave endêmica a um ecossistema muito restrito como este, o qual vem sendo descaracterizado em decorrência da expansão pecuária e ação de carvoarias no estado, sugerimos incluí-la na categoria de vulnerável na listagem de espécies ameaçadas em âmbito nacional e/ou regional.

Pyrrhura molinae (tiriba-de-cara-suja): questiona-se muito a posição taxonômica deste periquito, presente no anexo II da CITES (2006). Para o Lexicon Foundation Dutch Parrot Refuge (2006), esta espécie possui várias subespécies ou raças geográficas, sendo *P. molinae hypoxantha,* restrita ao Morro do Urucum, município de Corumbá, Mato Grosso do Sul e *P. molinae phoenicura,* também ocorrente no oeste do estado e região noroeste do território boliviano. Entretanto, Sick (1997), considera as duas peles coletadas na região de Corumbá e tratadas como *P. hypoxantha,* apenas como uma mutação lutínica de *P. molinae*. Atualmente, uma dessas peles encontra-se na coleção de aves do Museu de Zoologia da USP (MZUSP) e outra, no American Museum of Natural History, em Nova York (L.F. Silveira, com. pessoal). Órgãos como o Centro de Referência em Informação Ambiental (CRIA, 2006) e o Sistema Integrado de Informação Taxonômica (ITIS, 2006), aceitam a *P. hypoxantha* como espécie válida. A ocorrência desta suposta nova espécie torna as matas secas das partes altas do município, como prioritárias à sua conservação, uma vez que automaticamente, *P. hypoxantha,* passa à categoria de espécie rara, endêmica e ameaçada de extinção. A tiriba *P. molinae,* e suas supostas subespécies, assim como a possível *P. hypoxantha,* merecem especial atenção, visto habitarem as matas semidecíduas e secas das partes altas de Corumbá, áreas estas de intensa exploração de minério de ferro.

Salvatoria xanthops (papagaio-galego): espécie tida como vulnerável (IUCN, 2006). Esta espécie é bastante comum e típica no cerrado, que freqüentemente nidifica em cupinzeiros terrícolas (Sick, 1997). No entanto, ressalta-se que a progressiva descaracterização do cerrado na região por meio da substituição de áreas naturais por pastagens e monoculturas, possivelmente torna-se uma grande ameaça, além do tráfico ilegal de animais silvestres.

Tyrannidae

Polystictus pectoralis (papa-mosca-canela): ave tida como quase ameaçada (IUCN, 2006) e vulnerável (IBAMA, 2006). De ocorrência restrita à região sul da planície (Passo da Lontra, Pantanal da Nhecolândia), segundo dados de Tubelis e Tomas (2003). A.P. Nunes (obs. pessoal), relata registro desta espécie na fazenda Pousada das Amoras, município de Aquidauana. Sendo ave muito exigente ecologicamente e típica de campos e cerrado (Sick, 1997), a descaracterização do habitat, pode ser uma importante ameaça e este migrante na região.

Alectrurus risora (tesoura-do-campo): ave migrante meridional (Nunes e Tomas, 2004b) e vulnerável (IUCN, 2006). Espécie de distribuição muito restrita na planície, tendo registro apenas no Pantanal do Nabileque, na Fazenda Quebracho (Tubelis e Tomas, 2003). Habita campos e a crescente tendência à substituição

das áreas de campos naturais por pastagens introduzidas, pode vir a ser uma séria ameaça à espécie.

Emberizidae

Porphyrospiza caerulescens (campainha-azul): segundo a IUCN (2006) é tida como quase ameaçada. Ave de distribuição restrita na planície de acordo com os dados de Tubelis e Tomas (3003), na região norte e Corumbá (MS). Pode vir a ser uma das espécies afetadas pela descaracterização das áreas naturais por pastagens introduzidas.

Sporophila ruficollis (caboclinho-de-papo-escuro): considerada quase ameaçada (IUNC, 2006). Espécie recentemente registrada na planície: RPPN SESC Pantanal (Antas e Palo Jr., 2004), fazenda Nhumirim, região da Nhecolândia (Nunes e Tomas, 2005), e RPPN Fazenda Rio Negro (Cestari, 2006). Como ave granívora e tipicamente campestre, pode vir a ser uma das espécies afetadas pela crescente substituição das áreas de campos naturais por pastagens introduzidas. Outra importante ameaça a ser considerada é a sua captura para o tráfico ilegal de animais silvestres.

Sporophila palustris (caboclinho-de-papo-branco): espécie migrante meridional, recentemente registrada para a planície, em Porto Murtinho, Pantanal do Nabileque (A.P. Nunes, obs. pessoal) e RPPN Fazenda Rio Negro (Cestari 2006). Seu "status" de conservação de acordo com a IUNC (2006) e IBAMA (2006) é de ameaçada. Assim como as demais espécies ecologicamente similares, as pressões de ameaças são o comércio ilegal de animais silvestres e a descaracterização de seus habitats, como campos naturais e bordas de brejos.

Sporophila cinnamomea (caboclinho-de-chapéu-cinzento): considerada globalmente vulnerável (IUCN, 2006) e ameaçada no Brasil (IBAMA, 2006). Ave rara (Sick, 1997), que na planície, está restrita à região de Porto Murtinho (Tubelis e Tomas, 2003). Dentre as possíveis ameaças, destaca-se sua captura para o comércio de animais silvestres e a substituição das áreas de campos naturais por pastagens introduzidas.

Sporophila maximiliani (bicudo): ave criticamente ameaçada (IBAMA, 2006) e rara, segundo dados de Tubelis e Tomas (2003), sendo sua distribuição restrita à região norte da planície (Rota Transpantaneira). Registros adicionais foram feitos recentemente por A. P. Nunes (não publicado), na região do Rio Taboco, município de Miranda. A principal ameaça à espécie é o tráfico ilegal de animais silvestres.

Conclusões

Nesta análise, ressalta-se a importância das listagens de espécies ameaçadas, bem como informações mais detalhadas a respeito dos tipos de ameaças, distribuição destes táxons nos respectivos territórios abordados e propostas de soluções que minimizem a pressão de ameaça a estas espécies. Dada a insignificante parcela de áreas oficialmente protegidas no Pantanal, tais informações podem servir de subsídios para a elaboração de estratégias de conservação e delimitação de novas áreas oficiais de proteção que contemplem áreas de distribuição destes táxons ameaçados e a diversidade de fauna e flora da planície do Pantanal. Ressalta-se também, o importante papel do Pantanal, como refúgio para várias espécies de aves ameaçadas em biomas e regiões vizinhas.

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Quantas espécies de aves ocorrem no Pantanal brasileiro?

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Alessandro Pacheco Nunes

ABSTRACT: How many bird species are there in Pantanal wetland? A checklist of new records of birds species in the Pantanal is presented. Here I report 122 new records of birds species in Pantanal. A total of 582 species has already been recorded in this wetland. However, the Pantanal wetland is unsatisfactorily sampled.

KEY-WORDS: Birds, Pantanal, diversity, new records, review.

PALAVRAS-CHAVE: Aves, Pantanal, diversidade, novos registros, revisão.

Saracuruçu: *Aramides ypecaha.* Foto: Walfrido Moraes Tomas.

O Pantanal brasileiro ocupa uma área de aproximadamente 140.000 km^2 entre os estados de Mato Grosso e Mato Grosso do Sul (Adámoli 1981). A paisagem pantaneira é extremamente complexa e os ecossistemas vizinhos, principalmente o Cerrado, exercem forte influência na fauna e flora local (Brown Jr. 1986, Nunes & Tomas 2004). Diferentes habitats, tipos de solos e regimes de inundação são responsáveis, em parte, pela complexa formação vegetal e pela heterogeneidade da paisagem, que alberga uma elevada biodiversidade (Pott & Adámoli 1999). Na paisagem pantaneira predominam os campos, seguida do cerradão, cerrado, campos inundáveis, floresta semidecídua, mata de galeria e tapetes de vegetação flutuante ou "baceiros" (Silva *et al.* 2000).

O clima na planície pantaneira é tropical subúmido (Aw) com estações bem definidas: cheia (novembro a abril) e seca (maio a outubro). A precipitação anual pode atingir até 1.180 mm, sendo a temperatura média mensal oscilando entre 21°C e 33°C (Soriano & Alves 2005). Os padrões e processos ecológicos no Pantanal são determinados pelos pulsos de inundação (Oliveira & Calheiros 2000).

A grande complexidade da paisagem e situações ecológicas particulares favorece a existência de vários nichos ecológicos, refletindo em uma também elevada diversidade e abundância de aves, notadamente as aquáticas (Tubelis & Tomas 2003). Essas peculiaridades têm atraído naturalistas e coletores de aves desde o desde o início do século XIX. Nesse contexto, enquadram-se as expedições de Johann Natterer, Alfredo Borelli, Herbert Smith, George Cherrie (Roosevelt-Rondon) e instituições nacionais, como o Museu de Zoologia da Universidade de São Paulo, Museu Nacional do Rio de Janeiro e Fundação Museu de Ornitologia (Tubelis & Tomas 2003).

A primeira listagem de aves ocorrentes no Pantanal foi elaborada Brown Jr. (1986) que relacionou 657 espécies. Dubs (1992) publicou uma segunda listagem, no livro ***Birds** of Southwestern Brazil: catalogue and guide to the **birds** of the Pantanal of Mato Grosso and its border areas*. Uma terceira lista foi produzida por Coutinho *et al.* (1997), durante a elaboração do Plano de Conservação da Bacia do Alto Paraguai. Nesta listagem, os autores relacionaram a ocorrência de 656 espécies para o Pantanal. No entanto, em ambas as listas produzidas por esses autores, as localidades não são georeferenciadas e as espécies ocorrentes nos planaltos adjacentes tam-

Tabela 1. Localidades e regiões com registros inéditos de espécies no Pantanal, Brasil, com as respectivas coordenadas geográficas e fontes de informação. As letras na coluna de referências correspondem à fonte dos registros, mencionada da metodologia.

N	Localidades	Latitude	Longitude	Referências
1	Fazenda Descalvados	16°43'S	57°44'W	V
2	RPPN SESC Pantanal	16°39'S	56°16'W	D, X, Y
3	Fazenda Rio Alegre	16°30'S	56°45'W	μ
4	Retiro Novo	16°22'S	56°17'W	V
5	Moquém	16°22'S	56°16'W	V
6	Pousada Piuval, Transpantaneira	16°23'S	56°37'W	S
7	Fazenda das Araras, Transpantaneira	16°30'S	56°42'W	A
8	Pirizal	16°14'S	56°23'W	H, π
9	Corumbá	18°09'S	57°01'W	R
10	Fazenda Nhumirim	18°59'S	56°39'W	B, G, Z
11	Fazenda Caité	18°43'S	55°15'W	R
12	Fazenda São Luis	18°08'S	57°01'W	R
13	Fazenda Caiman	19°56'S	56°20'W	I, L
14	Fazenda Santana	19°37'S	55°36'W	R
15	Fazenda Santa Emília	19°30'S	55°36'W	T
16	Aquidauana	20°25'S	55°48'W	W
17	Fazenda Rio Negro	19°30'S	56°17'W	E, J, K
18	Fazenda Barranco Alto	19°34'S	56°09'W	β
19	Pousada Xaraés	19°28'S	56°57'W	α
20	Fazenda Campo Novo	19°22'S	57°37'W	R
21	Fazenda Figueirinha	19°15'S	57°39'W	V
22	Curva do Leque	19°15'S	57°02'W	R
23	Fazenda Bela Vista	19°13'S	57°26'W	R
24	Fazenda Alegria	19°03'S	56°47'W	Z
25	Ponte do Nabileque	20°43'S	57°43'W	M
26	Reserva Kadiwéu	20°28'S	57°28'W	M
27	Fazenda Terra Preta	20°23'S	57°20'W	M
28	Fazenda Tarumã do Nabileque	20°17'S	57°37'W	M
29	Fazenda Aguapé	20°06'S	55°57'W	F, P
30	Fazenda San Francisco	20°04'S	56°36'W	O
31	Fazenda Taboco	20°04'S	55°37'W	R
32	Rio Tarumã	21°32'S	57°49'W	N
33	Fazenda Porto Conceição	21°28'S	57°55'W	N
34	Riacho Sanga Funda	22°04'S	57°34'W	N
35	Fazenda Braunal	26°06'S	57°43'W	N
	Regiões não georeferenciadas			
36	foz do rio Negro	-	-	C
37	rio Cuiabá	-	-	Q
38	Nhecolândia	-	-	Q
39	região do rio Negro	-	-	Q, U

bém foram inclusas, de forma que o respectivo resgate geográfico torna-se impossível.

Tubelis & Tomas (2003) elaboraram uma quarta lista, através de uma criteriosa revisão com base em listas de espécies disponíveis na literatura, exemplares depositados em museus institucionais no Brasil e exterior, bem como dados inéditos de campo, tornando-se uma importante fonte de dados sobre a avifauna do Pantanal. Junk *et al.* (2006) mencionaram a ocorrência de 766 espécies de aves no Pantanal, das quais apenas 390 foram consideradas pelos autores como realmente ocorrentes na planície. Segundo os mesmos autores, os demais registros não apresentam documentação comprobatória de ocorrência adequada.

O IBAMA (2007) relacionou apenas 290 espécies para o Pantanal, com base nos dados publicados por Brown Jr. (1986), desconsiderando as demais publicações disponíveis e subestimando a diversidade de aves ocorrentes na planície.

De acordo com Nunes *et al.* (2008) se considerados todas os dados disponíveis para a avifauna pantaneira, o número de espécies atribuídas a esse ecossistema pode ultrapassar 730. No entanto, os mesmos autores alertam que a ocorrência de 200 espécies, ou seja, 27,4% da avifauna atribuída à na planície pantaneira é questionável, pois a maioria é restrita aos planaltos adjacentes.

Nunes *et al.* (2008) consideraram apenas 553 como ocorrentes no Pantanal. Tomas *et al.* (2008) relatam que mais de 800 espécies de aves podem ser avistadas na Bacia do Alto Paraguai (Brasil, Bolívia e Paraguai), das quais pelo 567 já foram registradas no Pantanal brasileiro. Gwynne *et al.* (2010) relacionaram 740 espécies de aves para o Brasil Central, das quais apenas 496 foram creditadas ao Pantanal.

Apesar das importantes contribuições que sucederam Tubelis & Tomas (2003), a maioria delas tratam de registros pontuais de espécies e são pouco acessíveis à comunidade científica. Nesse artigo apresento uma criteriosa revisão dos registros recentes das espécies de aves ocorrentes no Pantanal.

Métodos

Nesse artigo considerei apenas os registros inéditos após a lista de aves do Pantanal publicada por Tubelis & Tomas (2003) (Tabela 1). Os dados foram obtidos através de consulta a periódicos científicos, teses, relatórios técnicos e sites da internet que hospedam informações sobre pousadas e hotéis fazendas no Pantanal.

Foram compilados dados das seguintes r**eferências:** A (Lopez-Lanus 1992), B (Tubelis & Tomas 1999), C (Nascimento *et al.* 2000), D (Antas & Palo Jr. 2004), E (Donatelli 2005), F (Endrigo 2005), G (Nunes *et al.* 2005), H (Pinho 2005), I Athanas (2006a), J (Cestari 2006a), K (Cestari 2006b), L (Melo 2006), M (Straube *et al.* 2006a), N (Straube *et al.* 2006b); O (Melo *et al.* 2007), P (Endrigo 2008), Q (Morrison *et al.* 2008), R (Nunes *et al.* 2008), S (Olmstead 2008a), T (Pivatto *et al.* 2008), U (Silveira & Straube 2008), V (Vasconcelos *et al.* 2008), W (Wittaker *et al.* 2008), X (Antas 2009), Y (Antas & Palo Jr. 2009), Z (Nunes *et al.* 2009), β (Leuzinger 2009), α (Nunes *et al.* 2010), μ (Oliveira *et al.* 2010), π (Signor & Pinho 2010).

As listas de aves publicadas por Brown Jr. (1986) e Coutinho *et al.* (1997), não foram consideradas nesse estudo, pois os registros não são georeferenciados, de forma que o respectivo resgate geográfico tornou-se impossível.

Objetivando inferir evidências o mais precisas possível sobre o registro das espécies de aves ocorrentes no Pantanal, foram estabelecidas três listas avifaunísticas de acordo com o Comitê Brasileiro de Registros Ornitológicos (CBRO 2010).

1 - Lista Primária (LP): inclui espécies com pelo menos um dos registros de ocorrência no Pantanal provido de evidência documental. Neste contexto, são evidências documentais os itens disponíveis, para consulta independente, na forma exclusiva de espécime integral ou parcial, fotografia, gravação de áudio ou vídeo, que permitam a determinação segura do táxon;

2 - Lista Secundária (LS): inclui espécies com provável ocorrência no Pantanal, providas de registros específicos publicados para a planície, mas cuja evidência documental não é conhecida ou disponível. Neste contexto, a 'provável ocorrência' da espécie no Pantanal é inferida a partir do seu padrão distribucional e de dispersão estabelecido com base em evidências documentais;

3 - Lista Terciária (LT)*:* inclui espécies providas de registros específicos publicados para o Pantanal, mas com evidência documental inválida ou com improvável ocorrência na planície e carentes de evidência documental.

A evidência superior é o nível máximo de certeza para considerar uma espécie como integrante da avifauna de uma dada região (Carlos *et al.* 2010). Com base nas propostas desses autores, considerei como evidência superior os seguintes documentos comprobatórios: espécime coletado, fotográfia, vídeo e arquivo sonoro. Com relação aos espécimes coletados considerei aqueles depositados em museu institucional no Brasil (ExB) ou no exterior (ExE). No caso dos registros fotográficos foram considerados: fotografia publicada (FoP), fotografia arquivada em museu institucional (FoM), fotografia presente em acervo privado (FoA) e fotografia disponível na internet (FoI). Com relação aos vídeos, considerei apenas aqueles arquivados em museu institucional (ViM). Consideraram-se os registros sonoros depositados em acervo privado (ASA) e disponível na internet (ASI). Foram considerados também, os registros visuais publicados (VSp) e não publicados (VSn). A evidência superior obedece à seguinte hierarquia: ExB, ExE, FoP, FoM, FoA, FoI, ViM, ASA, VSp.

Consideraram-se também, as informações sobre espécimes ou registros fotográficos e audiovisuais arquivados depositados nas seguintes instituições: American Museum of Natural History (AMNH, Nova York/EUA); Museu de Zoologia da Universidade de São Paulo (MZUSP, São Paulo); Departamento de Zoologia, Universidade Federal de Minas Gerais (DZUFMG, Belo Horizonte); Visual Resources for Ornithology (VIREO, Philadelphia); Coleção de Referência dos Vertebrados do Pantanal (Embrapa Pantanal, Corumbá).

Excetuando os táxons *Aburria nattereri, Aburria grayi, Pyrrhura hypoxantha* e *Picumnus corumbanus*, a ordenação taxonômica, bem como a nomenclatura científica e os nomes comuns utilizados nesse artigo seguem o CBRO (2010).

Resultados

Diversidade: Foram acrescidos 137 novos registros para o Pantanal (Apêndice I). Considerando as espécies relacionadas por Tubelis & Tomas (2003) e os dados apresentados nesse estudo (excetuando as espécies inclusas na lista terciária) um total de 582 espécies pode ser avistado no Pantanal. O Pantanal brasileiro ocupa o quarto lugar no ranking nacional de diversidade de aves.

A avifauna ocorrente no Pantanal é bastante diversificada quando comparada à de outras áreas úmidas do globo, tais como os Everglades na Florida, com 365 espécies (Ogden 1969). No Delta do Okavango, África; nos Llanos da Venezuela (Esteros de Camaguán) e nos Esteros de Ibera, Argentina; foram registradas 450, 258 e 343 espécies, respectivamente (Birdlife International 2009).

No Brasil, em áreas úmidas como a planície de inundação do Alto rio Paraná e a Lagoa do Peixe, Gimenes *et al.* (2007) e Nas-

cimento (1995) registraram a ocorrência de 373 e 181 espécies, respectivamente. De acordo com Junk *et al. (*2006) e Oliveira (2006), a comunidade de espécies aquáticas ocorrente na planície do Pantanal é similar àquela encontrada em outras áreas úmidas da América do Sul, tais como a Amazônia e os Llanos do Orinoco.

Registros duvidosos. Quatorze espécies *foram inclusas na lista terciária, uma vez que se trata de possíveis equívocos de identificação. Nesse sentido enquadram-se Crypturellus soui, Crypturellus obsoletus, Fulica leucoptera, Patagioenas plumbea, Patagioenas subvinacea, Thalurania glaucopis, Melanopareia torquata, Pyriglena leucoptera, Xiphocolaptes albicollis, Phylidor lichtensteini, Lochmias nematura, Lanio melanops, Schistochlamys melanopis e Agelasticus thilius. A área de ocorrência da maioria dessas espécies está centrada na Mata Atlântica.*

Várias espécies inclusas por Tubelis & Tomas (2003) nas categorias I, II, III, IV e V (espécies com registros imprecisos e não georeferenciados) foram avistadas recentemente no Pantanal (Apêndice I). Dentre elas se destacam *Botaurus pinnatus, Ixobrychus involucris, Accipiter poliogaster, Buteo brachyurus, Spizaetus tyrannus, Falco peregrinus, Pardirallus maculatus, Patagioenas speciosa, Primolius maracana, Colibri serrirostris, Heliomaster longirostris, Elaenia parvirostris, Platyrhynchus mystaceus, Myiarchus tuberculifer, Attila phoenicurus, Xenopsaris albinucha, Sporophila nigrorufa* e *Euphonia laniirostris*.

Considerando as espécies inclusas por Tubelis & Tomas (2003) na lista principal de aves do Pantanal, apenas 367 apresentavam evidência documental da sua ocorrência na planície. No entanto, durante a compilação de dados nesse estudo encontrei documentos comprobatórios (principalmente registros fotográficos) para 21 espécies. Nesse contexto, enquadram-se *Geranoaetus melanoleucus* (Melo & Teribeli 2008); *Callonetta leucophrys* (Straube *et al.* 2006a); *Urubitinga coronata* (Chiaravalloti *et al.* 2009); *Lateralllus melanophaius, Athene cunicularia* e *Hylocryptus rectirostris* (Leuzinger 2009); *Laterallus viridis* (Olmstead 2008b); *Caprimulgus maculicaudus* (Athanas 2006b); *Nyctibius grandis* (Ubaid 2006) e *Coscoroba coscoroba, Podilymbus podiceps, Bubulcus ibis, Cathartes burrovianus, Ara ararauna, Nyctibius griseus, Pulsatrix perspicillata, Chloroceryle inda, Polystictus pectoralis, Cypsnagra hirundinacea, Cacicus haemorrhous* e *Passer domesticus* (VIREO 2010).

Uma parcela significativa da avifauna relacionada para o Pantanal, aproximadamente 70% (419 espécies) apresenta evidência documental satisfatória, conforme o CBRO (2011). As demais espécies ainda carecem de documentação satisfatória que comprove sua ocorrência na planície do Pantanal.

Tubelis & Tomas (2003) mencionam a possível ocorrência de *Taphrospilus hypostictus* em Cáceres, Mato Grosso. Entretanto, essa espécie não conta na lista primária das espécies de aves ocorrentes no Brasil (CBRO 2010). Pacheco (2000) relata que os indícios da presença dessa espécie no Brasil é produto de um mero engano. Ainda segundo o mesmo autor, os registros atribuídos a *T. hypostictus* no Mato Grosso, sul da Bolívia e Argentina devem ser convertidos em favor de *Amazilia chionogaster*. O registro de *Calidris alba* na Fazenda Rio Alegre (Oliveira *et al.* 2010) pode ser considerado o primeiro para a planície do Pantanal, pois de acordo com Straube *et al.* (2006b), o espécime proveniente de Porto Quebracho (Tubelis & Tomas 2003) corresponde à *Phalaropus tricolor*.

Raposo *et al.* (1998) realizaram estudos taxonômicos, morfométricos e bioacústicos no grupo *Hylophilus poicilotis/H. amaurocephalus* e verificaram equívocos na identificação dos espécimes coletados em várias regiões do Brasil, incluindo o Mato Grosso do Sul e a planície do Pantanal. Desta foram, todos os registros atribuídos à *H. poicilotis* no Mato Grosso do Sul e Pantanal devem ser convertidos em favor de *H. amaurocephalus.*

Vários autores têm atribuído os registros de alguns exemplares do gênero *Picumnus* em algumas regiões do Pantanal e planaltos do entorno à *P. corumbanus* (Naumburg 1930; Vieira 1940; Nunes *et al.* 2008, 2009, 2010; Vasconcelos *et al.* 2008). *P. corumbanus* foi descrita a partir de exemplares coletados no Maciço do Urucum (Lima 1920). Naumburg (1930) também relata a coleta de exemplares desse suposto táxon em Urucum, bem como também em Descalvados, Tapirapoã e rio São Lourenço. Vasconcelos *et al.* (2008) coletaram exemplares do gênero *Picumnus* no Maciço do Urucum, os quais foram tratados pelos autores, como *P. corumbanus*. Ainda segundo os mesmos autores, há grande variação na coloração das partes inferiores dos exemplares coletados no Maciço do Urucum, notadamente a região ventral, que remete a presença de características intermediárias entre *P. cirratus* e *P. albosquamatus*. Fenômeno similar é relatado por Neto (1995), em Santa Mariana, Paraná e por Machado *et al.* (2010) em Itarumã, Goiás. No entanto, Vasconcelos *et al.* (2008), ressaltam a necessidade de estudos moleculares para esclarecer esse problema taxonômico. Apesar dessas recomendações, optei por considerar provisoriamente os registros desse pretenso táxon em favor de *P. albosquamatus.*

Dúvidas históricas pairam sobre a tiriba-de-barriga-amarela (*Pyrrhura hypoxantha,* Salvadori 1899), táxon descrito a partir de exemplares coletados por Adolfo Boreli na borda oeste do Pantanal (Naumburg 1930). Atualmente esse táxon não é considerado espécie válida, sendo tratado como uma variação lutínica de *P. molinae* (Sick 1997, Straube 2010). Em fevereiro de 2007 foi o avistado um suposto casal de *P. molinae* com plumagem ventral amarela, tal como na descrição original do táxon e também ilustrada por um exemplar coletado na região (MZUSP-9954), reacendo a discussão sobre a alegada variação lutínica de *P. molinae* (Tomas *et al.* 2010). Entretanto, apesar dessas considerações optei por não considerar o suposto táxon nesse estudo.

Grau *et al.* (2004) reconhecem três espécies do gênero *Aburria* no território nacional: *A. jacutinga* (restrita à mata atlântica do sul e sudeste), *A. cujubi* (restrita à floresta amazônica, porção norte do Pantanal e parte de Mato Grosso do Sul) e *A. cumanensis,* com ampla distribuição na região norte da América do Sul e parte do Peru, Bolívia, Paraguai e Brasil (bacia do alto rio Paraguai). No entanto, estudos realizados por Lopes (2009) revelaram a existência de sete espécies plenas de *Aburria* na América do Sul. Ainda segundo o mesmo autor, as subespécies *A. cumanenis grayi* e *A. cujubi nattereri* devem ser elevadas à categoria de espécies plenas. Desta forma, nesse artigo optei por converter todos os registros atribuídos à *A. cujubi nattereri* e *A. cumanensis grayi*, em favor de *A. nattereri* e *A. grayi,* respectivamente.

Ao sul do Amazonas, as populações de *Icterus cayanensis* são compostas por quatro subespécies: *pyrrhopterus*, *tibialis*, *periporphyrus* e *valencio-buenoi (Ridgely & Tudor 1989)*. Na Bacia do Alto Paraguai ocorrem três delas: *I. cayanensis pyrrhopterus* na borda oeste do Pantanal e em Salobra, *I. cayanensis valencio-buenoi* em Cáceres e Poconé e, *I. cayanensis periporphyrus ao sul da Serra de Maracajú (Naumburg 1930, Vieira 1940,* Straube 2010). Estudos moleculares mostram que os grupos do sudeste, a exemplo daqueles ocorrentes na Amazônia são monofiléticos, sem evidências de hibridização (Omland *et al.* 1999, D'Horta *et al.* 2008, Sturge *et al.* 2009). Com base nessas evidências, D'Horta *et al.* (2008) sugerem que tais subespécies sejam elevadas à categoria de espécies plenas. Desta forma, todos os registros de *I. cayanenis* na planície do Pantanal e na Bacia do Alto Paraguai devem ser revistos.

Potencial ornitológico: Vinte e sete novas localidades foram amostradas desde publicação da lista de aves ocorrentes no Pantanal, elaborada por Tubelis & Tomas (2003). Entretanto, ainda há regiões insuficientemente amostradas, tais como os pantanais ou sub-regiões do Nabileque (Chaco), do Paiaguás e de Cáceres. Nas regiões limítrofes do Pantanal brasileiro com o Chaco boliviano e paraguaio, há um grande potencial para novos registros e ocorrências de espécies.

Straube *et al.* (2006b) relatam a ocorrência do curiango-do-banhado (*Hydropsalis anomalus*) na Colônia Risso, situada a poucos quilômetros da fronteira com o Brasil. Próximo a essa localidade está a foz do rio Apa, onde Aquino *et al.* (2000) e Cockle *et al.* (2007) relacionam a ocorrência de espécies como papagaio-de-peito-roxo (*Amazona vinacea*), o andorinhão-de-sobre-cinzento (*Chaetura cinereiventris*) e a juruva-verde (*Baryphthengus ruficapillus*). Outra potencial espécie ocorrente no pantanal do Nabileque é a andorinha-chilena (*Tachycineta meyeni*), que de acordo com Hayes (1995) ocorre em Puerto 14 de Mayo, a poucos quilômetros de Forte Coimbra, no Brasil.

Propostas: Para melhorar o conhecimento atual sobre a biodiversidade de aves na planície pantaneira, bem como tornar as listas de espécies ai ocorrentes mais confiáveis e menos discordantes faz-se necessário:

1) Os inventários avifaunísticos devem ser concentrados em regiões com grandes lacunas de conhecimento, tais como os pantanais de Cáceres e Paiaguás, bem como as áreas limítrofes do Brasil com o Chaco do Paraguai e os Bosques Secos Chiquitanos da Bolívia;

2) Padronização das informações oriundas dos registros das espécies ocorrentes no Pantanal, conforme as orientações do Comitê Brasileiro de Registros Ornitológicos.

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Apêndice I. Novos registros de espécies de aves para o Pantanal, Brasil. As localidades podem ser encontradas na Tabela 1, cujas respectivas fontes de informação podem ser encontradas na metodologia. As informações sobre as localidades e as evidências de ocorrência das espécies estão disponíveis na metodologia.

Táxons	Localidades	Evidência	Status
Tinamidae			
Crypturellus soui	17, 18	VSp	LT
Crypturellus obsoletus	18	VSp	LT
Nothura boraquira	35	VSp	LS
Anatidae			
Anas sibilatrix	14	VSp	LS
Anas bahamensis	18, 19	FoM^{EMBRAPA}, VSp	LP
Anas cyanoptera	22	VSp	LS
Anas platalea	18, 19	FoM^{EMBRAPA}, VSp	LP
Netta peposaca	18, 36	FoA, VSp	LP
Oxyura vitata	18	FoI, VSp	LP
Cracidae			
Aburria nattereri	2, 3, 7, 13, 29	ExB^{MZUSP}, ExE^{AMNH}, VSp	LP
Ardeidae			
Botaurus pinnatus	17, 18	VSp	LS
Ixobrychus involucris	29	VSp	LS
Accipitridae			
Harpagus diodon	2, 3, 10, 18	VSp	LS
Accipiter poliogaster	18	VSp	LS
Accipiter superciliosus	3	VSp	LS
Ictinia mississippiensis	2, 3, 8, 10, 13, 16, 18, 21	FoM^{EMBRAPA}, FoA, ViM, VSp	LP
Helicoletes hamatus	2	VSp	LS
Parabuteo unicinctus	17, 18, 19, 29, 32	FoP, VSp	LP
Buteo brachyurus	17, 18, 26	VSp	LS
Harpia harpyja	2	FoI	LP
Spizaetus tyrannus	33	VSp	LS
Falconidae			
Falco peregrinus	9	VSp	LS
Rallidae			
Coturnicops notatus	17	VSp	LS
Aramides ypecaha	25, 28, 32, 34, 37	FoM^{EMBRAPA}, VSp	LP
Laterallus viridis	2	ASI, VSp	LP
Porzana flaviventris	13	VSp	LS
Pardirallus maculatus	30	FoM^{EMBRAPA}	LP
Fulica leucoptera	18	VSp	LT
Recurvirostridae			
Himantopus mexicanus	10, 29, 37, 38, 39	VSp	LS
Scolopacidae			
Gallinago undulata	29	VSp	LS
Numenius phaeopus	38	VSp	LS
Arenaria interpres	38	VSp	LS
Calidris alba	3	VSp	LS

Táxons	Localidades	Evidência	Status
Calidris bairdii	13	VSp	LS
Calidris himantopus	2	VSp	LS
Sternidae			
Sterna trudeaui	13	VSp	LS
Columbidae			
Columba livia	9, 16, 29	FoM, VSn	LP
Patagioenas speciosa	2, 8	VSp	LS
Patagioenas plumbea	18	VSp	LT
Patagioenas subvinacea	18	VSp	LT
Psittacidae			
Orthopsittaca manilata	19, 20, 29	FoM[VIREO], VSp	LP
Primolius maracana	8, 34	VSp	LS
Cuculidae			
Micrococcyx cinereus	12, 17	VSp	LS
Coccyzus euleri	2	VSp	LS
Dromococcyx pavoninus	3, 10, 15, 29	VSp	LS
Strigidade			
Strix virgata	3, 13, 18	FoI, VSp	LP
Strix huhula	3, 5, 8, 13, 17, 18, 29	FoA, FoI, VSp	LP
Glaucidium minutissimum	8, 18	VSp	LS
Aegolius harrisii	2	VSp	LS
Caprimulgidae			
Lurocalis semitorquatus	15, 17, 18, 33	VSp	LS
Hydropsalis forcipata	29	VSp	LS
Chordeiles minor	13	VSp	LS
Apodidae			
Streptoprocne zonaris	12	VSp	LS
Trochilidae			
Aphantochroa cirrochloris	13	VSp	LS
Colibri serrirostris	29	VSp	LS
Lophornis magnificus	3	VSp	LS
Thalurania glaucopis	13	VSp	LT
Hylocharis cyanus	8	VSp	LS
Heliomastes longirostris	2	VSp	LS
Bucconidae			
Nystalus maculatus	8	FoM	LP
Nonnula rubecula	33	VSp	LS
Chelidoptera tenebrosa	8	VSp	LS
Ramphastidae			
Ramphastos tucanus	15	VSp	LS
Picidae			
Melanerpes flavifrons	17, 18	VSp	LS
Veniliornis spilogaster	17	VSp	LS

Táxons	Localidades	Evidência	Status
Celeus flavus	2, 3, 8, 15, 17, 18, 29	FoM^{VIREO}, FoA, ASI, VSp	LP
Melanopareiidae			
Melanopareia torquata	18	VSp	LT
Thamnophilidae			
Thamnophilus torquatus	2, 17	VSp	LS
Thamnophilus punctatus	3	VSp	LS
Thamnophilus pelzelni	8, 15, 17	ASA, VSp	LP
Herpsilochmus atricapillus	2, 23	VSp	LS
Pyriglena leucoptera	18	VSp	LT
Dendrocolaptidae			
Xiphocolaptes albicollis	18	VSp	LT
Dendrocolaptes platyrostris	10, 13, 18, 19, 27, 29	ASI, VSp	LP
Xiphorhynchus fuscus	17, 18	VSp	LS
Furnariidae			
Philydor lichtensteini	18	VSp	LT
Automolus leucophthalmus	20	VSp	LS
Lochmias nematura	18	VSp	LT
Rhynchocyclidae			
Tolmomyias flaviventris	3	VSp	LS
Poecilotriccus plumbeiceps	19	VSp	LS
Myiornis auricularis	14, 23	VSp	LS
Myiornis ecaudatus	8	VSp	LS
Tyrannidae			
Phyllomyias reiseri	26	VSp	LS
Phyllomyias fasciatus	17	VSp	LS
Myiopagis caniceps	2, 13, 19, 26, 29, 34	VSp	LS
Elaenia chilensis	8, 13	VSp	LS
Elaenia parvirostris	8, 13, 17, 18, 19, 29	VSp	LS
Elaenia mesoleuca	8	VSp	LS
Elaenia cristata	2, 8, 17	VSp	LS
Elaenia obscura	8	VSp	LS
Suiriri islerorum	8	FoP, VSp	LP
Capsiempis flaveola	3, 8, 13, 17, 18	VSp	LS
Pseudocolopteryx sclateri	19	VSp	LS
Pseudocolopteryx acutipennis	1, 13	ExB^{DZUFMG}, FoI, VSp	LP
Platyrinchus mystaceus	3, 8, 13, 17 18, 27, 34	VSp	LS
Empidonax alnorum	21	ExB^{DZUFMG}, VSp	LP
Hymenops perspicillatus	10, 12, 19, 24	FoM, VSp	LP
Fluvivola nengeta	2, 13, 29	FoI, VSp	LP
Alectrurus tricolor	17, 29	FoP, VSp	LP
Tyrannus tyrannus	13	VSp	LS
Myiarchus tuberculifer	2	VSp	LS
Attila phoenicurus	8	VSp	LS

Táxons	Localidades	Evidência	Status
Attila cinnamomeus	3	VSp	LS
Attila spadiceus	2	VSp	LS
Pipridae			
Neopelma pallescens	4, 8, 17, 18	VSp	LS
Neopelma sulphureiventer	8	VSp	LS
Tityridae			
Schiffornis virescens	18	VSp	LS
Pachyramphus margiantus	8	VSp	LS
Pachyramphus validus	2, 8, 13, 17, 18, 19, 33	VSp	LS
Xenopsaris albinucha	3, 11, 13, 17, 18, 19, 32	FoI, VSp	LP
Hirundinidae			
Alopochelidon fucata	17, 18	VSp	LS
Progne elegans	13	VSp	LS
Turdidae			
Catharus fuscescens	8	VSp	LS
Turdus fumigatus	2	VSp	LS
Thraupidae			
Lanio melanops	18	VSp	LT
Neothraupis fasciata	15, 17, 18, 29	VSp	LS
Schistochlamys melanopis	18	VSp	LT
Schistochlamys ruficapillus	29	VSp	LS
Pipraeidea melanonota	8, 13, 17, 18, 29	VSp	LS
Pipraeidea bonariensis	19	VSp	LS
Emberizidae			
Sporophila bouvronides	8	VSp	LS
Sporophila nigricollis	2, 13, 15, 17, 18, 19	VSp	LS
Sporophila nigrorufa	17	VSp	LS
Sporophila ruficollis	2, 3, 10, 13, 17, 18, 29	FoP, VSp	LP
Sporophila palustris	13, 17, 26	VSp	LS
Sporophila hypochroma	17	VSp	LS
Sporophila melanogaster	39	VSp	LS
Arremon taciturnus	8	VSp	LS
Charitospiza eucosma	18	VSp	LS
Coryphaspiza melanotis	15, 17, 18	VSp	LS
Parulidae			
Basileuterus leucophrys	8	VSp	LS
Icteridae			
Icterus jamacaii	7, 8	ASI, VSp	LP
Agelasticus thilius	13	VSp	LT
Pseudoleites guirahuro	15, 17, 18	VSp	LS
Sturnella militaris	2	VSp	LS
Fringillidae			
Euphonia laniirostris	2	VSp	LS
Estrildidae			
Estrilda astrild	29	VSp	LS

Status: LP (lista primária), LS (lista secundária), LT (lista terciária). **Acrônimo das instituições que abrigam evidência superior da ocorrência de espécies**: EMBRAPA (Coleção de Referência de Vertebrados do Pantanal, Embrapa Pantanal, Corumbá); DZUFMG (Departamento de Zoologia, Universidade Federal de Minas Gerais); MZUSP (Museu de Zoologia da Universidade de São Paulo); AMNH (American Museum of Natural History, Nova York); VIREO (Visual Resources for Ornithology, Philadelphia).

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Alessandro Pacheco Nunes
Walfrido Moraes Tomas

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Apresentação

O Pantanal é um ecossistema de relevante importância para as aves abrigando espécies originárias dos biomas circundantes, tanto terrestres como aquáticas. Atuar como importante rota de migração de visitantes setentrionais, meridionais e regionais. Apesar de toda essa diversidade, pouco se conhece dessas aves.

Neste trabalho é apresentada uma listagem das espécies de aves migratórias com ocorrência na planície Pantaneira, bem como dados sobre suas origens e destinos, contribuindo o desenvolvimento da Ornitologia na região.

Emiko Kawakami de Resende
Chefe-Geral da Embrapa Pantanal

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Aves Migratórias Ocorrentes no Pantanal: Caracterização e Conservação

Alessandro Pacheco Nunes
Walfrido Moraes Tomas

Introdução

Periodicamente o Brasil é visitado por milhares de aves que realizam movimentos sazonais da América do Norte para a América do Sul e vice-versa (Sick 1983, Morrison *et al.* 1989, Chesser 1994). Dentre as aves que visitam o território nacional, destacam-se aquelas que migram com a proximidade do inverno boreal (Antas 1994). Os migrantes vêm ao Brasil à procura de locais de invernada, onde encontram alimentação farta, propiciando-lhes a continuidade do seu ciclo de vida (Telino Jr. *et al.* 2003).

Estas aves apresentam extraordinária capacidade de percorrer longas distâncias (Hayman *et al.* 1986; Antas 1989; Morrison *et al.* 1989; Sick 1983, 1997; Azevedo Jr. *et al.* 2002, Alerstan *et al.* 2003). No período de inverno, a baixa oferta de recursos alimentares aliada a fatores endógenos, induz a migração de várias espécies dos Hemisférios Norte e Sul aos sítios de alimentação ou áreas de invernada em países vizinhos ou outros continentes. Nestas áreas permanecem até o início da primavera em seu local de origem, para onde retornam e se reproduzem (Hayman *et al*. 1986, Antas 1989, Azevedo Jr. *et al.* 2002).

No território nacional, são encontrados vários sítios de invernada, os quais são de extrema importância para conservação e manutenção destas espécies, desde o Amapá até o Rio Grande do Sul, como a Ilha de Campechá (MA), a Lagoa do Peixe (RS), a Coroa do Avião (PE) o Pantanal (MS e MT). Outras áreas úmidas como as do Rio das Mortes (MT) e Araguaia (região da Ilha do Bananal, no MT e TO), a planície de inundação do Rio Guaporé (RO) e as várzeas remanescentes do Rio Paraná (MS e PR), destacam-se pela sua grande

importância como sítios de invernada para várias espécies de aves migratórias. Famílias de aves, como Charadriidae (batuíras), Scolopacidae (maçaricos e narcejas) e Laridae (gaivotas), se aglomeram todos os anos nessas áreas devido à riqueza e disponibilidade de alimento (Azevedo Jr e*t al.* 2001b). A fartura de alimento propicia a essas aves a garantia de engorda, aquisição de energia suficiente para efetuar a muda das penas e retorno ao seu sítio de reprodução (Andrade 1997; Sick 1983, 1997; Azevedo Jr. e*t al.* 2001a,b; Fedrizzi *et al.* 2004).

As aves migratórias são subdivididas em três grupos: as do Hemisfério Norte, do Hemisfério Sul e Neotropicais. As que vêm do Hemisfério Norte são consideradas as grandes migrantes, visto que cruzam hemisférios. Estas voam mais de 20 mil quilômetros desde os pontos de reprodução no Ártico até chegarem ao Brasil. Elas entram no Brasil principalmente pela costa Atlântica e pela Amazônia, atravessando a região central através do Pantanal até alcançarem o sul do continente, em direção à Patagônia (Argentina e Chile), ponto principal de concentração dessas aves (Sick 1983).

Estes migrantes entram no Brasil através de quatro rotas conhecidas: a do Pacífico, a Cisandina; a do Brasil Central (incluindo as rotas do Rio Negro – Pantanal e dos Rios Xingú - Tocantins) e a Atlântica (Antas 1983, Castro e Myers 1987; Myers *et al*. 1985a,b). Estudos têm mostrado que várias espécies de aves migratórias são fiéis às áreas de invernada, retornando ao mesmo local todos os anos (Castro e Myers 1987; Finch 1991; Holmes e Sherry 1992; Walkentin e Hernández 1996; Pereira *et al.* 1997; Azevedo Jr. *et al.* 2001a,b; 2002). De acordo com Zimmer (1938) e Stotz *et al.* (1992), as aves migratórias setentrionais que se deslocam para a América do Sul utilizam as áreas de baixa elevação do leste americano, até atingirem o Golfo do México, cruzando as Ilhas do Mar das Antilhas, alcançando o continente Sul-Americano pela costa Venezuelana e Colombiana e, a partir daí, podem utilizar-se de uma das quatro rotas citadas anteriormente. A rota Cisandina aproxima-se da região do Acre, e daí as aves podem seguir um trajeto que as leva em direção à Patagônia e outro que adentra a região oeste do território nacional, na qual podem conectar-se com outras rotas, como a do Brasil Central. Estas rotas são vantajosas para as aves, uma vez que permite desviar da Cordilheira dos Andes e da Serra da Pacaraima, na Venezuela (Sick 1983, Stotz *et al.* 1992).

Para o Brasil migram espécies oriundas do Hemisfério Norte (Estados Unidos, Canadá e México), e países da América Central, bem como também do sul do continente (Argentina, Chile e Uruguai), e até mesmo da Antártida. O grupo que vem do Hemisfério Norte, concentra-se em vários pontos dentro do território nacional, principalmente no norte, em duas regiões conhecidas popularmente como o Salgado Paraense, no Pará, e as Reentrâncias Maranhenses, no Maranhão. O terceiro ponto de maior concentração é o Parque Nacional da Lagoa do Peixe, no Rio Grande do Sul. As espécies que realizam deslocamentos

regionais entre a região central (Pantanal) e Sul, tais como os cabeças-secas (*Mycteria americana*) e colhereiros (*Platalea ajaja*), que migram conforme a subida e a descida das águas do Pantanal (Yamashita e Valle 1986; Antas e Nascimento 1992, 1996; Antas *et al.* 1993; Silva e Fallavena 1995). De acordo com Sick (1997), as espécies que vem do Sul, representam apenas 40% dos migrantes, e na maioria são aves aquáticas. Ainda segundo o mesmo autor, os migrantes Passeriformes meridionais são pouco representativos, com apenas 15 espécies, pertencentes às Famílias Tyrannidae (os mais representativos, com 7 espécies), Hirundinidae, Mimidae, Cardinalidae e Icteridae. O comportamento e rota migratória é variável dentro dos grupos taxonômicos. Desta forma, aves da ordem Passeriforme deslocam-se por ambientes terrestres, como florestas, campos e cerrado, bem como ambientes antropizados (Luna *et al.* 2003).

Tubelis e Tomas (2003) reconhecem 463 espécies de aves ocorrendo no Pantanal, baseando-se em todos os inventários e coletas já realizadas na planície. Publicações salientam a importância do Pantanal para as aves, principalmente por suportar uma extraordinária abundância de aves aquáticas (Sick 1997) e por atuar como importante rota de migração de visitantes que sazonalmente deixam o Sul do continente ou o Hemisfério Norte (Antas 1983, 1994; Cintra & Yamashita 1990).

No entanto, pouco se conhece a respeito das espécies que utilizam a planície do Pantanal como sítio de invernada durante seus deslocamentos migratórios, quer sejam migrantes em larga escala ou regionais.

Metodologia

Para a elaboração da listagem de espécies migratórias, foram comparadas as espécies ocorrentes no Pantanal (Tubelis e Tomas 2003) com as citadas como migratórias em larga escala, como as Setentrionais e Meridionais (Hyman *et al.* 1986; Sick 1997; Ridgely e Tudor 1989, 1994; Fraga 2000), migrantes dentro do Continente Americano e, as migrantes regionais (Sick, 1997, Luna *et al.* 2003). As informações referentes ao habitat das espécies, bem como os destinos das mesmas foram obtidos em Luna *et al.* (2003) e Sick (1997), respectivamente. Considerou-se como migrantes em larga escala; os meridionais (M), ou seja as espécies oriundas do extremo Sul do continente Americano; migrantes setentrionais (S), aquelas vindas do Norte da América do Sul, da América do Norte e Central. Migrantes regionais (R), espécies com deslocamentos dentro do território nacional e (MA), as que realizam

deslocamentos dentro do continente Sul Americano, ou seja, oriundas da Argentina, Uruguai e outros países vizinhos. Informações referentes às rotas usadas pelas aves não foram inclusas, visto todas utilizarem a Rota Rio Negro-Pantanal para atingirem a região do Pantanal. O estado de conservação das espécies foi baseado na listagem de aves ameaçadas na região do Pantanal (Tomas *et al.* 2004), a partir da Red List of Threatened Species publicada pela The World Conservation Union (IUNC 2004) e Convention on Migratory Species (CMS 2004).

Aves migratórias no Pantanal

O Pantanal está localizado na porção central da América do Sul, onde ocupa cerca de um terço da bacia do alto Paraguai. Este ecossistema apresenta uma extensão de cerca de 140.000 km^2, com algumas características marcantes: baixa altitude, pouca declividade, alternância de períodos de cheias e de secas, grandes amplitudes térmicas anuais, um padrão de precipitação marcadamente sazonal e uma variação plurianual das cheias, resultados da ocorrência de anos consecutivos com altas precipitações interrompidos por seqüências de anos com precipitação mais moderada. Cheias e fatores topográficos e edáficos influenciam a vegetação, que ocorre como mosaicos diversificados contendo florestas, ambientes aquáticos e habitats abertos (Tubelis e Tomas 2003). A composição da fauna e da flora do Pantanal é influenciada pelos biomas vizinhos, como o Chaco, Cerrado, Amazônia e Floresta Atlântica (Brown 1986, Nunes e Tomas 2004).

Nesta revisão, foram listadas 133 espécies diferentes de aves distribuídas em 32 famílias, com ocorrência na planície do Pantanal que realizam deslocamentos migratórios (Tabela 1). As Famílias mais abundantes foram Tyrannidae, com 34 espécies (25,5%), Scolopacidae com 15 espécies (12%) e Anatidae, com 12 espécies (9%) como pode ser visto na Figura 1. De acordo com Sick (1997), Tyrannidae é a maior família de aves no hemisfério ocidental, constituindo 18% dos Passeriformes da América do Sul. Os "Não Passeriformes" predominaram com 69 espécies, correspondendo a 52% das aves migrantes observadas no Pantanal.

Cinqüenta e oito espécies (43,5%), são migrantes de longa distância, Setentrionais (34 espécies) e Meridionais (24 espécies), oriundas do extremo norte do continente americano e do sul da América do Sul, respectivamente. Observa-se que um maior número de migrantes Austrais, ou seja, espécies oriundas da região Sul do Continente Sul Americano. Aves com migrações

dentro do Sul do Continente Americano, ou seja, espécies oriundas da Argentina, Uruguai e outros países vizinhos, são representadas por 34 espécies (25,5%), e as que possivelmente realizam deslocamentos regionais ou dentro do território nacional, somam 41 espécies (31%). Estas últimas, além da fuga do inverno rigoroso em algumas regiões do país, possivelmente deslocam-se conforme os níveis de alagamento e seca na região, como registrado para o trinta-réis-grande (*Phaetusa simplex*) na região do Amazonas (Sick, 1997). Segundo Cavalcanti (1990) a disponibilidade de alimento é muito baixa no inverno (estação seca), aumentando na primavera e verão com a chegada das chuvas. As migrações de algumas espécies a nível regional são possivelmente, estratégias oportunistas.

Com relação ao habitat, 55 espécies (41,4%) são ocorrentes em ambientes aquáticos, enquanto as florestais e campestres representam 26,3% (35 espécies) e 31,6% (42 espécies), respectivamente. Apenas uma espécie (*Hirundinea ferruginea*) ocorre preferencialmente em escarpas rochosas. Quatro espécies encontram-se ameaçadas de extinção (Tomas *et al.* 2004, IUCN 2004 e CMS 2004), sendo uma migrante setentrional (*Numenius borealis*), uma meridional (*Alectrurus risora*) e duas regionais (*Sporophila palustris* e *S. cinnamomea*).

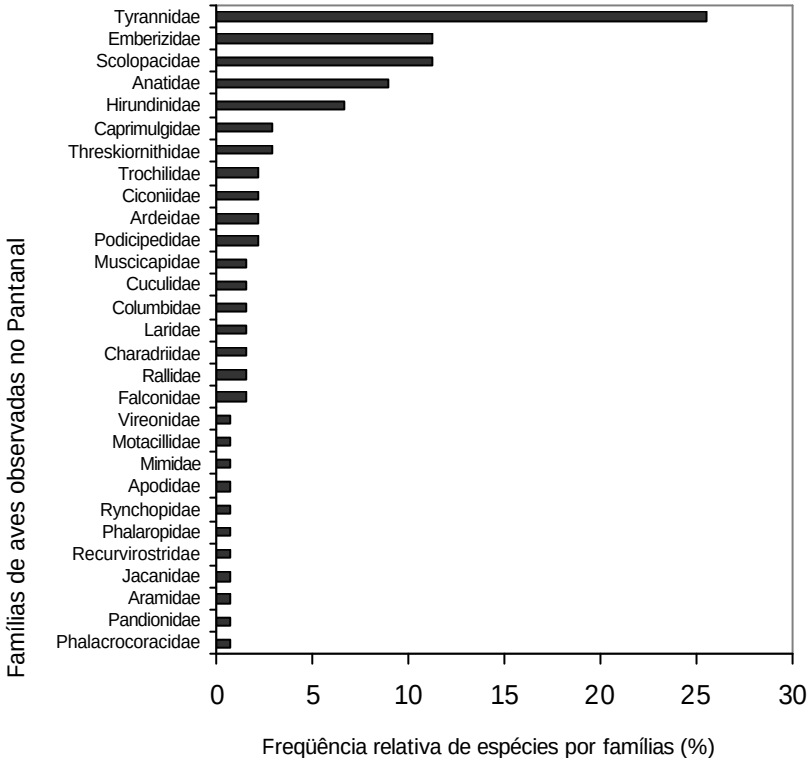

Fig. 1. Freqüência relativa de espécies de aves migratórias, por Família, que ocorrem no Pantanal.

Para Cordeiro *et al.* (1996) a conservação de aves migratórias está diretamente relacionada com a identificação de sítios de alimentação, repouso e reprodução, e que a perda dos sítios de invernada pode acarretar na diminuição e até mesmo a extinção local de alguma espécie ou população. Muitas espécies de aves interrompem seus deslocamentos migratórios para o processo de muda das penas. Este requer alta demanda energética e para isso, as aves selecionam suas áreas de "paradas" ou pontos de "descanso", de acordo com a qualidade, produtividade e risco de predação do local (Alerstan *et al.* 2003, Fedrizzi *et al.* 2004). Moore e Simons (1992) relatam a importância da qualidade dos habitats utilizados como ponto de descanso e alimentação para aves migratórias neotropicais, especialmente aquelas que atravessam grandes barreiras geográficas durante seus deslocamentos.

Nesta perspectiva, a manutenção das áreas de invernada ao longo da rota migratória das aves pelo Pantanal, como salinas e baías, bem como suas praias e campos de inundação tornam-se cruciais para a conservação das várias espécies de aves que passam pela região, quer sejam migrantes setentrionais, meridionais ou regionais. Muitas se reproduzem ao longo das praias, como os trinta-réis-grande (*Phaetusa simplex*), o talha-mar (*Rynchops niger*), a batuíra (*Charadrius collaris*), entre outras.

Estudos têm relacionado o declínio populacional de aves migratórias a diversos fatores, como a fragmentação do habitat, o desmatamento, expansão das atividades agrícolas, contaminação por pesticidas, predação de ninhos e efeitos cumulativos de alterações no habitat ao longo das rotas migratórias (Goldstein *et al.* 2003). Jahn *et al.* (2002) ressaltam que a as alterações humanas no Chaco Boliviano, por exemplo, podem afetar negativamente espécies de ave migratórias que passam pela região e que dependem de seus recursos durante os deslocamentos. Segundo Litwin e Smith (1992) espécies de aves migratórias que ocorrem no interior de matas são mais sensíveis ao processo de fragmentação florestal.

Nas últimas décadas, tem havido uma tendência à intensificação na produção pecuária no Pantanal, cujos habitats naturais vêm sendo substituídos por áreas de pastagens cultivadas (Tubelis e Tomas 1999). Tais alterações no habitat podem causar impactos significativos às espécies migrantes na região, principalmente aquelas dependentes de ambientes florestais, como a maioria dos Passeriformes, os quais representam 46,3% dos migrantes ocorrentes na planície. As espécies campestres representam aproximadamente 49% (31 espécies) dos Passeriformes e as florestais, 46% (29 espécies). Espécies migrantes regionais, cuja dieta baseia-se em sementes, sendo representadas principalmente pelos membros do gênero *Sporophila*, podem ser afetados pela substituição das pastagens nativas por espécies exóticas, como a braquiária.

Outro aspecto das aves migratórias é discutido por Rappole *at al.* (2000), Rappole e Hubálek (2003) e Luna *et al.* (2003): o importante papel das aves migratórias na disseminação do Vírus do Nilo Ocidental (VNO) no Velho Mundo no eixo norte-sul e leste-oeste. As espécies migrantes do hemisfério norte, principalmente da região Neártica, destacam-se devido ser esta a área na qual o vírus tem sido recentemente detectado. Luna *et al.* (2003) destacam os membros da ordem Passeriformes como possíveis responsáveis pela introdução do vírus nas cidades próximas às suas rotas migratórias, uma vez que utilizam florestas, áreas abertas e antropizadas para se deslocarem durante suas migrações, enquanto as aves de hábitos aquáticos, que incluem a maioria dos Não Passeriformes, utilizam rotas próximas a mares e grandes coleções d'água. Ressalta-se, no entanto, que a realização de estudos a médio e longo prazo acerca dos deslocamentos da avifauna ocorrente na planície do Pantanal, podem esclarecer melhor as atividades migratórias destas espécies.

Tabela 1. Listagem de aves migratórias com ocorrência na planície do Pantanal. A nomenclatura científica e a ordenação taxonômica adotada seguem o Comitê Brasileiro de Registros Ornitológicos (CBRO 2004). Os nomes vernáculos estão de acordo com Sick (1997).

Famílias/Espécies	Nomes vernáculos	Migrante	Destino	Habitat
Anatidae				
Dendrocygna bicolor * [A]	marreca-caneleira	R	D	A
Dendrocygna viduata * [A]	irerê	R	D	A
Dendrocygna autumnalis * [A]	marreca-cabocla	R	D	A
Coscoroba coscoroba	copororoca	MA	D	A
Neochen jubata * [A]	pato-corredor	R	D	A
Cairina moschata * [A]	pato-do-mato	R	D	A
Sarkidiornis sylvicola * [A]	putrião	R	D	A
Callonetta leucophrys	marreca-de-coleira	M	D	A
Amazonetta brasiliensis * [A]	marreca-pé-vermelho	R	D	A
Anas versicolor	marreca-cricri	M	D	A
Anas cyanoptera	marreca-colorada	S	ASs	A
Nomonyx dominica * [A]	marreca-de-bico-roxo	R	D	A
Podicipedidae				
Rollandia Rolland * [A]	mergulhão-de-cara-branca	R	D	A
Tachybaptus dominicus * [A]	mergulhão-pequeno	R	D	A
Podilymbus podiceps * [A]	mergulhão	R	D	A
Phalacrocoracidae				
Phalacrocorax brasilianus * [A]	biguá	R	D	A

...continuação da Tabela 1.

Famílias/Espécies	Nomes vernáculos	Migrante	Destino	Habitat
Ardeidae				
Butorides striata * [L]	socozinho	MA	ASs,ASn	A
Bubulcus ibis * [A]	garça-vaqueira	MA	ASs	C
Egretta caerulea * [A]	garça-azul	MA	D	A
Threskiornithidae				
Plegadis chihi	caraúna	MA	ASs	^
Mesembrinibis cayennensis * [A]	corocoró	R	D	**continua**
Phimosus infuscatus * [A]	tapicuru-de-cara-pelada	R	D	A
Platalea ajaja	colhereiro	MA	D	A
Ciconiidae				
Ciconia maguari	maguari	MA	D	A
Jabiru mycteria	tiuiuiu	MA	D	A
Mycteria americana	cabeça-seca	MA	D	A
Pandionidae				
Pandion haliaetus [CMS II]	águia-pescadora	S	ASs, ASn	A
Accipitridae				
Elanoides forficatus	gavião-tesoura	R	D	C
Rostrhamus sociabilis * [A]	caramujeiro	R	D	A
Ictinia plumbea	sovi	R	D	C
Falconidae				
Falco sparverius * [A]	quiriquiri	R	D	C
Falco femoralis * [A]	falcão-de-coleira	MA	D	C

...continuação da Tabela 1.

Famílias/Espécies	Nomes vernáculos	Migrante	Destino	Habitat
Aramidae				
Aramus guarauna * [A]	carão	R	D	A
Rallidae				
Gallinula chloropus * [A]	frango-d'água-comum	MA	D	A
Porphyrio martinica	frango-d'água-azul	MA	D	A
Famílias/Espécies	**Nomes vernáculos**	**Migrante**	**Destino**	**Habitat**
Recurvirostridae				
Himantopus melanurus * [A]	pernilongo	R	D	A
Charadriidae				
Pluvialis dominica	batuiruçu	S	ASs,ASn	A
Pluvialis squatarola	batuiruçu-de-axila-preta	S	ASs,ASn	A
Scolopacidae				
Gallinago paraguaiae * [A,L]	narceja	MA	D	A
Limosa haemastica	maçaricão-de-bico-virado	S	ASs,ASn	A
Numenius borealis [Cr CMS I]	maçarico-esquimó	S	ASs,ASn	A
Bartramia longicauda	maçarico-do-campo	S	ASs,ASn	A
Tringa melanoleuca	maçarico-grande-de-perna-amarela	S	ASs,ASn	A
Tringa flavipes	maçarico-de-perna-amarela	S	ASs,ASn	A
Tringa solitaria	maçarico-solitário	S	ASs,ASn	A
Actitis macularius	maçarico-pintado	S	ASs,ASn	A
Calidris canutus	maçarico-de-papo-vermelho	S	ASs,ASn	A
Calidris alba	maçarico-branco	S	ASs,ASn	A
Calidris pusilla	maçarico-rasteirinho	S	ASs,ASn	A

...continuação da Tabela 1.

Famílias/Espécies	Nomes vernáculos	Migrante	Destino	Habitat
Calidris minutilla	maçariquinho	S	ASs,ASn	A
Calidris fuscicollis	maçarico-de-sobre-branco	S	ASs,ASn	A
Calidris melanotos	maçarico-de-colete	S	ASs,ASn	A
Tryngites subruficollis	maçarico-acanelado	S	ASs,ASn	A
Phalaropus tricolor	pisa-n'água	S	ASs,ASn	A
Sternidae				
Phaetusa simplex * [A]	trinta-réis-grande	R	D	A
Sterna hirundo	trinta-réis-boreal	S	ASs,ASn	A
Rynchopidae				
Rynchops niger * [A]	talha-mar	R	D	A
Columbidae				
Claravis pretiosa * [A]	pomba-de-espelho	R	D	F
Patagioenas picazuro * [A]	asa-branca	R	D	F
Cuculidae				
Coccyzus americanus	papa-lagarta-norte-americano	S	ASs,ASn	F
Coccyzus melacoryphus * [A]	papa-lagarta	R	D	F
Caprimulgidae				
Chordeiles pusillus	bacurauzinho	S	D	C
Chordeiles acutipennis	bacurau-de-asa-fina	S	D	C
Podager nacunda	corucão	S	D	C
Caprimulgus parvulus	bacurau-pequeno	S	ASs,ASn	C
Apodidae				
Chaetura meridionalis	andorinhão-do-temporal	S	ASs,ASn	C

...continuação da Tabela 1.

Famílias/Espécies	Nomes vernáculos	Migrante	Destino	Habitat
Trochilidae				
Florisuga fusca * [A]	beija-flor-preto-e-branco	R	D	F
Anthracothorax nigricollis * [L]	beija-flor-preto	S	ASs,ASn	F
Chrysolampis mosquitus * [A]	beija-flor-vermelho	R	D	F
Tyrannidae				
Elaenia flavogaster * [A,L]	guaracava-de-barriga-amarela	MA	ASn	F
Elaenia spectabilis	guaracava-grande	M	D	F
Elaenia chiriquensis * [A,L]	chibum	MA	ASn	F
Serpophaga subcristata	alegrinho	M	D	F
Sublegatus modestus	sertanejo	M	ASs,ASn	F
Hirundinea ferruginea	gibão-de-couro	M	ASn	E
Lathrotriccus euleri * [L]	enferrujado	MA	ASs,ASn	F
Contopus cinereus * [A]	papa-moscas-cinzento	R	D	F
Pyrocephalus rubinus	verão	M	AC,ASn	C
Knipolegus striaticeps	maria-preta-acinzentada	M	D	C
Knipolegus hudsoni	maria-preta-do sul	M	D	C
Satrapa icterophrys	suiriri-pequeno	M	D	A
Xolmis cinereus * [A,L]	primavera	MA	ASn	C
Xolmis velatus * [A]	noivinha-branca	R	D	C
Xolmis irupero * [A]	noivinha	R	D	C
Gubernetes yetapa * [A]	tesoura-do-brejo	MA	ASn	C
Fluvicola albiventer	lavadeira-mascarada	M	D	A
Alectrurus risora [Vu CMS I]	bandeira-do-campo	M	D	C

...continuação da Tabela 1.

Famílias/Espécies	Nomes vernáculos	Migrante	Destino	Habitat
Colonia colonus * [A,L]	viuvinha	MA	ASs,ASn	F
Machetornis rixosa * [A,L]	bentevi-do-gado	MA	ASn	C
Legatus leucophaius	bentevi-pirata	M	ASs,ASn	F
Myiozetetes cayanensis * [A]	bentevi-assoviador	R	D	F
Myiozetetes similis * [A]	bentevi-de-coroa-vermelha	R	D	F
Myiodynastes maculatus	bentevi-rajado	M	D	F
Megarynchus pitangua * [L]	bentevi-de-bico-chato	MA	AS,NA	F
Empidonomus varius	peitica	M	ASn	F
Griseotyrannus aurantioatrocristatus	peitica-de-chapéu-preto	M	D	F
Tyrannus albogularis	suiriri-de-garganta-branca	M	D	F
Tyrannus melancholicus	suiriri	M	NA	F
Tyrannus savana	tesoura	M	AC,ASn	C
Sirystes sibilator * [L]	gritador	MA	SA,NA	F
Casiornis rufus	caneleiro	M	D	F
Myiarchus swainsoni	irrê	M	NA	F
Myiarchus tyrannulus * [A,L]	maria-de-asa-ferrugem	MA	SA,NA	F
Vireonidae				
Vireo olivaceus	juruviara	S	SA,NA	F
Hirundinidae				
Tachycineta leucorrhoa	andorinha-de-sobre-branco	MA	D	C
Progne tapera	andorinha-do-campo	MA	ASn	C
Progne subis	andorinha-azul	S	ASs	C
Progne chalybea	andorinha-grande	MA	ASn	C

...continuação da Tabela 1.

Famílias/Espécies	Nomes vernáculos	Migrante	Destino	Habitat
Pygochelidon cyanoleuca	andorinha-azul-e-branca	MA	ASs,ASn	C
Stelgidopteryx ruficollis	andorinha-serrador	MA	ASs,ASn	C
Riparia riparia	andorinha-do-barranco	S	ASs,ASn	C
Hirundo rustica	andorinha-de-bando	S	ASs,ASn	C
Petrochelidon pyrrhonota	andorinha-do-penhasco	S	ASs,ASn	C
Turdidae				
Turdus leucomelas * [A]	sabiá-barranco	R	D	F
Turdus amaurochalinus	sabiá-poca	R	D	F
Mimidae				
Mimus triurus	calandra-de-três-rabos	M	D	C
Motacillidae				
Anthus lutescens	caminheiro-zumbidor	R	D	C
Thraupidae				
Tersina viridis * [A]	saí-andorinha	MA	ASs,ASn	F
Conirostrum speciosum * [A]	figuinha-de-rabo-castanho	MA	ASs	F
Emberizidae				
Sicalis citrina	canarinho-rasteiro	R	D	C
Sicalis luteola	tipio	MA	D	C
Volatinia jacarina	tiziu	R	D	C
Sporophila lineola	bigodinho	MA	D	C
Sporophila caerulescens	coleirinho	MA	D	C
Sporophila leucoptera	patativa-chorona	R	D	C
Sporophila bouvreuil	caboclinho	R	D	C

...continuação da Tabela 1.

Famílias/Espécies	Nomes vernáculos	Migrante	Destino	Habitat
Sporophila hypoxantha	caboclinho-roxinho	R	D	C
Sporophila palustris [Ra,Am CMS I]	caboclinho-de-papo-branco	M	D	A
Sporophila cinnamomea [Vu]	caboclinho-vermelho	MA	D	C
Cardinalidae				
Pheuctictus aureoventris	rei-do-bosque	M	D	F
Parulidae				
Oporornis agilis	mariquita-de-connecticut	S	ASs	F
Icteridae				
Sturnella superciliaris	polícia-inglesa-do-sul	R	D	C
Dolichonyx oryzivorus	trite-pia	S	ASs,ASn	C

Migrantes: (S) Setentrional – espécies oriundas da América Central e do norte das Américas do Sul e do Norte, (M) Meridional – espécies oriundas do extremo sul da América do Sul, (MA) Migrante dentro do continente Americano, (R) migrantes dentro do território nacional. Fonte: (A) migrantes regionais segundo Sick (1997), (B) migrantes regionais e dentro do Continente Sul Americano segundo Luna *et al*. (2003). Destino: (AN) América do Norte, (AC) América Central, (ASn) Norte da América do Sul, (ASs) Sul da América do Sul, (D) Desconhecido. Habitat: (A) Ambientes aquáticos, (F) Florestas, (C) Campos, (E) Escarpas rochosas. Estado de Conservação: (Cr) Criticamente ameaçada de acordo com IUCN (2004), (Vu) Vulnerável de acordo com IUCN (2004), (Ra,Am) Rara e ameaçada de extinção de acordo com IUCN (2004), (CMS I) Categoria I da CMS/espécie migratória em perigo de extinção, (CMS II) Categoria II da CMS/espécie migratória cujo estado de conservação é desfavorável e necessita de acordos internacionais para sua conservação.

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Lists of Species

Fishes from the Parque Nacional do Pantanal Matogrossense, upper Paraguai River basin, Brazil

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Abstract: The Pantanal Biosphere Reserve contains one of the highest concentration of animal species in the Neotropics, including about 300 fish species living in diverse environments associated with wetlands in the upper Paraguai River basin. This biome spans portions of Bolivia, Brazil and Paraguay and includes the Parque Nacional do Pantanal Matogrossense (PNPM), a region of the Pantanal which has been assigned as high conservation priority in Brazil. This study reports the results of an ichthyological survey within the PNPM, where samples were taken at 12 sites during the dry season in 2001, 2010 and 2011. We record 182 species representing three classes, 10 orders and 41 fish families. We report the first occurrence of the genus *Anchoviella* (order Clupeiformes), in the La Plata basin. This survey will provide information for future studies concerning conservation and management plans for the PNPM as well as for the Pantanal, which is one of the largest permanent wetland areas in the world and among the most unique and important South American biomes.

Introduction

Occupying the middle of the upper Paraguay River basin and draining portions of Bolivia, Brazil and Paraguai, the Pantanal biome is one of the largest continuous tropical wetlands on Earth, spanning approximately 150,000 km^2 (IBGE 2004). It has dry (March to September) and rainy (October to February) seasons, creating an annual rise and fall of water level that supports an abundant fish fauna (Catella and Petrere Jr. 1996; Corrêa *et al*. 2009). Because the Pantanal Biosphere Reserve contains one of the highest animal species richness of the Neotropical region, it is considered along with the Amazon an UNESCO World Natural Heritage Site and part of the RAMSAR convention (IBAMA 2004). This international zone includes the Parque Nacional do Pantanal Matogrossense (PNPM), which was created in 1981 and is considered to be a high priority area for the conservation of the Pantanal under Brazilian law (SNUC 2000).

The South American fish fauna is estimated to contain more than 7,000 species representing a great fraction of the world's freshwater fishes (Carvalho and Albert 2011). Beginning in the 19th Century, many publications concerning the fishes from the upper Paraguai River basin have been produced (Perugia 1891; Boulenger 1895; 1897; 1900; Eigenmann and Kennedy 1903; Eigenmann *et al*. 1907; Britski *et al*. 1999; 2007). The number of estimated species from the upper Paraguai River basin is about 330 species (Reis *et al*. 2003) and the last faunistic compilation (Britski *et al*. 2007) assigned 269 species to the Pantanal's core. However, formal and well-documented fish surveys from Brazilian protected areas like the PNPM are scarce (*e.g.* Aquino *et al*. 2009; Ferreira *et al*. 2011; Pedroza *et al*. 2012), and lists of species from management plans are not usually published.

This study presents a survey of the ichthyofauna of the PNPM in the upper Paraguai River basin. Because its habitats remain virtually unchanged relative to their original condition, we aim to contribute to fish conservation in the Brazilian system of protected areas.

Materials and Methods

The PNPM covers 1,350 km^2 at the border of Brazil (Poconé county, Mato Grosso State) and Bolivia (Figure 1). Within the PNPM, fishes were sampled at 12 sites in three different aquatic environments: river channels (*rios,* two sites), lakes (*baías*, six sites) and small streams (*corixos*, four sites) (Table 1, Figure 2). Rivers represent major waterways (*e.g.* Rio Cuiabá and Rio Paraguai), while lakes are large, lentic lagoons that are connected to river channels during the rainy season and isolated during the dry season. Streams (or *corixos*) are channels that connect the main rivers to lakes.

Data were collected in April, June and September 2001 (as part of the fish inventory management plan of the PNPM), in October and November 2010, and in October and November 2011 (in an attempt to capture and account for species not sampled in 2001) during daylight. Sampling efforts in 2010 and 2011 were standardized at all sites. Each site was sampled with seven gillnets blocking fish passage for two hours, two castnets (15 casts each) and

30 tows of dipnets along the vegetated margins by three collectors. A 20-meter bottom trawl was used at two lakes to complete the sampling of associated fish fauna. In 2001, the 12 sites were inventoried without standardization of gear. The Pantanal expeditions were entirely coordinated by the ICMBio/MMA team who has permission to collect wild species in protected areas in Brazil (SISBIO 15261-1 and 22855-1).

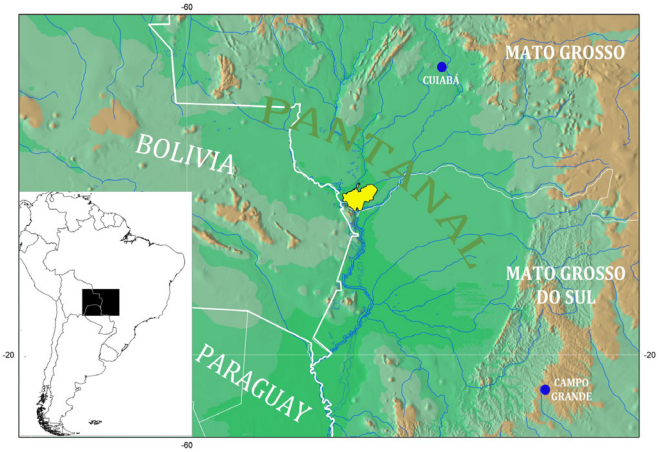

Figure 1. Map of the Pantanal biome showing the Parque Nacional do Pantanal Matogrossense in the yellow area, at the border of Bolivia and Brazil, upper Paraguai River basin.

The specimens were counted and sacrificed in a solution of clove oil (Eugenol, 2 drops per liter; *cf.* American Veterinary Medical Association 2001). After that, the fish were fixed in 96% ethanol (for molecular studies) or 10% formalin solution (for morphological studies) and then preserved in 70% ethanol. Large specimens or those in poor conditions were not deposited in museums. Muscle tissues were collected and preserved in 96% ethanol to support later genetic analyses (voucher specimens were also preserved). Species identifications were performed consulting the taxonomic literature and identification keys (Britski *et al*. 1999; 2007; Costa 2011; Ferraris 2007; Géry 1977; Lucena 2003; 2007; Malabarba 2004; Souza-Filho and Shibatta 2007; Vari 1991; 1992a, b). Specimens that were not identified to species level were not inventoried to avoid accidentally listing a species twice. We used

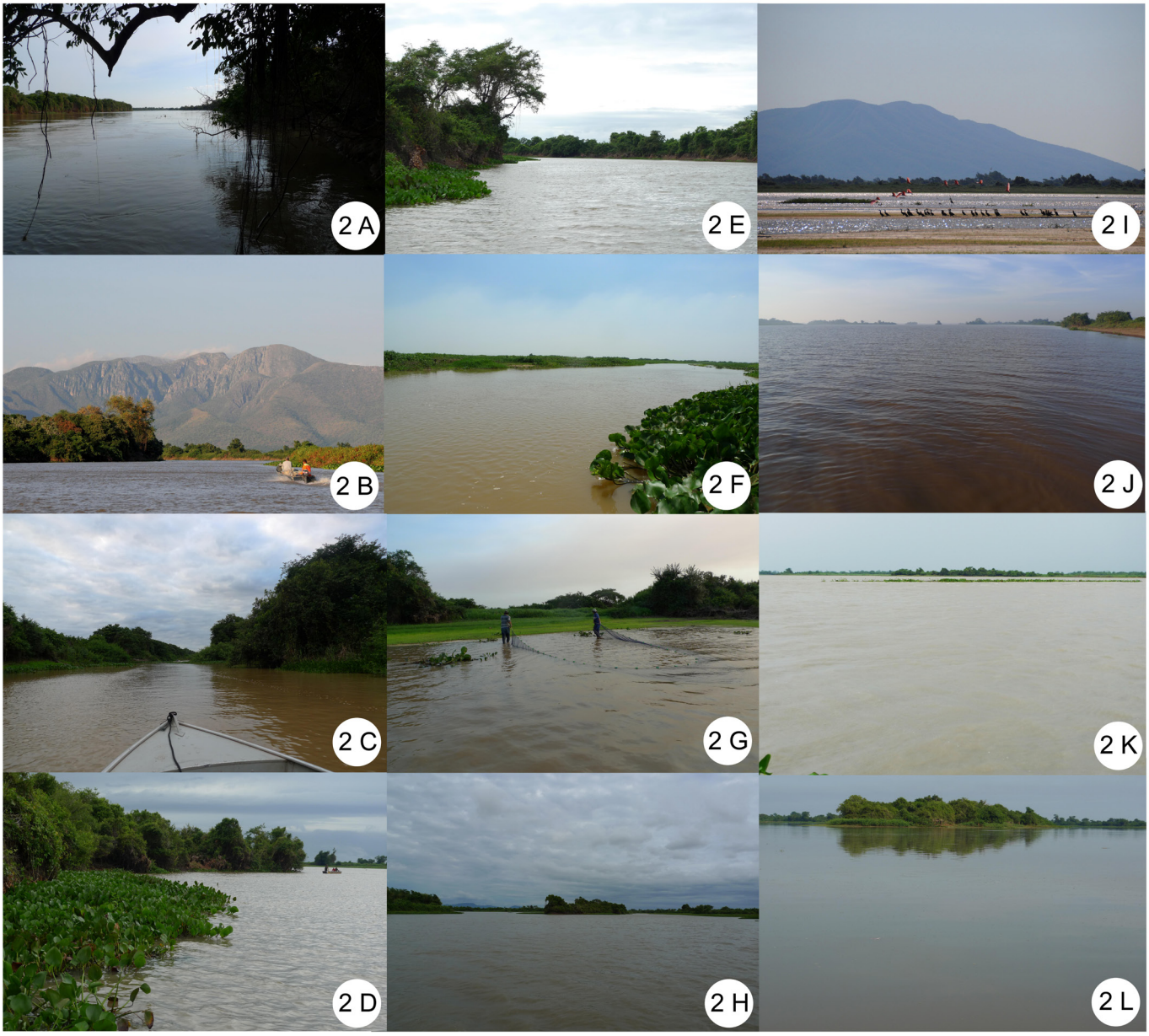

Figure 2. Sampled localities in the Parque Nacional do Pantanal Matogrossense, upper Paraguai River basin, Brazil. See Table 1 for detailed locality information. Photos by Carla N.M. Polaz (2A, 2C, 2D, 2E, 2F, 2G, 2H, 2J, 2K and 2L) and Leonardo Milano (2B and 2I).

CLOFFSCA (Reis *et al.* 2003) for classification of classes, orders and families, except in Characiformes in which we used the classification of Oliveira *et al.* (2011), and an alphabetical order for genera and species. The specimens and tissues were deposited at the Laboratório de Biologia e Genética de Peixes, Universidade Estadual Paulista, Botucatu, SP, Brazil (LBP) and Laboratório de Ictiologia de Ribeirão Preto, Universidade de São Paulo, Ribeirão Preto, SP, Brazil (LIRP). Additional uncatalogued material is housed at Embrapa Pantanal, Campo Grande, MS, Brazil (collection of Pantanal fishes under construction).

Results

A total of 182 fish species were collected during this survey, representing three classes, 10 orders and 41 families (Table 2). The orders comprising the highest percentage of species richness were Characiformes (45%) and Siluriformes (34.8%), followed by Perciformes (8.7%) and Gymnotiformes (5.4%). These four orders represented 93.9% of the total richness. The most highly represented family was Characidae (20.8% of the species), followed by Loricariidae (9.3%) and Cichlidae (8.2%). These values are consistent with other ichthyofaunal compilations in South American freshwaters (*e.g.* Langeani *et al*. 2007; Ortega and Hidalgo 2008; Vari *et al.* 2009; Le Bail *et al*. 2012). In collecting expeditions from 2010 and 2011, we sampled specimens of the genus *Anchoviella*, representing the first record of the genus in the upper Paraguai River basin (Figure 3).

Discussion

Each habitat requires distinct and suitable methods for collecting fishes most effectively (Uieda and Castro 1999). Such methods can be ordinarily divided into active and passive approaches (Oyakawa and Esteves 2004). In 2010 and 2011, when methods were standardized, active methods were more efficient than passive ones. Nearly 75% of fish richness was collected with seines while gillnets were responsible for less than 20%. Although the bottom trawl was applied only in two localities (*baías*), it was the second most effective equipment for fish sampling. We strongly recommend the use of bottom trawls in surveys of the Pantanal whenever possible.

Some juveniles could not be identified to species-level (*Astyanax* sp., *Bryconamericus* sp., *Characidium* sp., *Hemigrammus* sp., *Hyphessobrycon* sp., *Odontostilbe* sp., *Pimelodella* sp., *Pimelodus* sp., and *Serrapinnus* sp.). Additionally, three species could only be identified to species complexes (*Ancistrus* sp., *Hypostomus* sp. and *Imparfinis* sp.). Such difficulties in identification are common among freshwater fishes, and many recent studies of systematics and taxonomy in the Paraguai basin have attempted to resolve such problems in many taxonomic groups, including characiforms (Malabarba 2004; Benine *et al*. 2009), gymnotiforms (Albert and Crampton 2003; Carvalho *et al*. 2011), and siluriforms (Zawadzki *et al*. 2010; Vera-Alcaraz *et al.* 2012).

The Pantanal expeditions made an interesting discovery in 2010 and 2011. We collected 24 specimens of *Anchoviella*, which represent the first report of the genus in the upper Paraguai River basin. Previously, the only member of Engraulidae known to occur in the freshwaters of the La Plata basin was the silver sardine *Lycengraulis grossidens* (Kullander and Ferraris 2003). The family Engraulidae comprises about 140 species

Table 1. Sampled localities in the Parque Nacional do Pantanal Matogrossense: environments, localities, geographic coordinates and their respective figures.

ENVIRONMENTS	LOCALITY	COORDINATES	FIGURES
Rivers	Rio Cuiabá	17°49′37.77″ S, 57°22′53.38″ W	Fig. 2A
	Rio Paraguai	17°52′41.80″ S, 57°28′42.90″ W	Fig. 2B
Small streams	*Corixo* Boca do Ricardo	17°51′36.14″ S, 57°24′06.49″ W	Fig. 2C
	Corixo Bigueirinho	17°47′33.70″ S, 57°33′26.70″ W	Fig. 2D
	Corixo Caracarazinho do Morro	17°49′28.09″ S, 57°30′43.68″ W	Fig. 2E
	Corixo Morro do Caracará	17°50′52.45″ S, 57°26′23.63″ W	Fig. 2F
Lakes	Baía do Burro	17°49′51.69″ S, 57°23′42.82″ W	Fig. 2G
	Baía Caracarazinho do Morro	17°49′26.40″ S, 57°31′06.32″ W	Fig. 2H
	Baía do Morro	17°50′49.50″ S, 57°27′10.70″ W	Fig. 2I
	Baía do Nove	17°47′59.00″ S, 57°23′41.60″ W	Fig. 2J
	Baía do Rio Bigueirinho	17°48′04.60″ S, 57°33′58.10″ W	Fig. 2K
	Baía das Três Bocas	17°51′29.60″ S, 57°28′34.10″ W	Fig. 2L

Figure 3. Specimen of *Anchoviella* sp., LBP 13692, 38.9 mm in total length, collected at corixo Bigueirinho in the PNPM, upper Paraguai River basin, Brazil.

worldwide, with some marine species entering brackish or freshwater environments (Whitehead *et al*. 1988; Kullander and Ferraris 2003). The genus *Anchoviella* lives in marine, estuarine, or freshwater habitats in South, Central, and North America (Loeb 2012). These specimens from Pantanal are currently being studied as part of a taxonomic review of *Anchoviella* (M. Loeb, personal communication).

Comparing across the two different sampling periods, 105 species (57.2% of the total) were collected in both 2001 and 2010-2011, while 26 species were found only in the first period and 61 were collected only in the most recent expeditions (2010-2011). Our survey obtained approximately 70% of the total species known to inhabit the Pantanal (Britski *et al*. 2007). As the PNPM area is still incompletely explored and studied, it is likely that more new records of fish species will be discovered within its borders in the near future.

Table 2. List of fish species collected in the Parque Nacional do Pantanal Matogrossense, upper Paraguai River basin. Samples were made in 2001[1] and 2010-2011[2]. ( ) Total of species - *Genus* sp. represents cases that were not included in species counts, to avoid the possibility of counting a species twice.

CLASS/ORDER/FAMILY/SPECIES	
CLASS CHONDRICHTHYES (1)	
MYLIOBATIFORMES (1)	
Potamotrygonidae (1)	
[1,2]*Potamotrygon motoro* (Müller & Henle, 1841)	LBP 12619
CLASS ACTINOPTERYGII (191 species)	
CLUPEIFORMES (2)	
Engraulidae (1)	
[2]*Anchoviella* sp.	LBP 13692, LBP 14024
Pristigasteridae (1)	
[1]*Pellona flavipinnis* (Valenciennes, 1837)	Embrapa uncatalogued
CHARACIFORMES (82)	
Parodontidae (1)	
[1,2]*Apareiodon affinis* (Steindachner, 1879)	LBP 12934, LBP 12989
Curimatidae (8)	
[1,2]*Curimatella dorsalis* (Eigenmann & Eigenmann, 1889)	LBP 13459
[1,2]*Curimatopsis myersi* Vari, 1982	LBP 13434, LBP 13540, LBP 13641, LBP 14006
[1,2]*Cyphocharax gillii* (Eigenmann & Kennedy, 1903)	LBP 13623, LBP 14014, LBP 14021, LBP 14064
[1,2]*Potamorhina squamoralevis* (Braga & Azpelicueta, 1983)	LBP 12629
[1,2]*Psectrogaster curviventris* Eigenmann & Kennedy, 1889	LBP 13338, LIRP 9538
[2]*Steindachnerina brevipinna* (Eigenmann & Eigenmann, 1889)	LBP 14057
[2]*Steindachnerina conspersa* (Holmberg, 1891)	LBP 12987, LBP 13461, LBP 14055
[2]*Steindachnerina "nigrotaenia"* Boulenger, 1902	LBP 13338
Prochilodontidae (1)	
[1,2]*Prochilodus lineatus* (Valenciennes, 1837)	Embrapa uncatalogued
Anostomidae (8)	
[1,2]*Abramites hypselonotus* (Günther, 1868)	LBP 12884, LBP 12918, LBP 13442, LBP 13522, LBP 13597, LBP 13718, LBP 14010, LBP 14049
[1,2]*Leporinus* cf. *friderici* Bloch, 1794	LBP13443, LIRP 9450
[1,2]*Leporinus lacustris* Amaral Campos, 1945	LBP 12906, LBP 12978, LBP 13339, LBP 13411, LBP 13517, LBP 13580, LBP 13629, LBP 13659, LBP 13696, LBP 16953
[1,2]*Leporinus macrocephalus* Garavello & Britski, 1988	Empraba uncatalogued
[1,2]*Leporinus obtusidens* (Valenciennes, 1836)	LIRP 9448, LIRP 9449, LIRP 9657
[1,2]*Leporinus striatus* Kner, 1858	LBP 12899, LBP 12938, LBP 12976, LBP 13481, LBP 13524, LBP 13568, LBP 13582, LBP 13619, LBP 13707, LBP 14028, LBP 14052
[1,2]*Schizodon borellii* (Boulenger, 1900)	LBP 12626, LBP 13404, LBP 13625, LBP 13640
[2]*Schizodon isognathus* Kner, 1858	LBP 14027
Crenuchidae (2)	
[1,2]*Characidium laterale* (Bouleger, 1895)	LBP 12894, LBP 12931, LBP 13414, LBP 13551
[1,2]*Characidium* aff. *zebra* Eigenmann, 1909	LBP 12932, LBP 13421, LBP 13464, LBP 13512
[2]*Characidium* sp.	LBP 13675
Hemiodontidae (1)	
[1,2]*Hemiodus orthonops* Eigenmann & Kennedy, 1903	Embrapa uncatalogued
Bryconidae (2)	
[1,2]*Brycon hilarii* (Valenciennes, 1850)	LBP 12624
[1]*Salminus brasiliensis* (Cuvier, 1816)	Embrapa uncatalogued
Triportheidae (3)	
[1]*Clupeacharax anchoveoides* Pearson, 1924	Embrapa uncatalogued
[1,2]*Triportheus nematurus* (Kner, 1858)	LBP 12640, LBP 12971, LIRP 9426
[1,2]*Triportheus pantanensis* Malabarba, 2004	LBP 13457, LIRP 9427

Table 2. ***Continued.***

CLASS/ORDER/FAMILY/SPECIES	
Gasteropelecidae (2)	
[2]*Gasteropelecus sternicla* (Linnaeus, 1758)	LBP 12940, LBP 12955, LBP 13429, LBP 13445, LBP 13715
[1,2]*Thoracocharax stellatus* (Kner, 1858)	LBP 14015
Characidae (38)	
[1,2]*Aphyocharax anisitsi* Eigenmann & Kennedy, 1903	LIRP 9552, LIRP 9553
[1,2]*Aphyocharax dentatus* Eigenmann & Kennedy, 1903	LBP 12941, LBP 13475, LBP 13514, LBP 13581
[1,2]*Aphyocharax nattereri* Steindachner, 1882	LBP 12939, LBP 13536, LBP 13608
[2]*Aphyocharax rathbuni* Eigenmann, 1907	LBP 13415, LBP 13533
[2]*Astyanax abramis* (Jenyns, 1842)	LBP 13584, LBP 13713
[1,2]*Astyanax asuncionensis* Géry, 1972	LBP 12997, LBP 14011, LBP 14018, LBP 14043
[2]*Astyanax* sp.	LBP 13530, LBP 13677
[1,2]*Bryconamericus exodon* Eigenmann, 1907	LBP 12926, LBP 13408, LBP 13463, LBP 13500, LBP 13565, LBP 13598
[2]*Bryconamericus stramineus* Eigenmann, 1908	LBP 12911
[2]*Bryconamericus* sp.	LBP 13711
[2]*Charax leticiae* Lucena, 1987	LBP 12935, LBP 13542, LBP 13620, LBP 13706, LBP 14025
[2]*Ctenobrycon alleni* (Eigenmann & Kennedy, 1907)	LBP 13668, LBP 14009, LBP 14032
[1,2]*Cynopotamus kincaidi* (Schultz, 1950)	LBP 12638, LBP 13658
[2]*Gymnocorymbus ternetzi* (Boulenger, 1895)	LBP 14005
[1,2]*Galeocharax humeralis* (Valenciennes, 1834)	LBP 12959, LBP 13453, LBP 13483, LBP 13694
[2]*Hemigrammus lunatus* Durbin, 1918	LBP 12927, LBP 12972, LBP 13472, LBP 13605
[2]*Hemigrammus marginatus* Ellis, 1911	LIRP 9559, LIRP 9560
[2]*Hemigrammus* sp.	LBP 14012
[1]*Hemigrammus ulreyi* (Boulenger, 1895)	Embrapa uncatalogued
[1,2]*Hyphessobrycon eques* (Steindachner, 1882)	LBP 12903, LBP 13419, LBP 13509, LBP 13534, LBP 13570, LBP 14007
[2]*Hyphessobrycon megalopterus* (Eigenmann, 1915)	LBP 13538
[2]*Hyphessobrycon* sp.	LBP 13498, LBP 14033
[1,2]*Jupiaba acanthogaster* (Eigenmann, 1911)	LBP 13572, LBP 13584, LBP 13713
[1]*Knodus chapadae* (Fowler, 1906)	Embrapa uncatalogued
[1,2]*Moenkhausia bonita* Benine, Castro & Sabino, 2004	LBP 17827
[1,2]*Moenkhausia dichroura* Kner, 1858	LBP 12948, LBP 12998, LBP 13422, LBP 13553, LBP 14040
[1,2]*Moenkhausia forestii* Benine, Mariguela & Oliveira, 2009	LBP 12946, LBP 12966, LBP 13423, LBP 13513
[1,2]*Moenkhausia* cf. *oligolepis* (Günther, 1864)	LIRP 9578, LIRP 9579, LIRP 9560
[1,2]*Odontostilbe paraguayensis* Eigenmann & Kennedy, 1903	LBP 12893, LBP 12942, LBP 12954, LBP 13508
[1,2]*Odontostilbe pequira* (Steindachner, 1882)	LBP 12912, LBP 12945, LBP 12975, LBP 13496
[2]*Odontostilbe* sp.	LBP 13574
[1]*Phenacogaster tegatus* (Eigenmann, 1911)	Embrapa uncatalogued
[2]*Piabarchus analis* (Eigenmann, 1914)	LIRP 9587, LIRP 9588, LIRP 9589
[1,2]*Poptella paraguayensis* (Eigenmann, 1907)	LBP 12969, LBP 13409, LBP 13447, LBP 13554, LBP 13680, LBP 13695, LBP 14044
[1,2]*Prionobrama paraguayensis* (Eigenmann, 1914)	LBP 12902, LBP 12951, LBP 13407, LBP 13564, LBP 13586
[1,2]*Psellogrammus kennedyi* (Eigenmann, 1903)	LBP 12933, LBP 12953, LBP 12988, LBP 13425, LBP 13433, LBP 13590, LBP 13617, LBP 14045, LBP 16951
[1,2]*Roeboides affinis* (Günther, 1868)	LBP 14023, LBP 14050, LBP 14066
[1,2]*Roeboides descalvadensis* Fowler, 1932	LBP 13618
[1,2]*Roeboides microlepis* (Reinhardt, 1851)	LBP 13456
[1,2]*Serrapinnus calliurus* (Boulenger, 1900)	LBP 12890, LBP 12947, LBP 12974, LBP 13420, LBP 13467, LBP 13511
[2]*Serrapinnus kriegi* (Schindler, 1937)	LBP 12900, LBP 12928, LBP 13503
[2]*Serrapinnus microdon* (Eigenmann, 1915)	LBP 12943, LBP 13497, LBP 13577
[2]*Serrapinnus* sp.	LBP 13550
[1,2]*Tetragonopterus argenteus* Cuvier, 1816	LBP 12990, 13558, 14036, 14046
Serrassalmidae (8)	
[2]*Metynnis maculatus* (Kner, 1858)	Uncatalogued
[1]*Metynnis mola* Eigenmann & Kennedy, 1903	Embrapa uncatalogued
[1,2]*Myleus levis* Eigenmann & McAtee, 1907	LBP 12644, LBP 13406
[1,2]*Mylossoma duriventre* (Cuvier, 1818)	LBP 12623, LIRP 9628, LIRP 9629
[1,2]*Piaractus mesopotamicus* Holmberg, 1887	Embrapa uncatalogued
[1,2]*Pygocentrus nattereri* Kner, 1858	LBP 12641
[1,2]*Serrasalmus maculatus* Kner, 1858	Embrapa uncatalogued
[1,2]*Serrasalmus marginatus* Valenciennes, 1837	LBP 12639

Table 2. ***Continued.***

CLASS/ORDER/FAMILY/SPECIES	
Acestrorhynchidae (1)	
[1,2]*Acestrorhynchus pantaneiro* Menezes, 1992	LBP 12632, LBP 13451
Cynodontidae (1)	
[1,2]*Rhaphiodon vulpinus* Spix & Agassiz, 1829	LBP 12615
Erythrinidae (3)	
[2]*Erythrinus erythrinus* (Bloch & Schneider, 1801)	LBP 16949
[2]*Hoplerythrinus unitaeniatus* (Spix & Agassiz, 1829)	LBP 12888
[1,2]*Hoplias* aff. *malabaricus* (Bloch, 1794)	LBP 13444, LBP 13557, LBP 13061
Lebiasinidae (1)	
[1,2]*Pyrrhulina australis* Eigenmann & Kennedy, 1903	LBP 12910, LBP 12937, LBP 13426, LBP 13614, LBP 13669, LBP 13704
Iguanodectidae (2)	
[1]*Bryconops melanurus* (Bloch 1794)	Embrapa uncatalogued
[2]*Piabucus melanostoma* Holmberg, 1891	LBP 12929, LBP 13410, LBP 13452, LBP 13462, LBP 17830, LIRP 9645
SILURIFORMES (63)	
Aspredinidae (3)	
[2]*Amaralia hypsiura* (Kner, 1855)	LBP 12968
[1]*Bunocephalus doriae* Boulenger, 1902	LBP 14063
[2]*Pseudobunocephalus rugosus* (Eigenmann & Kennedy, 1903)	LBP 13531, LBP 13594, LBP 13649, LBP 13689
Trichomycteridae (4)	
[2]*Ituglanis eichorniarum* (Miranda Ribeiro, 1912)	LBP 13585, LBP 14062
[2]*Ituglanis herberti* (Miranda Ribeiro, 1940)	LBP 13468
[1]*Ochmacanthus batrachostomus* (Miranda Ribeiro, 1912)	Embrapa uncatalogued
[2]*Trichomycterus johnsoni* (Fowler, 1932)	LBP 13468
Callichthyidae (4)	
[1]*Callichthys callichthys* (Linnaeus, 1758)	Embrapa uncatalogued
[1,2]*Corydoras hastatus* Eigenmann & Eigenmann, 1888	LBP 12901, LBP 13418, LBP 13502, LBP 13552
[1,2]*Hoplosternum littorale* (Hancock, 1828)	LBP 12885, LIRP 9433
[1,2]*Lepthoplosternum pectorale* (Boulenger, 1895)	LBP 16957, LIRP 9432
Scoloplacidae (2)	
[2]*Scoloplax distolothrix* Schaefer, Weitzman & Britski, 1989	LBP 12952
[2]*Scoloplax empousa* Schaefer, Weitzman & Britski, 1989	LBP 17829
Loricariidae (17)	
[2]*Ancistrus* sp.	LBP 12970
[2]*Farlowella paraguayensis* Retzer & Page, 1997	LBP 12914, LBP 13665
[1,2]*Hemiodontichthys acipenserinus* (Kner, 1853)	LBP 13593
[1,2]*Hypoptopoma inexspectatum* (Holmberg, 1893)	LBP 13602, LBP 13636, LBP 13655, LBP 13727, LIRP 9387, LIRP 9388, LIRP 9389
[2]*Hypostomus* aff. *ancistroides* (Ihering, 1911)	LIRP 9461, LIRP 9463
[2]*Hypostomus boulengeri* (Eigenmann & Kennedy, 1903)	LBP 12625, LBP 12944
[1,2]*Hypostomus cochliodon* Kner, 1854	LBP 12886, LBP 12963, LBP 13499, LBP 13555
[2]*Hypostomus latifrons* Weber, 1986	LBP 12887, LBP 12925, LBP 12965, LBP 13518
[1,2]*Hypostomus* sp.	LBP 13435, LBP 13437, LBP 13460, LBP 13600
[1,2]*Loricaria* sp.	LBP 13400
[2]*Loricariichthys labialis* (Boulenger, 1895)	LBP 17840
[1,2]*Loricariichthys platymetopon* Isbrücker & Nijssen, 1979	LBP 12621
[1]*Megalancistrus parananus* (Peters, 1881)	Embrapa uncatalogued
[1,2]*Otocinclus vittatus* Regan, 1904	LBP 13607, LBP 13729
[2]*Proloricaria prolixa* (Isbrücker & Nijssen 1978)	LBP 12620, LBP 17839
[1,2]*Pterygoplichthys ambrosettii* (Holmberg, 1893)	LBP 12618, LBP 13545, LIRP 9429, LIRP 9430
[1,2]*Rineloricaria parva* (Boulenger, 1895)	LBP 12922, LBP 12964, LBP 13439, LBP 13474, LIRP 9382, LIRP 9383, LIRP 9384
[1,2]*Sturisoma barbatum* (Kner, 1853)	LBP 12622, LBP 12895, LBP 12996
Pseudopimelodidae (1)	
[1]*Microglanis cottoides* (Boulenger 1891)	Embrapa uncatalogued
Heptapteridae (6)	
[2]*Imparfinis* sp.	LBP 17828, LBP 12892, LBP 12930, LBP 12950, LBP 13413, LBP 13465
[1,2]*Phenacorhamdia hoehnei* (Miranda Ribeiro, 1914)	LBP 13520
[1,2]*Pimelodella* cf. *gracilis* (Valenciennes, 1835)	LBP 13401, LBP 13450, LBP 13588
[2]*Pimelodella mucosa* Eigenmann & Ward, 1907	LBP 12646
[2]*Pimelodella notomelas* Eigenmann, 1917	LBP 12995

Table 2. ***Continued.***

CLASS/ORDER/FAMILY/SPECIES	
[2]*Pimelodella* sp.	LBP 17832
[1,2]*Rhamdia* aff. *quelen* (Quoy & Gaimard, 1824)	LBP 12628, LBP 12991, LBP 13454, LBP 13622
Pimelodidae (11)	
[1,2]*Pseudoplatystoma corruscans* (Spix & Agassiz, 1829)	Embrapa uncatalogued
[1,2]*Pseudoplatystoma reticulatum* Eigenmann & Eigenmann, 1889	Embrapa uncatalogued
[1,2]*Hemisorubim platyrhynchos* (Valenciennes, 1840)	LBP 12631
[2]*Hypophthalmus edentatus* Spix & Agassiz, 1829	Embrapa uncatalogued
[1]*Megalonema platanum* (Günther, 1880)	Embrapa uncatalogued
[1,2]*Pimelodus argenteus* Perugia, 1891	LBP 12634
[1,2]*Pimelodus ornatus* Kner, 1858	LIRP 9527
[1,2]*Pimelodus pantaneiro* Souza-Filho & Shibatta, 2007	LBP 12633
[2]*Pimelodus* sp.	LBP 17831
[1]*Pinirampus pirinampu* (Spix & Agassiz, 1829)	LBP 12611
[1,2]*Sorubim lima* (Bloch & Schneider, 1801)	LBP 12610
[1]*Zungaro jahu* (Ihering, 1898)	LBP 12612
Doradidae (6)	
[1,2]*Anadoras weddellii* (Castelnau, 1855)	LBP 13416, LBP 13523
[2]*Ossancora eigenmanni* (Boulenger, 1895)	LBP 13583, LBP 13637, LBP 16954
[1,2]*Oxydoras kneri* Bleeker, 1862	LBP 14650
[2]*Platydoras armatulus* (Valenciennes, 1840)	LBP 12973, LBP 13595, LBP 14001, LBP 14058
[1,2]*Pterodoras granulosus* (Valenciennes, 1821)	LBP 12613
[1,2]*Rhinodoras dorbignyi* (Kner, 1855)	Embrapa uncatalogued
Auchenipteridae (9)	
[1]*Ageneiosus inermis* (Linnaeus, 1766)	Embrapa uncatalogued
[1]*Ageneiosus ucayalensis* Castelnau, 1855	Embrapa uncatalogued
[1,2]*Auchenipterus nigripinnis* (Boulenger, 1895)	LIRP 9439
[1,2]*Auchenipterus osteomystax* (Miranda Ribeiro, 1918)	LBP 12637
[2]*Entomocorus radiosus* Reis & Borges, 2006	LBP 14003
[1]*Tatia neivai* (Ihering, 1930)	Embrapa uncatalogued
[2]*Trachelyopterus coriaceus* Valenciennes, 1840	LBP 12984
[1,2]*Trachelyopterus galeatus* (Linnaeus, 1766)	LBP 13426, LBP 13661, LBP 13699
[1,2]*Trachelyopterus striatulus* (Steindachner, 1877)	LBP 12635, LBP 12889, LBP 13603, LIRP 9454, LIRP 9455
GYMNOTIFORMES (10)	
Gymnotidae (3)	
[1]*Gymnotus* cf. *carapo* Linnaeus 1758	Embrapa uncatalogued
[2]*Gymnotus inaequilabiatus* (Valenciennes, 1839)	LBP 12616, LBP 12996
[2]*Gymnotus paraguensis* Albert & Crampton, 2003	LBP 12979, LBP 13477
Sternopygidae (3)	
[1,2]*Eigenmannia trilineata* López & Castello, 1966	LBP 12909, LBP 12961, LBP 13404, LBP 13458, LIRP 9378, LIRP 9379
[1,2]*Eigenmannia virescens* (Valenciennes ,1842)	LBP 13431, LBP 13685
[1]*Eigenmannia* sp.	Embrapa uncatalogued
[1,2]*Sternopygus macrurus* (Bloch & Schneider, 1801)	LBP 12916, LBP 12923, LBP 12962, LBP 13404, LBP 13412, LIRP: 9393, LIRP 9394, LIRP 9395
Ramphichthyidae (2)	
[2]*Gymnorhamphichthys britskii* Carvalho, Ramos & Albert, 2011	LBP 13624
[1,2]*Rhamphichthys hahni* (Meiken, 1937)	LBP 13486, LBP 14013, LIRP 9421, LIRP 9422, LIRP 9423
Hypopomidae (2)	
[1,2]*Brachyhypopomus* sp.	LBP 12981, LBP 13516
[1,2]*Brachyhypopomus* sp. B	LBP 12993
Apteronotidae (2)	
[1,2]*Apteronotus albifrons* (Linnaeus, 1766)	LBP 12982, LBP 13720
[2]*Apteronotus caudimaculosus* de Santana, 2003	LBP 12908, LBP 12919, LBP 13440, LIRP 9430
CYPRINODONTIFORMES (3)	
Rivulidae (2)	
[2]*Melanorivulus punctatus* (Boulenger, 1895)	LBP 12980, LBP 13493, LBP 13644
[1]*Neofundulus paraguayensis* (Eigenmann & Kennedy, 1903)	Embrapa uncatalogued
Poeciliidae (1)	
[2]*Pamphorichthys hasemani* (Henn, 1916)	Uncatalogued

Table 2. ***Continued.***

CLASS/ORDER/FAMILY/SPECIES	
BELONIFORMES (1)	
Belonidae (1)	
[1,2]*Potamorhaphis eigenmanni* Miranda Ribeiro, 1915	LBP 13721, LBP 14004
SYNBRANCHIFORMES (1)	
Synbranchidae (1)	
[1,2]*Synbranchus marmoratus* Bloch, 1795	LBP 13417, LBP 13628, LBP 13647
PERCIFORMES (16)	
Sciaenidae (1)	
[1,2]*Plagioscion ternetzi* Boulenger, 1895	LBP 12617
Cichlidae (15)	
[1,2]*Aequidens plagiozonatus* Kullander, 1984	LBP 12983, LBP 13473, LBP 13480
[1,2]*Apistogramma borellii* (Regan, 1906)	LBP 11492, LBP 11495, LBP 12999, LBP 13579
[1,2]*Apistogramma commbrae* (Regan, 1906)	LBP 11493, LBP 11496, LBP 11498, LBP 13539
[1,2]*Apistogramma trifasciata* (Eigenmann & Kennedy, 1903)	LBP 11490, LBP 11494, LBP 11497, LBP 13490, LBP 13587
[2]*Astronotus crassipinis* (Heckel, 1840)	Uncatalogued
[1]*Astronotus ocellatus* (Agassiz, 1831)	Embrapa uncatalogued
[1,2]*Bujurquina vittata* (Heckel, 1840)	LBP 14035
[1,2]*Cichlasoma dimerus* (Heckel, 1840)	LBP 12905, LBP 13430, LBP 13630
[1,2]*Crenicichla lepidota* Heckel, 1840	LBP 12636, LBP 12897, LBP 12920, LBP 12972
[1,2]*Crenicichla vittata* Heckel, 1840	LBP 12967, LBP 14031
[1]*Crenicichla semifasciata* (Heckel, 1840)	Embrapa uncatalogued
[1]*Gymnogeophagus balzanii* (Perugia, 1891)	Embrapa uncatalogued
[1,2]*Laetacara dorsigera* (Heckel, 1840)	LBP 13562
[2]*Mesonauta festivus* (Heckel, 1840)	LBP 12645, LBP 13529, LBP 13638, LBP 14000
[1]*Satanoperca pappaterra* (Heckel, 1840)	Embrapa uncatalogued
CLASS SARCOPTERYGII (1)	
LEPIDOSIRENIFORMES (1)	
Lepidosirenidae (1)	
[1]*Lepidosiren paradoxa* Fitzinger, 1837	Embrapa uncatalogued

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Plant diversity of the Pantanal wetland

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Abstract

This is a review of current studies in diversity of the flora and main vegetation types in the Brazilian Pantanal. The flora of this wetland, nearly 2,000 species, constitutes a pool of elements of wide distribution and from more or less adjacent phytogeographic provinces, such as *Cerrado*, dry seasonal forests, Chaco, Amazonia and Atlantic Forest. The most numerous group includes wide-distribution species, mainly herbs, while the second contingent comes from the *Cerrado*. Endemic plants are rare, numbering only seven. The vegetation of the sedimentary floodplain is a mosaic of aquatics, floodable grasslands, riparian forests, savannas (*cerrados*), *cerrado* woodlands, dry forests, and a large area of mono-dominant savannas, and pioneer woodlands. The main vegetation types are briefly described with their characteristic species, and their estimated areas are given according to the latest mapping.

Keywords: Cerrado, Chaco, flora, forest, savanna.

Diversidade de plantas do Pantanal

Resumo

Esta é uma revisão sobre o estado do conhecimento sobre a flora e os principais tipos de vegetação do Pantanal brasileiro. A flora da planície inundável, de aproximadamente 2.000 espécies, é um encontro de elementos de ampla distribuição e de províncias fitogeográficas mais ou menos vizinhas, tais como o Cerrado, florestas estacionais, Chaco, Amazônia e Mata Atlântica. O grupo mais numeroso é de espécies de ampla distribuição, enquanto o segundo contingente vem do Cerrado. Plantas endêmicas são raras, somente sete. A vegetação da planície sedimentar é um mosaico de aquáticas, campos inundáveis, florestas ripárias, savanas (cerrados), cerradão, floresta decidual, e uma grande parte de savanas e florestas pioneiras monodominantes. Os principais tipos de vegetação são brevemente descritos em termos de espécies características, e suas áreas estimadas são dadas conforme o recente mapeamento.

Palavras-chave: Cerrado, Chaco, flora, floresta, savana.

1. Introduction

The history of the botany of the Pantanal goes back to early European naturalists who visited the region, as reported by Sampaio (1916). Later on, Hoehne (1923), collecting beyond the confined areas along river routes, gave the first broader report on the vegetation and plant species of the old State of Mato Grosso, including the Pantanal. A few geographers gave some landscape descriptions, with scanty reports of the vegetation. Veloso (1947, 1972) and Prance and Schaller (1982) gave some details on vegetation types. With aerial photographs and the onset of satellite imaging, a general view of the physiography was shown and the first vegetation maps were produced (Furtado et al., 1982; Loureiro et al., 1982; Abdon et al., 1998). The Brazilian botanist who most collected in Mato Grosso and Mato Grosso do Sul was Hatschbach (Museu Botânico Municipal, Cutitiba), as can be verified in Dubs (1988). Quite recently local botanists and collaborators have started to collect and to publish information on the flora (*e.g.*, Pott and Pott, 1994, 1999, 2000) and the vegetation (*e.g.*, Ratter et al., 1988; Nunes da Cunha and Junk, 2001; Damasceno-Junior et al., 2005; Nunes da Cunha et al., 2007).

A brief review will be given on the state of art concerning diversity of vegetation types and main plants in the Pantanal.

2. Results and Discussion

2.1. Flora

Considering only the Pantanal plain, 1,863 species of phanerogams were listed, legumes being the most numerous (240 spp.), followed by more than 200 grasses (Pott and Pott, 1999). The list could be updated to nearly 2,000 species (Pott and Pott, 2009). The most numerous families are Fabaceae (240), Poaceae (212), Malvaceae (98), Cyperaceae (92), Asteraceae (87), Rubiaceae (62), Myrtaceae (45), Convolvulaceae (41), and the best represented genera are *Paspalum* (35), *Cyperus* (29), *Ipomoea* (24), *Panicum* (22), *Eugenia* (20), *Ludwigia* (19), *Mimosa* (18) and *Rhynchospora* (18) (Pott and Pott, 1999), with a prominence of herbaceous species, around 1,000, due to their adaptation to floodable areas, largely occupied by amphibious and grassland habitats. Pott and Pott (2000) show 242 aquatic macrophytes, lately re-counted as 280 species. There are 10 species of palms (Pott and Pott, 1994), and two additional species of *Bactris* have been found, as yet unidentified.

2.2. Phytogeography

The central position of the Pantanal in South America has allowed the encounter among distinct phytogeographic provinces, which are Amazonia to the North, the Cerrados to the East, the Meridional Forests to the South, and the Bolivian and Paraguayan Chaco to the West, favouring a great variety of vegetation types, one of the reasons for the plural term "pantanals" (Adámoli, 1982; Alho, 2008a,b; Oliveira, 2008). Uetanabaro et al. (2007, p. 280) stated that the region lies within the "central portion of the large diagonal area of open vegetation forms of South America, which goes from the Caatinga in Northeast Brazil to the Chaco in Argentina, where areas of contact occur among Pantanal, Chaco and *Cerrado*", qualifying it "of great biogeographic importance". The Meridional Forests may be considered as the Paraná basin Forest (Spichiger et al., 2007).

Due to the floristic mix, with gallery forests, palmlands, floodable grasslands, *Tabebuia aurea* savannas, *cerrados*, *cerrado* grasslands, and flood-free ridges (paleodykes) covered with *cerrado* woodlands and forests, the vegetation used to be called "Pantanal Complex", a concept dropped by Adámoli (1982), considering "mosaic" a more proper term.

The flora receives influence from some main neighbouring phytogeographic domains (Adámoli, 1982). The main influence is the group of wide distribution, mostly herbaceous species; around 160 of them are weedy. The second contingent is the *Cerrado* (with uppercase C when referring to a biogeographic province), connected to the sandy highlands where the woody savanna called *cerrados* (lowercase c to designate the vegetation form) are the main vegetation type. A great part of the areas inside the Pantanal with *Cerrado* have soils deposited by the Taquari River. The Taquari alluvial fan covers 50,000 km^2, about 30% of the Pantanal, but only a small part of it is actually occupied by *cerradão* type woodland, while most of it is covered with grasslands and floodable vegetation, with some woody elements of *Cerrado*.

The other floristic province which influences the region is the Amazon forest, mainly on the Paraguay River floodplains. The headwaters of many affluents of this river begin near the transition with the Amazon basin and so work as corridors for some species to reach the Pantanal, especially those from floodable areas (*Igapó* or *Várzea*) such as *Nectandra amazonum* Nees, *Victoria amazonica* (Poepp.) J.C. Sowerby and *Alchornea castaneifolia* (Willd.) A. Juss., or occur in a similar wetland, the Araguaia floodplains, and Lhanos de Mochos, *e.g. Vochysia divergens* Pohl. The flooding regime of the Paraguay River has a few months lag after the rains fall on the upper watersheds, to reach the Pantanal. So, when inundation occurs the dry season has already begun in the lowland, and even without local rain the Amazon species can survive due to the floods.

The next phytogeographical influence is the Chaco, which occurs mainly in Paraguay, Bolivia and Argentina. According to Prado et al. (1992) the real Chaco areas inside the Pantanal can be found only in Porto Murtinho. Nevertheless, some Chaco species can be found in other sub-regions, and the most widespread is the palm *Copernicia alba* Morong, which forms mono-dominant types in extensive areas, mainly in the South Pantanal.

Other types of flora characterising the Pantanal are the seasonal deciduous and semideciduous forests (dry forests). Both occur on ancient levees (locally called "cordilheiras"), mainly in the São Lourenço and Taquari fans. These formations have in fact two distinct origins. The semi-deciduous forest has floristic elements present in the Brazilian Atlantic Forest, according to the official Brazilian classification (IBGE, 1992), such as *Albizia hassleri* (Chodat) Burkart. The deciduous forest contains floristic elements of the Pleistocene arch (Prado and Gibbs, 1993), found in the Chiquitania (Bolivia) and in Central Brazil in connection with the *Caatingas* of NE Brazil, contributing with species such as *Amburana cearensis* (Allemão) A.C. Sm., *Phyllostylon rhamnoides* (J. Poiss.) Taub., *Sebastiania brasiliensis* Spreng., *Seguieria aculeata* Jacq., etc. Damasceno-Junior et al. (2009) estimated about 1.5 % of the Pantanal was covered with deciduous forests. Dry forests are mainly found on the calcareous hills of Corumbá and on residual plateaus of Urucum-Amolar and Bodoquena, which are part of the Paraguay Upper Basin.

2.3. Main vegetation types

According to Silva et al. (2000), *Cerrado* occupies about 36 % of the region. There are various degrees of *Cerrado* cover: more than 70% in the sub-regions of Aquidauana, Barão de Melgaço and Paiaguás (central and Eastern part of Pantanal); between 40 and 50% in the sub-regions of Cáceres, Nhecolândia and Miranda; and 10% in the sub-region of Poconé), whereas *Cerrado* vegetation is absent in the sub-regions of Nabileque and Paraguay – with dominance of Chaco and Amazonian vegetation, respectively.

According to Prance and Schaller (1982), Pott and Pott (1994, 2000) and Silva et al. (2000), there are various vegetation types in the region, and mosaics of floodable grasslands, *cerrado* woodland (*cerradão*), *cerrado*, semideciduous forest, riparian forest, swamps and floating vegetation are particularly conspicuous, plus other physiognomies. A synthesis of vegetation types is given in Table 1.

The Savanna (*Cerrado*) predominates in 50% of the Pantanal. Flood dynamics causes rapid changes in vegetation cover and promotes great diversity in pioneer types, varying from herbaceous to woody formations. In general there is a continuum from semi-deciduous forests to dry and forested savanna (*cerradão*). The species listed for the vegetation types described below were recorded during field work on inspected remnants and are based on herbarium collection and the authors' experience.

1) Seasonal Deciduous Forest (Tropical Dry Forest), found on rich or calcareous soils, presenting a tree stratum average 20 m tall with deciduousness above 50%, with two very distinct seasons (one rainy and another dry); it can be subdivided into:
   1.1) Lowland Seasonal Deciduous Forest, commonly called dry forest, or calcareous forest, with more than 60% of trees dropping their leaves; species include *Anadenanthera colubrina* (Vell.) Brenan, *Aspidosperma pyrifolium* Mart., *Myracrodruon urundeuva* Allemão, *Phyllostylon rhamnoides*, *Tabebuia impetiginosa* (Mart. ex DC.) Standl., etc;
   1.2) Submontane Seasonal Deciduous Forest, amongst several species, *Acacia paniculata* Willd., *Albizia hassleri*, *Anadenanthera colubrina*, *Aspidosperma pyrifolium*, *M. urundeuva*, etc. can be cited, but some are rare on the plain, such as *Chorisia pubiflora* (A. St.-Hil.) Dawson, *Sterculia striata* A. St.-Hil. & Naudin, or were not found, *e.g.*, *Acosmium cardenasii* H.S. Irwin & Arroyo, *Coutarea hexandra* (Jacq.) K. Schum.;
2) Seasonal Semi-deciduous Forest, characterised by leaf loss in 20 to 50% of trees, average 20 m tall, reaching up to 30 m. It is subdivided into:
   2.1) Alluvial Seasonal Semi-deciduous Forest, also called riparian forest, found lining rivers of the basin and often periodically flooded, with denser formations found mainly along the Paraguay River, in the sub-regions of Paraguay and Poconé, and along the São Lourenço River in Barão do Melgaço, with trees such as: *Albizia inundata* (Mart.) Barneby & J.W Grimes, *Cassia grandis* L.f., *Vitex cymosa* Bertero, etc;
   2.2) Lowland Seasonal Semi-deciduous Forest, occurring on flood-free ground (ridges or ancient levees), with species such as: *Anadenanthera colubrina*, *Astronium fraxinifolium* Schott, *Attalea phalerata* Mart. ex Spreng., *Copernicia alba*, *Protium heptaphyllum* (Aubl.) Marchand, *Pterogyne nitens* Tul., *Tabebuia impetiginosa*, *T. roseo-alba* (Ridl.) Sandw., etc;
3) Savanna, regionally called *cerrado* and which is already internationally accepted, is found in areas with vegetation presenting xeromorphic features due to the dry season, usually on dystrophic soils, except for the forested type. *Cerrado* and *cerrado* woodland ("cerradão") on poor sands in the central and Eastern parts of the Pantanal show a lack of palms except for the small *Allagoptera leucocalyx* (Drude) Kuntze, many Fabaceae [*Acosmium dasycarpum* (Vog.) Yakol., *Andira cuyabensis* Benth., *Bowdichia virgilioides* Kunth, *Hymenaea stigonocarpa* (Mart.) Hayne, *Vatairea macrocarpa* (Benth.) Ducke], Myrtaceae [*Eugenia* spp., *Gomidesia palustris* (DC.) Kausel, *Myrcia* spp.], and Vochysiaceae [*Qualea* spp., *Salvertia convallariodora* A. St.-Hil., *Vochysia* spp.], *Kielmeyera rubriflora* Cambess. There are few hardwoods on poorer soils, used for fencing, usually legumes, *e.g.*, *Dipteryx alata* Vog., *Diptychandra aurantiaca* (Mart.) Tul., *Plathymenia reticulata* Benth.; also *Lafoensia pacari* A. St.-Hil. Other common *Cerrado* trees: *Aspidospermum tomentosum* Mart., *Byrsonima coccolobifolia* Kunth and *Caryocar brasiliense* Cambess.

During dry years some *cerrado* and other pioneering species "invade" grasslands, even occurring in dried-out pond beds: in sandy areas, *Annona dioica* A. St.-Hil., *Bowdichia virgilioides*, *Buchenavia tomentosa* Eichler, *Caryocar brasiliense*, *Curatella americana* L., *Hymenaea stigonocarpa*, *Luehea paniculata* Mart., *Simarouba versicolor* A. St.-Hil., etc.; on clay, other species increase, *e.g. Callisthene fasciculata* (Spreng.) Mart. and *Tabebuia aurea* (Manso) Benth. & Hook. f. ex S. Moore, etc.

   3.1) Forested Savanna, called "Cerradão", is a denser woodland where tree canopies touch each other and part of the species are semi-deciduous, 8 to 15 m tall, occurring more in the East and centre of the plain, on sandy soils (sub-regions of Cáceres, Barão do Melgaço, Nhecolândia, Aquidauana and Miranda), on flood-free ground; some of the species are: *Byrsonima crassifolia* (L.) Kunth, *Caryocar brasiliense*, *Dimorphandra mollis* Benth., *Eriotheca gracilipes* (K. Schum.) Robyns, *Kielmeyera coriacea* Mart., *Qualea grandiflora* Mart., *Q. parviflora* Mart., *Xylopia aromatica* (Lam.) Mart., etc;
   3.2) Woody Savanna, also called *cerrado* grassland, *cerrado* or open *cerrado*, is a form of *cerrado stricto sensu*, well represented in the Pantanal, with shrubs and scattered trees up to 10 m tall, with thick bark and tortuous trunks, on a predominant grassy/herbaceous stratum, occurring more in the Eastern and central parts of the plain, on sandy soils

Table 1. Quantification (km^2) of the vegetation cover of the Pantanal, mapping based on Landsat images of the year 2002. Vegetation names according to the official Brazilian nomenclature (IBGE, 1992), common terms in parentheses.

Phytoecological region, formation or subtype	Area (km^2)
I – Semi-deciduous Seasonal Forest	
Alluvial forest (riparian forest, gallery forest)	6,131.0
Submontane forest (dry forest)	92.3
II – Deciduous Seasonal Forest	
Alluvial forest (riparian forest, gallery forest)	9.6
Lowland forest ("Mata", dry forest, calcareous forest)	519.0
Submontane forest ("Mata", dry forest, calcareous forest)	910.0
III - Savanna (*Cerrado*)	
Forested (*Cerrado* woodland, *Cerradão*)	8,984.0
Wooded (*Cerrado* grassland, *Cerrado*, open *Cerrado*), with and without gallery forest	25,205.9
Grassy-Woody (Grassland, open grassland, bushy grassland, *Elyonurus* grassland, and flooded grassland), with and without gallery forest	8,880.7
Forested + Wooded and Wooded + Forested	80.3
Wooded + Grassy-Woody and Grassy-Woody + Wooded	734.5
IV – Steppic Savanna (Chaco)	
Wooded	213.3
Park ("Carandazal")	6,590.7
Grassy-Woody ("campo")	4,526.1
Wooded + Forested	80.3
Wooded + Grassy-Woody	244.2
Grassy-Woody + Grassy-Woody	490.3
V – Pioneer Formations: Vegetation with Fluvial and/or Lacustrine Influence: *Mauritia* palmland ("Buritizal"), Spiny scrub ("Espinheiral"), *Vochysia divergens* woodland ("Cambarazal"), Giant sedge ("Pirizal"), tussock grassland ("Macega"), *Couepia uiti* woods ("Pateiral"), *Licania parvifolia* woods ("Pimenteiral"), Fireflag ("Caetezal"), Swamp, floating meadow and bushy grassland	5,216.2
VI – Areas of ecological tension or floristic contacts	
Ecotone	
Savanna/Deciduous Seasonal Forest ("Mata")	315.9
Savanna/Semi-deciduous Seasonal Forest ("Mata")	2,258.5
Deciduous Seasonal Forest/Pioneer Formations ("Mata")	4,697.4
Savanna/Pioneer Formations (*Cerrado*, Bushy Grassland, "Cambarazal")	16,429.5
Steppic Savanna/Deciduous Seasonal Forest ("Mata")	803.9
Enclave	
Savanna/Deciduous Seasonal Forest ("Mata")	904.9
Savanna/Deciduous Seasonal Forest ("Mata")	53.3
Savanna/ Semi-deciduous Seasonal Forest ("Mata")	298.5
VII – Vegetation refuges (remnant communities): Herbaceous submontane refuge (Grassland)	28.4
VIII – Anthropic areas	
Secondary vegetation (of Savanna, Forest, Forested and Park Steppic Savanna)	403.6
Agriculture	411.5
Sown pasture (in Seasonal Forest, Savanna and Steppic Savanna)	16,511.8
IX – Other Anthropic Areas: Urban Influence + Mining degraded areas	132.7
X – Others: Water bodies (rivers, streams, oxbows, channels, lakes, ponds, brackish ponds)	2,557.3
TOTAL	151,186.2

Source: Silva et al. (2007).

(sub-regions of Cáceres, Barão do Melgaço, Paiaguás, Nhecolância, Aquidauana and Miranda), on lower areas, tending to grassland as the degree of inundation increases, or the opposite, to woodier when drier. The most common species found are: *Annona dioica*, *Buchenavia tomentosa*, *Curatella americana*, *Dimorphandra mollis*, *Luehea paniculata*, *Qualea parviflora*, *Simarouba versicolor* and *Stryphnodendron obovatum* Benth., among others;

3.3) Park Savanna (Park of *Cerrado*) occurs in floodable areas, normally with dominance of a single tree or shrub species over a grassy stratum:

3.3.1) *Byrsonima orbignyana* scrub ("canjiqueiral") – homogeneous shrubby formation, 1-5 m tall, dominated by *B. orbignyana* A. Juss., on sandy or silty soils, floodable (*ca.* 50 cm deep), in the sub-regions of Paiaguás, Nhecolândia, Aquidauana, Abobral and Cáceres; as a pioneer woody element, it is considered a pasture weed, and in past decades it was the main controlled species. *Byrsonima orbignyana* savanna, on floodable sandy areas, also sometimes occurs on ancient silted drainage channels amongst *Tabebuia aurea* savanna and spread over most of the plain;

3.3.2) *Curatella americana* ("lixeiral") – a sort of park savanna dominated by this tree, which occurs in floodable areas; often it is associated with slightly higher ground, while it is a rather shrubby (multi-stem) dwarfed shrub on ill-drained land or a *ca.* 15 m tall tree in flood-free woodland (Pott and Pott, 2004, 2005); it is the most frequent woody species in the Pantanal, being very abundant on the dystrophic sands of the Eastern zone (Pott and Pott, 2004), and in the earth-mound savanna in the Northern part of the floodplain (Ponce and Nunes da Cunha, 1993); it is also considered a weed by ranchers, mainly during dry years (Pott and Pott, 2004);

3.3.3) *Tabebuia aurea* ("paratudal") – floodable savanna with a single tree species stratum, mean density of 363 individuals/ha (Soares and Oliveira, 2009), 5-12 m tall, generally growing on a type of earth-mound or termite-like hummocks; other woody species (*e.g. Astronium fraxinifolium*) appear in drier years, but are kept back by wildfires or return of floods; occurs mainly in the South of the Pantanal between the rivers Nabileque and Miranda, associated with slightly alkaline waters and sediments (Pott, 1994); it used to be interpreted as *cerrado* (Furtado et al., 1982; Loureiro et al., 1982), but lately it has been considered to be linked to the Chaco flora (Silva et al., 2007), due to the associated species, such as *Aposorella chacoensis* (Morong) Spegazz., *Camptosema paraguariense* Chodat & Hassl., *Dolichopsis paraguariensis* (Benth.) Hassl., *Prosopis rubriflora* Hassl., etc. (Pott, 1994), and because such vertic soils do not exist under *Cerrado*.

3.4) Grassy-woody Savanna, called *Campo* or flooded grassland, normally made up of grasses and herbs. It can be divided into flooded and dry grasslands, the proportions varying in function of local rainfall and/or river overflow, representing 31.1% of the vegetation of the region, being more associated with drainage factor than soil fertility. Higher predominance in some portions of the Pantanal (Abobral, Paiaguás, Nhecolândia and Nabileque), with dominance of grasses and sedges. Among coarse grasses [*Andropogon* spp., *Paspalum carinatum* Humb. & Bonpl., *P. lineare* Trin. and *Trachypogon spicatus* (L. f.) O. Kuntze], there are other species such as wild-rice *Oryza* spp., *Mesosetum* spp., *Reimarochloa* spp., *Paratheria prostrata* Griseb., plus *Paspalum* spp., *Digitaria* spp., *Panicum* spp. Some species are found more on poor soils, such as *Axonopus purpusii* (Mez) Chase, while *Paspalum almum* Chase is associated with fertile soils. Grasslands, depending on cycle of flood or drought, can be taken over by woody vegetation of *cerrado*, or vice-versa.

4) Steppic Savanna, commonly called Chaco and linked to the floristic province of Chaco in Argentina, Paraguay and Bolivia; the only true Brazilian Chaco occurs at the SW end of Mato Grosso do Sul and belongs to the *Chaco Húmedo* (Prado et al., 1992). There is a predominance of spiny vegetation with features of semi-arid vegetation (presence of xeromorphic species, plus cacti), with physiognomy similar to the Brazilian *Caatinga*, although it also contains wet areas, mainly in the Eastern Chaco; it is present on salty clays in the sub-regions of Nabileque and Porto Murtinho, and can be subdivided into four vegetation forms:

4.1) Forested Steppic Savanna, commonly called Chaco, dry forest or Chaquenian forest, with dry forest appearance, deciduous, average 5-7 m tall; some typical species are *Aspidosperma quebracho-blanco* Schltdl., *Caesalpinia paraguariensis* (D. Parodi) Burkart, *Diplokeleba floribunda* N.E. Br., *Parkinsonia praecox* (Ruiz & Pav. ex Hook.) J. Hawkins, *Piptadenia viridiflora* (Kunth) Benth., *Prosopis rubriflora*, *P. ruscifolia* Griseb., *Schinopsis balansae* Engl., *Zizyphus oblongifolius* S. Moore, etc.; lately undergoing strong deforestation;

4.2) Steppic Scrub Savanna, also called Chaco, is similar to the previous one, but with shorter and

spaced trees, interspersed in a stratum of spiny treelets which normally do not surpass 4 m, such as *Acacia farnesiana* Willd., *A. paniculata*, *Capparis retusa* Griseb., *C. speciosa* Griseb., *C. tweediana* Eichl., *Celtis pubescens* Kunth, *Zizyphus* spp., etc., and frequently a ground cover of *Selaginella sellowii* Hieron.;

4.3) Steppic Park Savanna ("Carandazal", "Campina de Carandá") – made up of a grassy sward and a woody stratum with predominance of the palm *Copernicia alba*, 8-20 m tall, occurring mainly in the Southern Pantanal, in large areas of the sub-regions Nabileque and Porto Murtinho, on black alkaline or saline clays, with sub-surface calcium carbonate concretions; it also occurs on sandy soils, if fertile or high pH, as around brackish ponds (Nhecolândia) or shell-derived hummocks (Abobral), in floodable areas, while on drier patches it becomes denser, as palm woodland, with associated species such as *Capparis speciosa*, *Cereus bicolor* Rizzini & Mattos, *Diplokeleba floribunda*, *Machaerium hirtum* (Vell.) Stellf., *Mimosa* spp., *Prosopis ruscifolia*, *Tabebuia nodosa* (Griseb.) Griseb., etc;

4.4) Steppic Woody-grassy Savanna, various types of grassland, such as open grassland, bushy grassland, flooded grassland or spiny grassland, made up of a grassy sward with spiny dwarf plants; common species: *Acacia farnesiana*, *Celtis spinosa* Spreng., *C. pubescens*, *Mimosa* spp., *Paspalum simplex* Morong, etc;

5) Pioneer formations or monodominant vegetation types – areas under fluvial and/or lacustrine influence (sedimentation habitats, periodically or permanently flooded), made up of unstable ground covered by vegetation in constant succession, such as *Vochysia divergens*, spiny scrub, giant sedge stands, plus others described below. This type of vegetation, a result of abiotic (soil and/or hydrological) factors, allows the presence of various types of association, few plant species dominating large areas, forming typical landscapes with their local names in brackets:

5.1) *Attalea phalerata* ("acurizal") – homogeneous or mixed forest understory made up of this shady palm, occurring on flood-free ridges and grooves and on river banks, which are periodically flooded by flowing water; it often indicates anthropic action, as it can colonise cleared or frequently burned areas;

5.2) *Attalea speciosa* palmland ("babaçual") – homogeneous dense forest predominantly of this palm, 10-22 m tall, occurring in the extreme North of Cáceres sub-region and central Nhecolândia (0.3% of the region); some dry forest trees grow inside, held back by periodical fires, such as *Astronium fraxinifolium*;

5.3) Floating mats ("camalote") and floating islands ("baceiro", "batume") – both found in permanent water bodies such as ponds, lakes, canals, oxbows and rivers; floating mats are attached banks of floating macrophytes, or not anchored, which then float downriver or move by wind; the main species are the water hyacinths *Eichhornia crassipes* (Mart.) Solms and *E. azurea* (Sw.) Kunth, both rooted or free-floating, and other aquatic plants, water lettuce *Pistia stratiotes* L. and water fern *Salvinia auriculata* Aubl., free-floating; floating meadows have denser vegetation, made up of grasses and sedges, mainly *Oxycaryum cubense* (Poepp. & Kunth) Lye and *Eleocharis plicarhachis* (Griseb.) Svens., rooted on histosol (decomposing organic material) (Pivari et al., 2008) accumulated on the densely entangled roots, most frequent in the sub-regions of Abobral and Cáceres and along the rivers Paraguay, Cuiabá, Negro, Miranda and Nabileque;

5.4) Swamp ("brejo") – permanently flooded or waterlogged areas, except in drier years, are confined to a few places, such as the Negro River (Aquidauana) and sub-regions of Abobral, Paraguay and Poconé; contains shrubby species, climbers, grasses and sedges, often forming dense thickets of spiny shrubs (*Byttneria filipes* Mart. ex K. Schum., *Mimosa weddelliana* Benth., etc.) and vines (*Cissus spinosa* Cambess., *Combretum* spp., *Ipomoea* spp.). Giant sedge *Cyperus giganteus* Vahl ("pirizal") and fireflag *Thalia geniculata* L. ("caetezal") is a sort of swamp or temporary pond dominated by these herbaceous species, mainly in the sub-regions of Abobral, Nabileque and Poconé, and increasing in the flooded Taquari delta; cat-tail *Typha domingensis* Pers. ("taboal") is a similar tall aquatic herb which occurs in permanent or temporary ponds and increases in disturbed flooded areas;

5.5) *Vochysia divergens* woodland ("cambarazal") – homogeneous formation of an Amazonian tree, 5-18 m tall, on clay or loamy soils, tolerates periodical flood well, but not permanently; found mainly in the sub-regions of Barão do Melgaço, Poconé and Paraguay, adding up to 3.2% of the Pantanal vegetation, in fact much more nowadays; it is a pioneer which forms dense pure stands, considered a natural grassland weed for shading out grasslands (Allem and Valls, 1987). Since 1980, large areas have been invaded on floodplains of the Cuiabá and Paraguay rivers, now also on the lower Taquari flooded delta (Pott and Pott, 2005), but it slowly dies back under permanent deep flood;

5.6) *Elyonurus muticus* grassland ("caronal"), on intermediate, and only occasionally flooded or flood-free sandy ground, lately being replaced to cultivate *Brachiaria humidicola* Rendle or other exotic grasses;

5.7) *Bromelia balansae* stands ("gravateiro") – community of a pineapple-like plant, generally indicating flood limit; when in large amounts inside groves and woods, it may indicate selective logging with opening of gaps, which allow fast growth and spread, blocking passage of large animals, then the leaves have very spiny edges; it is not viable to map it yet;

5.8) *Couepia uiti* scrub ("pateiral") – native grassland area invaded by this tree species, considered a weed (pioneer), being abundant on sandy soils on floodplain and among riparian vegetation;

5.9) *Licania parvifolia* scrub ("pimenteiral") – native grassland areas invaded by this pioneer tree, occurring over nearly the whole Pantanal floodplain;

5.10) *Tabebuia heptaphylla* woods ("piuval"), a deciduous tree occurring in savanna or woodland, in floodable areas, generally not far from rivers and seasonal streams, tending to riparian forest in the succession;

5.11) *Mauritia flexuosa* palmland ("buritizal") – almost homogeneous formation of "buriti" palm, 5-15 m tall, with restricted distribution near the Eastern border of the plain, along the Aquidauana and Taquari Rivers, and in Barão de Melgaço;

5.12) *Erythrina fusca* woods ("abobral") – one of the main trees, usually in groups, along the Paraguay River in the Cáceres sub-region, also spread along the margins of the Aquidauana river; the flowers are visited by psittacids;

5.13) *Xylopia aromatica* savanna ("pindaival") – *Cerrado* tall shrub or tree community common in the NE of the plain.

2.4. Remarks upon vegetation types

- Dry forests – Dry forests, more abundant on the hills rather than on the plain (Hoehne, 1923; Prance and Schaller, 1982; Ratter et al., 1988), were recently described in more detail by Damasceno-Junior et al. (2009). This vegetation type covers *c.* 4% of the Pantanal, as few significant areas occur on the plain: Mata do Cedro and Fuzil in Paiaguás, Mata do Bebe in Barão de Melgaço, and other scattered patches in South Poconé, Abobral, Miranda, around brackish ponds in SE Nhecolândia, Soldado and Porto Murtinho (Damasceno-Junior et al., 2009). Typical species are: *Acrocomia aculeata* (Jacq.) Lodd. Ex Mart., *Astronium fraxinifolium*, *Casearia gossypiosperma* Briq., *Combretum leprosum* Mart., *Cordia glabrata* (Mart.) A. DC., *Dipteryx alata*, *Myracrodruon urundeuva*, *Pisonia zapallo* Griseb., *Pouteria gardneri* (Mart. & Miq.) Baehni, *Pterogyne nitens*, *Rhamnidium elaeocarpum* Reiss., *Spondias mombin* L., *Sterculia apetala* Karst., *Tabebuia impetiginosa*, *Zanthoxylum caribaeum* Lam., etc. (Damasceno-Junior et al., 2009). The Chaco influence becomes stronger southwards, as in the areas of Soldado and Porto Murtinho. Some of the dry forest areas can be interpreted as a junction of many ancient levees, generally an alluvial fan built at the earlier encounter of a tributary with the calm flood waters of a larger river. For example, sediments of the Taquari River were deposited where they met the still flood waters of the Paraguay River, before the Paraguay was gradually pushed westwards.
- Riparian forests – Most information on gallery forests is given by Damasceno-Junior et al. (2005), for the Southern part of the Pantanal, and by Nunes da Cunha and Junk (2001), for the Northern sub-regions. Some riparian trees are sort of generalists, found along almost every water course, such as *Andira inermis* Kunth and *Inga vera* ssp. *affinis* (DC.) T.D. Penn., whereas others tend to be more frequent on heavily flooded clay, *e.g.*, *Albizia inundata* and *Sapium obovatum* Klotzsch ex Müll. Arg. In the Northern section of the Paraguay River on the plain a few grow in nearly pure stands, such as *Erythrina fusca* Lourt. and *S. obovatum*, often like orchards, and some Amazonian species occur which have not been found much downstream, such as *Brosimum lactescens* (S. Moore) Berg and *Sloanea garckeana* K. Schum., plus an as yet unidentified red-fruited species of *Bactris*. Along some outgoing temporary streams (diffluents) of the Taquari River, there occur dense stands of *Tapirira guianensis* Aubl., hardly seen elsewhere in the Pantanal. It seems rather paradoxical that some trees share very distinct habitats, such as the riverside and dry forests; for example, *Albizia hassleri* and *Vitex cymosa*. Many species of gallery forests of upland streams do not grow on the plain, or only as far as the river is fast-flowing, such as *Hirtella gracilipes* (Hook. F.) Prance and *Licania humilis* Cham. & Schltdl. on the Taquari River, still close to the Eastern border. A curious case is *Salix humboldtiana* Willd., which has restricted occurrence on sandy levees of the Aquidauana River at the very entrance to the plain; after a disjunction it reappears on heavy clay along the Paraguay River at the far end of the Pantanal. Below Corumbá the Paraguay River does not often exhibit a proper riparian forest, but pioneer stages of flexible shrubs, which withstand flood flow, such as *Alchornea castaneifolia*.

Due to the dynamics of the rivers, strips of "old" forest are eroded away and new ones start on the opposite bank,

where sediments accumulate and become first colonised by aquatic plants, often nearly mono-dominant, mainly grasses (*Panicum dichotomiflorum* Michx., *P. pernambucense* (Spreng.) Mez ex Pilg., *Paspalum fasciculatum* Willd.) and sedges (*Cyperus*, *Fuirena*, *Rhynchospora*), *Polygonum* spp., then subshrubs [*Aspilia latissima* Malme*, Ipomoea carnea* var. *fistulosa* (Mart. ex Choisy) D.F. Austin], shrubs (*Alchornea castaneifolia*), later trees, all entangled with a great mass of vines, such as *Combretum lanceolatum* Pohl, *Cissus spinosa*, *Mikania* spp. Some of the main species of riparian forests are: a) early stage of succession with *Cecropia pachystachya* Trécul, *Ruprechtia brachysepala* Meisn., *Inga vera*, *Sapium obovatum* and *Vochysia divergens*; b) late successional stage trees are, for example *Erythrina fusca*, *Ficus* spp., *Genipa americana* L., *Pouteria glomerata* (Miq.) Radlk. and *Triplaris americana* L. Succession stages frequently occur in progressive chronological zoning, but are also intermingled due to gaps caused by flood or fire. Along seasonal streams often grows a hedgerow of *Licania parvifolia* Hub., sometimes *Calophyllum brasiliense* Cambess. The sequence described here depends on the level of inundation that the considered river can reach, and on the region drained.

Riparian species may grow many kilometres from the river, such as *Combretum lanceolatum*, *Licania parvifolia* and *Vochysia divergens*, often in closed mono-dominant populations, therefore frequently considered undesirable invasive woody plants, as they may take over and even shade out useful grasslands.

- Grasslands – Allem and Valls (1987) produced the first comprehensive study, a benchmark on natural grasslands of the Pantanal. Grasslands are by far the biggest vegetation type of the Pantanal. Often the open landscape is mistaken for deforested area, instead of natural vegetation due to seasonal flood, even though there is some spotty shrub control done by ranchers. The effect of flood holding back woody vegetation can be observed during years without flood, when grasslands become shrubby, as during the last 15 years.

Grassland composition depends so much on flood level that a few centimetres difference is enough to determine change in species. Besides the main grasses, there is a great number of herbaceous plants, annuals or perennials, most of them growing in particular conditions of flood or soil, and these may be indicators, for example: therophytes or annual species propagated by seed (*Bacopa arenaria* (J.A. Smith) Edwall, *Heliotropium filiforme* Lehm., *Ludwigia octovalvis* (Jacq.) Raven, *Sacciolepis myuros* (Lam.) Chase); indicators of clay [annuals *Brachiaria adspersa* (Trin.) Parodi, *Eriochloa punctata* (L.) Desv., *Heliotropium procumbens* Mill., and perennials *Hemarthria altissima* (Poir.) Stapf & Hubb., *Paspalum millegrana* Schrad.]; indicators of salinity [annuals *Microchloa indica* (L.f.) Beauv., *Sporobolus pyramidatus* (Lam.) Hitchc., *Tripogon spicatus* (Nees) Ekm., and perennial *Paspalum vaginatum* Sw.]; and indicators of poor soils [*Gymnopogon spicatus* (Spreng.) O.Kuntze, *Leptocoryphium lanatum* (H.B.K.) Nees, *Mesosetum cayennense* Steud., *Panicum stenodes* Griseb.] (Pott, 1988).

2.5. Endemic and rare species

As the Pantanal is a geologically-recent (Holocene) Quaternary floodplain, very few endemic species have been found, such as *Arachis diogoi* Hoehne, *A. hoehnei* Krapov. & W.C. Greg., or new and also endemic plant species, *e.g. Arachis vallsii* Krapov. & W.C. Greg., *Euplocca pottii* J.I.M. Melo, *Habranthus pantanensis* Ravenna, *Stilpnopappus pantanalensis* H. Rob., *Xanthosoma pottii* E.G. Gonçalves. Some are endemics in the broad sense, such as *Bergeronia sericea* Mich. and *Lonchocarpus nudiflorens* Burkart. There seem to be more endemic plants on surrounding hills than on the plain, such as *Aspilia grazielae* Santos, *Discocactus ferricola* Buining & Bradero, *Gomphrena centrota* Holzh., *G. matogrossensis* Suessenguth, *Lonchocarpus variabilis* R.R. Rodrigues & Tozzi, *Mentzelia corumbaensis* Hoehne, *Mimosa ferricola* R.R. Silva & A.M.G.A. Tozzi, *Deuterocohnia meziana* Kuntze ex Mez, etc.

- Rare species: *Cereus saddianus* Rizz. & Mattos, *Dieffenbachia aglaonematifolia* Engl., *Discolobium psoralifolium* Benth., *Eichhornia diversifolia* (Vahl) Urb., *Evolvulus pterygophyllus* Mart., *Eulophia alta* (L.) Fawc. & Rendl., *Habenaria nabucoi* Ruschi, *Ipomoea piresii* O'Donell, *Ludwigia affinis* (DC.) Hara, *Nymphaea belophylla* Trickett, *Utricularia trichophylla* Spruce ex Oliv., *Xanthosoma aristiguietae* (Bunting) M. Madison.

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A conservation plan for the jaguar *Panthera onca* in the Pantanal region of Brazil

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The results of three years of research on jaguars *Panthera onca* in the Pantanal region of Brazil are used to develop a comprehensive conservation plan for the species in the region. The plan attempts to integrate space and ecological requirements of the species with existing land features and socioeconomic realities of the region. A reserve of at least 2000–3000 km² is recommended for each of two areas which still support relatively undisturbed populations of jaguars. Second, the plan calls for the protection of riverine forests between the two reserves as corridors for inter-refuge movement. Lastly, several recommendations are made to address jaguar–cattle conflicts.

INTRODUCTION

The jaguar *Panthera onca* is the largest felid in the Western Hemisphere. Although originally distributed from the southern United States to northern Patagonia (Guggisberg, 1975), the jaguar's range has been considerably reduced since European settlement of the Americas. The present range has not been precisely defined, although some recent surveys (Mercado & Sanchez, 1978; Vaughan, 1983; Melquist, 1984; Swank & Teer, 1989) have aided in the status assessment of the species. In Mexico and Central America, Swank and Teer (1989) found that jaguar populations existed in only 33% of their former range, and 75% of those populations were considered to exist in reduced numbers; in South America, jaguars existed in 62% of their original range, and were considered reduced in 36% of that area (Swank & Teer, 1989). The range of the jaguar continues to decrease rapidly despite its protected status internationally (Emonds, 1981; IUCN, 1982*a*; Fuller & Swift, 1985).

Until recently, little scientific information was available on the ecology of the jaguar (Schaller & Crawshaw, 1980; Rabinowitz & Nottingham, 1986; Emmons, 1987). New findings, however, present biological information on which to base conservation efforts. These findings have shown substantial variation in several aspects of its ecology (Quigley, 1987). Additional variation exists with regard to human impact on the species. Although direct killing and habitat destruction are responsible for its decline (Ojeda & Mares, 1982; Brown, 1983; Melquist, 1984; Swank & Teer, 1989), the importance of these activities varies regionally due to differences in habitat, prey availability, economic development, and cultural mores. As a result, many areas require site-specific conservation strategies for the jaguar. Such regional approaches have the greatest hope for success (Dourojeanni, 1980).

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This paper presents a status report and conservation strategy for the jaguar in the Pantanal region, Mato Grosso do Sul, Brazil. The plan includes a proposal for reserve design and a strategy for reducing jaguar–livestock conflicts. The presentation is based on recent research on the ecology of the jaguar in the region (Quigley, 1987).

DESCRIPTION OF REGION

The Pantanal is an area of over 100000 km², situated on the frontiers of Brazil, Bolivia, and Paraguay at approximately 16° to 20° S Latitude and 55° to 58° W Longitude. The region is the largest naturally flooded land area in the world (Alho *et al.*, 1988). More than 50% of the annual rainfall of 1200 mm occurs from December through March. During this period, rivers overflow into a floodplain which slowly drains through the Paraguay River. A dry season occurs from July through November; during high-water years, however, many areas remain inundated the entire year.

The region supports a vegetation matrix largely determined by the degree of flooding. Lower areas are dominated by open habitats such as grassland and open woodland (cerrado). On slightly more elevated ground within lower areas are forest patches which flood little and vary in size from a few hectares to several square kilometers. These low areas also contain meandering streams and sloughs, normally bordered by closed forest. Riparian forest averages approximately 50 m in width, but can form large, forested blocks at the confluences of water courses or near oxbows. Semi-deciduous forest occurs on higher, non-flooding areas. Prance and Schaller (1982) present a detailed description of Pantanal vegetation.

In the past, the region was sparsely populated with indigenous peoples (Guato, Bororo, and Caudiueu groups); it now supports a population of about 250000 ethnically mixed people, living mostly in towns on the periphery of the floodplain. The dominant economic base is cattle ranching. Although farming has been attempted, flooding interferes and the soil over large portions of the Pantanal has low fertility (Sioli, 1986).

CONSERVATION PLAN

Schaller (1979) considered the jaguar already extirpated or reduced to scattered individuals in much of the Pantanal. Our observations, combined with the interviews of landowners and managers, confirmed the extant populations defined by Schaller for the region (Schaller, 1979; Quigley, 1987). Individual cats and small populations are reported locally, but, compared to other areas in the Pantanal, relatively undisturbed, intact populations exist only in the north-central and the extreme southern parts of the region (Fig. 1; Schaller, 1979; Quigley, 1987). Future development, both in and around the Pantanal, will eliminate populations. Such increased isolation of populations and habitat alteration are major influences in the local extinction of species (Salwasser *et al.*, 1983; Soulé, 1983; Samson *et al.*, 1985).

At present, the Pantanal National Park (Parque Nacional do Pantanal; 1370 km²) is the only major, officially dedicated, reserve in the Pantanal ecosystem (Fig. 1) and there is a pressing need for additional protected areas (Dourojeanni, 1980). Not only has the park's administrative effectiveness been questioned (Alho *et al.*, 1988), but its small size and extremely low percentage of dry land during the wet season offer minimal protection for jaguars. Outside of the park, most of the Pantanal is privately owned and wildlife protection on private lands in Brazil and elsewhere depends largely on the individual desires of the owner or manager. A large, more integrated system of protective measures within the Pantanal would enhance survival of the jaguar in the region. We present a three-faceted, integrated approach to jaguar conservation in the Pantanal. Rather than standing on its own, each facet is meant to be a complement to, and be augmented by, the other two.

Preservation

More than 95% of the Pantanal is privately owned. The persistence of jaguars within the two areas described above (Fig. 1) is likely to be a result of protective attitudes of private landowners towards wildlife, inaccessibility of the areas, and patterns of annual flooding which have discouraged intensive ranch management. Over the past several decades, ranches of this region have decreased in size as land was divided by family members. This trend is likely to continue, thus intensifying the need for increased access, the destruction of forests to create pasture, and attempts at water control. Conservation of the jaguar in the Pantanal will depend heavily on the

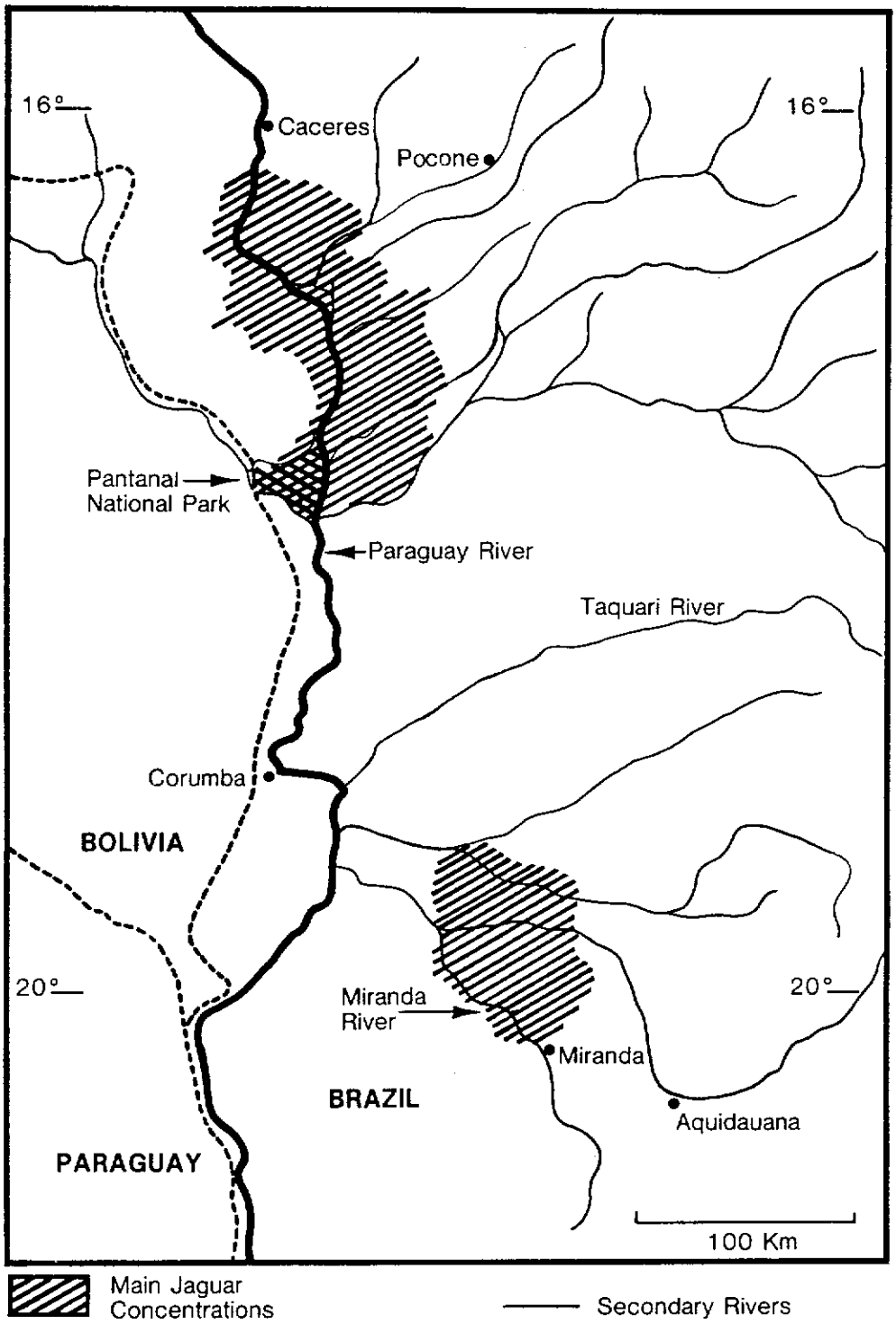

Fig. 1. Distribution of the jaguar in the Pantanal region, Mata Grosso do Sul, Brazil.

acquisition and protection of large blocks of land within each area occupied by the two large subpopulations.

A species protection plan must provide for support of enough individuals to maintain population viability and provide for the protection of an area large enough to maintain those individuals. Despite recent information on the ecology of the jaguar, insufficient data are available to allow calculation of a precise minimum viable population size (MVP) for the species (see Reed *et al.*, 1986; Soulé, 1987*a*). In the absence of species-specific information, attempts must be made to protect as large a population as is economically and politically feasible. These populations can be used as a 'starting point for assessing viability' and for making further recommendations (Salwasser *et al.*, 1983).

Inevitably, discussions of reserve size conclude that saving the largest possible area is best for the

ecosystem or species involved (e.g. Soulé & Simberloff, 1986). An effective population of 500 individuals or greater has been recommended for long-term survival (Franklin, 1980; Soulé, 1980; Salwasser *et al.*, 1983). Further analyses in population viability may result in numbers in the low thousands for long-term persistence (Soulé, 1987*b*). However, the preservation of a reserve capable of encompassing and protecting even 500 jaguars is unrealistic given the political, cultural, and economic realities in the Pantanal. The two areas still supporting relatively intact, undisturbed jaguar populations in the northern and southern Pantanal (Fig. 1) are approximately 10 000 and 5000 km². We recommend that 2000–3000 km² be acquired for protection within each of the two areas.

To estimate the number of jaguars an area will support, their natural density in the region must be known. The mean home range size in our study was 142 km² (Quigley, 1987); however, a high degree of overlap was found between individuals. Thus, only jaguars with sympatric home ranges were used to determine density. Four of the seven individuals radio-tracked during our study had overlapping home ranges. The boundary encompassing the home ranges of all four individuals was 320 km². Through the examination of fresh sign, in conjunction with the known locations of radio-collared individuals over a three-year period, we determined that at least one, and possibly two, male jaguars also used the area, but we were unable to capture and radio-collar these individuals. Using the minimum of at least one adult male resident, the density of resident adult jaguars was one per 64 km². This estimate will change with variations in jaguar densities due to local variations in prey density, habitat composition, and human exploitation (see Rabinowitz & Nottingham, 1986). However, we feel this density is generally applicable in the Pantanal region in undisturbed populations, given the similarity in vegetation, prey, and physical characteristics between our study area and the rest of the region. Furthermore, these home range estimates are taken from a dynamic situation in which individuals were followed for more than 12 months and in which some females were barren while others were in the company of offspring; at times, seasonal and annual home range estimates were much smaller than the area used for the above calculation (Quigley, 1987). Our aim in this approach was to err on the conservative side (if at all) for the sake of species conservation security. Thus, the reserve sizes recommended above would support 30 to 50 adult jaguars.

Should the above populations of 30 to 50 individuals become isolated, even short-term survival is not assured (Schonewald-Cox, 1983; Lehmkuhl, 1984; Samson *et al.*, 1985; Shaffer & Samson, 1985). Further actions, however, can moderate the effects of population isolation by integrating the proposed reserve design with existing natural features and the socioeconomics of the region.

Travel corridors

The interconnectedness of populations is a strong influence on their survival (see Noss, 1983; Gilpin, 1987). Shaffer (1987) identifies four stochastic processes which affect the extinction potential of populations: demographic uncertainty, environmental uncertainty, natural catastrophes, and genetic uncertainty. Corridors between refuges can alleviate the pressures that at least two of these factors, demographic uncertainty and genetic uncertainty, have on small populations (Simberloff & Cox, 1987; Forney & Gilpin, 1989). This seems especially true for the latter.

Although our practical knowledge of the dynamics of genetic resources in wild populations remains somewhat crude, population genetics models and computer simulations have revealed much about the potential of dispersals for conserving genetic viability. Inter-refuge dispersals conserve genetic resources (Boecklen, 1986) and reconstitute subpopulation genetic variation (Chesser, 1983), thus countering potentially debilitating effects of inbreeding and demographic stochasticity (Simberloff & Cox, 1987). As such, the genetic viability of species with discontinuous distributions is strengthened through their use of corridors between local populations (Samson *et al.*, 1985). Such a situation is preferable to genetically isolated refuges (Harris, 1984; Soulé & Simberloff, 1986), especially when isolated refuges support very small populations.

The Pantanal offers an opportune situation for establishing corridors between the two proposed refuges. Jaguars are closely associated with closed forests and permanent water sources in the Pantanal (Schaller & Crawshaw, 1980; Quigley, 1987), as they are elsewhere (Rabinowitz & Nottingham, 1986; Emmons, 1987). Our study animals used riparian forest more than expected given its availability ($n=4$, $p<0{\cdot}10$). In addition, the mean

distance radio-collared jaguars were located from permanent water sources (500 m, $n = 318$) was significantly different (t-test, $p < 0.001$) than the distance from water of randomly generated points within jaguar home ranges (1700 m, $n = 318$). The borders of major rivers in the Pantanal have received little development and riparian forests remain intact over most of the region. This river system could provide natural corridors between protected blocks of land. The enforcement of existing deforestation laws could protect these travel corridors.

The direct distance between the subpopulations in Fig. 1 is 150 km, but is greater by river corridor. Single dispersing male and female jaguars in our study established home ranges 30 km and 8 km, respectively, from their natal area (Quigley, 1987). If these represent standard dispersal distances in the Pantanal, small, intermediate pockets of resident jaguars, or 'stepping stone' islands of habitat (Harris, 1984), may promote gene flow between the two subpopulations. Simulations by Boecklen (1986) indicate an interchange rate as low as 0·03 (genetic exchange every 33 generations, or about 100 years for jaguars) can preserve heterozygosity longer in two subpopulations of 50 individuals than in a single population of 100. Periodic capture and relocation of jaguars from one subpopulation to the other is an alternative to natural dispersal. Such intervention may be the only means of maintaining large, low-density species in disjunct populations (Miller, 1979; Soulé *et al.*, 1979; Goodman, 1987).

Jaguars and livestock

Historically, direct killing has been the primary cause of jaguar losses in the Pantanal, although habitat loss has become increasingly important as economic pressures have increased. Local people usually justify jaguar killing on the basis of their cattle-killing habits. That jaguars kill cattle is not in question, but misconceptions and surrounding circumstances need clarification if the problem is to be dealt with realistically.

Schaller (1979) noted that cattle management in the Pantanal was so poor that only one cow in four or five successfully raises her calf, and many cattle were 'wholly feral'. Although feral cattle cannot be caught and cared for, even controlled cattle receive little attention. Improved husbandry and herd management would lessen losses to disease, starvation, malnutrition, and related factors, such as predation. Increased access to veterinary personnel, education of ranch managers, and the economic rewards of husbandry improvements show much promise in reducing cattle losses and jaguar problems.

Typically, cattle are moved into lower areas as flood waters recede. After the dry season, attempts are made to move them back to non-flooding ground. If wet-season rains begin early, manpower is limited, or the drive is begun too late, many cattle remain in these lower areas for the wet season. During this time, grass becomes inaccessible under water and cattle gather on small patches of forested land which quickly become devoid of accessible vegetation. Malnutrition follows, and many starve before the flood waters recede. Cattle in this weakened state are easy prey for jaguars and other predators. Mondolfi and Hoogesteijn (1986) found a similar situation in the Venezuelan Llanos region where jaguar depredation is a problem and management of cattle is 'rudimentary', thus exposing them 'to the hazards of floods, droughts, epidemic disease, parasites and malnutrition...such conditions favor predation'. Increased effort should be applied before the wet season to move cattle from lands highly susceptible to flooding.

Increased control over calving could also lessen predation losses. One-third of cattle killed by jaguars ($n = 24$) on Miranda Ranch were calves (Quigley, 1987). Since, as stated above, jaguars are closely associated with riparian forest and permanent water courses, limiting calving to areas with a high percentage of open grassland and a minimum amount of permanent water courses would likely decrease jaguar predation on cattle. Most large ranches in the Pantanal have this habitat option available to them.

Unregulated hunting and the decimation of wild game also affect jaguar predation on cattle. Hunting of native wildlife on the Miranda Ranch in Brazil was prohibited and strictly enforced; thus, much prey other than cattle was available to jaguars (Quigley, 1987). This policy, however, appears to be the exception in the Pantanal and in much of Latin America (Dourojeanni, 1980; Ojasti, 1984). On most ranches native species are severely decimated and cattle are the most abundant prey. The maintenance of other prey populations would lessen the jaguar's reliance on cattle. In most cases, when jaguar predation on cattle is discovered, trained dogs are used to hunt and kill the suspected predator.

In some instances, the selective removal of individual depredating jaguars can be a justifiable option. Since there is evidence that individual jaguars and other felids sometimes specialize on particular prey species (Brock, 1963; Kruuk, 1986; Mondolfi & Hoogesteijn, 1986; Rabinowitz, 1986), removal of targeted, cattle-killing jaguars may reduce losses. Moreover, cats develop their killing skills through exposure to prey and practice (Leyhausen, 1979). If the mother has predilection for killing cattle, her offspring may develop the same behavior. Therefore, the highest priority in a selective removal program would appear to be the depredating female jaguar.

Relocating depredating jaguars is largely untested. Rabinowitz (1986) radio-tracked two relocated jaguars known to be cattle killers and considered relocation to be of limited utility. Experimental relocation of other large cats as a remedy for depredation problems is also largely untested. Hamilton (1976) relocated two stock-killing leopards with equally discouraging results, but added that successful relocation (i.e. the animal takes up residence in or near the release area) may depend in part on the availability of openings in the territorial matrix of resident conspecifics. The relocation of a problem tiger *Panthera tigris* by Seidensticker *et al.* (1976) failed when the cat was killed by a resident tiger at the release site. Further research on relocation techniques is necessary.

Some observers have noted age or health disabilities in cattle-killing jaguars (Rabinowitz, 1986). In addition, Rabinowitz (1986) believed jaguars were reluctant to cross man-made 'boundaries' where forest patches were cut for use as grazing land. A. De Almeida (pers. comm.) describes a similar situation in Amazonia. In contrast, it seems that healthy jaguars in the Pantanal attack cattle as prey items little different from native prey (Schaller & Crawshaw, 1980; Quigley, 1987). The natural mosaic of grasslands and forests in the Pantanal could be a factor since cattle move freely between the two habitats. In parts of the Venezuelan Llanos region, which is comparable to the Pantanal in vegetation and flooding characteristics, the jaguar–cattle relationship appears to be similar to that found in the Pantanal (Mondolfi & Hoogesteijn, 1986).

Since unlimited access to forest habitats may predispose cattle to jaguar attacks, restricting their access to forested lands may reduce jaguar predation. This is especially true during calving. Thus, fencing can become a valuable tool in reducing jaguar predation. Such action will be most practical and most economically beneficial in naturally open, non-flooding high ground or in planted pasture in the Pantanal.

DISCUSSION AND CONCLUSIONS

As Barriga and Byers (1982) point out, comprehensive Latin American conservation strategies 'must consider not only a country's conservation priorities, but also its economic and cultural character'. This sentiment is echoed by a number of scientists and conservation organizations working in developing countries (IUCN, 1980). Such action can best be performed on a local or regional level. We feel our proposed conservation plan meets this goal by integrating regional conservation needs and socioeconomic considerations on two levels: the establishment of reserves and the integration of conservation into the culture and economics of cattle ranching.

A high potential for tourism exists in the Pantanal (Dourojeanni, 1980), due in part to the visibility of many species, such as caiman *Caiman crocodilus*, capybara *Hydrochaeris hydrochaeris*, and a large number of wading birds. Tourism in the region is already on the rise and is increasingly considered a viable economic alternative (Alho *et al.*, 1988). However, the Pantanal's culture and economy currently revolve around cattle ranching. Conservation of the jaguar in the Pantanal, with or without the establishment of reserves, will depend heavily on the resolution of jaguar–ranching conflicts, which to date have been poorly addressed not only in the Pantanal, but in Latin America in general (see Melquist, 1984; Rabinowitz, 1986).

Moreover, in comparison to other consumptive development options, cattle ranching may be the economic use most compatible with conservation in the Pantanal (Dourojeanni, 1980; Prance & Schaller, 1982; Alho *et al.*, 1988). Realistic predator management programs should be developed based on sound ecological information, with professionally developed and applied control methods, and public education (Berryman, 1972; Hornocker, 1972; McCabe & Kozicky, 1972; Talbot, 1976). Implementation of such programs will ensure survival of jaguars in the Pantanal and enhance the effectiveness of its reserves.

Additionally, experimentation with well-managed cattle ranching in the reserves or in buffer zones around the reserves has the potential to provide a valuable integration of conservation and economics. These approaches will offer a regional conservation program for the jaguar, and mediate conflicts which exist between its survival and the only proven economic base of the region.

Conflicts between conservation efforts for large predators and the activities of humans are not unique to jaguars. In all cases of successful program development, there was a need for governmental agency involvement and leadership; this is likely a key to success. Thus, if jaguar–ranching conflicts are to be overcome, ranching interests must be shown the success and learn by example.

Ranching in the Brazilian Pantanal, as in many regions of the world, is an economic activity which has displayed little change in the past century. Those changes which have occurred (i.e. changes in cattle breeds or pasture grasses) were introduced from within the historical ranks of the ranching community, and spread to other ranches after economic benefits were proven. In light of this, we suggest that one effective method for implementing some of the husbandry and management changes in Pantanal ranching is through example.

Many conservation-minded ranchers still exist in the Pantanal. By contract (and with help from government and non-governmental agencies and organizations working in the region), model ranching operations could be established to test and showcase the management alternatives suggested herein. The benefits, financial and otherwise, will provide incentive for other ranches to adopt these approaches. This type of experimental showcase has been used in African ranching for many years (Darling, 1960).

The conservation strategy presented herein contains implications and applications in a larger framework outside of the conservation of the jaguar.

(1) Although Brazil has performed an admirable job in dedicating lands for reserves (Padua, 1981; IUCN 1982*b*; Camara, 1983), the Pantanal is underrepresented in the park system, or presents a 'gap' (Scott *et al.*, 1987; Burley, 1988) in conservation efforts for the country. This may be a result of a simple lack of recognition, since many maps of the major global ecological types do not delineate the Pantanal as a separate entity, but incorporate it into surrounding types (e.g. Udvardy, 1975; IUCN, 1982*b*)—this despite the fact that the Pantanal is the largest seasonally flooded wetland in the world (Alho *et al.*, 1988). Although its recognition nationally has been maintained (Alcantara, 1983), the Pantanal has only recently drawn international attention (National Research Council, 1980; Schaller *et al.*, 1984; Alho *et al.*, 1988). Still, less than 3% of the Pantanal is in official reserve status (Fig. 1).

(2) A single-species protection plan centered on a large predator offers protection for large 'functioning ecosystems' (Soulé & Simberloff, 1986) because of the ecological and spatial requirements of large predators (Belovsky, 1987). This 'ecosystem approach' to conservation has worked well in conservation efforts for the tiger in India and the spin-off benefits to other species (Panwar, 1987). The Pantanal has been called the 'largest faunal concentration in the Americas, at least in the forms and numbers of individuals' (Padua & Coimbra-Filho, 1979; see also Dourojeanni, 1980). A conservation program emphasizing the jaguar, one of the lowest density vertebrates in the neotropics (Eisenberg, 1980; Schaller, 1983; Arita *et al.*, 1990), would create a 'coattail effect' (Soulé, 1985) not only securing a number of abundant species, but also many threatened and endangered species. This includes the giant otter *Pteronura brasiliensis*, the maned wolf *Chrysocyon brachyurus*, the marsh deer *Blastocerus dichotomus*, the hyacinth macaw *Anodorhynchus hyacinthus*, and the giant armadillo *Priodontes giganteus*.

Even in relatively well-protected, well-managed ecosystems, large carnivores are often obvious only by their absence (Harris, 1984). The Pantanal offers a rare chance to counter this trend through (1) the acquisition and protection of strategically located lands as they become available; (2) the enforcement of forest protection laws, especially as they affect riparian forests; and (3) the development and application of sound policies relating to jaguar–livestock conflicts.

Such an approach addresses shortcomings in land protection for the region, directs conservation efforts toward one of the most human-impacted wildlife species, and deals directly with the socioeconomic conflicts which exist between this species and man. These efforts may require international cooperative assistance due to financial and personnel limitations of the national government.

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A range-wide model of landscape connectivity and conservation for the jaguar, *Panthera onca*

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ABSTRACT

Large, wide-ranging carnivores face greater threats and more persistent declines than most other mammal species. An important conservation tool for these carnivores has been range-wide priority-setting exercises that have helped identify critical threats and key populations. However, such exercises often fail to identify functional movement corridors or account for genetic connectivity. We present a new model for jaguar (*Panthera onca*) conservation that uses a geographic information system (GIS) and expert input to create a dispersal cost surface and identify least-cost corridors connecting the 90 known populations across the jaguar's range. Results indicate 78% of historic jaguar range, an area of approximately 14.9 million km^2, still holds potential for jaguar movement and dispersal. We identified 182 potential corridors between populations, ranging from 3 to 1607 km in length; 44 of these corridors are characterized as being of immediate concern due to their limited width, and thus their high potential for being severed. Resultant maps, displaying priority populations and corridors, are used to direct field-based research and conservation efforts. Field assessment and refinement of the corridors is ongoing. This is the first attempt to create and implement such a holistic model of range-wide conservation for a large carnivore species.

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1. Introduction

Over the past century, species extinction has accelerated an estimated 1000 times more rapidly than expected background rates (Pimm et al., 1995; Millennium Ecosystem Assessment, 2005). The acknowledged causes of such extinction rates include the extensive loss of wild habitats and the deterioration of genetic diversity within increasingly small, isolated populations. Larger, wide-ranging carnivore species have historically shown periods of extensive range collapse and high extinction rates (Purvis et al., 2001) and are, at present, in persistent and continuing decline (Ginsberg, 2001).

Range-wide priority-setting exercises for large carnivores have been important tools for shifting the traditional conservation paradigm from a focus on discrete populations or geographic regions to a consideration of how aggregate populations or metapopulations contribute to the biology, conservation, and extinction potential of a species as a whole (Wikramanayake et al., 1998, 2004; Sanderson et al., 2002, 2006; Thorbjarnarson et al., 2005). Such exercises also necessitate conservation thinking beyond protected areas, in regions of heaviest carnivore mortality (Woodroffe and Ginsberg, 1998). Unfortunately, most range-wide priority-setting exercises have fallen short on addressing corridors and connectivity. Corridors can provide one of the most basic requirements for species persistence–genetic exchange. Reduction or loss of genetic exchange leads to smaller effective population sizes (Frankham, 1996), increased levels of genetic drift and inbreeding (Soulé and Mills, 1998; Young and Clarke, 2000; Stockwell et al., 2003), and potential deleterious effects on sperm production, mating ability, female fecundity, and juvenile survival (Frankham et al., 2002). Such effects eventually compromise adaptive potential (Saccheri et al., 1998; Lehmann and Perrin, 2006), reduce fitness, and contribute to extinction risk for a population and, ultimately, for the species (Frankham, 2005). Finally, corridors may increase the chances of persistence in small populations by providing opportunities for ameliorating the negative effects of demographic and environmental stochasticity (Brown and Kodric-Brown, 1977; Hilty et al., 2006).

We present an approach that moves beyond the traditional range-wide species conservation models by identifying, assessing, and implementing potential travel corridors between core populations of the jaguar (*Panthera onca*). The jaguar, a near-threatened species (IUCN, 2009) and the largest cat in the New World, historically occupied a continuous range from the southern United States to central Argentina (Swank and Teer, 1989). By the end of the 20th century, hunting for the fur trade, persecution for livestock depredation, and habitat loss caused an estimated 54% reduction in the

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historic range of the jaguar, with high levels of habitat fragmentation (Sanderson et al., 2002). Yet studies of genetic variation among jaguars using mitochondrial DNA from fecal samples showed little evidence of significant geographical partitions and barriers to gene flow range-wide (Eizirik et al., 2001; Johnson et al., 2002; Ruiz-Garcia et al., 2006). The genetic data supported earlier morphometric analyses (Larson, 1997) indicating a single taxon, counter to the division of jaguars into any of the eight subspecies accepted at the time (Pocock, 1939).

These studies highlight the fact that the jaguar has maintained relatively high levels of gene flow throughout its range in the recent past. Given this, and the demographic benefits of corridors, we recognized that identifying connectivity between jaguar breeding areas is a vital component in conservation planning for the species. This paper describes our process for indentifying potential jaguar corridors between the 90 known populations of jaguars, or Jaguar Conservation Units (JCUs), identified in earlier range-wide priority-setting exercises (Sanderson et al., 2002; Zeller, 2007).

2. Methods

We chose a least-cost functional connectivity model (Adriaensen et al., 2003; Epps et al., 2007) to analyze jaguar range for corridors. Because functional connectivity requires accounting for both landscape structure and species' responses to the landscape (Pither and Taylor, 1998), we used a grid-based model in which movement costs were assigned to each landscape element in the intervening matrix (Ray et al., 2002). We sought to quantify the potential difficulty, or ease, with which jaguars could move across any given landscape within jaguar range in a permeability matrix (Bélisle, 2005; McRae, 2006). Using such a matrix allows us to expand beyond the simple notion of habitat connectivity, where two patches are connected by a swath of similar habitat type, by quantifying different landscape features that a large carnivore such as a jaguar might use (Singleton et al., 2002). With such a landscape matrix in place, we could then perform a least-cost-corridor analysis between known jaguar populations in order to delineate potential movement corridors across the matrix.

2.1. Geographic information system (GIS) layer compilation

Using ArcGIS v9 software, we chose six GIS-based landscape characteristics considered to most affect jaguar movement and survival: land cover type, percent tree and shrub cover, elevation, distance from roads, distance from settlements, and human population density (Table 1). Land cover type, percent tree and shrub cover, and elevation are closely related to movement behavior in many large mammal species (Carroll et al., 2003; Naves et al., 2003; Dickson et al., 2005), whereas distance from roads, distance from settlements, and human population density are considered to be correlated with human persecution of jaguars, including direct mortality (Naves et al., 2003; Rabinowitz, 2005; Woodroffe et al., 2005). Layers were standardized to the same projection and resampled to a 1 km^2 grid. The roads and settlements vector layers were converted into distance grids using the Spatial Analyst Euclidean Distance function.

2.2. Creation of cost surface or permeability matrix

Least-cost path analyses and individual-based movement models for wide-ranging animals depend on an understanding of how individuals move (Dickson et al., 2005). Since scientific data on jaguar dispersal was not available, we asked 15 jaguar experts throughout jaguar range to assign cost values to the attributes of the individual landscape layers based on how costly a particular attribute would be to jaguar movement. Cost values ranged from 0 (no cost to jaguar movement) to 10 (a high cost for jaguar movement). Attributes could be assigned an N/A if the physical characteristics of that cell would prevent a jaguar from moving through it. Experts also provided a value representing the cumulative cost of all the layers beyond which a jaguar would not likely travel. We averaged the values across the jaguar's range to obtain an overall movement cost for the attributes of each landscape layer (Table 2). Movement costs were then applied to each cell of the six grids and the grids were combined into one layer by adding them in Raster Calculator. To create the final cost surface or permeability matrix, we reclassified the output from the Raster Calculator so that all the pixels whose sums were above 25 (the average cumulative score indicating a barrier to movement) represented a break in the matrix.

2.3. Corridor delineation

To determine optimal routes of travel across the permeability matrix, we used the Cost-Distance function in Spatial Analyst to create movement cost grids from each of the 90 JCUs. This tool accumulates costs as it moves away from a population, taking into account distance and direction. These cost-distance grids were used as inputs for the Corridor function in Spatial Analyst. We used the Corridor function between all proximate pairs of jaguar populations to derive least-cost corridors between these populations. To combine all overlapping corridors and display the best routes for jaguar movement, we used the minimum mosaic method and then extracted the lowest 0.1% of grid cell values. While no empirical

Table 1
Geographic data bases used for creating the jaguar permeability matrix.

Data Base	Dataset name and scale	Year of data	Source
Elevation	Global 30 arc-second elevation data set 1 km resolution	1996	Center for earth resources observation and science (EROS)
Land cover type	Global land cover 2000 1 km resolution	1999–2000	Global land cover 2000
Percent tree and shrub cover	Continuous vegetation fields 500 m resolution	2000	Global land cover facility
Population settlements	Vector map level 0 population settlements 1:1,000,000 scale	1960s–1990s	National imagery and mapping agency (NIMA)
Human population density	Gridded population of the world v3 2.5 min resolution	2000	Center for international earth science information network (CIESIN)
Roads	Vector map level 0 roads 1:1,000,000 scale	1960s–1990s	National imagery and mapping agency (NIMA)

Table 2
Classes of landscape layers and expert-determined cost values for jaguar movement. Possible values ranged from 0 (no cost to jaguar movement) to 10 (a high cost for jaguar movement). A class could also be assigned an N/A if its physical characteristics would create a barrier to jaguar movement.

Landscape Layer	Land Cover Type		Percent Tree and Shrub Cover		Human Population Density (people/km2)		Elevation (meters)		Distance from Roads (kilometers)		Distance from Settlements (kilometers)	
	Class	*Cost Value*	*Class*	*Cost Value*	*Class*	*Cost Value*	*Class*	*Cost Value*	*Class*	*Cost Value*	*Class*	*Cost Value*
	Tree Cover, broadleaved, evergreen	0	0 – 10%	9	0-20	1	0 – 1000	0	0 to 2	7	0 – 2	8
	Tree Cover, broadleaved, deciduous	0	10% - 20%	7	20-40	5	1000 – 2000	2	2 to 4	4	2 – 4	5
	Tree Cover, needle- leaved, evergreen	1	20% - 40%	5	40-80	7	2000 – 3000	7	4 to 8	2	4 – 8	4
	Tree Cover, mixed leaf Type	0	40% - 60%	2	80 - 160	9	3000 – 5000	10	80 to 160	1	8 - 16	1
	Tree Cover, regularly flooded, fresh water	2	60% - 80%	0	160-320	10	>5000	N/A	> 16	0	> 16	0
	Tree Cover, regularly flooded, saline water	2	80% - 100%	0	>320	N/A						
	Mosaic: Tree cover/other natural vegetation	1										
	Shrub Cover, evergreen	2										
	Shrub Cover, deciduous	3										
	Herbaceous Cover	5										
	Sparse herbaceous or sparse shrub cover	6										
	Regularly flooded shrub and/or herbaceous cover	5										
	Cultivated and managed areas	8										
	Mosaic: Cropland/Tree Cover/ Other natural Vegetation	5										
	Mosaic: Cropland/Shrub or grass cover	7										
	Bare areas	8										
	Water Bodies	6										
	Snow and Ice	N/A										
	Artificial surfaces and associated areas	10										

data exist on the width at which corridors fully lose their functionality, corridor width likely becomes more important as the corridor length increases. Beier (1993) suggested cougar corridors to be at least 400 m wide, while Florida panthers disperse through areas 3–7 km wide (Kautz et al., 2006). In this model, we made special demarcation of corridors less than 10 km in width at any point along their length; these were designated *corridors of concern* due their potential to be severed or become genetic bottlenecks.

2.4. Field-based corridor assessment and corridor refinement

While the least-cost corridors focus our efforts on areas with potential connections between jaguar populations, these analyses do not account for jaguar prey availability, inherent errors with GIS data, changes to the landscape since the GIS data were collected, and the error associated with subjective expert opinion of resistance values (Beier et al., 2008). Therefore, we are currently assessing the GIS-based corridors in the field. Using detailed land cover classifications developed from recent satellite imagery for areas between JCUs, we examine the landscape for habitat that may have been erroneously excluded from the least-cost corridor analysis. We then apply a grid-based data collection protocol using standardized interview techniques with local people about jaguars and prey species (Zeller et al., unpublished results) as an indirect index to create presence–absence data for an occupancy analysis (MacKenzie et al., 2002; Stanley and Royle, 2005). Only first-hand sightings of jaguars or jaguar sign by the interviewees are recorded. We check the reliability of responses using photographs of target species. We also include sightings or sign of jaguar collected by the field teams in the presence–absence data. The resultant probability of habitat use of jaguars and prey are used to identify the most functional corridors between JCUs. Where appropriate, corridor boundaries are adjusted based on these field assessment data.

3. Results

The final permeability matrix from this analysis (Fig. 1), represents areas that could potentially be used by a dispersing jaguar. The results indicate that 78% of the jaguar's historic range still allows for potential jaguar movement. The least-cost corridor analysis resulted in corridors connecting all JCUs except two, between the Sierra de las Minas JCU in southern Guatemala and the Pico Bonito/Texiguat JCU in north central Honduras. Fig. 2 portrays the 182 resultant corridors. These corridors represent areas with both the shortest distance and least dispersal cost between jaguar populations. The total area of all 90 JCU's is 1.9 million km^2 (Zeller, 2007), while the total area of the corridors connecting these JCUs is 2,562,378 km^2. For Mexico and Central America, the average corridor length between known jaguar populations is 174.42 km (range: 3–1102 km) compared to South America with an average corridor length of 489.14 km (range: 12–1607 km). Including the Guatemala/Honduras connection, the model indicates five *corridors of concern* in Central America and Mexico and 39 *corridors of concern* in South America (Fig. 2).

Of the 32 JCUs that were ranked as having the highest priority for jaguar conservation (Zeller, 2007), 17 are linked to other JCUs by *corridors of concern*. Clusters of the highest priority JCUs and *corridors of concern* are found in the extreme northern and southern parts of jaguar range as well as in Colombia, a critical link for jaguar connectivity between Central and South America (Fig. 2). These clusters point to areas where efforts would significantly contribute to a range-wide jaguar conservation strategy.

Fig. 1. Jaguar dispersal permeability matrix. The lower the value the more permeable a pixel is to jaguar movement.

4. Discussion

The negative effects of habitat loss and fragmentation, particularly on large-bodied, wide-ranging, solitary carnivores is well documented (Crooks, 2002). Conservation biology theory suggests that corridors between isolated habitat patches may maintain levels of genetic exchange through inter-population dispersal (Hanski and Ovaskainen, 2000; Mech and Hallett, 2001) and may contribute positively to demographic factors and metapopulation dynamics (Gilpin and Hanski, 1991; Hanski, 1998). While corridor cost and functionality can be questioned (Simberloff and Cox, 1987; Simberloff et al., 1992; Horskins et al., 2006), a growing body of literature supports corridors as valuable conservation tools (Beier and Noss, 1998) that can help preserve the viability of a species (Gilpin and Soulé, 1986; Noss, 1987; Lidicker and Koenig, 1996; Mech and Hallett, 2001; Coulon et al., 2004; Wikramanayake et al., 2004; Hilty et al., 2006).

Ours is the first attempt to identify and implement functional corridors throughout the entire range of a large carnivore species. In our model, we used a permeability matrix to identify potential dispersal corridors between known jaguar breeding populations. In conjunction with data from previous analyses (Sanderson et al., 2002; Zeller, 2007), our results help to prioritize not only individual jaguar populations, but corridors between populations for a truly range-wide framework for jaguar conservation and planning.

The jaguar situation is unique. While most landscape analyses detect genetic discontinuities of a species after the fact (McRae

Fig. 2. Jaguar Conservation Units, Least-Cost Jaguar Corridors and Corridors of Concern. Jaguar Conservation Units and their level of prioritization from the latest range-wide priority-setting exercise (Zeller, 2007) are displayed along with the least-cost jaguar corridors and corridors of concern from our jaguar connectivity model.

and Beier, 2007), preliminary genetic data on jaguars indicate potential linkages between jaguar populations that were not previously considered. This allows us to examine how landscape features might be allowing, rather than preventing, jaguar dispersal and movements between seemingly disparate populations.

For the jaguar, the permeability matrix can be defined by the landscape characteristics that appear to still facilitate movement and gene flow between separated populations (Harris and Scheck, 1991). With 78% of the jaguar's historic range still potentially allowing movement through the landscape, we have the opportunity to identify specific routes of travel that can be used by jaguars. While we recognize this may no longer be possible for most other large-bodied, wide-ranging carnivore species, potential dispersal pathways that can enhance effective population sizes, or create metapopulations, should always be considered in any comprehensive species conservation plan.

While scientific data on jaguar dispersal or long range movements are lacking, de Almeida (1990) cites jaguars moving 15 km or more in a single night on hunting patrols in the Brazilian Pantanal. Crawshaw and Quigley (1991) and Crawshaw (1995) documented dispersal distances of 30 and 64 km respectively for male jaguars in different areas of Brazil. One jaguar dispersed for three months, a second for eight months before being killed. Leopold (1959) speculated that a jaguar killed in California in the 1950s had traveled more than 800 km from its point of origin.

Clearly, the occasional jaguar traversing corridors ranging from 3 to 1607 km in length throughout their range is not unlikely. However, as distances between core jaguar populations increase,

relatively small patches of habitat that might not normally support even a single resident jaguar take on greater importance. Such stepping stone islands, where a jaguar might rest and/or feed, greatly increase the ability of individuals to disperse (Sondgerath and Schroder, 2001) and thus become important landscape features for possible connectivity (Harris, 1984). The identification and maintenance of these stepping stones will be an integral element in corridor conservation and planning.

The fact that many dispersing carnivores are killed once they travel outside of protected areas is balanced by the fact that very few individuals need to succeed in their trek to other populations. Mills and Allendorf (1996) suggested that populations needed at least one migrant but not above 10 migrants per generation to preserve genetic vigor. Recent data indicate that isolated jaguar populations that have shown divergent genetic patterns are eventually "rescued" by the occasional immigrant that disperses into these populations (E. Eizirik, personal communication). Computer simulations also indicate that subdivided populations typically preserve more alleles and maintain more heterozygotes over the long term than do intact populations with the same total numbers of individuals (Boecklen, 1986) – suggesting that smaller populations connected by occasional migrants may have genetic advantages. To account for demographic and environmental stochasticity and markedly increase the probability of population persistence, it was found that as few as one to four cougars per decade are needed to immigrate into a small population (~20 animals) (Beier, 1993).

An important goal of our work was to create a valid framework for practical conservation actions on the ground. The least-cost corridor model provides that framework, given a quantifiable set of limits on physical and biological features important to jaguars. The scale of the analysis, the fact that animals don't always act the way we predict, and the limitations of least-cost corridors (see McRae (2006) and Theobald (2006)), means that this model output should be regarded as a first step and not a substitute for actual field surveys. Field assessment and the incorporation of data on the actual use of a corridor by jaguars and their prey is necessary before corridor boundaries are finalized and presented to governments, local communities, and conservation planners. The field data also allow us to integrate the presence of prey species into the identification of the corridors, making these connections important not only for jaguars, but for a suite of species, thereby increasing their contribution to biological conservation throughout jaguar range.

The maps and analyses presented here represent a practical range-wide conservation strategy for the jaguar as well as a platform for regional and site-based actions for the species. We also believe that this model provides important insight for conservation planning initiatives for other species. Implementation of the jaguar corridor, including additional research and conservation in the JCUs, is ongoing and will need continuous monitoring. While the *corridors of concern* are our first priority, other factors such as manpower, politics, and funding, play a role in where, when, and how we implement the jaguar corridor. Field surveys by our teams and other scientists in Mexico, Central America, Colombia and Brazil have already indicated jaguar presence in predicted corridor areas. One recent data point of note includes the photograph of a jaguar in a corridor of concern in central Mexico where jaguars had been thought long extirpated (Monroy-Vilchis et al., 2008).

For a corridor of any significant scale to have a chance at success and sustainability, conservation practitioners must negotiate a maze of land tenure, land use, jurisdiction issues, and legal issues before deciding upon strategies and approaches. Each corridor has its own unique set of circumstances, threats, and opportunities that need to be addressed for implementation to occur. Long-term financial and political commitments are a key component of the process.

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Flávio Henrique Guimarães Rodrigues
Ísis Meri Medri
Walfrido Moraes Tomas
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Apresentação

Trata-se de obra que revisa os conhecimentos disponíveis sobre a ocorrência e distribuição de mamíferos no Pantanal. Como informações inéditas apresenta dados de densidade de grandes mamíferos que ocorrem no Pantanal, como resultado do Programa Ecológico de Longa Duração do Pantanal, PELD-Pantanal, com apoio financeiro do CNPq.

Emiko Kawakami de Resende
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Revisão do conhecimento sobre ocorrência e distribuição de Mamíferos do Pantanal

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Ísis M. Medri
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Resumo

O Pantanal é reconhecido como um importante refúgio da fauna silvestre. Entretanto, apesar de alguns inventários já terem sido realizados no Pantanal, sua fauna de mamíferos ainda é mal conhecida. Apesar de em geral ainda estar bem conservado, o Pantanal já sofre impactos ambientais visíveis, como mudanças no pulso de enchentes, causadas por assoreamento e/ou represamento de rios, e remoção da vegetação arbórea. Estes impactos podem ameaçar a fauna silvestre, e pesquisadores e conservacionistas se preocupam em identificar organismos indicadores da "saúde" deste bioma. Os mamíferos carnívoros são considerados bons indicadores biológicos, pois são predadores de topo e com isso dependem de toda a estrutura de presas e seus ambientes, em bom estado de conservação. Além disso, os carnívoros podem funcionar como reguladores das populações de presas, com fortes implicações nas comunidades de plantas. Os mamíferos do grupo Xenarthra também funcionam como bons indicadores biológicos, já que neste grupo encontram-se animais ameaçados de extinção e altamente especializados, como o tamanduá-bandeira e o tatu-canastra. Apesar de o Pantanal possuir uma alta abundância de espécies de mamíferos, o mapeamento de ocorrência destas espécies é insatisfatório, sendo necessário o acesso a informações secundárias e a aquisição de dados primários, geo-referenciados, da ocorrência das espécies. O aumento e a disponibilização de conhecimento sobre a biologia e distribuição das espécies de mamíferos do Pantanal pode permitir a elaboração de estratégias gerais para a conservação destas espécies.

Introdução

Apesar de alguns inventários já terem sido realizados no Pantanal (p. ex. Schaller 1983, Alho *et al*. 1988), sua fauna de mamíferos ainda é mal conhecida, principalmente no que se refere aos animais de pequeno porte, como roedores, marsupiais e morcegos. Porém, mesmo entre animais de maior porte, a ocorrência ou distribuição de algumas espécies é ainda incerta. Em 1997, o Plano de Conservação da Bacia do Alto Paraguai – PCBAP (Coutinho *et al*. 1997) foi produzido com o intuito de compilar a informação então disponível, fazer um diagnóstico da situação de conservação da região e identificar estratégias de desenvolvimento e conservação de seus recursos naturais. O PCBAP (Coutinho *et al*. 1997) fornece a listagem mais completa já publicada dos mamíferos que ocorrem na bacia do alto rio Paraguai, sendo uma referência para a região do Pantanal. Ainda assim, o PCBAP é inadequado para uma análise mais compreensiva da fauna do Pantanal. Uma das dificuldades se refere à adoção da classificação de Brown Jr. (1986), que divide a região em categorias muito abrangentes, dificultando a identificação de padrões de ocorrência de espécies. Além disso, esta classificação não é freqüentemente adotada em trabalhos sobre a ecologia do Pantanal, em oposição a outras mais amplamente aceitas (p. ex. Adámoli 1982, Hamilton *et al*. 1996, Silva & Abdon 1998). A segunda dificuldade é que a fonte primária de boa parte da informação veiculada no PCBAP não é identificada com clareza, dando margem a dúvidas e desinformação. Falta também ao PCBAP uma análise mais aprofundada sobre os padrões de distribuição de espécies da fauna do Pantanal e identificação de lacunas.

Durante o Workshop Ações Prioritárias para a Conservação do Cerrado e Pantanal, realizado em Brasília, em fevereiro de 1998, a lista de espécies de mamíferos do Pantanal foi revista e ampliada, porém o resultado desta compilação de dados não foi publicado no relatório final do Workshop (MMA 1999) e ainda é inacessível.

As classificações mais utilizadas do Pantanal, como as de Adámoli (1982) e a de Hamilton *et al*. (1996), que dividem a região em diferentes sub-áreas de acordo com características hidrológicas, fitofisiográficas e edáficas, podem significar um avanço em relação às divisões usadas por Brown Jr. e pelo PCBAP (Coutinho *et al*. 1997), mas possivelmente ainda são muito amplas para determinar a distribuição de espécies na região. Para chegarmos a uma visão compreensiva da zoogeografia do Pantanal, serão necessários mapas detalhados com pontos de ocorrência e, quando possível, referenciando a abundância de espécies em cada área. Este trabalho deve ser feito não só compilando as informações disponíveis,

mas também adquirindo dados primários em campo, uma vez que a maior parte do Pantanal não foi inventariada.

Levantamentos e mapeamentos populacionais em grande escala estão disponíveis para algumas espécies de mamíferos silvestres, como para veado-campeiro, *Ozotoceros bezoarticus* (Coutinho *et al*. 1997, Mourão *et al*. 2000); cervo-do-pantanal, *Blastocerus dichotomus* (Schaller & Vasconcelos 1978a, Coutinho *et al*. 1997, Mauro *et al*. 1998, Mourão *et al*. 2000); capivaras, *Hydrochaeris hydrochaeris* (Coutinho *et al*. 1997, Mourão *et al*. 2000) e tamanduá-bandeira, *Myrmecophaga tridactyla* (Coutinho *et al.* 1997). Além disso, há estimativas populacionais em escala espacial mais restrita, porém para poucas localidades (Schaller 1983, Alho *et al*. 1988, Tomas *et al*. 2001 a,b). O monitoramento a longo prazo destas populações será importante para identificar tendências de alteração no tamanho das populações e com isso traçar estratégias para conservação da fauna do Pantanal.

Os objetivos deste trabalho foram compilar a informação disponível sobre a fauna do Pantanal, avaliar o atual status de conhecimento sobre os mamíferos do Pantanal e identificar as principais lacunas do conhecimento em relação à fauna silvestre e sua conservação.

A Fauna do Pantanal: Distribuição, Riqueza e Abundância

Riqueza de Espécies e Relações com Outros Biomas

Segundo o PCBAP (Coutinho *et al.* 1997) apenas 89 espécies de mamíferos ocorrem na planície do Pantanal. Este número representa menos da metade das espécies relacionadas para o bioma Cerrado (p. ex. Marinho-Filho *et al*. 2002, 194 espécies). Este valor baixo pode refletir a deficiência de inventários na maior parte do Pantanal, e um inventário mais completo provavelmente elevará consideravelmente o número de espécies arroladas para a região. Entretanto, muitos biólogos concordam que o Cerrado seja um bioma mais rico em espécies do que o Pantanal, embora os estudos disponíveis ainda sejam insuficientes para se tirar conclusões definitivas. Isso poderia ser explicado pela maior área (maior diversidade de situações climáticas, relevo, contato com outros biomas, etc). No Pantanal, em duas localidades de 137 e 43 km^2 foram anotadas 43 e 33 espécies de mamíferos não-voadores (Schaller 1983, Alho *et al*. 1988), respectivamente, enquanto que em áreas de Cerrado variando de 104 a 1407 km^2, a riqueza variou entre 50 e 68 espécies (Rodrigues *et al*. 2002, Schneider 2000, Schneider *et al*. 2000, Marinho-Filho *et al*. 1998). Considerando também os mamíferos voadores, algumas localidades de Cerrado têm número de espécies similar ao registrado para a planície do Pantanal como um todo:

Parque Nacional das Emas, 85 espécies (Rodrigues *et al*. 2002); Hidrelétrica do Rio Manso, 93 espécies (Schneider 2000).

Por outro lado, o Pantanal abriga algumas espécies em densidades superiores às normalmente encontradas no Cerrado. A densidade de veados-campeiros, por exemplo, é muito maior em algumas áreas do Pantanal. Pelas características ambientais do Pantanal, há regiões mais e menos propícias à ocorrência desta espécie. Porém, para o Pantanal como um todo a densidade de indivíduos chega a 1,67 ± 0,85 indivíduos/km^2 e a de grupos a 0,25 grupos/km^2 (Mourão *et al*. 2000), podendo atingir, em áreas mais favoráveis, entre 5,53 e 9,81 indivíduos/km^2 (Tomas *et al*. 2001a). No Cerrado do Parque Nacional das Emas, GO, um dos sítios, dentro do bioma Cerrado, mais favoráveis à ocorrência desta espécie e onde são visualizados com facilidade, a densidade encontrada é de aproximadamente 1,00 indivíduo/km^2 ou 0,44 grupos/km^2 (Rodrigues 1996). O mesmo padrão pode ser observado para populações de outras espécies de mamíferos, como capivaras, quatis, porcos-do-mato e cervos-do-pantanal, e mesmo de outros vertebrados, como jacarés, aves Ciconiiformes etc. Brown Jr. (1986) ressalta esta característica do Pantanal, de extrema abundância de algumas espécies, mas com baixo grau de espécies endêmicas ou especialistas. Assim, o Pantanal serve como criadouro para espécies de distribuição ampla, mas a diversidade não é notadamente alta (Brown Jr. 1986) e, em geral, as espécies que ocorrem no Pantanal são características dos biomas adjacentes: Cerrado, Chaco e Amazônia (Tabela 1).

O Cerrado é o bioma que mais compartilha espécies de fauna com o Pantanal, tanto em relação à planície, quanto em relação às áreas do entorno (Fig.s 1, 2 e 3). A maior parte das espécies da BAP (59%) ocorrem nos três biomas vizinhos, 11% ocorrem no Cerrado e Chaco mas não na Amazônia, igual número habita o Cerrado e a Amazônia, mas não o Chaco e apenas 2 espécies (1,6%) ocorrem no Chaco e Amazônia, mas não no Cerrado (Tabela 1). Algumas das espécies de mamíferos que ocorrem no Pantanal ocorrem em apenas um dos biomas vizinhos (2,3% no Cerrado, 3,9% no Chaco e 9,3% na Amazônia) e para apenas 3 espécies (2,3%) não encontramos registros de ocorrência em outros biomas adjacentes (Tabela 1). Porém, esta análise é ainda preliminar e terá que ser mais detalhada. Da mesma forma, a lista de espécies precisará ser revisada, para eliminar incongruências de sinonímias e atualização dos epítetos.

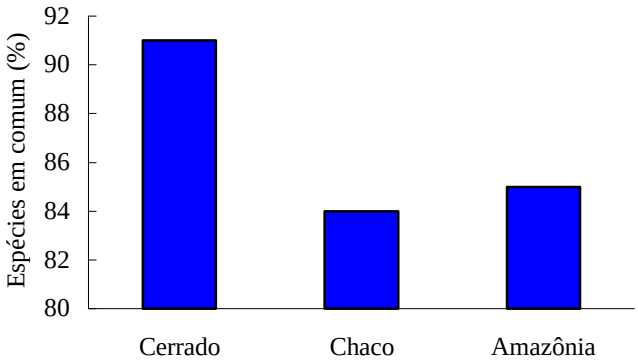

Fig. 1. Proporção de espécies de mamíferos do Cerrado, Chaco e Amazônia em comum com as espécies da planície do Pantanal.

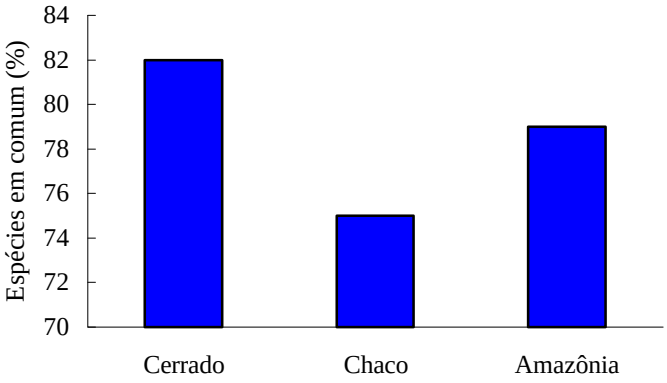

Fig. 2. Proporção de espécies de mamíferos do Cerrado, Chaco e Amazônia em comum com as espécies da área de entorno do Pantanal.

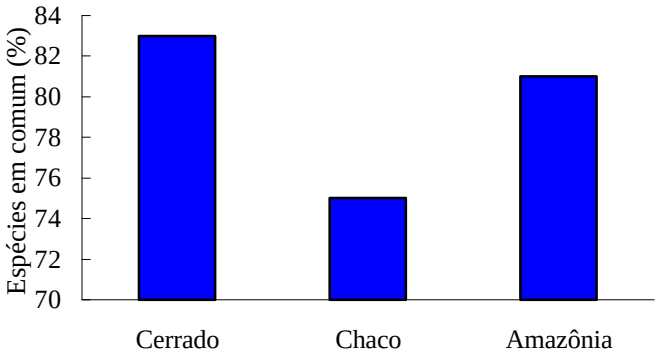

Fig. 3. Proporção de espécies de mamíferos do Cerrado, Chaco e Amazônia em comum com as espécies da Bacia do Alto Paraguai.

Tabela 1. Lista comparativa da fauna do Pantanal com a dos três biomas adjacentes.

Família Espécie	**Nome Comum**	**Pantanal**				
		Planície	**Entorno**	**Cerrado**	**Chaco**	**Amazônia**
Didelphidae						
Caluromys lanatus	cuica lanosa	x	x	x	x	x
Caluromys philander	mucura chichica		x	x		x
Chironectes minimus	cuica d'água		x	x		x
Didelphis albiventris	gambá de orelha branca	x	x	x	x	x
Didelphis marsupialis	gambá de orelha preta		x	x	x	x
Gracilinanus agilis	catita	x	x	x	x	x
Micoureus cinereus	catita cinzenta	x		x	x	x
Micoureus constantiae	catita pálida		x		x	x
Marmosa murina	gambazinha	x	x	x		x
Thylamys pusilla	catita anã de rabo gordo		x	x	x	
Marmosops noctivagus	catita noturna		x			x
Metachirus nudicaudatus	cuica rabo de rato		x	x	x	x
Monodelphis domestica	rato cachorro	x	x	x	x	x
Monodelphis brevicaudata	catita					x
Philander opossum	jupati	x	x	x	x	x
Myrmecophagidae						
Myrmecophaga tridactyla	tamanduá-bandeira	x	x	x	x	x
Tamandua tetradactyla	tamanduá-mirim	x	x	x	x	x
Dasypodidae						
Cabassous unicinctus	tatu de rabo mole pequeno		x	x	x	x
Dasypus kappleri	tatu de quinze quilos		x	x		x
Dasypus novencinctus	tatu-galinha	x	x	x	x	x
Dasypus septencinctus	tatu-mirim		x	x	x	x
Euphractus sexcinctus	tatu-peba	x	x	x	x	x
Priodontes maximus	tatu-canastra	x	x	x	x	x
Tolypeutes matacus	tatu-bola	x	x	x	x	
Emballuronidae						
Centronycteris maximiliani	morcego	x		x		x

Família Espécie	**Nome Comum**	**Pantanal**				
		Planície	**Entorno**	**Cerrado**	**Chaco**	**Amazônia**
Peropteryx macrotis	morcego	x	x	x	x	x
Rhynchonycteris naso	morcego	x		x	x	x
Saccopteryx bilineata	morcego	x		x	x	x
Noctilionidae						
Noctiolio albiventris	morcego pescador pequeno	x	x	x	x	x
Noctilio leporinus	morcego pescador grande	x	x	x	x	x
Mormoopidae						
Pteronotus davyi	morcego		x			x
Phyllostomidae						
Anoura geoffroyi	morcego		x	x	x	x
Anoura caudifer	morcego			x	x	x
Artibeus lituratus	falso vampiro grande	x	x	x	x	x
Artibeus planirostris	falso vampiro grande	x	x	x	x	x
Artibeus cinereus	morcego			x	x	x
Artibeus jamaicensis	morcego	x		x	x	x
Carollia perspicillata	morcego	x	x	x	x	x
Carollia brevicauda	morcego			x		x
Choeroniscus sp.	morcego					x
Chiroderma villosum	morcego de olhos grandes	x		x	x	x
Chiroderma trinitatum	morcego			x		x
Desmodus rotundus	morcego vampiro verdadeiro	x		x	x	x
Diaemus youngi	morcego vampiro de asa branca	x	x	x	x	x
Diphila ecaudata	morcego vampiro	x		x	x	x
Glossophaga soricina	morcego de língua comprida	x	x	x	x	x
Micronycteris cf. behni	morcego	x	x	x		x
Micronycteris minuta	morcego	x		x	x	x
Micronycteris megalotis	morcego		x	x		x
Mimon benneti	morcego nariz de lança	x	x	x		x

Família Espécie	**Nome Comum**	**Pantanal**				
		Planície	**Entorno**	**Cerrado**	**Chaco**	**Amazônia**
Platyrrhinus helleri	morcego			x	x	x
Platyrrhinus lineatus	morcego	x	x	x	x	x
Phyllostomus hastatus	morcego	x	x	x	x	x
Phyllostomus discolor	morcego			x	x	x
Rhinophylla pulmilio	morcego			x		x
Sturnira lilium	falso vampiro flor de lis	x	x	x	x	x
Tonatia bidens	morcego	x	x	x	x	x
Tonatia silvicola	morcego	x	x	x	x	x
Uroderma bilobatum	morcego	x	x	x	x	x
Uroderma magnirostrum	morcego			x	x	x
Vampyrum spectrum	morcego	x	x			x
Vespertilionidae						
Eptesicus furinalis	morcego	x		x	x	x
Histiotus velatus	morcego		x	x	x	x
Myotis nigricans	morcego	x	x	x	x	x
Myotis albescens	morcego	x		x	x	x
Molossidae						
Eumops perotis	morcego	x		x	x	x
Eumops auripendulus	morcego	x		x	x	x
Molossops mattogrossensis	morcego			x		x
Molossops planirostris	morcego	x		x	x	x
Molossops temminckii	morcego	x		x	x	x
Molossus ater	morcego	x		x	x	x
Molossus molossus	morcego	x		x	x	x
Nyctinomops cf. laticaudatus	morcego	x	x	x	x	x
Promops cf. nasutus	morcego	x		x	x	x
Callithricidae						
Callithrix argentata (melanura)	sauin	x	x	x	x	x

Família Espécie	**Nome Comum**	**Pantanal**				
		Planície	**Entorno**	**Cerrado**	**Chaco**	**Amazônia**
Cebidae						
Alouatta caraya	bugio preto	x	x	x	x	
Aotus azarae	macaco-da-noite	x	x		x	x
Ateles paniscus	coatá preto		x			x
Callicebus donacophilus	guigó		x			x
Cebus apella	macaco-prego	x	x	x	x	x
Canidae						
Chrysocyon brachyurus	lobo-guará	x	x	x	x	
Atelocynus microtis	cachorro do mato de orelhas curtas		x			x
Cerdocyon thous	lobinho	x	x	x	x	x
Pseudalopex vetulus	raposinha	x	x	x		
Speothos venaticus	cachorro do mato vinagre	x	x	x	x	x
Procyonidae						
Nasua nasua	coati	x	x	x	x	x
Potos flavus	jupará		x	x	x	x
Procyon cancrivorus	mão-pelada	x	x	x	x	x
Mustelidae						
Conepatus sp.	jaritataca	x	x	x	x	x
Eira barbara	irara	x	x	x	x	x
Galictis vittata	furão	x	x	x		x
Lontra longicaudis	lontra	x	x	x	x	x
Pteronura brasiliensis	ariranha	x	x	x	x	x
Felidae						
Oncifelis colocolo	gato palheiro	x	x	x	x	
Puma concolor	onça-parda	x	x	x	x	x
Oncifelis geoffroyi	gato do mato grande		x		x	
Leopardus pardalis	jaguatirica	x	x	x	x	x
Leopardus tigrinus	gato do mato pequeno	x	x	x	x	x
Leopardus wiedii	gato maracajá		x	x	x	x

Família Espécie	**Nome Comum**	**Pantanal**				
		Planície	**Entorno**	**Cerrado**	**Chaco**	**Amazônia**
Herpailurus yagouaroundi	gato mourisco	x	x	x	x	x
Panthera onca	onça-pintada	x	x	x		x
Tapiridae						
Tapirus terrestris	anta	x	x	x	x	x
Tayassuidae						
Tayassu pecari	queixada	x	x	x	x	x
Pecari tajacu	cateto	x	x	x	x	x
Cervidae						
Blastocerus dichotomus	cervo-do-pantanal	x	x	x	x	x
Mazama americana	veado-mateiro	x	x	x	x	x
Mazama goazoubira	veado-birá	x	x	x	x	x
Ozotoceros bezoarticus	veado-campeiro	x	x	x	x	
Sciuridae						
Sciurus aestuans	caxinganga da poaia		x	x	x	x
Sciurus spadiceus	caxinganga vermelho	x	x			x
Muridae						
Akodon cursor	rato-do-mato		x	x		x
Akodon varius	rato-do-mato	x	x		x	
Akodon toba	rato-do-mato		x		x	
Bolomys lasiurus	rato-do-mato	x	x	x	x	x
Bolomys lenguarum	rato-do-mato		x		x	
Calomys callosus	rato-do-mato	x	x	x	x	
Holochilus brasiliensis	rato-do-mato	x		x	x	
Kunsia tomentosus	rato-do-mato		x	x	x	
Neacomys spinosus	rato-espinhoso		x			x
Nectomys squamipes	rato d'água		x	x	x	x
Oryzomys megacephalus (capito)	rato-do-mato		x	x		x
Oecomys bicolor	rato-do-mato			x	x	x
Oecomys roberti	rato-do-mato					x
Oecomys concolor	rato-do-mato	x	x	x		x

Família Espécie	**Nome Comum**	**Pantanal**				
		Planície	**Entorno**	**Cerrado**	**Chaco**	**Amazônia**
Oligoryzomys fornesi	rato-do-mato	x				
Oligoryzomys eliurus	rato-do-mato		x	x	x	
Oligoryzomys nigripes	rato-do-mato			x	x	
Oryzomys subflavus	rato-do-mato		x	x	x	
Oryzomys delicatus	rato-do-mato	x				
Oryzomys utiaritensis	rato-do-mato		x			
Oryzomys capito	rato-do-mato			x		x
Oxymycterus roberti	rato-do-mato			x		
Pseudoryzomys simplex	rato-do-mato			x	x	
Rhipidomys mastacalis	rato trepador		x	x		x
Erethizontidae						
Coendou prehensilis	ouriço	x	x	x	x	x
Caviidae						
Galea musteloides	preá	x	x		x	
Cavia aperea	preá			x	x	
Hydrochaeridae						
Hydrochaeris hydrochaeris	capivara	x	x	x	x	x
Agoutidae						
Agouti paca	paca	x	x	x	x	x
Dasyproctidae						
Dasyprocta azarae	cutia de azara		x	x	x	
Dasyprocta punctata	cutia	x				x
Ctenomyidae						
Ctenomys cf. nattereri	tuco tuco de natterer		x			
Echimyidae						
Carterodon sulcidens	rato-do-mato		x	x		
Clyomys laticeps	rato espinhoso cavador	x	x	x	x	
Isothryx bistriatus	rato arbóreo espinhoso		x			x

Família Espécie	**Nome Comum**	**Pantanal**				
		Planície	**Entorno**	**Cerrado**	**Chaco**	**Amazônia**
Makalata armata	rato arbóreo de nariz		x			x
Proechimys guyannensis	sauiá		x			x
Proechimys longicaudatus	sauiá		x	x	x	x
Trichomys apereoides	sauiá	x	x	x	x	
Leporidae						
Sylvilagus brasiliensis	candimba	x	x	x	x	x
TOTAL		93	110	124	109	121

FONTES: Auricchio (1995); Eisenberg e Redford (1999); Emmons & Feer (1990); Marinho-Filho *et al*. (2002); Oliveira e Cassaro (1999); Coutinho *et al.* (1997); Rodrigues *et al*. (2002); Schaller (1983); Stallings *et al*. (1989) e Willig *et al*. (2000).

Distribuição e ocorrência de mamíferos no Pantanal: Conhecimento sobre as espécies de alguns grupos

Com o objetivo de traçar a distribuição conhecida dos mamíferos do Pantanal, faremos uma compilação das informações disponíveis na literatura, acrescidos de dados não publicados. Neste trabalho abordaremos os resultados preliminares obtidos para quatro ordens de mamíferos: Xenarthra, Primates, Carnivora e Artiodactyla (abordando somente a família Cervidae).

Xenarthra (Edentata)

Myrmecophagidae

Myrmecophaga tridactyla (tamanduá-bandeira): é a maior das quatro espécies de tamanduás existentes e ocorre tanto na planície, como nas áreas de entorno. Há registros na Chapada dos Guimarães (Cope 1889), na hidrelétrica do rio Manso (Schneider 2000) e na Serra do Amolar (Schaller 1983). Na planície, já foi citada

para a área da RPPN SESC-Pantanal entre os rios São Lourenço e Cuiabá (Travassos *et al*. 1927; J. C. Dalponte, com. pessoal), a sub-região da Nhecolândia, no Campo Experimental de Nhumirim e proximidades (Alho *et al*. 1988, Medri 2002) e Fazenda Rio Negro (G. Mourão & Í. M. Medri, obs. pessoal), e na região do chaco (Coutinho *et al.* 1997). Apesar da ampla distribuição, em todo o território nacional, são poucas as áreas onde é possível observar tamanduás-bandeira com freqüência. Dados de levantamentos aéreos no Pantanal indicam que os tamanduás-bandeira foram avistados quase sempre em baixa densidade (0,035 indivíduos/km^2) e foi estimado um índice de abundância de cerca de 5 mil tamanduás-bandeira em todo o Pantanal (Coutinho *et al.* 1997). O monitoramento de tamanduás-bandeira, em 2001, registrou áreas de vida de 4 a 19 km^2 no Pantanal da Nhecolândia (Medri 2002; Mourão & Medri 2002), valores maiores do que os encontrados por Shaw *et al*. (1987) para os tamanduás-bandeira da Serra da Canastra (MG), sugerindo que as áreas necessárias para a conservação de populações viáveis desta espécie no Pantanal, devem ser muito maiores do que se acreditava até então.

Tamandua tetradactyla (tamanduá-mirim): segundo o PCBAP (Coutinho *et al.* 1997), esta espécie ocorre tanto na planície quanto na área de entorno do Pantanal, abrangendo regiões de chaco e de cerrado. Há registros de ocorrência de tamanduás-mirim na região da hidrelétrica do rio Manso (Schneider 2000), na Chapada dos Guimarães (Cope 1889), na Serra do Amolar (Schaller 1983) e no Pantanal da Nhecolândia, nas Fazendas Nhumirim (Alho *et al*. 1988) e Rio Negro (G. Mourão & Í. M. Medri, obs. pessoal).

Dasypodidae

Cabassous unicinctus (tatu-de-rabo-mole-pequeno): é uma das maiores espécies do gênero, considerado raro na planície inundável do Pantanal e comum nas áreas de entorno, como no Alto Rio Paraguai, na região da hidrelétrica do rio Manso (Schneider 2000), Chapada dos Guimarães (Cope 1889), região de Cuiabá e proximidades, em Coxim, e na região chaquenha de Corumbá e suas proximidades (Coutinho *et al.* 1997).

Dasypus kappleri (tatu-de-quinze-quilos): é uma espécie considerada ameaçada na Bacia do Alto Paraguai (Coutinho *et al.* 1997). Não há registros da espécie na planície do Pantanal. Tem ocorrência rara nas áreas de Tapirapoan e outras localidades na escarpa sul da Serra de Parecis, Alto do rio Paraguai, Chapada dos Guimarães e vizinhanças (Coutinho *et al.* 1997).

Dasypus novemcinctus (tatu-galinha): é comum tanto na região de planície inundável do Pantanal, como nas suas áreas de entorno, sendo assinalado na

região da hidrelétrica do rio Manso (Schneider 2000), Alto rio Paraguai, Cuiabá e proximidades, Chapada dos Guimarães (Cope 1889), Coxim até Rondonópolis, Porto Murtinho, Bodoquena, Campo Grande e proximidades (Coutinho *et al.* 1997), e na Serra do Amolar (Schaller 1983). Há registro confirmado na Fazenda Nhumirim (Alho *et al*. 1988) e na Fazenda Rio Negro (W. M. Tomas, registro de pegada em gesso).

Dasypus septemcinctus (tatu-mirim): é considerado espécie rara, com registro de ocorrência apenas nas regiões da hidrelétrica do rio Manso (Schneider 2000), Alto rio Paraguai, Chapada dos Guimarães (Cope 1889) e vizinhança, Cuiabá e proximidades, sem ocorrência registrada na planície inundável do Pantanal (Coutinho *et al.* 1997).

Euphractus sexcinctus (tatu-peba): é comum tanto na planície inundável como nas áreas de entorno do Pantanal (Coutinho *et al.* 1997). Na área de entorno, tem registro de ocorrência na região da hidrelétrica do rio Manso (Schneider 2000), na Serra do Amolar (Schaller 1983), e na Chapada dos Guimarães (Cope 1889). Na planície, há registros para o Campo Experimental de Nhumirim (Alho *et al*. 1988) e Fazenda Rio Negro (W. M. Tomas, não publicado - registro fotográfico).

Priodontes maximus (tatu-canastra): esta espécie rara é o maior tatu existente. Tem ocorrência registrada no Alto do rio Paraguai, na região da hidrelétrica do rio Manso (Schneider 2000), na Serra do Amolar (Schaller 1983) e na Chapada dos Guimarães (Cope 1889). Na planície do Pantanal, ocorre no Campo Experimental de Nhumirim (Alho *et al*. 1988; Í. M. Medri, não publicado - registro fotográfico) e na região chaquenha de Corumbá (MS) e suas vizinhanças (Coutinho *et al.* 1997), e na Bacia do Rio Negro (W. M. Tomas, com. pessoal).

Tolypeutes matacus (tatu-bola): esta espécie está ameaçada na Bacia do Alto Paraguai (Coutinho *et al.* 1997), e tem ocorrência no setor norte da planície inundável do Pantanal como a região de Poconé, Serra do Amolar (Schaller 1983) e outras localidades como a Fazenda Descalvados no sul de Mato Grosso (Sanborn 1930). No setor sul da planície inundável, a espécie ocorre nas regiões da Nhecolândia, com registro confirmado na Fazenda Nhumirim (Alho *et al*. 1988), Miranda e Rio Negro (Coutinho *et al.* 1997).

Primates

As espécies conhecidas como ocorrentes na planície do Pantanal não possuem distribuição uniforme. Em vastas áreas, apenas uma espécie tem sido registrada (*Alouatta caraya*), notadamente em regiões com predomínio de cerrado, como na Nhecolândia, no Paiaguás, porção norte de Poconé e algumas áreas de Barão de Melgaço; *Cebus apella* parece estar relacionado com cerradões e matas semidecíduas mais extensas e com pouca descontinuidade, como na região centro-sul de Poconé, Barão de Melgaço e Cáceres, além de certas áreas das regiões de Miranda e Aquidauana; a distribuição de *Callithrix argentata melanura* também não é contínua, mas pouca informação existe sobre a espécie na planície do Pantanal. *Aotus azarae* tem sido registrado em áreas restritas da planície, aparentemente confinado em áreas limítrofes a regiões montanhosas onde a espécie é comum, como na região de Corumbá (W. M. Tomas, não publicado). Há um registro para área da baía Negra, contígua ao maciço do Urucum (Í. M. Medri, com. pessoal). Dados coletados por Lima Borges & Tomas (2000) indicam que *Alouatta* é mais flexível, ocorrendo em áreas onde as matas de galeria dos rios Aquidauana e Miranda apresentam-se descontínuas ou em forma de capões, enquanto *Cebus* se restringiu a áreas de matas de galeria contínuas.

Carnivora

Canidae

Atelocynus microtis (cachorro-do-mato-de-orelha-curta): Emmons & Feer (1990) consideram o Pantanal (inclusive a planície pantaneira) como parte da distribuição deste canídeo embora, outros autores não relacionam esta espécie para o Pantanal (Eisenberg & Redford 1999, Schaller 1983, Alho *et al*. 1988). O cachorro-do-mato-de-orelha-curta, no entanto, é relatado para a bacia do alto Paraguai (Coutinho *et al.* 1997). A espécie é muito pouco conhecida e há necessidade de mais dados para confirmar ou refutar sua ocorrência no Pantanal.

Cerdocyon thous (lobinho): amplamente distribuído no Brasil e no Pantanal, tanto na planície quanto na área de entorno, na bacia do Alto Paraguai (Coutinho *et al.* 1997). É o canídeo silvestre mais comum do Pantanal.

Chrysocyon brachyurus (lobo-guará): espécie típica do Cerrado, comum nas áreas altas da bacia do Alto Paraguai, mas é raro na planície pantaneira (Coutinho *et al.* 1997). Ocorre na planície principalmente na parte norte (Coutinho *et al.* 1997), sendo raro ou ausente da maior parte das regiões ao sul. Antigos moradores

relatam que durante anos de seca aguda do Pantanal, entre 1963 e 1973, o lobo-guará era comum na região Centro-sul do Pantanal, retraindo sua distribuição nos anos seguintes, quando o Pantanal voltou a encher.

Speothos venaticus (cachorro-vinagre): espécie rara, mas com alguns pontos de ocorrência na região do Pantanal, tanto nas regiões altas da bacia do Paraguai, Chapada dos Guimarães (Thomas 1903 *apud* Coutinho *et al.* 1997) e região da hidrelétrica do rio Manso (Schneider 2000), quanto na planície, com ocorrência confirmada na RPPN SESC-Pantanal (J. C. Dalponte & W. M. Tomas, com. pessoal), na Fazenda Nhumirim (Alho *et al*. 1988), na Fazenda Rio Negro (W. M. Tomas, não publicado - registro de pegada em gesso), na Fazenda Bodoquena (animal encontrado atropelado e coletado por H. Herrera e R. P. Herrera e depositado na coleção de referência da Embrapa Pantanal), e na região oeste de Paiaguás (W. M. Tomas, com. pessoal).

Pseudalopex vetulus (raposa-do-campo): é comum na região da bacia do Alto Paraguai, mas rara na planície (Coutinho *et al.* 1997), onde possui registros apenas na sub-região da Nhecolândia nas Fazendas Nhumirim (F. H. G. Rodrigues, obs. pessoal; L. Silveira, não publicado - registro fotográfico; J. C. Dalponte, com. pessoal) e Rio Negro (F. H. G. Rodrigues, obs. pessoal).

Procyonidae

Nasua nasua (coati): espécie de ampla distribuição pelo território brasileiro sendo muito comum tanto na planície quanto nas áreas altas da bacia do Paraguai (Coutinho *et al.* 1997).

Procyon cancrivorus (mão-pelada)*:* embora menos comum que o coati, também é amplamente distribuído tanto na planície quanto nas áreas de entorno (Coutinho *et al.* 1997).

Potos flavus (jupará): ocorre nas áreas altas da bacia do Paraguai, não tendo registros para a planície (Coutinho *et al.* 1997). Segundo o PCBAP (Coutinho *et al.* 1997) é comum em áreas externas à planície, existindo registros para a região da Chapada dos Guimarães (Cope 1889; Schneider 2000).

Mustelidae

Conepatus sp. (jaritataca): não há registros publicados da espécie no Pantanal ou nas áreas de entorno, entretanto um dos autores deste trabalho já observou a ocorrência da espécie no Pantanal da Nhecolândia (W. M. Tomas).

Eira barbara (irara): na hidrelétrica do rio Manso (Schneider 2000) e na Serra do Amolar (Schaller 1983). É comum tanto na planície quanto na área de entorno do Pantanal. Há registros de ocorrência da espécie na região de Tapirapoan e outras localidades na escarpa sul da Serra do Parecis, na região do Alto rio Paraguai, em Cuiabá e proximidades, na Chapada dos Guimarães (Thomas 1903 *apud* Coutinho *et al.* 1997) e na região chaquenha do Maciço de Urucum, Corumbá e vizinhanças (Coutinho *et al.* 1997). Na planície do Pantanal, ocorre no setor norte, rios São Lourenço, Paraguai, Piquiri e Cuiabá (Coutinho *et al.* 1997), com registros confirmados na área da RPPN SESC-Pantanal entre os rios São Lourenço e Cuiabá (Travassos *et al*. 1927) e na Fazenda Nhumirim (Alho *et al*. 1988; Í. M. Medri, obs. pessoal).

Galictis vittata (furão): é comum nas regiões altas da bacia do Paraguai, com registro confirmada na Chapada dos Guimarães (Cope 1889) e na hidrelétrica do rio Manso (Schneider 2000) e raro na planície do Pantanal, com ocorrência na região dos rios Negro e Miranda e na Nhecolândia (Coutinho *et al.* 1997).

Lontra longicaudis (lontra): segundo o PCBAP (Coutinho *et al.* 1997) é comum tanto na área de planície quanto nas áreas de entorno do Pantanal. Na planície a espécie é citada para a região dos rios São Lourenço, Paraguai, Piquiri, Cuiabá, Taquari, Miranda (Coutinho *et al.* 1997), Negro e Salobra (G. Mourão, obs. pessoal). Nas áreas de entorno a espécie é citada na Chapada dos Guimarães (Cope 1889), na região da hidrelétrica do rio Manso (Schneider 2000) e na Serra do Amolar (Schaller 1983).

Pteronura brasiliensis (ariranha): é comumente encontrada na planície do Pantanal, e raramente nas áreas de entorno. Na planície há registros de ocorrência da espécie na RPPN SESC-Pantanal (G. Mourão, obs. pessoal), na região dos rios São Lourenço, Paraguai, Piquiri e Cuiabá (Coutinho *et al.* 1997) e na região dos rios Negro (Mourão & Carvalho 2001) e Miranda (Coutinho *et al.* 1997; G. Mourão, obs. pessoal). Nas áreas de entorno do Pantanal, ocorre na região da hidrelétrica do rio Manso (Schneider 2000), no Alto rio Paraguai e região de Barra do Bugres até Cáceres e Caiçara, e na região de Taunay, Aquidauana, Bodoquena, Bonito, Maracaju até Dourados e Piraputanga (Coutinho *et al.* 1997).

Felidae

Panthera onca (onça-pintada): maior felino das Américas, ocorre na Bacia do Pantanal tanto na planície quanto nas áreas altas (Coutinho *et al.* 1997). Nas áreas altas, há registros na Chapada dos Guimarães (Cope 1889) e Serra da Bodoquena, entre outros. É comumente avistada na região de Passo do Lontra (Rio Miranda e Rio Vermelho). Ocorre na região da RPPN SESC-Pantanal (J. C. Dalponte, com. pessoal), na Fazenda Acurizal (Schaller & Crawshaw 1980) e Serra do Amolar (Schaller 1983), no Rio Miranda (Crawshaw & Quigley 1991) e no Rio Negro (W. M. Tomas, não publicado - registro fotográfico). Predador de topo de cadeia, sua alimentação inclui o cervo-do-pantanal (*Blastocerus dichotomus*), capivara (*Hydrochaeris hydrochaeris*), queixadas (*Tayassu pecari*) e caititus (*Pecari tajacu*), antas (*Tapirus terrestris*), lontras (*Lontra longicaudis*), macaco-da-noite (*Aotus trivirgatus*) e jabutis (*Geochelone* sp.), além de presas domésticas, como cães e gado (Schaller & Vasconcelos 1978b).

Quigley & Crawshaw (1992) notaram que a distribuição de onças-pintadas no Pantanal não é homogênea, havendo áreas de densidades mais altas e áreas onde a espécie é praticamente ausente. Eles observaram que as duas áreas de maior densidade correspondem àquelas com maior densidade florestal, uma a noroeste do Pantanal, no Mato Grosso, representada por parte da região de Cáceres e de Poconé, até a divisa com o Mato Grosso do Sul, incluindo a área do Parque Nacional do Pantanal Mato-grossense e a Serra do Amolar, e outra entre os rios Miranda, Aquidauana e Negro, já no Mato Grosso do Sul. Também observaram que um dos principais problemas para a conservação de onças-pintadas no Pantanal vem do seu hábito de predar animais de criação, o que faz com que algumas vezes seja perseguida e morta por fazendeiros ou peões de fazendas. Estes mesmos autores estimaram a densidade de onças para as áreas de maior concentração da espécie, baseado no tamanho das áreas de vida (142 km^2 na região do Rio Miranda, Crawshaw & Quigley 1991) e a sobreposição entre indivíduos, resultando em uma onça a cada 64 km^2. Porém as estimativas variam de uma área para outra. Na região da Serra do Amolar, a área de vida de duas fêmeas foi 25 e 34 km^2, resultando em densidades estimadas de 1 onça a cada 12,5 km^2 a 1 onça a cada 25 km^2 (Schaller & Crawshaw 1980). Com base nestes resultados, Quigley & Crawshaw (1992) sugeriram um plano de conservação para a onça-pintada, através da criação de unidades de conservação nas duas áreas de grande densidade de onças. Estas unidades deveriam abranger cerca de 2000 a 3000 km^2 em cada Estado, somando-se aos 1749 km^2 em unidades de conservação já existentes, referentes ao Parque Nacional do Pantanal Mato-grossense e as Estações Ecológicas de Taiamã e da Serra das Araras. O plano envolve ainda o estabelecimento de corredores ligando estas unidades de conservação e conectando as duas áreas propostas, além da implementação de melhores práticas de manejo do gado, de forma a diminuir a possibilidade de

predação de rezes pelas onças, especialmente de bezerros mais novos. Hoje algumas unidades de conservação já foram estabelecidas dentro da área proposta, como o Parque Estadual do Pantanal do Rio Negro e a RPPN da Fazenda Rio Negro, da Conservation International do Brasil e as comunidades científicas e conservacionistas têm feito esforços para o estabelecimento de corredores ligando as grandes áreas de preservação.

Oncifelis colocolo (gato-palheiro): segundo o PCBAP (Coutinho *et al.* 1997) esta espécie ocorre tanto na planície quanto na área de entorno, na bacia do Paraguai. Nas áreas altas da bacia, ocorre na Chapada dos Guimarães e rio Manso (Cope 1889, Silveira 1995, Schneider 2000, Bagno *et al*. submetido) e Serra do Maracaju (Silveira 1995). Na planície há registros para a região de Cáceres (localidade Descalvados), Aquidauana, Miranda e Fazenda Tupanceretã nas proximidades do Rio Negro (Silveira 1995).

Oncifelis geoffroyi (gato-do-mato): tem ocorrência confirmada apenas nas áreas mais altas da BAP (Coutinho *et al.* 1997), ainda assim em baixas densidades. Sua distribuição conhecida vai do sul da Bolívia até o sul da Argentina (Oliveira 1994). No Brasil, só há registros confirmados nos estados da Região Sul, mas alguns autores apontam a possibilidade de ocorrência no Mato Grosso do Sul (Ximenez 1975). Ocorre nos países vizinhos ao Pantanal: Paraguai e Bolívia (Oliveira 1994), e é possível que venha a ocorrer em baixas densidades também na planície.

Puma concolor (suçuarana ou onça-parda): amplamente distribuída e comum tanto na planície quanto nas áreas de entorno (Coutinho *et al.* 1997). Assim como a onça-pintada, também a onça-parda é apontada como predadora de animais de criação.

Leopardus pardalis (jaguatirica): ocorre tanto na planície quanto nas áreas de entorno da bacia, sendo comum em ambas as áreas (Coutinho *et al.* 1997). Crawshaw & Quigley (1989) estimaram o tamanho das áreas de vida de 3 fêmeas no Pantanal de Miranda em respectivamente 0,76, 1,47 e 1,57 km^2. Entretanto, estes valores possivelmente representam sub-estimativas, já que as curvas de área acumulada não atingiram a assíntota.

Leopardus tigrinus (gato-do-mato): segundo o PCBAP (Coutinho *et al.*1997), ocorre tanto nas áreas altas da bacia quanto na planície, sendo raro em ambos. Porém, faltam registros confiáveis da espécie. A similaridade com outras espécies de gatos pintados, seus hábitos crípticos e a falta de inventários são fatores que dificultam o mapeamento da ocorrência desta espécie. Oliveira (1994) incluiu o Pantanal na distribuição da espécie.

Leopardus wiedii (maracajá): possui registros apenas nas áreas de entorno (Coutinho *et al.* 1997), tendo sido registrado na região do rio Manso e Chapada dos Guimarães (Thomas 1903 *apud* Coutinho *et al.* 1997, Schneider 2000). Oliveira (1994) inclui o Pantanal na distribuição desta espécie e é possível que tanto *L. wiedii* quanto *L. tigrinus* ocorram na planície.

Herpailurus yagouaroundi (jaguarundi): é comum tanto na planície como no resto da Bacia do Alto Paraguai (Coutinho *et al.* 1997).

Artiodactyla

Cervidae

A distribuição de cervídeos no Pantanal é diferenciada em função dos habitats. As quatro espécies que ocorrem na planície possuem nichos ecológicos distintos que moldam sua distribuição e variações na abundância. *Blastocerus* ocorre em áreas inundáveis, e suas maiores densidades são encontradas onde o gradiente de inundação inclui áreas relativamente altas e áreas acentuadamente baixas (Mourão *et al.* 2000, Tomas *et al.* 2001b). *Ozotoceros* ocorre principalmente nas porções centrais do Pantanal, notadamente nas regiões da Nhecolândia e Paiaguás, com maiores densidades em áreas de campos e vazantes (Mourão *et al.* 2000, Tomas *et al.* 2001a). As espécies do gênero *Mazama* ocorrem em toda a planície. Entretanto, *M. americana* parece ocorrer em área de matas semi-decíduas e matas de galeria extensas, enquanto *M. guazoupira* é mais flexível, ocorrendo em áreas de cerrado, cerradão e matas semidecíduas. Dados coletados através de câmeras fotográficas automáticas nas fazendas Nhumirim e Rio Negro indicam que a abundância de *M. gouazoupira* é maior que a de *M. americana* na primeira fazenda (com predomínio de cerrado e cerradão), enquanto que *M. americana* predomina na segunda área, onde há extensas formações de matas semidecíduas, matas de galeria e cerradão denso (W. M. Tomas, não publicado).

Densidade de Algumas Espécies: Levantamentos Aéreos

O grupo de estudos de fauna do Centro de Pesquisas Agropecuárias do Pantanal – Embrapa Pantanal, através do Programa Ecológico de Longa Duração – PELD/CNPq (Processo #520056/98-1), vem desenvolvendo o monitoramento desde 1998, por meio de levantamentos aéreos de populações de algumas espécies de grandes vertebrados, incluindo três espécies de mamíferos (cervo-do-pantanal, veado-campeiro e capivara), com objetivo de identificar as possíveis tendências de alteração do tamanho populacional. Parte destes dados será discutida neste trabalho. A metodologia adotada foi a de contagens em transectos, com faixa de largura fixa. A altitude de vôo foi padronizada em 60 m e as contagens foram feitas em uma faixa de 200 m de largura delineada por réguas afixadas nos montantes da asa de um CESSNA 206. Usamos o método de contagem dupla (Bayliss & Yeomans 1989), derivado dos métodos de marcação e recaptura, para aumentar a acuidade das contagens e diminuir as diferenças nas contagens devido ao período do dia em que se fez a contagem (manhã ou tarde).

Cervo-do-pantanal

Nos levantamentos de 2001, um total de 113 cervos foi avistado durante as manhãs e 94 durantes as tardes (Tabela 2), resultando em um fator de correção estimado para um dos pesquisadores (Walfrido Tomas – WT) em 1,31 para o período da manhã e 1,34 para o período da tarde. Dessa forma, estimamos uma densidade corrigida de 0,22 cervos/km^2 (EP = 0,046), podemos observar que as populações de cervos têm flutuado ao redor de 0,3 cervos/km^2 desde a contagem de 1991 (Fig. 4ª). As diferenças na área de inundação entre anos parecem não afetar essas densidades (Fig. 4b).

Tabela 2. Número de cervos-do-pantanal avistados por observador e período do dia, nos levantamentos aéreos de setembro de 2002, e o fator de correção estimado para o observador WT, segundo Bayliss & Yeomans (1989).

	Manhã	**Tarde**	**Total**
WT	58	39	97
GM	13	14	27
ambos	42	41	83
TOTAL	113	94	207
Fator de Correção WT	1,31	1,34	-

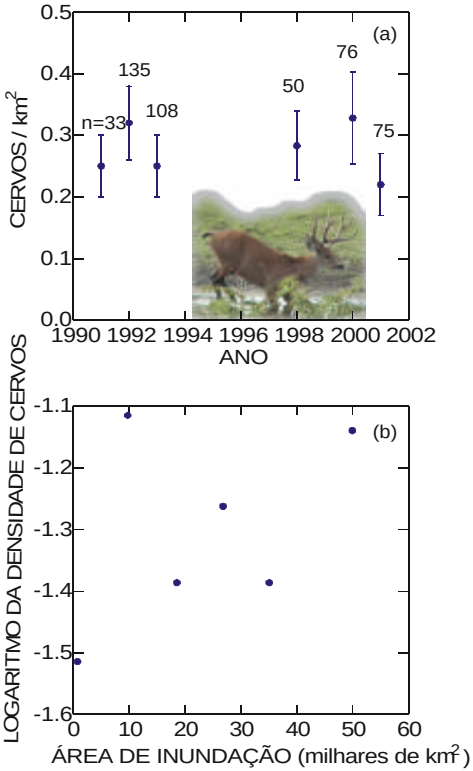

Fig. 4. (a) Variação na densidade corrigida para hora do dia e erros de visibilidade de cervos-do-pantanal, em levantamentos aéreos, amostrando todo o Pantanal compreendido entre os paralelos 16 e 21º S. As barras representam o erro padrão das estimativas. O número de transectos percorrido em cada levantamento está assinalado acima de cada ponto. **(b)** Relação das densidades observadas com a área estimada de inundação no período do levantamento.

Veado-campeiro

Como os veados se distribuem em grupos, utilizamos os grupos como unidade de contagem. Um total de 31 grupos foi avistado durante as manhãs e 123 durante as tardes (Tabela 3), resultando em um fator de correção estimado para WT em 2,75 para o período da manhã e 1,56 para o período da tarde. Dessa forma, estimamos uma densidade corrigida de 0,21 grupos de veados/km^2 (EP = 0,04) e podemos observar que a tendência de decréscimo acentuado nas estimativas de densidades de grupos de veados observados por Mourão *et al.* (2000) no período 1991-93 não se manteve para o período 1998-2001. De qualquer forma, ainda não dispomos dos 12 anos de dados necessários para detectar decréscimos da ordem de 10% ao ano (Mourão *et al*. 2000). Há uma tendência das densidades estimadas de grupos serem positivamente correlacionadas com a área de inundação a cada ano (Fig. 5), mas a aderência a um modelo linear não é forte.

Tabela 3. Número de grupos de veado-campeiro avistados por observador e período do dia, nos levantamentos aéreos de setembro de 2002, e o fator de correção estimado para o observador WT, segundo Bayliss & Yeomans (1989).

	Manhã	**Tarde**	**Total**
WT	20	59	79
GM	7	23	30
Ambos	4	41	45
TOTAL	31	123	154
Fator de Correção $_{WT}$	2,75	1,56	-

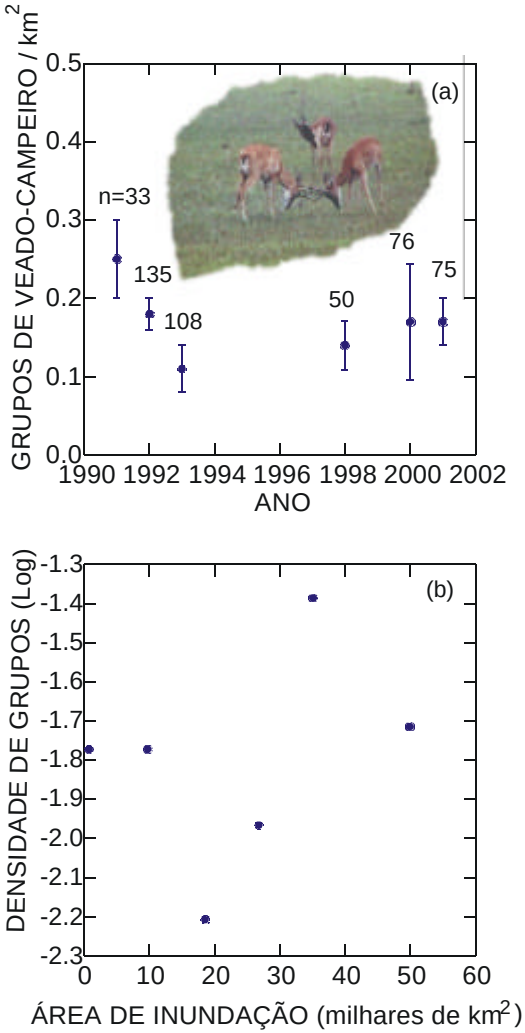

Fig. 5. (a) Variação na densidade corrigida para hora do dia e erros de visibilidade de grupos de veado-campeiro, em levantamentos aéreos, amostrando todo o Pantanal compreendido entre os paralelos 16 e 21º S. As barras representam o erro padrão das estimativas. O número de transectos percorrido em cada levantamento está assinalado acima de cada ponto. **(b)** Relação das densidades observadas de grupos com a área estimada de inundação no período do levantamento.

Capivara

Um total de 313 grupos foi avistado durante as manhãs e 291 durantes as tardes (Tabela 4), resultando em um fator de correção estimado para WT em 1,35 para o período da manhã e 1,62 para o período da tarde. Dessa forma, estimamos uma densidade corrigida de 0,69 grupos de capivaras/km^2 (EP = 0,07). As densidades estimadas de grupos de capivaras foram lineares e negativamente correlacionadas com a área de inundação a cada ano (Tabela 5, Fig. 6).

Tabela 4. Número de grupos de capivaras avistados por observador e período do dia, nos levantamentos aéreos de setembro de 2002, e o fator de correção estimado para o observador WT, segundo Bayliss & Yeomans (1989).

	Manhã	**Tarde**	**Total**
WT	163	124	287
GM	39	64	103
Ambos	111	103	214
TOTAL	313	291	604
Fator de Correção WT	1,35	1,62	-

Tabela 5. Regressão do logaritmo das densidades de grupos de capivaras corrigidas para os observadores e para o período do dia (LCAPTOD) em função da área de inundação (AREAINUN) estimada para o mês de setembro (segundo Hamilton *et al*. 1996).

Dep Var: LCAPTOD N:5 Multiple R: 0.937 Square multiple R: 0.878

Adjusted square multiple R: 0.837 Standard error of estimate: 0.085

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P (2 Tail)
CONSTANT	-0.294	0.061	0.000	.	-4.796	0.017
AREAINUN	-0.011	0.002	-0.937	1.000	-4.637	0.019

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.157	1	0.157	21.500	0.019
Residual	0.022	3	0.007		

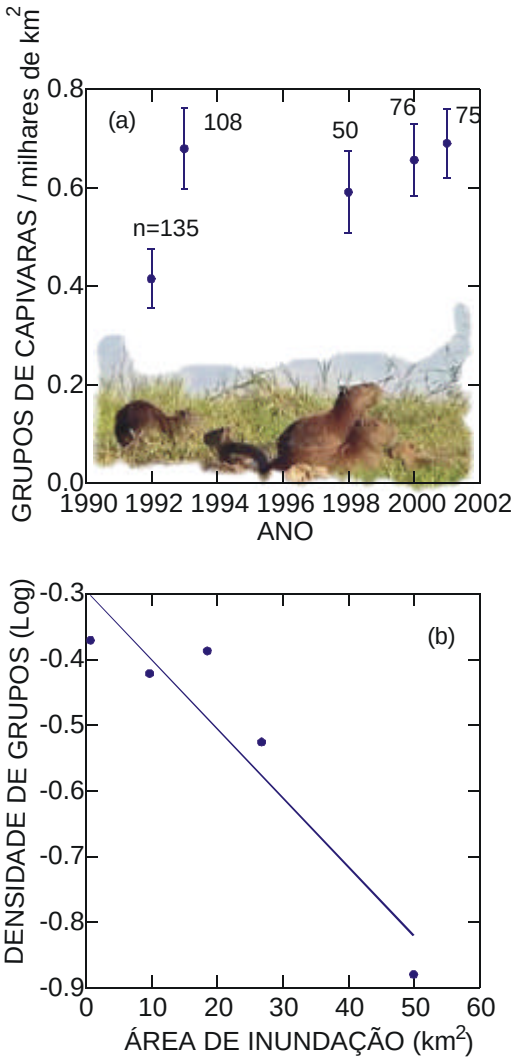

Fig. 6. (a) Variação na densidade corrigida para hora do dia e erros de visibilidade de grupos de capivaras, em levantamentos aéreos, amostrando todo o Pantanal compreendido entre os paralelos 16 e 21º S. As barras representam o erro padrão das estimativas. O número de transectos percorrido em cada levantamento está assinalado acima de cada ponto. **(b)** Relação das densidades observadas de grupos com a área estimada de inundação no período do levantamento.

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Conservation Biology

Diversity

Upland habitat loss as a threat to Pantanal wetlands

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The fate of Pantanal, one of the world's largest, most pristine and diverse wetlands, stands in the balance. The most recent (2014) and comprehensive land-cover change assessment of the upper Paraguay River Basin (UPRB), comprising both lowlands (Pantanal floodplain) and their surrounding upland savannas (Cerrado plateaus), shows the extent of decline of native vegetation (Fig. 1). Around 80% of the Pantanal floodplain native vegetation remains (Fig. 1), and over 60% of its Cerrado plateaus have been converted into pasture and croplands (SOS-Pantanal et al. 2015). The most worrying aspect is the fast rate of land clearing during the last 30 years (Supporting Information). In fact, the Cerrado is experiencing higher native vegetation conversion rates than Amazon and Atlantic Forest ecosystems in recent years but is still largely unprotected (Overbeck et al. 2015).

Biodiversity loss in the UPRB has been caused by a plethora of human activities, including elimination of native vegetation via damming in the headwaters and channelization of the Paraguay River channel on the floodplain, burning to clear vegetation, unsustainable fishing, water pollution, river-flow modification, unsustainable tourism, and invasive species (e.g., Alho & Sabino 2011; de Sousa Jr et al. 2011; Junk et al. 2011). We argue that a new viewpoint based on landscape thresholds should be applied to predict biodiversity loss in the UPRB. We suggest prompt actions to avoid crossing critical thresholds of vegetation loss in the uplands to prevent collapse of biodiversity and ecosystem functioning of the Pantanal wetlands. Our approach is consistent with 2 predominant characteristics of the UPRB that make the system particularly sensitive to regional tipping points (Brook et al. 2013): high spatial homogeneity in drivers of habitat loss (Supporting Information) and tight functional and ecological interdependency between lowlands and Cerrado uplands.

We measured the amount of native vegetation in each of the 4546 planning units that comprise the UPRB and found that in 60% of them, <40% of native vegetation remains (Fig. 2). The native vegetation deficit was severe and widely distributed across the plateau, which is consistent with spatial homogeneity of vegetation-loss drivers (Supporting Information). Given that the Forest Act (FA) allows Cerrado ecosystem conversions of up to 80% of each property, an additional 12.8% of natural vegetation cover could be legally converted to planted pasture or crops (Brazilian Forest Act 2012; Soares-Filho et al. 2014).

If historic (1976–2008) trends of land conversion in the UPRB continue (business as usual scenario in combination with weak enforcement), a complete loss of native vegetation can be expected by 2029 in the plateau and by 2045 in the floodplain (Silva et al. 2011). Considering that 1087 km^2 of land was converted in the plateaus from 2012 to 2014 (SOS-Pantanal et al. 2015), we posit that the plateau's native vegetation is approaching critical levels of degradation. Conversions of over 60% of native tropical ecosystems have led to abrupt species loss due to exponential increase in the distance between forest fragments, which has affected survival and dispersal among subpopulations (Banks-Leite et al. 2014; Ochoa-Quintero et al. 2015).

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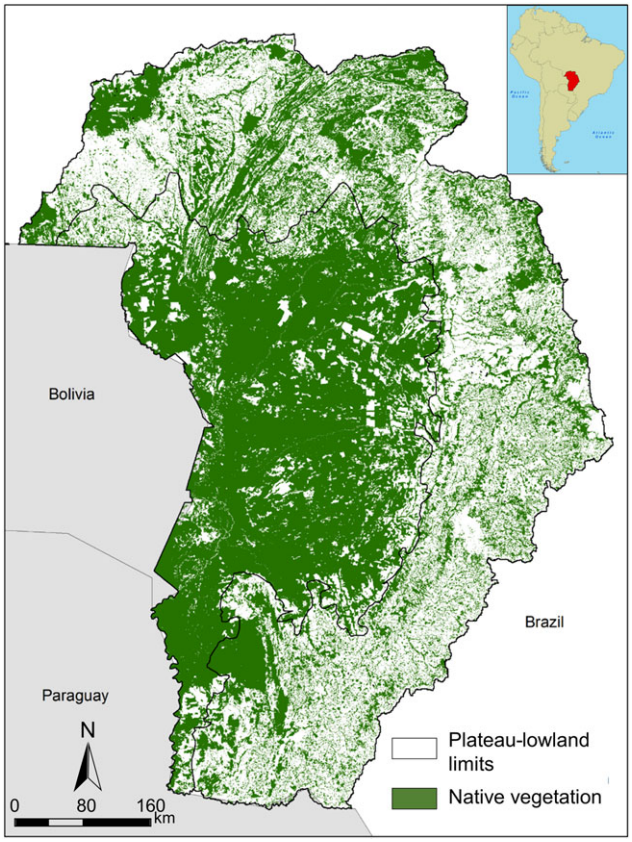

Figure 1. Upper Paraguay River Basin: remaining native vegetation on the Pantanal lowland and its surrounding savanna (Pantanal plateau).

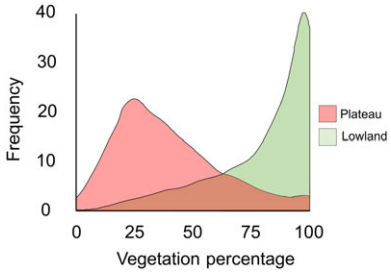

Figure 2. Frequency distribution of native vegetation within landscapes on the Pantanal lowland and on its surrounding plateau savanna. Each landscape represents a hexagonal planning unit of 10,000 ha (Supporting Information).

Despite an incomplete understanding of the complex hydrology of the UPRB (Hamilton 2002), there is sufficient evidence that land conversion in the plateau's headwaters is affecting the hydrodynamics of UPRB (Bergier 2013). Unsustainable agroecosystems in the plateau are reducing the catchment's water storage and buffering capacity and have resulted in increased sediment runoff of up to 191% and increased water discharge of up to 82% in the lowlands, the result of which is significant alterations in flood dynamics, ecosystem functioning, and ecosystem services (Bergier 2013).

The way in which impacts of land-use changes on the plateau are transferred to the Pantanal wetlands through hydrodynamic processes is explained by the phenomenon of river avulsion. This phenomenon is characterized by the diversion of flow from an aquatic channel onto the floodplain, eventually resulting in new channel belts, as reported for alluvial megafan systems. The Taquari megafan, one of the largest (50,000 km^2) and most threatened in the world, is a river network that drains the plateau toward the lowlands and has specific intersection nodes that control flow direction. The avulsion in Taquari occurs during river discharge events with a magnitude close to an avulsion threshold, which is related to the degree of sedimentation and a reduction in the capacity of the channel flow downstream (Assine 2005). The intensification of erosion caused by cattle ranching and agriculture in the plateau over the last 30 years has accelerated the avulsion processes, and avulsion thresholds have been crossed more frequently. These events have affected the spatial arrangement of wetland vegetation and affected biodiversity dynamics, ecosystem processes, and the local economy (Assine 2005).

Changes in intensity and duration of the flood regime impact the distribution, areal extent, and seasonal persistence of wetlands, grasslands, and forests and have already altered biodiversity patterns and species distributions in the Pantanal (Junk et al. 2011). These changes can induce sharp transitions between vegetation communities (e.g., seral stages), such as grasslands, wetlands, and forested areas (Lourival et al. 2011), typical of the nonlinear dynamics of savannah-forest systems (Hirota et al. 2011). Landscape changes in uplands may also have direct impacts on seasonal animal movements between plateau and lowlands. The UPRB supports approximately 300 fish species, including 12 species of economically important migratory fish inhabiting lowlands, which use the main river channels to migrate to headwaters for spawning, a phenomena called *piracema*. Forest degradation in the headwaters alters the input of sediments and coarse organic matter in aquatic environments and jeopardizes fish migration routes and habitat quality (Resende 2003). Bird migration also illustrates the ecological connectivity between uplands and lowlands. At least 41 migratory birds occurring on the floodplain use Cerrado areas in their migratory routes. Land-use changes on the plateau affect food availability for migrants, such as 2 endangered granivorous species of *Sporophila* that depend on seeds of native plants in both the plateau and lowlands (Nunes & Tomas 2004).

We argue that urgent government action is needed to avoid additional natural vegetation conversion and probable collapse of ecosystems in the Pantanal. One

opportunity lies in environmental compliance and regulation at the state-governance level because offsets from land conversion are legally restricted to the same biome. Recognition of the UPRB as a management unit for compliance and offsetting would allow compensating vegetation deficits between the Cerrado and Pantanal as interdependent parts of the same basin. Considering the UPRB a single unit would require compromise and collaborative initiatives among states, and such initiatives are particularly critical because the Pantanal is a transnational wetland. An intrabasin offsetting strategy could reduce the economic pressure on existing native vegetation, adding value to the remaining Cerrado and wetlands through offsetting. Such a regulation is biogeographically and ecologically critical given the wetland hydrology is associated with contiguous catchment areas.

Despite recognition of the Pantanal as a wetland of global importance (UNESCO Biosphere Reserve, 3 RAMSAR sites, and a cluster of 4 protected areas that comprise a World Heritage site), the state of Mato Grosso do Sul, which contains 65% of the Brazilian Pantanal, has enacted a decree (Decreto no. 14.273, de 8 de Outubro de 2015) that allows habitat conversion in lowlands (i.e., up to 60% of grassland habitats and 50% of Cerrado on private property) without consulting neighboring states and countries and without considering the National Heritage status, conferred by the Brazilian Constitution, of the area. This decision contradicts the idea of wise use proposed by the RAMSAR Convention on Wetlands, of which Brazil is a signatory.

Currently, <4% of the plateau is under no-take reserves, a low proportion considering the Aichi 17% representation targets for terrestrial biodiversity. Protected areas are the most effective strategy to safeguard biodiversity, particularly when following a systematic planning approach that considers ecosystem dynamics and functioning (Lourival et al. 2011). Achieving a comprehensive, representative, and adequate protected-areas system in the UPRB requires substantial commitment and government involvement. At the federal and state levels, several priority-setting exercises for the entire UPRB prioritized the need to conserve critical areas for ecological connectivity. However, public reserves are still underrepresenting the regional biodiversity.

We recommend strategies to reverse the potential collapse of biodiversity, particularly through halting deforestation, minimizing damming for electricity production, and encouraging socioeconomic incentives for restoration and protected area creation. Applying the FA regulatory framework will require additional adjustments to ensure fairness in the offsetting compensation schemes. The adjustments should encourage compensation and restoration of environmental debts from other areas of Cerrado while creating incentives for landowners from other states to invest in restoration of the integrity of this globally important basin. More importantly, state-level policies should go beyond the legal 20% requirements for reserve set-asides and set targets for wetland integrity in the lowlands while maintaining native vegetation above potential tipping thresholds in the plateau. These strategies can be reinforced through effective environmental governance at the basin level. Improving conservation efforts across the entire basin and enhancing connectivity between lowlands and Cerrado uplands are urgently needed to maintain the Pantanal's status as one of the world's most pristine wetlands.

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Supporting Information

A historical view of land-use changes in the UPRB over the last 30 years (Appendix S1), land-cover change and a vegetation map of UPRB (Appendix S2), and an analysis of the spatial structure of the proportion of natural vegetation across the plateau's planning units with a generalized additive model (Appendix S3) are available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

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ANALYSIS

Cattle ranching and deforestation in the Brazilian Pantanal

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Abstract

Regional economic indicators and incentives for agricultural landowners in the Brazilian Pantanal were explored in order to understand better the observed increases in deforestation for the implantation of cultivated pastures to assist in the extensive management of beef cattle. About 95% of Pantanal lands are privately owned and about 80% are used as extensively managed cattle ranches. The mean size of agricultural property in the Pantanal is increasing, the cattle density and numbers are decreasing, the proportion of land in cultivated pastures is decreasing, but the area is increasing, land and animal wealth is highly concentrated, and the amount and proportion of land in natural pastures is decreasing. Statistical analyses reveal that land and animal wealth, intensification of agricultural effort, human population, natural pastures and location relative to infrastructure and regional markets influence either the magnitude or the proportion of Pantanal lands deforested for the purpose of implanting cultivated pastures or both. A nonlinear link between wealth measures and deforestation was not established. Improving the profitability of forestland should unambiguously improve the likelihood of its continued management as forest and the maintenance of biological diversity. Potential sustainable uses of forested lands and native biological diversity in the Pantanal include the sustainable extraction of forest species, ranching of wild and feral species, and tourism. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Brazil; Pantanal; Deforestation; Cattle ranching; Incentives

1. The Brazilian Pantanal

At more than 138 000 km^2, the Brazilian Pantanal is known as the largest freshwater wetland in the world. The Pantanal is home to at least 650 species of birds, 260 species of fish, 80 mammal species, 50 species of reptiles (Wade et al., 1993), and more than 2000 identified floral species (Pott, 1998). Among its most renowned fauna are the jaguar, jaburu stork, blue hyacinth macaw, capybara, anaconda, giant anteater, coati and piranha.

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The Pantanal's principal economic activities include fishing, mining, tourism, and cattle ranching. Extensive cattle ranching has been the dominant economic activity and land use in the region for the past two centuries. About 95% of Pantanal lands are privately owned. About 80% (118 000 km^2) of the lands are found on cattle ranches (Silva et al., 2000). The estimated present value of the existing herd of 3 million is about US$1 billion (Seidl et al., 1999).

According to the Brazilian constitution, the Pantanal is considered to be a part of the 'national patrimony' and is of high priority for protective management of its natural condition. This designation can run counter to the perceived interests of agriculturists. For example, the largest extensively managed cattle ranch in the southern Pantanal reported more than 1700 calf deaths due to jaguar attacks from 1993 to 1996 or about 1/3 of the calf crop (Marson, 1996). Article 1 of Federal Law 5197 legally protects jaguars and other wild species by stating:

> those animals of any species, in any phase of development, which live naturally out of captivity, are considered wild species, as well as their offspring, and their breeding areas, and are considered property of the state, making their utilization, persecution, hunting or apprehension prohibited (Marson, 1996) (translated from the Portuguese).

Since cattle ranchers are stewards of the great majority of Pantanal lands and since aspects of extensive cattle ranching, namely, deforestation for implanting pastures, may conflict with national (and international) priorities for protection of the region's unique natural resources, an exploration of the relationships between the 'pantaneiros' and their landscape is proposed. A principal objective of this analysis is to provide information toward crafting agricultural and natural resource policy such that individual and regional objectives for natural resource management can be met for the least expense. A regional perspective is adopted recognizing that precise farm/ranch level information is also necessary for policy formation and implementation. Factors affecting agricultural land use in the Pantanal region of Brazil are discussed including economic incentives' role in understanding land use relationships; regional land use trends and correlates with natural habitat conversion (deforestation); and strategies to meet 'pantaneiros' objectives while minimizing the rate and absolute amount of natural habitat conversion in the Pantanal.

2. Land use, cattle and economic incentives

2.1. Land use

The carrying capacity of the Pantanal for terrestrial species is constrained by the magnitude and duration of the annual floods. Aquatic species diversity and health are affected by human actions on the land and the water. As the primary stewards of Pantanal lands, sustainable development and biodiversity conservation of the region are dependent upon the behavior of cattle ranchers. Ranchers are likely to follow the economic incentives they feel they are facing. Since the early 1970s, ranchers have cleared land and planted pastures in order to increase the cattle stocking rates. Clearing land and implanting pastures for cattle is perceived as the economically optimal land use alternative.

Ranchers tend to plant pastures on the highest ground available, which also tends to be forested since it is not subject to regular flooding. Clearing the land in order to plant pastures has resulted in more than 500 000 ha of deforested land (13% of woodlands) over the past quarter of a century (Silva et al., 1998a,b), likely increases in land erosion, sedimentation of rivers, decreases in floral and in faunal biodiversity (Coutinho et al., 1997).

2.2. Economic incentives

In order to encourage the conservation of regional biodiversity, improved understanding of Pantanal cattle ranchers' responses to economic incentives is required (e.g. Angelsen, 1999). Traditionally, regional research and extension efforts have concentrated on improving the productive

Table 1
Influence of model specifications on variable expectations[a]

Variable/model	Subsistence	Chayanovian	Open economy
Higher agricultural prices	⇓	⇔	⇑
Population growth	⇑	⇑	∅
Lower transport costs	∅, ⇓	⇑	⇑
Higher agricultural productivity	⇓	⇔	⇑
Higher wages	NA (⇓)	NA (⇓)	⇓

[a] Source: Kaimowitz and Angelsen, 1998; ⇑, increase; ⇓, reduce; ∅, no effect; ⇔, indeterminant; NA, not applicable.

efficiency of Pantanal beef cattle operations. It is implicitly assumed that improving per hectare returns to cattle production entices conservation of lands not in native pasture. However, by improving the profitability of land in pasture, the opportunity cost of land not yet in pasture increases, increasing the profitability of land in pasture may increase the incentive to convert 'unproductive' land to cultivated pastures.

Since cattle ranching is commonly viewed as the only economically viable activity in the region, land that is not producing beef is perceived as 'unproductive'. Whether improved profitability of natural pastures results in more or less habitat conversion through deforestation depends upon: (1) the relative scarcity of other productive inputs; and/or (2) how Pantanal cattle ranchers respond to economic incentives. If ranchers respond to increasing profitability of natural pasture land by conserving (not converting) non-pasture lands, other productive inputs (e.g. labor, financial capital) may have become the principal cost factor constraining cattle production; the rancher maximizes profits. Alternatively, 'unproductive' land conservation due to increasing land productivity may result from a rancher reaching some acceptable living standard for his family; the rancher maximizes happiness where income is only one factor to be balanced against other conflicting objectives (e.g. recreation, time with family), or to 'be satisficed' with respect to income.

Table 1 reviews the implications of different behavioral assumptions in efforts to model tropical deforestation. If ranchers respond to increasing profitability of natural pastureland by converting non-pasture lands, they behave in concert with the theory of the profit-maximizing firm (production and consumption decisions are separable) and small open economy expectations for descriptive variables apply. If they are observed to respond by maintaining lands in forests, either subsistence or consumption tradeoff (Chayanovian), behavioral assumptions may be more appropriate (Kaimowitz and Angelsen, 1998). Only ecologically and economically sustainable alternative practices on forested lands (explored later) should have unambiguously desirable impacts on deforestation pressures.

2.3. Land productivity and profitability

One estimate of the biophysically sustainable stocking rate for extensively managed beef cattle on planted (converted, cultivated) pasture in the Pantanal is 1.25 AU/ha[1] in the summer and 0.77 AU/ha in the winter. Estimates for natural (native) pasture are 0 in the summer (due to inundation) and 0.4 AU/ha in the winter (Marson, 1996). Alternatively, Comastri Filho (1997) puts the carrying capacity of planted pasture at 0.77 AU/ha, does not mention seasonal differences, and fails to consider any productivity on native pastures. Comastri Filho (1997) estimates that planted pasture would need to cover 10% of the Pantanal in order to accommodate traditional cattle densities.

Assuming 6-month seasons and the ability to seasonally adjust herds to reflect annualized stocking constraints, the Marson (1996) estimates can be manipulated to demonstrate that planted

[1] An AU is an 'animal unit'. AU normalizes livestock across different sexes, ages, and species based upon the weight of each. For example, 1 beef cow = 1.00 AU, 1 calf = 0.25 AU and 1 bull = 1.25 AU.

pasture provides the ability to increase stocking rates by 0.81 AU/ha over native pasture and 1.02 AU/ha over forestlands. Comastri Filho (1997) estimates yield an improvement of 0.55 and 0.77 AU/ha over native pasture and forestlands, respectively. These estimates constitute overestimates of the value of planted pasture because not all native pastures are seasonally inundated, and summer grazing is possible on semi-forested lands. Unfortunately, estimates of their productivity are not available.

In addition to biological productivity measures, the fixed costs of clearing land for implanting pastures and the variable costs of their maintenance must be considered in estimating the relative benefits of cultivated over natural pastures in the Pantanal. Marson (1996) estimates the cost of a cattle operation on a very large industrial ranch (70 000 ha in cultivated pastures and 120 000 ha in planted pastures) with some highland and some Pantanal land as about $35/AU. About 40% of these costs are in land maintenance activities and 27% are labor costs (Marson, 1996). Comastri Filho (1997) estimates the cost of pasture formation as $287/ha for higher ridges and $227/ha for flatter woodlands. Deforesting or clearing land comprises about 20% of these cost estimates. Much of the remaining formation costs are attributed to various types of tractor work. These estimates could not be confirmed as either accurate or representative of the region. For example, field visits to several ranches in the Nhecolandia subregion in 1997 yielded estimates of $120/ha for clearing costs.

Using these rough estimations, the net present value of native pasture or forested land conversion to cultivated pasture can be calculated. The current value of an animal unit is about $250 in the Pantanal (Seidl et al., 1999). Cultivated pasture life is about 15 years (Moraes, 1999) and, lacking information, we assume productivity is maintained over the period of use. The net benefits of converting native pasture to cultivated pasture are 0.81 or 0.55 AU/ha. The net benefits of converting forestland to cultivated pasture are 1.02 or 0.77 AU/ha. The fixed costs of cultivated pasture formation including forest clearing are $227/ha for land with little forest cover and $287/ha for forested land. Finally, we assume the variable costs of cultivated pastureland maintenance are the same as native pastureland on a per head basis, or $35/AU. Higher discount rates discourage the investment in land conversion, but also discourage good long-term land management practices and the converse (Angelsen, 1994, in Kaimowitz and Angelsen, 1998). For illustrative purposes, we explore the implications of discount rates of 8–14% (Table 2).

Table 2 indicates that our best estimate of the net present value of investment in conversion of native pasture to cultivated pasture for increasing beef cattle herd size is between $499 and 1466/ha, or an annualized return of $81–171/ha per year over the 15-year estimated project life. Our best estimate of the net present value of the conversion of forestland to cultivated pasture is between $730 and, $1845/ha, or an annualized return of $119–

Table 2
Returns to native pasture and forestland conversion to cultivated pasture in the Pantanal (US$)[a]

	Native I	Native II	Forest I	Forest II
NPV 8%	1466	922	1845	1322
Annualized return @ 8%	171	108	216	155
NPV 10%	1098	672	1381	972
Annualized return @ 10%	144	88	182	128
NPV 12%	959	578	1207	840
Annualized return @ 12%	141	85	177	125
NPV 14%	843	499	1060	730
Annualized return @ 14%	137	81	173	119

[a] Notes: native I and forest I calculations are derived from estimates found in Marson (1996). Native II and forest II are calculated from Comastri Filho (1997). NPV, net present value. Project life, 15 years.

216/ha per year over the estimated project life. Estimate variation depends upon the source of information and the imposed discount rate. These calculations imply that if the annualized net benefits from complementary or alternative uses of native pasturelands relative to cultivated pasture exceed $171/ha per year, then land conversion is unjustified from an economic perspective. Analogously, if the sum of the annualized direct and indirect values of forest products, tourism, decreases in river sedimentation, and wildlife habitat from forestlands relative to cultivated pastures exceed $216/ha per year, either the rancher should choose not to deforest his land or he may be enticed to do so through policy incentives worth no more than $216/ha per year on average.

3. Regional analysis of land use change

3.1. Data

Analyses of panel census data may provide some insights into existing incentives and the behavior of ranchers faced with these incentives. Available census data for agricultural properties include, total area; area of various agricultural land uses (not rural residential, however); number of cattle; number of people; number of tractors; municipality; and time period. Urban (commercial, industrial and residential) land uses were excluded from analysis. Unfortunately, neither regional nor representative property level data were available for wage rates, land values, values of other agricultural property, transportation costs, or cattle prices. Weather information is not available for the entire time period and is not in a useful form. Agricultural credit programs are not evident in the region, nor can individual property data be tracked over time.

Trends in land use in the Pantanal region from 1975, 1980 and 1985 censuses were reviewed. An agricultural census was not conducted in 1990. The 1995 census is not yet available by geophysical unit. Regional land use trends indicate that agricultural property size is increasing, the cattle density and herd size are decreasing, the proportion of land in cultivated pastures is increasing, land and animal wealth is highly concentrated, the amount and proportion of unproductive land is increasing, and the amount and proportion of land in natural pastures is decreasing (Silva et al., 2000).

3.2. Variable definition

Following approaches in the literature (reviewed in Lambin, 1994; Pearce and Brown, 1994; Reis and Margulis, 1994; Kaimowitz and Angelsen, 1998), existing regional information was used to understand better deforestation decisions. The Pantanal is divided among 16 municipalities and two states of Brazil (Fig. 1). None of the municipalities lies entirely within the Pantanal wetland. Portions of each municipality lie in the surrounding highlands, or Planalto. Planalto residents influence municipal and state level policy formation having implications for Pantanal lands and waterways. However, both geopolitical and geophysical land use designations can be useful in designing policy and predicting its influence. By combining census data with GIS images, the Center for Research in the Pantanal (CPAP-EMBRAPA) has created 11 geophysical sub-regions based upon drainage, topographical features and traditional use patterns. Municipal and subregional information was included as a series of dummy variables.

First, wealth has been hypothesized to influence the rate and magnitude of deforestation. However, the expected direction of influence depends upon the behavioral assumptions assigned to decision-makers (Fearnside, 1993; Reis and Margulis, 1994; Faminow, 1998; Kaimowitz and Angelsen, 1998; Angelsen, 1999). Land is wealth and cattle are primary sources of both income and wealth to the Pantanal cattle rancher. Macroeconomic instability, particularly due to political transitions and inflation, make more traditional income measurements potentially less reliable than these proxies.

Secondly, size and density of human population are commonly considered potential explanatory variables in deforestation models (e.g. Reis and Margulis, 1991, 1994; Billsborrow and Geores, 1994; Kummer and Sham, 1994; Palo, 1994;

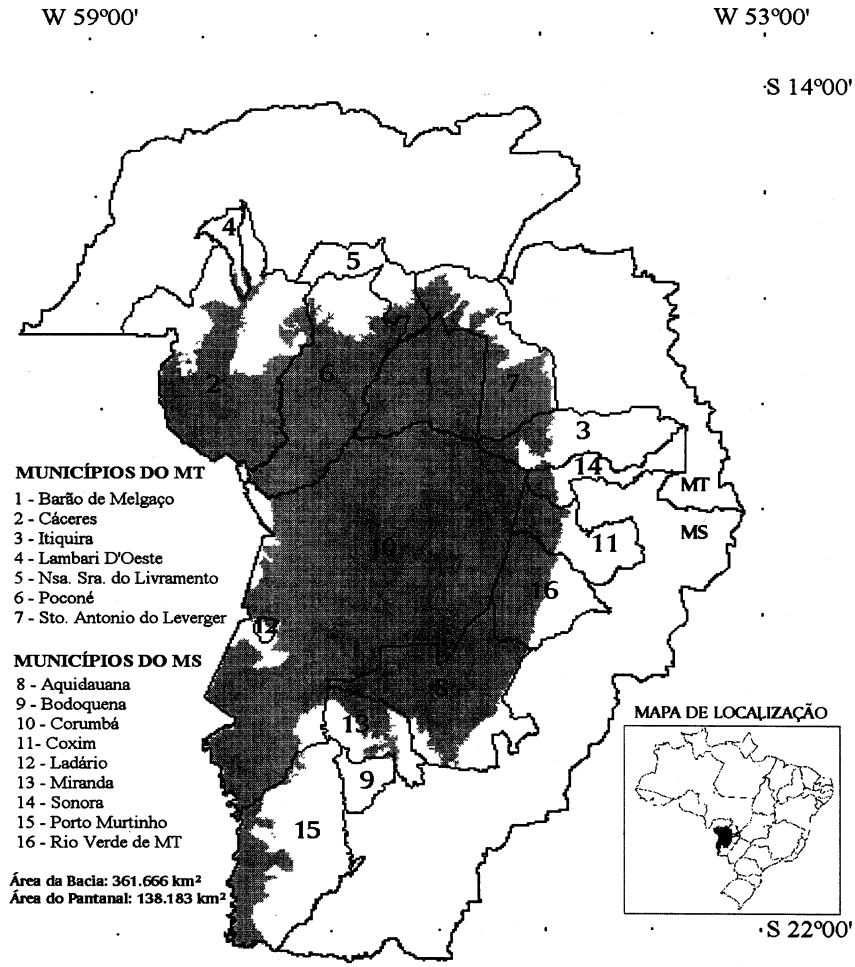

Fig. 1. Municipalities (Municipios) of the Brazilian Pantanal.

Rudel, 1994; Faminow, 1998). Regional and municipal rural population and net migration information is available and used in the analysis.

Thirdly, land use intensification and 'investment' potentially influence the rate and magnitude of deforestation (Fearnside, 1993; Mahar and Schneider, 1994; Southgate, 1994; Faminow, 1998). Tractors and 'controlled' fires are the principal land clearing tools available to Pantanal cattle ranchers. Tractors constitute a large financial investment and are probably a good indicator of the intensification of agricultural land use.

Fourthly, infrastructure and transportation costs may influence deforestation rates (Reis and Margulis, 1991, 1994; Fearnside, 1993; Mahar and Schneider, 1994; Southgate, 1994; Faminow, 1998). The transportation of cattle from ranches in the interior of the Pantanal to regional trade centers along its perimeter is normally executed on foot, but may involve small barges or trucks, depending on ranch location. The only paved road in the region connects the three main trade centers and runs along the Southern, Eastern and Northern perimeter of the Pantanal. A combination of municipality information and a variable designating the property as either in the Pantanal or the Planalto may provide some (imperfect) insight into transportation costs.

Since practically all of the land is privately owned, natural pasture (as opposed to cultivated

pasture) can only be created or lost through fluctuations in the flood cycle. Extended periods of flooding will reduce the amount of natural pasture available and result in either greater pressure to convert forested lands to cultivated pasture or a reduction in herd size. Since regional herd numbers are fairly consistent at about 3 million head over the period, changes in the amount of cultivated pasture correlated with changes in the amount of natural pasture can be viewed as the influence of weather on the rate and magnitude of regional deforestation. Cultivated pasture is a direct result of the conversion of land from its natural state. Due to physical and economic issues and the perception that the land is only useful as pasture, most land will be converted from forested or semi-forested lands rather than natural pasture. Long-term conversion of forested and semi-forested lands to some other use is deforestation, by definition (Faminow, 1998; Kaimowitz and Angelsen, 1998).

3.3. Model formation

Using these variables and data, we intend to better understand land use decisions of Pantanal ranchers regarding, (1) the absolute amount; and (2) the rate of deforestation by tracing the principal correlates with changes in cultivated pasture. The dependent variables chosen for the two models are, (1) area of cultivated pasture; and (2) proportion of cultivated pasture per hectare. The independent variables chosen are operation size, area of natural pasture, number of cattle, people, and tractors, cattle density, human population density, tractor density, or number of tractors per hectare, proportion of land in native pasture, and a dummy variable for location in the Pantanal or the Planalto sub-region, for each of the 16 municipalities and for each of the three censuses.

In the first model, the data were modeled using a multivariate first order ordinary least squares regression technique. In the second model, the dependent variable is continuous, but truncated to values ranging from zero to one, necessitating the use of a double-bounded Tobit procedure for the derivation of unbiased estimators.

3.4. Results

3.4.1. Model 1

Through three estimation iterations, the deletion of insignificant variables and subsequent testing for model improvement in the reduced form (Chow test), model 1 was reduced to the form shown in Table 3. The process of model reduction to statistically significant variables indicates that location, proxy for transportation costs to regional hubs, is not a strong predictor of the amount of land converted in the Pantanal. Nor does there appear to be a significant time trend in deforestation for implanting cultivated pastures.

Many of the implications of the estimated model are straightforward and as expected. For each 100 ha increase in operation size, the model predicts an increase of deforestation for cultivated pastures of 7 ha. Each 100 head increase in herd size implies an increase in cultivated pasture of 2

Table 3
Model of land area deforested for implanting pastures in the Brazilian Pantanal[a]

Area in cultivated pasture (ha)	Coefficient	S.E.	*T*-statistic
Constant	−9.73	1.24	−7.87
Operation size (ha)	0.07	0.002	33.53
Number of cattle (#)	0.02	0.001	27.68
Number of people (#)	2.71	0.13	21.57
Number of tractors (#)	27.47	1.22	22.44
Amount of native pasture (ha)	−0.15	0.003	−44.63
Tractor density (#/ha)	−186.47	43.51	−4.29
Proportion of land in native pasture (%)	−11.12	2.45	−4.55

[a] $N = 12\,972$; $F\ (8,\ 12\,963) = 1424$; $P < 0.0001$; $R^2 = 0.468$.

ha. The model predicts that one additional person (laborer) on a property implies an increase of 2.7 ha in cultivated pasture. An increase in 27.5 ha of cultivated pasture is predicted with each additional tractor, indicating increased intensity and capitalization of production. A decrease in native pasture of 100 ha, hypothesized to have been caused by an increase in flooding, results in an increase in deforestation for cultivated pasture of 15 ha. Using the same logic, the model predicts that the greater the proportion of land currently in native pasture, the lower the tendency for deforesting the remaining land for implanting cultivated pasture. The predicted relationship indicates that a 10% decrease in the proportion of land in native pasture is associated with an increase of 1.1 ha in cultivated pasture.

The only significant variable that defies expectation is the strongly negative relationship between tractor density and the predicted amount of cultivated pasture. One potential explanation is that the tractor density or intensity of use measure was skewed toward smaller properties since each property received equal weight in these calculations. The presence of tractors on small properties makes large-scale land conversion impossible and sharing or leasing tractors among small producers is read as '0 tractors per ha' in the calculations. As a result, where tractors are present there is little conversion and where there is conversion, but no tractors, land use change is attributed to other variables.

In the modeled relationship, the influence of the wealth indicative variables (i.e. land, cattle, tractors) was assumed to have a linear relationship with the amount of deforestation for implanting pasture. It is no great surprise that larger operations with more cattle and more tractors have a tendency to convert more land. However, increases in wealth may accelerate or decelerate the amount of land converted and may do so in a non-linear fashion. We re-estimated the reduced form model transforming these three variables to indicate acceleration (X_i^2) and deceleration in the amount of land conversion ($\log_{10} X_i$) in order to test this hypothesis. The re-estimated models were inferior to the original model. The only substantive difference among the models is that tractor density became statistically insignificant in each of the re-estimated models. These findings lead to the tentative conclusion that the wealth distribution in the Pantanal does not appear to differentially influence the amount of deforestation for implanting cultivated pastures; regional deforestation is proportional to land and animal wealth measures.

3.5. Model 2

In model 2, a double bounded Tobit estimation approach is used to understand the relationship between the degree of deforestation for implanting cultivated pasture in the Pantanal and the independent variables proposed earlier. The reduced form of model 2 is quite distinct from model 1. Most notably, many of the location variables and time are significant in model 2. Due to the significance of a number of dummy variables and the characteristics of maximum likelihood estimators, interpretation of the estimated model parameters is less straightforward than in model 1. Marginal parameter effects were calculated from the mean variable values to facilitate the interpretation of model 2 (Table 4).

The model estimate for the relationship between the number of cattle and the proportion of the land in cultivated pasture indicates that an increase from the mean of 732 head of cattle to 733 head on an average 269-ha property implies an increase from 7.36% of the land in cultivated pasture to 7.36002%. If the marginal effect holds for larger changes, an increase of 100 head implies an increase in deforestation for cultivated pasture of 0.2 m^2/ha, or about 54 m^2 increase in cultivated pasture on the average property. A 1% increase in cattle density implies a 0.0004% increase in the proportion of cultivated pasture per hectare in the Pantanal.

In turn, an increase of one person from the mean of 6.3 has about 120 times the implied impact of a marginal increase in the number of cattle. However, counter to expectations, a 1% increase in the human population density implies a 0.005% decrease in the proportion of lands in cultivated pasture. This result also may be an artifact of the data's biases toward smaller prop-

Table 4
Model of proportion of land deforested for implanting pastures in the Brazilian Pantanal[a]

Cultivated pasture/ha	Coefficient	S.E.	*T*-statistics	Marginal effect
Cattle (#)	0.000007	0.000002	3.51	0.000002
People (#)	0.0007	0.0004	1.75	0.00024
Tractors (#)	0.0225	0.0039	5.84	0.0075
Area of native pasture (ha)	−0.000035	0.000008	−4.54	−0.000012
Cattle density (#/ha)	0.0011	0.0001	12.54	0.00037
Population density (#/ha)	−0.0146	0.0005	−29.01	−0.0049
Proportion of native pasture (ha/total ha)	−0.1937	0.0109	−17.74	−0.064
Located in Pantanal (1, 0)	−0.0771	0.0096	−8.05	−0.026
Municipality 1 (1, 0)	−0.2478	0.0090	−27.55	−0.082
Municipality 2 (1, 0)	−0.1032	0.0088	−11.68	−0.034
Municipality 4 (1, 0)	−0.2024	0.0092	−22.10	−0.067
Municipality 5 (1, 0)	−0.0838	0.0125	−6.71	−0.028
Municipality 6 (1, 0)	−0.1755	0.0363	−4.84	−0.058
Municipality 7 (1, 0)	−0.2733	0.0201	−13.60	−0.091
Municipality 10 (1, 0)	−0.1062	0.0213	−4.99	−0.035
Municipality 12 (1, 0)	−0.1443	0.0472	−3.06	−0.048
Municipality 13 (1, 0)	−0.2154	0.0513	−4.20	−0.071
Municipality 14 (1, 0)	−0.2710	0.1015	−2.67	−0.09
1975 (1, 0)	0.1888	0.0130	14.56	0.063
1980 (1, 0)	0.2083	0.0102	20.48	0.069
1985 (1, 0)	0.2600	0.0101	25.77	0.086

[a] $N = 12\,972$; $F\ (20,\ 12\,951) = 101.45$; $P < 0.00001$; log-likelihood = −4127.45.

erties described above. Smaller properties may have a lower cultivated pasture density due to the potential economies of scale in the fixed costs of land conversion. Since a single family can easily reach the mean number of people per agricultural property, small properties are likely to have a high population density relative to larger holdings.

Each additional tractor from the mean of 0.25 implies a 0.75% increase in the proportion of land deforested for cultivated pasture, or an increase in deforested area of about 12% for each tractor increase. A one-tractor increase from the mean on an average property implies an increase in the proportion of cultivated pasture to 8.11% of 269 ha, or an increase of about 2 ha deforested per additional tractor.

As in model 1, model 2 indicates that cultivated pasture is a substitute for native pasture. Each hectare of native pasture lost implies an increase in proportion of land in cultivated pasture of 0.0012% on the average property, or 32 m^2. A 1% decrease in the proportion of native pasture implies a 0.64% increase in the proportion of cultivated pasturelands, potentially reflecting the productivity differences between the two pasture types discussed previously.

Location of an operation within the Pantanal implies 2.6% lower density of cultivated pasture relative to location in the Planalto, or highland region surrounding the Pantanal. Although probably mitigated by the effect of inundation within the Pantanal, this result is expected since cropland and more intensive management of livestock are the dominant land uses in the highland region. Location in municipalities 1, 2, 4, 5, 6, 7, 10, 11, 12, 13, and 14 implies a lower proportion of land in cultivated pasture than location in municipalities 3, 8, 9, 15 or 16. Municipalities 1, 7 and 14 demonstrate the least proportion of land in cultivated pastures while 2, 5 and 10 are closer to the mean responses (Fig. 1).

Potentially, these results may be explained as a combination of physical characteristics and location relative to regional markets that may reflect transportation costs. Those municipalities demon-

strating the lowest proportion of cultivated pasture (i.e. Barao do Melgaco (1), Santo Antonio do Leverger (7), and Sonora (14)) are all located in the state of Mato Grosso and are among the farthest from regional markets and the most difficult to navigate. With the exception of Itiquira (3), those municipalities with the greatest proportion of cultivated pasture (i.e. Aquidauana (8), Bodoquena (9), Porto Murtinho (15), and Rio Verde (16)) are located on the eastern edge of the Pantanal in the state of Mato Grosso do Sul. They have easiest access to regional markets and trade routes through the state capitol, Campo Grande. Those falling into the intermediate range have either proximity to regional markets (i.e. Caceres (2), Ladario (12), Coxim (11), Ladario (12), Miranda (13), Corumba (10)) or physical conditions conducive to land conversion (e.g. Lambari d'Oeste (4), Nossa Senhora de Livramento (5)), but generally not both.

The time trend variables demonstrate the relative irreversibility of the decision to clear (sub) tropical forests indicating an increase in the proportion of land in cultivated pasture over time. In the period between 1980 and 1985, the proportion of converted land not attributed to other factors increased almost three times from 1975 to 1980; The estimated difference between 1975 and 1980 is an 0.6% increase in the proportion of cultivated pasture per hectare, whereas the estimated difference between 1980 and 1985 is 1.7%.

4. Discussion: alternatives and approaches

Although it is not clear what impact increasing cattle profitability might have on natural habitat conversion, an increase in the profitability of land not in cultivated pasture would have an unambiguous impact on conversion pressures. Avenues for future research include an exploration of the extractive and non-extractive income-generating alternatives available to Pantanal landowners on their forested land, in view of our opportunity cost estimates of forestland conversion to cultivated pasture.

Several estimates of the economic potential of extractive tropical forest products have been undertaken, although none so far in the Pantanal (e.g. Peters et al., 1989; Wilson, 1992; Mendelsohn and Balick, 1995). Pantanal research has concentrated upon identifying potential products and understanding their biological growth conditions. A variety of extractive Pantanal forest products have been identified that have some local and sometimes broader market potential. Coutinho et al. (1997) list more than 50 spices, 20 fruits and vegetables, 5 medicinal herbs, 5 wood species, and about one dozen artisanal uses of Pantanal forestlands and native pastures with local and national markets. Both Goncalves (1996) and Souza and Guarim (1996) cite more than 100 plants used for medicinal purposes in the northern Pantanal.

Several wildlife or feral species may have potential to provide additional sources of income to the Pantanal rancher. Caiman (*Caiman crocodilus yacare*), capybara (*Hidrochaeris hidrochaeris*), wild pig (*Sus scrofa*), and rhea (*Rhea americana*) each has local meat and products markets. Except for perhaps capybara, all have national and international markets. However, regulatory barriers persist and a history of poaching damages public opinion and the efficacy of these alternatives (Goudy, 1997). The pitfalls of suggesting such market and product development are well known; low volume local markets subject to excess supply conditions, high transportation costs, high costs and skill requirements of developing national or international markets, economic rents accruing outside of the producing region, and unintended cultural and environmental impacts of facilitating extractive activities, for example.

In addition to sustainable extractive industries, potentially profit-generating non-extractive uses of natural land show potential. Rural, archeological (Peixoto and Boeira, 1996) or ecological tourism (Geist, 1994; Bordest et al., 1996; Coutinho et al., 1997; Goudy, 1997) may provide economic incentives to conserve forested habitat and biological diversity in the region. A recent study of recreational anglers found that the primary reason for people to fish in the Pantanal was experiencing the unique natural environment, including wildlife-viewing activities. Approximately 46 000 visitors spent an estimated $36 million in 1995 in the Southern Pantanal engaged in this

pursuit (Moraes and Seidl, 1998). Bordest et al. (1996) point to the potentials and the limiting factors regarding tourism development in the Pantanal including poor communication infrastructure; a lack of tourism planning, zoning, and local training/understanding; insufficient fresh water, and water treatment, provisions for human waste management. The combination of information on traditional regional economic practices with research-based information on these potential alternative income generating and habitat preserving activities are among the highest priorities of CPAP.

5. Concluding remarks

Regional economic indicators and incentives for agricultural landowners in the Brazilian Pantanal were explored in order to better understand observed increases in deforestation for the implantation of cultivated pastures to assist in the extensive management of beef cattle. Regional indicators and trends can help researchers and policy makers to begin to understand the incentives for deforestation and biodiversity preservation in the Pantanal.

About 95% of Pantanal lands are privately owned and about 80% are used as extensively managed cattle ranches. The mean size of agricultural property in the Pantanal is increasing, the cattle density and numbers are decreasing, the proportion of land in cultivated pastures is decreasing, but the area is increasing, land and animal wealth is highly concentrated, but becoming somewhat less so, the amount and proportion of unproductive land is increasing, and the amount and proportion of land in natural pastures is decreasing. Whether improving the profitability of cattle production per hectare in the Pantanal results in more deforestation depends upon how landowners react to economic incentives and what the primary constraining factors to cattle production are. Improving the profitability of forestland should unambiguously improve the likelihood of its continued management as forest and the maintenance of biological diversity.

In sum, our attempts at regional census data manipulation to better understand the relationships between Pantanal land owners and their land use decisions have supported conventional wisdom in some situations, provided additional precision to these assertions in other cases, and have refuted these suppositions in still other instances. By and large, land and animal wealth, intensification of agricultural effort, human population, natural pastures and location relative to infrastructure and regional markets influence either the magnitude or the proportion of Pantanal lands deforested for the purpose of implanting cultivated pastures or both. Through these estimations we were not able to establish a nonlinear link between wealth measures and deforestation. Poorer or smaller landowners were equally likely to deforest lands in the same relative proportions as richer or larger landowners. From a policy perspective, it may be more efficient to focus on larger landowners since the magnitude of their deforestation activities is so much greater and, therefore, more land area can be affected with changes in the behavior of fewer people.

Taking these issues into account, several possibilities to improve the likelihood that forested lands and native biological diversity in the Pantanal would be preserved through incentives were suggested including the sustainable extraction of forest species, the potential for generating additional income through ranching of wild and feral species, and the potential to develop various types of tourism in the region. Applied research initiated to improve the profitability of Pantanal lands in order to conserve the unique flora and fauna of the region needs to be cognizant of the additional incentives or disincentives that ranchers face as a result of research design and recommendations. Broader ecosystem-based information requires a broader conception of land productivity than is traditionally assumed within disciplinary bounds.

These results and assertions are not yet ‘ground-truthed’ through completed analyses of on-farm studies. Research continues in building a sufficient store of case study information to analyze the costs of Pantanal calf production at the farm level under a variety of management regimes and land use scenarios. Forage and animal nutrition, livestock breeding and management, live

stock diseases, transportation modes and routes are receiving applied research attention at CPAP. Specific research on nontraditional forest and rangeland products, tourism, impacts of ranch management decisions on river water quality and quantity and fish stocks also continue. The results of these research efforts need to be integrated in order to provide a more complete picture of optimal land use alternatives available to Pantanal ranchers.

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EVOLUTION OF DEFORESTATION IN THE BRAZILIAN PANTANAL AND SURROUNDINGS IN THE TIMEFRAME 1976 - 2008

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Abstract

Maps elaborated from five different periods were recovered and inserted within a single GIS. Considering these maps, the evolution of deforestation in the Pantanal and its surroundings in Brazil was analyzed for the last 32 years and scenarios were described for the timeframe 2010-2050. The results for the different BAP (Floodplain and Plateau), BAP (Mato Grosso and Mato Grosso do Sul States), BAP (Biomes: Pantanal, *Cerrado* and Amazon). Until 2008, the deforestation on the Pantanal floodplain affected 12,14% of its area, while on the Plateau 58,90% were concerned. The actual deforestation percentages indicate that, if no effective control actions are taken, the natural vegetation from this region could be eliminated till 2050. As an instrument for the effective deforestation control, we suggest the implantation of a deforestation monitoring system on the river basin of the Upper Paraguay, based on information technology.

Key words: Geo-Technology. Average rate of geometric growth. Deforestation scenarios. Biomes. Upper Paraguay river basin.

Resumo

Evolução do desmatamento no pantanal brasileiro e entorno de 1976 a 2008

Mapas elaborados em cinco épocas distintas foram recuperados e inseridos num único Sistema de Informação Geográfica. Por meio desses mapeamentos foi analisada a evolução do desmatamento do Pantanal e seu entorno no Brasil nos últimos 32 anos e traçados cenários para o período de 2010 a 2050. São apresentados resultados para cada uma das épocas em diversas subdivisões BAP (planície e planalto), BAP (MT e MS), BAP (Biomas: Pantanal, Cerrado e Amazônia). Até 2008, o desmatamento na planície do Pantanal atingiu 12,14% de sua área, enquanto que no planalto havia atingido 58,90%. Os percentuais atuais apontam, que se não houver ações de controle efetivas, a vegetação natural da região poderá ser suprimida até o ano de 2050. Como uma das formas de efetividade no controle do desmatamento, sugere-se a implantação de um sistema de monitoramento do desmatamento na bacia hidrográfica do Alto Paraguai baseado na tecnologia da informação.

Palavras-chave: Geotecnologia. Taxa média de crescimento geométrico. Cenários de desmatamento. Biomas. Bacia hidrográfica do alto Paraguai.

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INTRODUCTION

The deforestation issue permeates discussions worldwide (ANGELSEN; KAIMOWITZ, 2001), involving managers, scientists, environmentalists and developers, each one with his/her interests and arguments. Nevertheless there is an almost unanimous certainty: the indiscriminate and without control deforestation is prejudicial for the planet Earth, and it is responsible for changes and climate impacts. It causes harmful effects to the planet, both on global and regional or local scale. Actions related to deforestation are frequently associated to the emission of greenhouse gases, specially on the emission of CO_2 which, according to Cerri et al. (2009), is emitted above the global average by Brazil, contributing to climatic changes that affect directly the equilibrium of the environment.

There are many impacts of human activities on natural resources, and among them the transformation of the natural landscape by deforestation, can be considered as one of the most significant ones, because it fragments ecosystems and substitutes native vegetation to livestock with planted pasture, to plantations of grains and fruits, to reforestation and to buildings. Such impacts over the biodiversity are appointed out by Vieira et al. (2008) in his study from the Amazon region.

The natural vegetation cover is an important indicator of the environmental conditions from a region. It propitiates soil protection, reducing sediment transport and siltation of water bodies, besides being the habitat for wild animals contributing so for the maintenance of biodiversity. According to Alho (2008) the loss or alteration of habitats due to conversion of natural vegetation by human occupation, is a real threat with prejudice for the biodiversity of the Pantanal, which is expressive in superior plants (3,400 species – 1,863 phanerogams); fishes (400 species – 263 in the Pantanal); reptiles (179 species, 85 in the Pantanal and 94 on the Plateau); amphibians (80 species, 35 occurring in the Pantanal and 45 on the Plateau); Birds (661 species, 444 in the flooded part of the Pantanal); mammals (195 species distributed in the Pantanal and in the surrounding *Cerrado*) (MMA, 2006).

In the Upper Paraguay river basin (BAP), where the Pantanal is inserted, the suppression of native vegetation is extremely important, because the environmental impacts (siltation of rivers, inundation, loss of habitats) which occur on its floodplain, are caused by transportation of sediments originated from the Plateau adjacent to the basin (ABDON, 2004: ABDON et al. 2005) caused by deforestation. It is emphasized that the production system on the adjacent Plateau is based on livestock over planted pasture and on grain (soybeans, maize, cotton) and so the pressure to deforestation is higher on the Plateau than on the plain, where the production system is based on livestock (breeding) on natural pasture (SILVA et al. 2003; SILVA et al. 2005).

To know where deforestation is occurring, which is the speed of its increase in time, the identification of possible regions (biomes, States, Plateau, Floodplain) where the deforestation pressure is higher, are helpful information for managers to take decisions and transform them in public policies, for the benefit of society.

The Pantanal region and its river basin at the Brazilian part of it has a reasonable set of mappings on deforestation. At the Upper Paraguay (BAP) river basin located at both States (Mato Grosso and Mato Grosso do Sul), the deforestation until 1994, according to Silva & Abdon (1997) totalized over 110,000 km^2. The largest part of this deforestation is localized on the Plateau (93.7%) and the remaining (6.3%) on the Pantanal. Within the Pantanal 5% was deforested till 1994, while at the Plateau this figure reaches 46.2%.

Besides this deforestation mapping at BAP till 1994, in Silva et al. (2001a and 2001b) there are deforestation mappings at BAP, scale 1:250,000, till 1976 and 1984. At Silva et al. (1998) one verifies the deforestation mapping in the Pantanal floodplain till 1991; Padovani et al. (2004) shows the deforestation of this area till 2000 and Abdon et al. (2007) presents the deforestation of the Pantanal biome till 2002. Considering the studies performed by the

Ministry for Environment (MMA, 2009), Monitoriamento (2009) and MMA (2010), it was possible to elaborate a continuous deforestation mapping for the entire basin till 2008.

We emphasize that presently the Ministry for Environment has a monitoring program from the vegetation cover of the Brazilian Biomes, but this program does not consider data earlier than 2002, precluding the construction of scenarios. In this frame it would be important that governmental agencies implant a monitoring system for the Upper Paraguay river basin, which considers also earlier data.

OBJECTIVES

a) To analyze the deforestation at the Brazilian Upper Paraguay river basin in the timeframe 1976-2008, considering the following sub-divisions: Plateau, Floodplain, Mato Grosso and Mato Grosso do Sul States.

b) To analyze the deforestation at the Brazilian Upper Paraguay river basin in the timeframe 1976-2008, considering the existing biomes: Pantanal, *Cerrado* and Amazon region.

c) To analyze the deforestation within the Brazilian Pantanal (Floodplain and Biome) in the timeframe 1976-2008.

d) To elaborate deforestation scenarios at the Brazilian Upper Paraguay river basin for the next 40 years.

MATERIALS AND METHODS

Area under study

In this paper we focus on areas whose borders define the Brazilian Upper Paraguay river basin and the biomes composing it, specially the Pantanal floodplain and the Pantanal biome in Brazil.

A) The Upper Paraguay river basin in Brazil – according to Silva & Abdon (1998) this area is located in the center of South America, occupying sections in Brazil, Paraguay and Bolivia. In the Brazilian territory it has an area of 361,666 km^2 , between latitudes S 15º 30' to S 22º 30' and longitudes W 54º 45' to W 58º 30', bordering with Bolivia and Paraguay. The Brazilian portion occupies partial areas of States Mato Grosso and Mato Grosso do Sul. Referring to the relief, two distinct areas can be observed: the Pantanal floodplain and the adjacent Plateau.

B) Existing biomes in the Upper Paraguay river basin - the Brazilian portion of this basin, according to IBGE (2004) has partial areas of the Cerrado and Amazon biomes, and totally the Pantanal biome.

C) The Pantanal floodplain and biome in Brazil – the floodplain of Pantanal occupies an area of 138,183 km^2 , (SILVA; ABDON, 1998) and the Pantanal biome 150,335 km^2 , according to IBGE (2004).

After conversion to the Albers projection system and necessary adjustments, those BAP and Pantanal floodplain areas (SILVA; ABDON, 1998) and of the Pantanal biome (IBGE, 2004) were recalculated to 361,782 km^2 , 138,424 km^2 and 151,072 km^2 respectively. Therefore for the calculation of percentage these values were used.

In order to improve the different sub-divisions of BAP, figure 1 was elaborated, where the following sub-divisions can be observed: division by States (Mato Grosso and Mato Grosso do Sul), Biomes (Pantanal, *Cerrado* and Amazon) and Plateau and Floodplain.

These delimitations are helpful for the reader to situate himself when analyzing the occurrence of deforestation in the region under study. Special attention must be given to the contours of Biome and of the Pantanal floodplain because they have different borders at Northwest, where the Biome includes a large flat area from the Pantanal depression to the west of the city of Cáceres and also at the western border where the adjacent mountains are included. Due to that, those deforested areas in the Biome present always higher values than those from the floodplain, which can lead to erroneous decisions related to planning and definition of public policies.

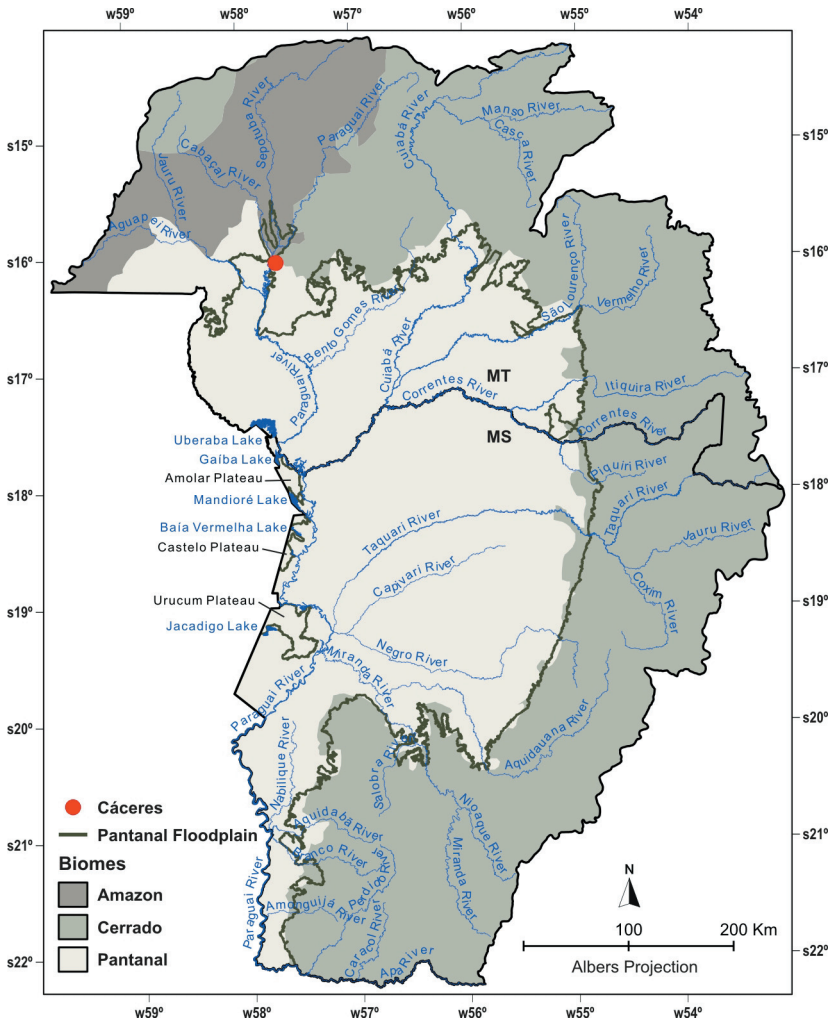

Figure 1 – Upper Paraguay river basin and its different sub-divisions

Methodology

The following accumulated deforestation mappings for the BAP were recovered until the years: 1976 (SILVA et al., 2001a), 1984 (SILVA et al., 2001b), 1994 (SILVA et al.,1997), 2002 (SILVA et al., 2007; ABDON, 2007; FERRARI et al.,2009, MONITORAMENTO, 2009) and 2008 (MMA, 2009; MMA, 2010; MONITORAMENTO, 2009). The first three mappings mentioned (1976, 1984 and 1994) were made by visual interpretation in analogical images at scale 1:250,000, using data from LANDSAT 5 satellite, sensor TM5. The mappings for the years 2002 ands 2008 were executed also by visual interpretation and with satellite images, but using digital images.

The deforestation maps of 1976, 1984 and 1994 were elaborated from 34 charts at 1:250,000 which compose the BAP. These maps were articulated and adjusted using the SPRING GIS (CÂMARA et al., 1996).

The deforestation map from 2002 was elaborated as follows: a) the Pantanal Biome was worked from the vegetation maps of the Pantanal (SILVA et al., 2007; ABDON et al., 2007; FERRARI et al. 2009) which was already articulated and a mosaic made; b) the biome *Cerrado* in the State Mato Grosso do Sul was recovered from the paper authored by Silva et al., (2010), whose mosaic was elaborated from using charts from Mapeamento (2007); c) The Cerrado biome, in the Mato Grosso State, was elaborated by an articulation, adjustment and junction of charts at 1:250,000, recovered from Mapeamento (2007); d) the biome Amazon was elaborated by subtracting deforested areas till 2008 from those deforested in the timeframe 2002-2008, originated from Monitoramento (2009) after the due cutting of Amazon biome area included at BAP. For cutting and junction of deforested areas the SIG Spring and ArcGIS were used.

The deforestation map of 2008 was elaborated as follows: a) the Pantanal Biome was used without change from the MMA (2010) study; b) the *Cerrado* Biome was elaborated from the mosaic of the *Cerrado* Biome (MMA, 2009) and the inherent part to BAP was cut; c) the Amazon Biome was cut from the mapping made by Monitoramento (2009).

After the due conversions, cuts, adjustments and mosaicing, the maps of five dates were converted to a single GIS – SPRING, at Albers projection, Datum SAD69, where the calculations of the deforested areas for the Pantanal floodplain and the adjacent plateau were done, totaling in each State (Mato Grosso and Mato Grosso do Sul); total Biomes (Pantanal, Cerrado, Amazon) and BAP for each State. The crossed tab function was used, with 60 m resolution for intersection and calculation of areas.

It must be highlighted that the older maps (from 1976, 1984 and 1994) of BAP and from the floodplain were constructed on analogical form and digitized using a light table. They were recovered in form of 1:250,000 charts (1º x 1.5º) and UTM projection. When the junction procedure started, some inclusions and exclusions of data in the border of the charts were verified, which were eliminated and adjusted to the new base, created automatically. Such imperfections can be attributed to discrepancies of observed areas. Referring to the map of biomes received, it was at scale 1:5,000,000, at poly-conic projection, because it is a map covering the entire national territory. There was no need to do adjustments but, after cutting the Pantanal biome, the calculated area was different from that one published by IBGE (2004).

For the analysis of the evolution of deforestation at BAP and its different sub-divisions, graphs were elaborated with the accumulated values of deforested areas until each period analyzed. So the values for 1976, 1984, 1994, 2002 and 2008 refer to the area mapped and quantified off all deforestation till each date.

From each period analyzed the average yearly increment of deforestation was obtained, using the average geometric growth rate, obtained by the following expression:

TMGC = (((D(t+n))/D(t))^(1/n))-1,

Where:

n is the number of years of the interval for the calculus of the rate;
D(t+n) is the deforested area calculated at a later date (or at the final time);
D(t) is the deforested area calculated at a later date (or at the final time), in km² for this case;
(1/n) is the inverse number of years from the interval for the calculation of the rate.

RESULTS AND DISCUSSION

Table 1 presents the accumulated deforestation values of five dates (1976, 1984, 1994, 2002 and 2008) for the period analyzed at BAP and its sub-divisions. Such data were used for the calculation of deforestation percentage per territory, the elaboration of graphs and average geometric growth rates, which subsidize the discussion to follow.

Table 1 - Area (km²) of accumulated deforestation at BAP till 1976, 1984, 1994, 2002 and 2008

Physiographic Delimitation	Physical area	Deforested area (km²) till				
		1976	1984	1994	2002	2008
BAP (floodplain/plateau						
Floodplain	138,423.7	634.9	2,880.2	7,021.4	11,818.7	16,798.1
Plateau	223,358.7	10,783.5	53,509.3	104,948.7	112,729.1	131.566.8
BAP total	361,782.4	11,418.4	56,389.5	111,970.1	124,547.8	148,364.9
BAP (States)						
Mato Grosso						
Floodplain	49,285,0	244,2	882,1	2,342,6	3,495,8	5,135,7
Plateau	124,786.1	6,270.2	28,687.8	55,258.0	57,372.8	68,175.4
Pantanal Biome	60,996.8	358.2	2,618.9	6,890.9	9,126.0	11,474.9
Cerrado Biome	82,058.5	2,694.3	15,783.3	33,464.9	32,154.4	41,138.9
Amazon Biome	31,015.7	3,462.0	11,167.7	17,244.7	19,588.3	20,697.3
Total BAP in MT	174,071.1	6,514.4	29,569.9	57,600.6	60,868.7	73,311.1
Mato Grosso do Sul						
Floodplain	89,138.7	390.7	1998.1	4,678.8	8322.9	11,662.5
Plateau	98,572.6	4,513.3	24,821.6	49,690.8	55,356.3	63,391.4
Pantanal Biome	90,075.4	613.1	2379.0	4,919.4	8315.2	11,484.5
Cerrado Biome	97,635.9	4,290.9	24,440.6	49,450.1	55,363.9	63,569.4
Amazon Biome	0,0	0,0	0,0	0,0	0,0	0,0
Total BAP in MS	187,711.3	4,904.0	26,819.6	54,369.5	63,679.2	75,053.9
BAP (Biomes)						
Pantanal	151,072.2	971.3	4,998.0	11,810.3	17,441.2	22,959.4
Cerrado	179,694.3	6,985.2	40,223.8	82,915.1	87,518.3	104,708.3
Amazon	31,015.7	3,462.0	11,167.7	17,244.7	19,588.3	20,697.3
Total BAP	361,782.2	11,418.4	56,389.5	111,970.1	124,547.8	148,365.0

Deforestation at the Upper Paraguay river basin (BAP) – Pantanal floodplain, Plateau and States

At figures 2, 3, 4 and 5 there are graphs with deforested areas in absolute and relative values at BAP from the timeframe 1976 to 2008 in different cuttings, and there are always growing values of deforestation in the region. Information on the floodplain, plateau and BAP are found on figure 2; information about the States which compose the BAP are at figure 3 and data on each of the States composing BAP are found on figures 4 and 5.

At figure 2 one observes that deforestation at the Pantanal floodplain is low if compared to the deforestation occurring on the plateau. Plans and governmental incentives, roads, closeness and expansion of cities, the division of States (Mato Grosso [MT] and Mato Grosso do Sul [MS]) executed in 1979, a good soil and adequate relief as well as mechanization of agriculture, they all contributed strongly for the suppression of the natural vegetation and installation of livestock. Some of the factors mentioned, related to the deforestation at BAP, where the Pantanal biome is located, were also observed in the Amazon biome, whose deforestation advancement is related to development policies in the region, such as land speculation along the roads, growth of cities and the dramatic increase of livestock, timber exploration and subsistence agriculture and more recently the mechanized agriculture, specially soybeans and cotton (FEARNSIDE, 2003; ALENCAR et al. 2004; LAURANCE et al. 2004).

In spite of the low deforestation activities in the Pantanal, the curve presented at figure 2, suggests an exponential behavior, different from the deforestation on the plateau which presented a low fall in the curve during 1984 and 2002. It is noteworthy that the exponential behavior in the deforestation evolution will lead to the exhaustion of the natural vegetation resources if no actions are started to inhibit such growth. This fact will initiate a series of negative implications, mentioned already by Hass (2002) and among them the fact that the excessive reduction of areas with native vegetation could cause the extinction of bird species, because they don't survive in small fragments.

In relative terms (calculated by data from table 1) until 2008, the Pantanal floodplain had 12.14% of its area deforested, while at the plateau this figure reached 58.9%. This percentage of deforestation from the plateau area causes preoccupation, since probably the natural area to be suppressed in the plateau adjacent to the Pantanal is close to its limits, requiring more efficient and stringent control actions. One must take into account that the deforestation in the Cerrado areas, where the headwaters of rivers are located, caused erosion and siltation of rivers, changing the water flows and hydrologic regimen in the Pantanal, with negative consequences for the regional biodiversity (HARRIS et al., 2006). According to these authors, the hydrologic processes, modified due to the removal of the vegetation cover change the flood and drought cycles (inundation pulse), largely responsible for all the biological richness of the Pantanal region.

In the BAP analysis, the deforestation advanced from 11,418 km^2 in 1976 to 148,365 km^2 in 2008 (Table 1), with a 13 times increment. While the deforested area in the basin represented 3.2% in 1976, it went up to 41.0% in 2008.

In the period between 1976 and 2008 (table 1) one observes that in the two first periods which comprehend 1976 to 1994, 71.6% of all deforestation in the plateau occurred, while for the floodplain the largest deforestation occurrence (58.2%) was verified in the two last periods, comprehending from 1994 to 2008.

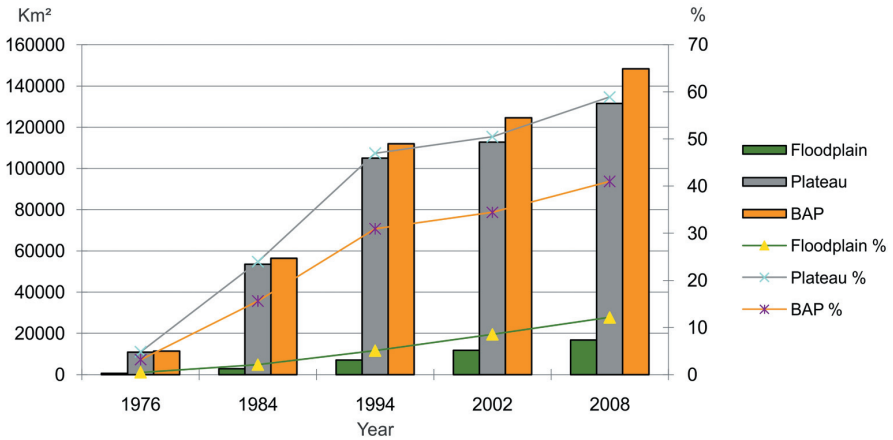

Figure 2 – Accumulated deforested area in the Brazilian BAP in the period from 1976 to 2008

The analysis of the evolution from the deforestation in the State portions of BAP components can be obtained from figure 3 and table 1. Differently when one compares the plateau and the floodplain of the Pantanal, the deforested areas in Mato Grosso and Mato Grosso do Sul States at BAP had a similar behavior during the 32 years analyzed and the deforestation in Mato Grosso State was slightly higher than at the southern State. Nevertheless, from the five dates with accounted deforestation, only in 2002 the difference among both States was 4.13%, falling to 2.14% in 2008. In absolute terms (Table 1) till 2008, BAP in Mato Grosso lost 75,054 km² of its original vegetation cover, while BAP in Mato Grosso do Sul lost 73,311 km² equivalent to the loss of respectively 42.12% and 39.98% from its territory.

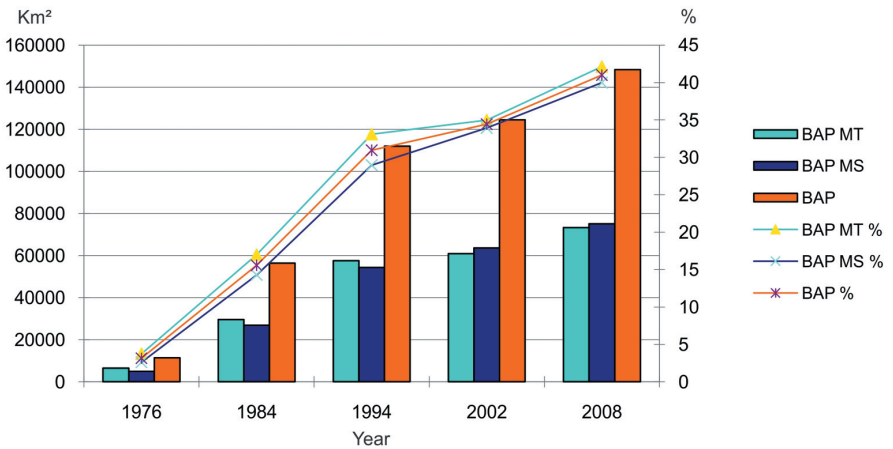

Figure 3 – Accumulated deforested area in the States of Brazilian BAP in the period from 1976 to 2008

At figures 4 and 5 one observes the evolution of deforestation in the territory portions referring to the plateau, Pantanal floodplain and BAP at each one of the States. Comparing these two figures with figures 2 and 3 one verifies that the behavior of the deforestation evolution on the plateau of BAP (Figure 2) is similar to the evolution of deforestation at BAP portions from each State (Figure 3), in both the plateaus of Mato Grosso State (Figure 4) and Mato Grosso do Sul (Figure 5). On the other hand, the behavior of deforestation in the Pantanal (Figure 2) is not similar to the evolution of the deforestation in the BAP, but it is similar to the evolution occurring in the floodplain from each of the two States (Figures 4 and 5).

This finding is quite obvious, since the deforestation on the plateau defines the behavior of the evolution of deforestation at BAP, because of the 148,365 km^2 (Table 1) deforested in PAB till 2008, 88.7% occurred in the plateau.

Analyzing the deforestation occurred till 2008 on the plateau of BAP for each State, one verifies that proportionally the area located in Mato Grosso do Sul is approximately 10% more deforested than the equivalent one in Mato Grosso State. On the plateau of Mato Grosso do Sul State 64.3% were deforested, against 54.3% of the plateau in Mato Grosso State.

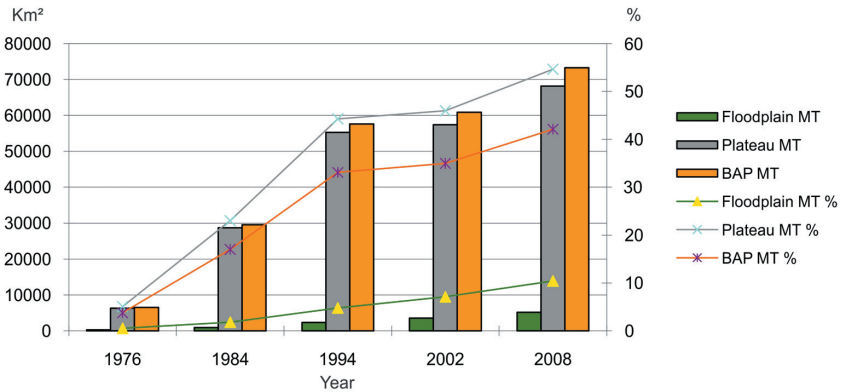

Figure 4 – Accumulated deforested area in the State Mato Grosso localized at BAP in the period from 1976 to 2008

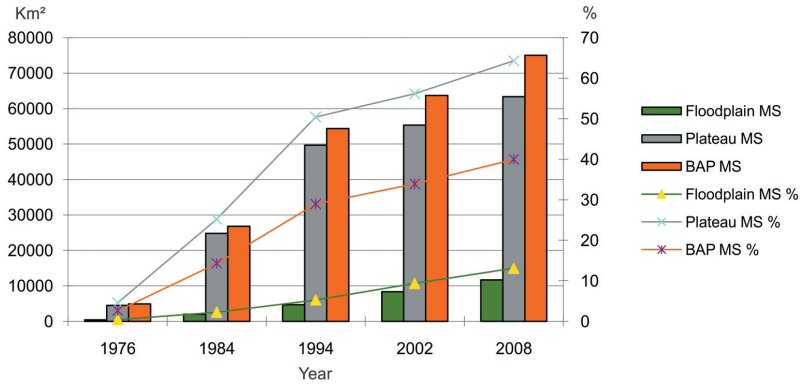

Figure 5 – Accumulated deforested area in the State Mato Grosso do Sul localized at BAP in the period from 1976 to 2008

The deforestation in the biomes at the Upper Paraguay river basin

Analyzing the graphs of figure 6, one verifies precisely the contribution, on absolute values, of the deforestation occurring on the Cerrado biome for the total of the area deforested in the basin. Based on data from table 1, the deforestation in the Cerrado represents 70.6% of the natural vegetation suppression occurred at BAP, and the remaining occurs on portions of the biomes Pantanal (15.5%) and Amazon (13.9%). One observes that the deforestation occurred in the Pantanal biome has a quite similar behavior to what occurred in the Amazon one, with quite close absolute values over time. Nevertheless, when one compares the deforestation of each biome proportionally to its area at the BAP, the behavior is quite different. While at the entire Pantanal biome only 15.2% of the natural vegetation was suppressed till 2008 in partial areas of the biomes Cerrado and Amazon present at BAP, the suppression of natural vegetation reached till this date respectively 58.3% and 66.7% of its territories.

On the plateau and in the Cerrado biome there was a light reduction on the intensity of deforestation in the period from 1994 to 2002 (Figure 6), what is reflected in the basin as a whole, since the Cerrado occupies the largest territory of BAP. In the Amazon biome one notes a little tendency for the reduction of accumulated deforestation between 2002 and 2008, perhaps because this part of the biome in the BAP reached its occupation limit. Such fact can be confirmed by the small inflection observed on the curve from the deforestation evolution at this biome (Figure 6) since 1994.

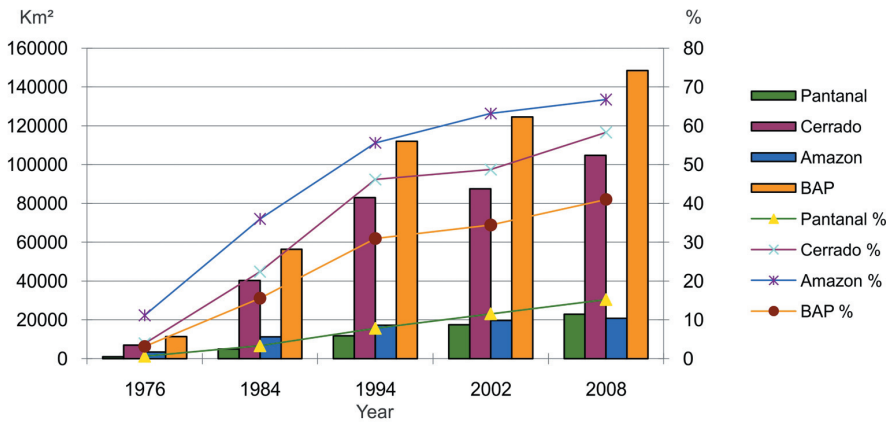

Figure 6 - Accumulated deforested area in the portion of the biomes localized at BAP in the period 1976 to 2008

The deforestation in the Pantanal floodplain and in the Pantanal biome

The behavior of the curve from the deforestation evolution in the Pantanal floodplain and in the Pantanal biome (Figure 7) is similar, but the biome presents higher deforestation values along the period analyzed, both in absolute and relative numbers.

Using data from table 1 we calculate that, in relation to its physical area, in the Pantanal biome, the loss of natural area reached 0.6%, 3.3%, 7.8%, 11.5% and 15.2% till respectively 1976, 1984, 1994, 2002 and 2008.

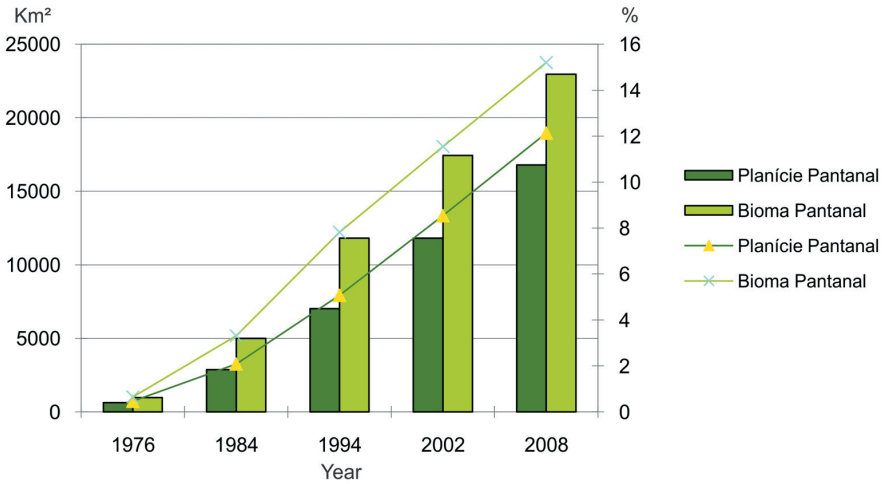

Figure 7 – Accumulated deforested area in the Brazilian Pantanal at BAP in the period from 1976 to 2008

One verifies that the deforestation in the floodplain increased 26,5 times in the period 1976-2008, while at the biome this rate attained 23,6 times, in relation to its physical area. However the deforested area in the biome in 2008 is 36.7% higher to the figure in the floodplain, reaching till now 22,959.4 km^2.

Referring to the deforestation at the basin till 2008, the floodplain known as Pantanal corresponds to 11.3% of the deforested area, but considering the biome, it corresponds to 15.5%.

Spatial evolution of deforestation at BAP

For the spatial analysis of deforestation at BAP, figures 8 and 9 were prepared where it is possible to check the distribution of deforested areas at distinct sub-divisions of the area under study.

Analyzing these figures it is easy to verify how the pressure for deforestation in the basin occurs on the plateau, whether considering the Pantanal floodplain or the Pantanal biome. However, when the floodplain is considered (Figure 9) one verifies the occurrence of strong deforestation in the south of the Pantanal and when one considers the biome (Figure 8), to this area is summed up the NW section of the biome, localized to the West of the Cáceres city. The central objective of these figures is to show to the reader the spatial evolution of deforestation in specific areas, without intending to show details of this evolution.

Proportionally the deforestations are quite similar when compared to the sections of the Pantanal floodplain localized in each of the two States. There is a little difference of 1.1% in this proportion for the floodplain located in Mato Grosso do Sul, because while 10.4% of the natural vegetation from this area were already suppressed till 2008, in the portion of Mato Grosso this occurs at only 9.3% of its territory.

Figures 8 and 9 show that in the period 1976-84 and 1984-94 most deforestation occurred at BAP, because large spaces in white at the figures were filled up by gray, the color considered for deforestation. However in the period 1984-94 the deforestation was higher in 23.5%. While in the first period 45,000 km^2 of natural vegetation was eliminated, in the second one the total reached 55,600 km^2. Two events are considered as inductors of

this event, as already commented by Silva et al. (2005): the National Plan for the Land Reform (PNRA 1985-1989) and the promulgation of the Federal Constitution of 1988. While the PNRA prioritized the re-establishment of the Land Reform, the Constitution foresees the expropriation of land for this objective in the rural properties which did not comply with its social function.

In relation to the biomes which compose BAP, comparing figure 1 with 8, one identifies the occurrence of the deforested areas at its respective portions. Even if lightly, one verifies at figure 8 that there isles space without deforestation in the area related to the Cerrado biome than at the Amazon biome till the year 2008.

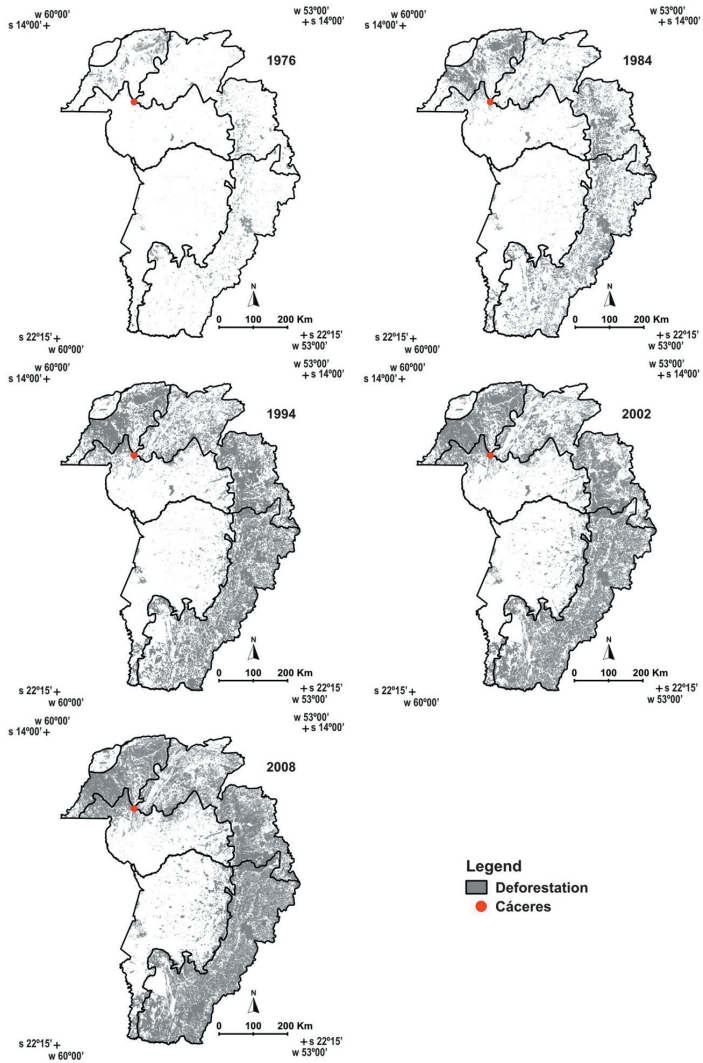

Figure 8 – Deforestation at BAP and biomes in the period from 1976 to 2008

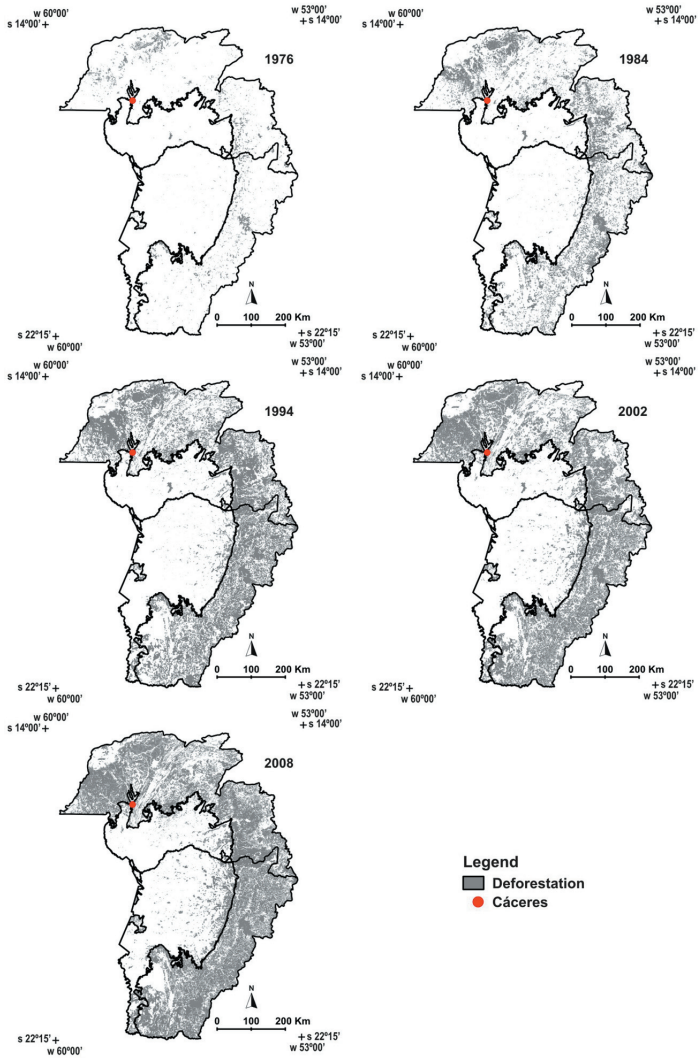

Figure 9 – Deforestation at BAP and at the floodplain in the period from 1976 to 2008

Estimation of tendencies of deforestation at BAP and its sub-divisions

To analyze the tendency of deforestation at BAP and its several territorial portions, average rates of geometric growth were elaborated for the periods 1976-1984, 1984-1994, 1994-2002 and 2002-2008 (Table 2). Based on these data, figures 10,11,12 and 13 were elaborated, showing the evolution of these rates along time.

Table 2 - Average rates of geometric growth at BAP and sub-divisions in the four periods analyzed

Physiographic delimitation	Average rates of geometric growth			
	1976_84	1984_94	1994_2002	2002_08
BAP (floodplain/plateau)				
Floodplain	0.208	0.093	0.067	0.060
Plateau	0.222	0.070	0.009	0.026
BAP Brazil	0.221	0.071	0.013	0.030
BAP (States)				
BAP MT	0.208	0.069	0.007	0.031
BAP MS	0.237	0.073	0.020	0.028
BAP Brasil	0.221	0.071	0.013	0.030
BAP (Biomes)				
Pantanal	0.227	0.090	0.050	0.047
Cerrado	0.245	0.075	0.007	0.030
Amazon	0.158	0.044	0.016	0.009
BAP Brazil	0.221	0.071	0.013	0.030
Pantanal (Floodplain/Biome)				
Pantanal floodplain	0.208	0.093	0.067	0.060
Pantanal biome	0.227	0.090	0.050	0.047
BAP Brazil	0.221	0.071	0.013	0.030

One observes at table 2 and figures 10 to 13 that the highest growth rates of deforestation occurred in the period 1976 to 1984. Except for the Amazon biome which presented yearly growth rates of 16.8%, for BAP and the other territorial portions composing it, the growth rates were above 20% per year.

The evolution of the growth rates for the floodplain, the plateau and BAP can be verified at figure 10. The Pantanal floodplain presents a decrease on the deforestation speed in the four periods analyzed while at the plateau and BAP the rates reduced continuously till 2002, but went up in the period from 2002 to 2008.

At the analysis of the average rates of geometric growth of deforestation in the biomes (Figure 11) which compose the BAP, the Pantanal and Amazon biomes also present a continuous decrease in the deforestation rates during all periods analyzed. However the Cerrado, after presenting a fall of rates till 2002, suffered an increase in the period 2002 to 2008. At figure 12 one observes the evolution of deforestation growth rates in the territorial portions of States present at BAP. In this analysis one sees also the same tendency of speed reduction from deforestation till 2002, and an increase in the period from 2002 to 2008. The increase verified in the period is associated to land use because, according to Santos & Câmara (2002), in those upstream of Pantanal, the soybean monoculture destined to export expanded, as well as sugarcane for the production of bio-fuels, causing indirectly in this region, negative social-economic effects, typical for this type of agricultural exploitation. It is important to consider that on the upriver areas of Pantanal there are several wellsprings which contribute directly to the maintenance of the inundation pulse. Accordingly the

deforestation on the headwaters caused a significant increase on sedimentation, resulting in the reduction of both soil and pasture productivity and on the increase of the frequency and level of flooding (LOURIVAL et al., 2000). The great biodiversity of the Pantanal is associated to the inundation regimen which keeps large areas flooded during periods varying from 6 to 12 months.

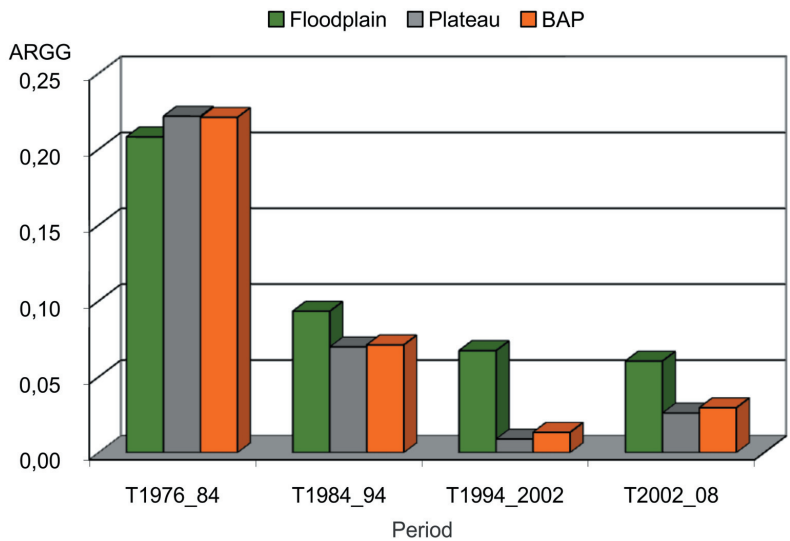

Figure 10 – Evolution of the average rate of geometric growth (ARGG) of deforestation in Brazilian BAP in the period 1976 to 2008

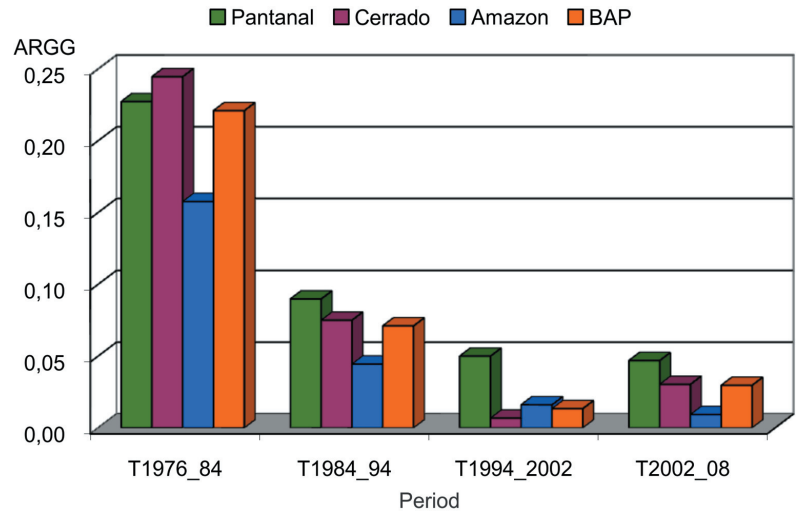

Figure 11 – Evolution of the average rate of geometric growth (ARGG) of deforestation in the Brazilian BAP biomes in the period 1976 to 2008

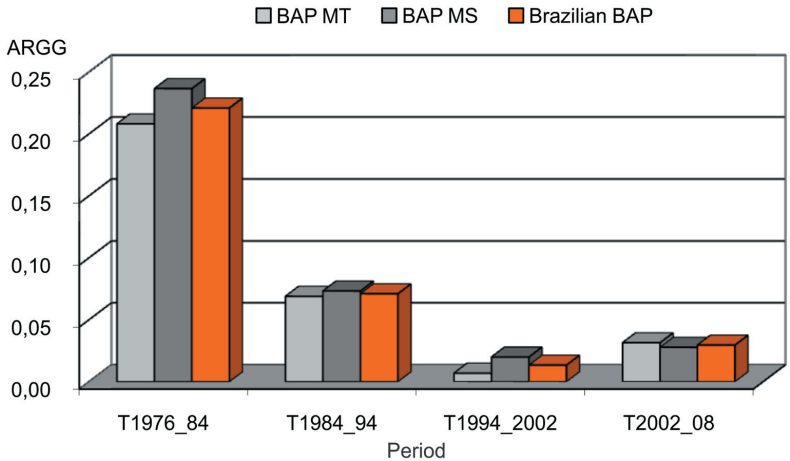

Figure 12 – Evolution of the average rate of geometric growth (ARGG) of deforestation in the States of Brazilian BAP in the period 1976 to 2008

Figure 13 shows in more detail the evolution of the deforestation growth rates in the biome and Pantanal floodplain. It is noteworthy that in these two territorial portions the tendency is the reduction of the deforestation speed that is different of the rate at BAP which, due to the deforestation on the plateau has a tendency of growth in the last period.

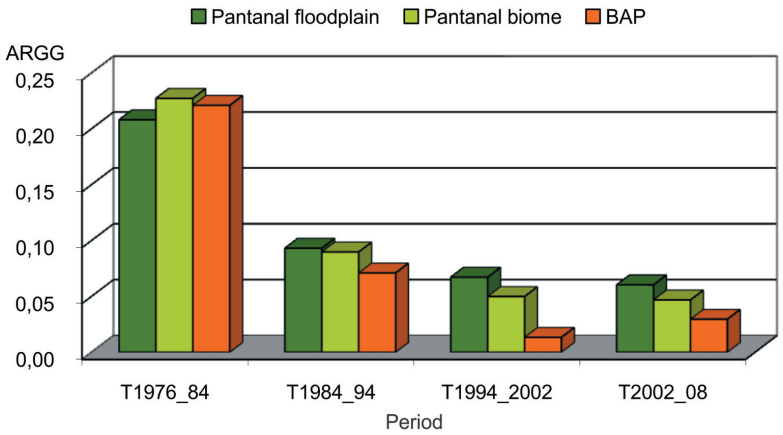

Figure 13 – Evolution of the average rate of geometric growth (ARGG) of deforestation in the Pantanal floodplain and on the biome Pantanal in Brazil in the period 1976 to 2008

Based on the average geometric growth rates it is possible to trace probable scenarios of deforestation for BAP and its sub-divisions. Using the rates of the period 2002 to 2008, figure 14 was elaborated with the scenario of deforestation from 2010 to 2050 for the Pantanal floodplain, the plateau, BAP and the Pantanal biome. If the present conditions

remain, the tendency is the suppression of the natural vegetation from the plateau of BAP till 2029 (i.e. in the coming 19 years) and of the floodplain till 2045 (i.e. in the coming 40 years). The study made by Harris et al. (2006) corroborates the scenario presented in our study. The authors used the deforestation rate of 2.3% per year (considering the period 2000-2004) and concluded that within a little over 45 years (2051) the original vegetation cover of the Pantanal will be completely lost or modified, so that it will be improbable to reconstitute the climatic-hydrologic complex, the exuberance of the waters and the rich regional biodiversity.

In the MMA (2006) report there is an alert about the increase of deforestation, mentioning that the forecasts demonstrate that by 2020 there could be an increase of population at BAP up to 2,250,000 inhabitants and in 2050 up to 3,920,000, which certainly would cause further problems [...] If the attention given to land use up to now would occur with the same perspective without planning, there would be an increment of deforestation by the occupation of new land for agriculture, which would increase the commitment of water resources by contamination of water sources and silting of rivers.

However the forecast presented eventually will not become concrete, considering that actions can be taken and the legislation implemented by governmental agencies, which must be more incisive in the control and monitoring of deforestation in the Pantanal.

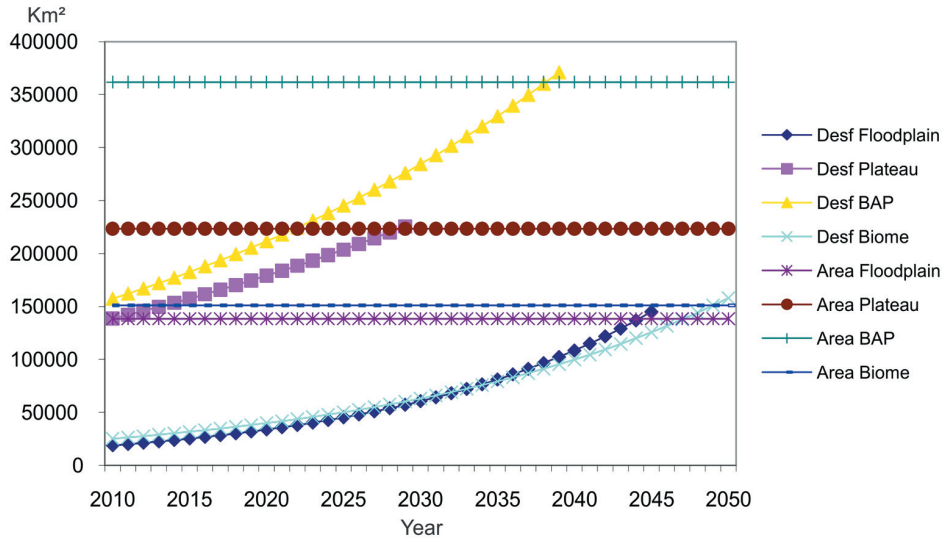

Figure 14 – Deforestation scenarios for the Pantanal floodplain, the plateau, BAP and the Pantanal biome for the period 2010 to 2050

Presently BAP does not have a monitoring system for the deforestation, neither a structured geo-referenced information base. It is noteworthy that the Brazilian Federal Government conducts the world largest program to monitor deforestation in the Amazon region, but this program does not include the Pantanal, because it is not localized in the region defined as "Legal Amazon". The National Institute for Space Research (INPE) developed efforts since the 90s to monitor the deforestation in the Amazon region (generation of maps, calculation of deforestation rates, making results available, etc.), contributing strongly for the definition and transference of methodologies used (DUARTE et al., 1999; SHIMABUKURO et al, (1998, 2005); CÂMARA et al., 2006, DUARTE et al., 2006). Such methodologies can be

adapted to the Pantanal region, creating a monitoring system for the Pantanal basin. This is feasible, if there is political interest to its realization. It is a fact that there is a growing demand of uses for production and infrastructure which generate pressures on the BAP region, allowing land use and occupation without integrated planning, executed on fragmented form by public policies for both States Mato Grosso and Mato Grosso do Sul, considering distinctly the hydrographic region and dissociating the relations existing among the form of land use on the floodplain and plateau regions (MMA, 2006).

In order to do that, we propose that such a system to monitor the dynamics of deforestation in the Pantanal is elaborated applying information technologies, based on free software and geo-technology tools (remote sensing, GIS, geo-referenced databanks, consultation and release of data by Web).

Finally we agree with Santos & Câmara (2002) that the scenarios generated by this study constitute possible images for the future, which will be the result of decisions taken presently.

CONCLUSIONS AND SUGGESTIONS

Deforestations are occurring systematically on the plateau adjacent to the Pantanal, causing impacts on it, considering the floodplain or the biome. The deforestation occurs in a larger extension and velocity on the plateau than at the Pantanal floodplain, and this suggests preventive and incentive decisions to minimize its effects on the environment, because the deforestation on the plateau influences directly the Pantanal.

Between 1976 and 1984 the deforestation occurred at a higher speed, decreasing till 2002, but presenting an increase in the period 2002 to 2008.

Historically the floodplain is known as Pantanal, but with the delimitation of the biome in a generalized scale and including portions beyond the floodplain, the total deforestation tends to increase, as shown in this work.

Overestimated deforestation values for the Pantanal result in unrealistic rates and tendencies, penalizing those who conserve the region and inducing the creation of wrong public policies.

The analysis and estimations of impacts due to the conversion of natural areas to land use, must always consider the adjacent plateau, since there is a synergism between these two territories. Similarly the development plans or programs to be implemented in the region must foresee this synergism.

Considering any delimitation for the analysis of deforestation at BAP, and if the present conditions remain, the natural vegetation from the region will disappear in the next 40 years, i.e. till 2050. Nevertheless, changes on attitudes of society and the requirement of fulfillment from legislation by governmental agencies, are capable to change the prognostic presented for the future of BAP.

We recommend the implantation of a monitoring system for deforestation in the Upper Paraguay river basin based on technology information, so that the scenario could be changed, according to what is done in the Amazon region.

ACKNOWLEDGEMENTS

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RESEARCH ARTICLE

The potential for large-scale wildlife corridors between protected areas in Brazil using the jaguar as a model species

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Abstract Most large reserves in Brazil do not hold viable populations of jaguars to guarantee the species' long-term survival. Corridors linking populations have been identified as a potential tool to avoid negative effects of isolation, increasing population viability. Here, we performed a Brazil-wide evaluation of potential large scale corridors connecting protected jaguar populations. Six variables (human population size, dam reservoir size, number of dams, roads, railways and cities) expected to negatively impact jaguar movement were analyzed across 180 potential corridors connecting 298 protected jaguar areas. We established overall disturbance scores for the corridors using a principal components analysis and compared them among the Brazilian biomes. We further investigated which variables separated biomes using a canonical variates analysis. The Atlantic Forest and the semi-arid Caatinga have the most impacted potential corridors, whereas the Amazon and Pantanal still have the best potential corridors. Corridor quality in the Cerrado grasslands was intermediate. All variables but human population size and corridor length contributed significantly to differences in corridor variables among biomes. Our conclusions suggest that we need to plan the implementation of large scale corridors in the Amazon, Pantanal and particularly the Cerrado soon, while potential corridors might still be economically viable. In the much more impacted Atlantic Forest and Caatinga, the need for conservation actions is strongest, but logistical difficulties and costs may turn implementation of corridors unfeasible.

Keywords Brazil · Conservation · Corridor · Disturbance · Jaguar · *Panthera onca* · Principal components analysis

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Introduction

Today, the main threat to large and wide ranging mammal species is habitat loss and fragmentation, and the consequent isolation and collapse of local populations (Fahrig 2003; Costa et al. 2005; Fortin and Agrawal 2005). Under the pressure of human population growth and simultaneous conversion of natural habitat (Gardner et al. 2009), the geographical

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distributions of many large mammals have suffered significant reductions (Morrison et al. 2007; Schipper et al. 2008). Reduction of suitable habitat does not occur in a continuous manner, but rather creates disconnected patches in which the species can be found. Habitat converted for anthropogenic use often represents barriers for, or reduces rates of animal dispersion (Bélisle et al. 2001; Gardner et al. 2009), leading to the isolation of populations that occur in suitable habitat patches. Particularly small isolated populations suffer high risks of extinction due to a greater susceptibility to stochastic events (Caughley 1994) and loss of genetic diversity, caused by genetic drift and/or inbreeding (Harrison and Hastings 1996). Genetic diversity is often associated with adaptability to changing or new environmental conditions and pathogens (Lacy 1997; Sih et al. 2000). Especially large-bodied species may suffer from the effects of habitat loss and isolation as they require large tracts of land to maintain viable populations (Fahrig 2003; Fischer and Lindenmayer 2007; Morrison et al. 2007).

Corridors that establish connections between suitable patches of habitat, and thus contribute to the maintenance of gene flow and other ecological processes, are considered one of the main strategies to mitigate or reverse consequences associated with habitat fragmentation/isolation problem, as they allow species to move across the landscape, (e.g., Chetkiewicz et al. 2006; Rocha et al. 2006; Gilbert-Norton et al. 2010). The resulting network of interconnected subpopulations is believed to contribute to the resilience of a species to extinction due to rescue effects (i.e., recolonization of patches where the species has gone extinct) (e.g., Hanski 1991). Corridors can range in scale from a few meters, facilitating the movement of individuals across man-made barriers (e.g., an overpass over a highway), to incorporating entire landscapes with mixed land use types and protection status (Simberloff et al. 1992). While the actual effectiveness of corridors remains controversial, evidence in favor of a positive effect on animal movement between patches is strong (Beier and Noss 1998; Gilbert-Norton et al. 2010).

Against this background, the objective of our study is to identify existing landscape structures in Brazil that can serve as potential large scale wildlife corridors, and evaluate these potential corridors regarding their current degree of human disturbance. Since the definition of a corridor depends largely on the biology (space and habitat requirements, movement ability, etc.) of the focal species (e.g., Haddad and Tewksbury 2006; Gillies and Clair 2008), we chose the jaguar (*Panthera onca*) as a model for our analysis. The jaguar is the largest felid in the Neotropics, and Brazil covers close to 50 % of the species' current range (Zeller 2007). Still, 75 % of the country's protected jaguar populations, when considered isolated, are not viable in the long term (Sollmann et al. 2008). Population isolation, loss of genetic diversity and consequent local extinction events have been observed in several regions of the jaguar's distribution (Cullen 2006; Soares et al. 2006; Mazzolli 2008; Haag et al. 2010). Maintaining or re-establishing connections between jaguar populations has been cited as a priority conservation concern for the species (Silveira and Jácomo 2002; Rabinowitz and Zeller 2010). Jaguars are mobile and wide ranging species with home range requirements of up to several hundred square kilometers (Astete et al. 2008). Thus, corridors for jaguars could provide living space and dispersal opportunities for many other species as the habitat needs for this charismatic umbrella species may encompass the need of other species within the ecosystem (Carroll et al. 2001).

With our analysis we present the first Brazil-wide assessment of large scale potential wildlife corridors. Our results provide guidance as to where to focus future research and conservation efforts aimed towards the implementation of such corridors throughout Brazil.

Methods

Study system

The jaguar occurs in five Brazilian biomes: the Amazon, Pantanal, Cerrado, Atlantic Forest and Caatinga (Table 1), being absent only from the Pampa in the very south of the country. These biomes represent distinct environmental realities, both in terms of habitat and human impact. The Amazon rainforest with its remaining largely undisturbed continuous blocks of forest is the largest stronghold for the jaguar throughout its distribution (Sanderson et al. 2002; Sollmann et al. 2008). With the advancement of the agricultural frontier into the Amazon, however, predictions of future deforestation are high

Table 1 General information about the five Brazilian biomes where jaguar occur, including total area in km^2, % of Brazil area covered by each biome, % of converted area to human use, main natural vegetation and number of protected jaguar areas (PJAs)

Biome	Total area	% of Brazil area	% of converted area	Main vegetation	No. PJAs
Amazon	4,196,943	49,29	12,47	Rain Forest	167
Cerrado	2,036,448	23,92	38,98	Wooded Savannah	60
Atlantic Forest	1,110,182	13,04	73,03	Rain Forest	49
Caatinga	844,453	9,92	36,28	Steppe Savannah	16
Pantanal	150,355	1,76	11,54	Savannah/Chaco	6

Source: IBGE (2004) and Sollmann et al. (2008)

(Costa et al. 2005). The Pantanal is considered a second stronghold for the jaguar (Sanderson et al. 2002). Extensive cattle ranching—the main economic activity in the area—and the seasonal flooding regime have preserved much of its native vegetation, and the high abundance of mammalian prey (Swartz 2000) supports comparatively high jaguar densities (Soisalo and Cavalcanti 2006), even in non-protected areas. The Cerrado, central Brazil's savanna, has been heavily impacted by large scale agriculture (soy bean, cotton, grains, and more recently sugar cane); 80 % of its area is under some degree of human influence (Cavalcanti and Joly 2002). Jaguars occur at low densities and isolation appears to be a predominant threat to the species in this biome (Silveira 2004; Sollmann et al. 2011). The semi-arid climate and poor soils of the Caatinga limit large scale agriculture and cattle ranching, but this biome in the northeast of Brazil suffers from intensive small-scale fragmentation. The poor rural population exerts a strong poaching pressure on the jaguar's prey base (Leal et al. 2005). Home to the major developing centers of Brazil, the coastal Atlantic Forest has lost much of its native vegetation and remaining patches are small (Gascon et al. 2000). Increasing anthropogenic pressures threaten the jaguar and other mammal species in this biome (Canale et al. 2012).

Defining a potential jaguar corridor

We adopt a corridor concept that does not necessarily require an individual to move through the entire length of a corridor to be functional; rather, these large scale corridors should provide living space for the target species outside of established protected populations, so that these maintain some degree of connectivity. This is similar to the concept of "regional corridors" discussed by Simberloff et al. (1992) in the context of allowing range shifts due to climate change. In order to identify potential jaguar corridors it is necessary to identify the populations to be connected in the landscape. We considered the *Protected Jaguar Areas* (PJAs) described in Sollmann et al. (2008) as the jaguar populations in Brazil in need of connection as this study currently represents the broadest assessment of jaguar populations in Brazil. The authors considered protected areas with jaguar presence and larger than 10,000 hectares, since these are, in theory, large enough to sustain a minimum of one resident breeding pair. When these areas were immediately adjacent to each other, they were considered as a single block with a contiguous jaguar population.

In a second step we identified potential connections between these populations. Corridors can be defined according to two aspects: *structural*, considering continuous strips of natural habitats connecting fragments; and *functional*, considering the species' behavioral response to structural elements of a corridor, like the mosaic of different land uses (Chetkiewicz et al. 2006; Fischer and Lindenmayer 2007). While jaguars are able to use anthropogenic habitat, they generally prefer natural habitat (Silveira 2004; Cullen 2006; Conde et al. 2010; Colchero et al. 2011). Riparian vegetation along river courses is among the species' preferred habitats and the species' affinity with water has been demonstrated throughout its distribution (Crawshaw and Quigley 1991; Naiman and Décamps 1997; Cullen 2006; Lees and Peres 2008). Further, in Brazil, environmental legislation requires landowners to protect habitat along water courses in the form of so-called areas of permanent protection (APP) (Brasil and Presidência da República 2012). Thus, river courses provide the highest potential for wildlife corridors in

general (legal protection status) and for the jaguar in particular (species specific preferences for riparian habitat and association with water). Therefore, our first choice for potential corridors was the shortest connection between PJAs along river courses, using a database from the National Water Agency (ANA 2006). In the absence of rivers, we also considered strings of natural habitat patches (sequences of native remnants between PJAs). In order for a string of habitat patches to be considered as a potential corridor, maximum distances between subsequent patches had to be below 500 meters. As a third possibility of connection, we chose mountain ranges or foothills, because similar to river courses, steep slopes also have to be protected in the form of APPs (Brasil and Presidência da República 2012). When these mountainous features did not cross the entire distance between two PJAs, we considered a combination of mountains and habitat patches, using the same distance restrictions as outlines above. We used the GIS data base of the Brazilian Institute of Geography and Statistics (IBGE 2004) to identify these landscape structures. Independent of the criteria to define the potential corridor, we considered a strip of 20 km on each side of the main connection as the area of the corridor (including any land use within this strip), assuming that this width would hypothetically cover enough area for a resident or transient jaguar to live in.

To classify the disturbance level of these potential corridors, we considered corridor length and the number of dams (ANA 2008), roads (IBGE 2005), railways (IBGE 2005), cities (IBGE 2010b), total dam reservoir size (ANA 2011) and total human population size of municipalities (IBGE 2010a) along the area encompassed by each corridor. While length is not per se a descriptor of disturbance, on a large spatial scale it is an essential variable determining migration between populations (Kadoya 2009). All other variables are indicators of anthropogenic impacts on the corridor. Jaguars have been shown to avoid roads (Colchero et al. 2011) and so have several other wildlife species (Forman and Alexander 1998). Although there is no information on the effect of the remaining variables on jaguar movement behavior, factors such as human presence and infrastructure have proven to negatively influence the presence and use of corridors by other large mammals (e.g., Shepherd and Whittington 2006).

We analyzed our data separately and comparatively across all five Brazilian biomes where jaguars are known to occur.

Statistical analysis

To reduce the number of parameters describing corridor disturbance, we used a Principal Component Analyzes (PCA) (Manly 1994). The variables *dam reservoir size, human population* along the corridor and *corridor length* were log-transformed prior to the statistical analyses. For further interpretation, we selected principal components axes with eigenvalues larger than 1.0, which also coincided with those selected according to a broken stick criterion (Legendre and Legendre 1998). We used the scores of the selected PCA axis for each corridor as an indication of its degree of disturbance. These scores were categorized into five classes, with the same number of corridors in each class, corresponding to five different disturbance levels (1 = least disturbed, to 5 = most disturbed).

To determine which variables describing corridor disturbance best discriminate the biomes, we further performed a canonical variate analysis (CVA). We used successive removal of roots/canonical functions to determine how many functions to retain in the analysis and built a structure matrix to investigate bivariate correlation of variables with the canonical functions. To see how well these functions separate the different biomes, we plotted the canonical scores of all corridors for the first and second canonical function and visually examined the plot.

Results

From a network of 298 PJAs (Sollmann et al. 2008), we identified 180 potential jaguar corridors connecting 151 PJAs (Fig. 1; Table 2). The majority of potential corridors were along river courses (n = 124, 68.88 %), followed by river courses with natural habitat patches (n = 33, 18.33 %) and only natural habitat patches (n = 10, 5.55 %). Few corridors were identified by mountain ranges and foothills (n = 7, 3.88 %) and by rivers in combination with mountain ranges (n = 6, 3.33 %).

The first axis of the PCA explained approximately 63.5 % of the total variance of the input variables.

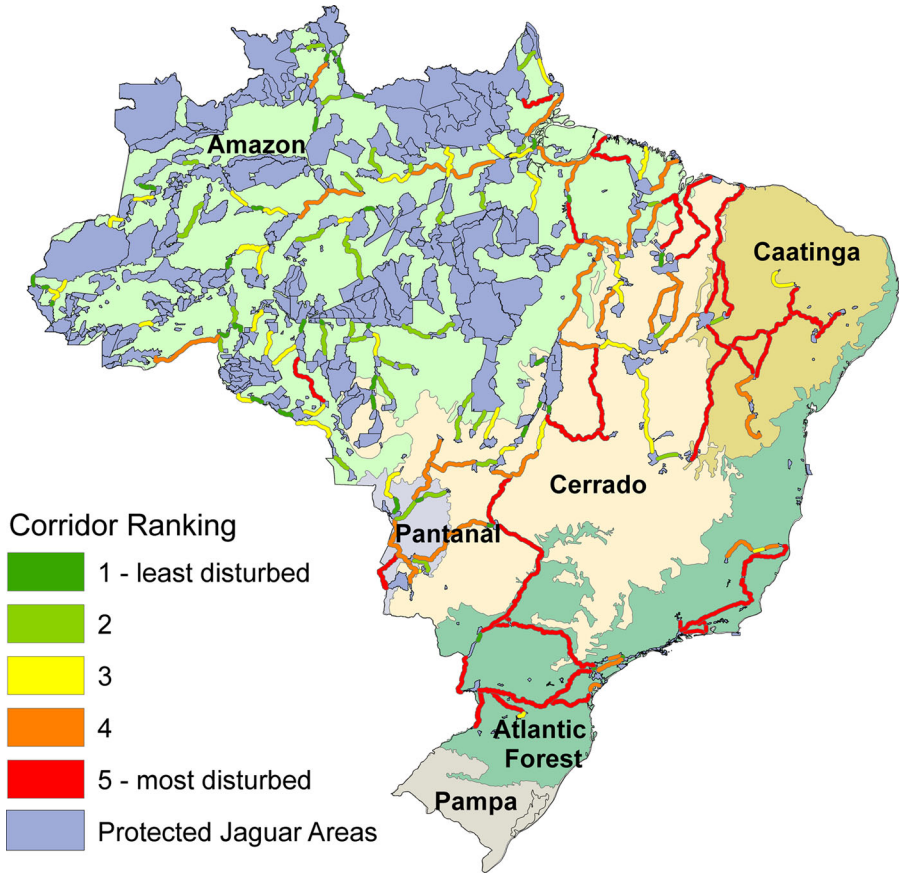

Fig. 1 Map of the potential corridors connecting protected jaguar populations in Brazil and degree of disturbance according to the variables considered in this study (corridor length, number of dams, roads, railways, cities, total dam reservoir size and total human population of municipalities along the area encompassed by each corridor)

Table 2 Characterization of potential jaguar corridors across the five Brazilian biomes where jaguars occur; numbers represent the sum of variables over all identified corridors

Biome	No. corridors	Total length (km)	Total no. dams	Total no. roads	Total no. railways	Total no. cities	Total dam reservoir area (km^2)	Total human population
Amazon	97	12,242	4	116	5	161	3,044.6	10,493,643
Cerrado	33	6,578	12	104	1	115	3,100.69	2,311,506
Caatinga	12	5,294	7	77	3	141	14,203.53	6,312,731
Pantanal	12	2,110	1	24	2	12	0	1,159,767
Atlantic Forest	26	5,551	93	157	25	235	13,474.31	7,686,158
Total	180	31,775	117	478	36	664	33,823.13	27,963,805

With an eigenvalue of 3.808, it was the only axis that fulfilled the criterion of an eigenvalue higher than 1. The eigenvalue was also higher than the one expected by the *Broken-stick* criteria (in this case, for axis 1 = 2.450) (Legendre and Legendre 1998).

The first principal component axis was positively correlated with all the variables (Table 4), thus indicating that it expresses a general gradient of disturbance. Disturbance varied among the biomes (Table 3): For the Amazon, the majority (>75 %) of corridors fell within the first (i.e. least disturbed) three classes, while for the Caatinga and Atlantic Forest the majority (83 and 80 %, respectively) fell within the two highest disturbance classes (Table 3).

Table 3 Percentage of potential jaguar corridors for each Brazilian biome according to the five disturbance levels (rank 1 = least disturbed, to rank 5 = most disturbed)

Biome	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5
Amazon	25.77	27.84	24.74	15.46	6.19
Cerrado	18.18	15.15	21.21	30.30	15.15
Caatinga	0.00	8.33	8.33	16.67	66.67
Pantanal	16.67	25.00	16.67	33.33	8.33
AtlanticForest	11.54	0.00	7.69	19.23	61.54

Table 4 Pearson correlation coefficient (r) between each variable used to classify the disturbance level of potential jaguar corridors in Brazil, and axis 1 of the principal components analysis, and variate 1 and 2 of the canonical variate analysis

Variables	r	Variate 1	Variate 2
Corridor length (km)	0.756	0.101	0.425
Hydroelectric dams	0.784	0.663*	−0.207
Roads	0.909	0.641*	0.452
Railways	0.751	0.570*	−0.181
Dam reservoir size (Km^2)	0.720	0.525*	0.312
Sum of human population	0.657	0.339	0.260
Cities	0.882	0.509*	0.429

* Mark strongest correlation between variable and variate 1

In CVA, successive removal of roots indicated that only the first two canonical variates significantly discriminate the biomes (Table 4). All variables showed their strongest correlation with the first canonical variate, apart from corridor length and human population size (Table 4), which showed strongest correlation only with the fifth variate (data not shown). Based on the structure matrix (Table 4), the variables *number of hydroelectric dams* and *number of roads* contributed the most to separating biomes. However, plotting the canonical scores for each corridor from variate 2 against variate 1, it becomes apparent that the separation between groups based on the variables used is not very strong, as point clouds show large overlap among groups (Fig. 2). Observable trends are that (1) Amazon and Pantanal corridors occupy largely overlapping point clouds, shared to some extend by Cerrado corridors; (2) Caatinga corridors are to some degree separated from the other biomes by variate 2, showing overall higher values on the y-axis; (3) Atlantic Forest corridors are largely separated from the Amazon/Pantanal/Cerrado cluster by variate 1, showing higher values on the x-axis.

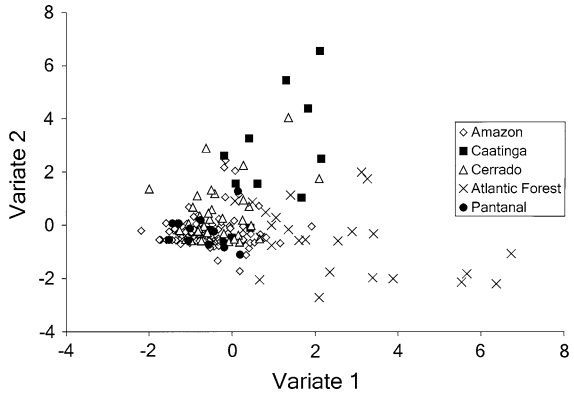

Fig. 2 Plot of scores from a canonical variates analysis of variables describing potential jaguar corridors in five Brazilian biomes; variate 2 is plotted against variate 1

Discussion

A global wildlife conservation problem is that most of the remaining large-bodied animal populations in protected reserves are not large enough to be viable in the long term (e.g., Grumbine 1990). This principle holds true for the jaguar in Brazil, where most protected areas alone are not large enough to sustain long-term viable populations (Sollmann et al. 2008). As a consequence, in order to guarantee long-term viable populations of these species we need to tackle their conservation using a landscape approach that encompasses both protected and non-protected areas. Using the jaguar as a model species, our results indicate that corridors connecting protected areas can still be a key landscape management tool for parts of Brazil.

The canonical variate analysis showed that, to a large degree, corridors of all five Brazilian biomes had similar combinations of variable values. Nevertheless, some trends of separation among biomes were observable. The Caatinga corridors were somewhat separated from the other biomes by variate 2 (Fig. 2). The variable most strongly—positively—correlated with variate 2 is number of roads (Table 4), so Caatinga corridors seem to be more strongly impacted by roads than other biomes. The Atlantic forest

corridors were separated from the Amazon/Pantanal/Cerrado cluster by variate 1, again towards the higher values. Here, number of hydroelectric dams was the most strongly and positively correlated variable.

In spite of these similarities, all Brazilian biomes suffer distinct human pressures which reflect directly on corridor quality, implementation costs and potential functionality. Thus, it is not surprising that with 25 % of its corridors in the lowest disturbance class, and over 75 % in the three lowest classes, the Amazon shows an overall better corridor quality than any other biome (Table 3). The Amazon is the least developed region of Brazil with an extremely low human population density and the highest numbers of large protected areas. The Pantanal wetlands appear to be the second most favored in terms of corridor quality. Again, in this biome there is a low human density, and extensive cattle ranching, at least partially on native pastures, is the predominant land use form. This land use pattern favors the species persistence across the biome as well as the maintenance of natural corridors.

Especially for the Amazon, the issue of connecting protected areas might not appear as urgent, considering the higher degree of continuity of natural (or permeable) habitats for the jaguar. But in spite of its sheer size, habitat loss and fragmentation pose a serious threat to the Amazon forest, with estimates of loss of up to 40 % by 2050 (Soares-Filho et al. 2006). Along the southern border of the Amazon, in the so-called Arc of Deforestation, jaguar populations are severely impacted by habitat loss and poaching (de Oliveira et al. 2012), in some cases leading to local extirpation (Michalski et al. 2006).

Large tracts of the Pantanal are unsuitable for intensive development because of the seasonal flooding regime of the area. Consequently, the biome retains much of is natural vegetation cover. Both habitat conversion and intensification of livestock ranching, however, have increased the degree of habitat fragmentation in the Pantanal, and are considered to pose serious threats to wildlife in the future (Fearnside 2005; Harris et al. 2005). Against this background, it seems to be the right time to adopt a proactive approach (Brooks et al. 2006) and plan jaguar corridors for the Amazon and the Pantanal, as long as human impact on suitable landscape structures is still relatively low.

The Atlantic Forest and the Caatinga both have a similar status of overall degradation and human impact. Both biomes were the first to suffer from human pressure since the country's colonization in 1500. According to Ribeiro et al. (2009) 88.3 % of the Atlantic Forest has already been lost. While values for the Caatinga are much lower (40 %, MMA 2007), the remaining habitat is extremely fragmented (Castelletti et al. 2004; Ribeiro et al. 2009), which may explain why both biomes hold the most disturbed, lowest quality corridors.

These high disturbance values suggest that the costs and logistics of implementing a jaguar corridor may already be prohibitive. At the same time, these biomes are likely the ones where jaguars are in most need for conservation intervention in order to persist. Studies in the Atlantic Forest have revealed extremely low population densities (Paviolo et al. 2008), clear genetic signals of population isolation (genetic drift; Haag et al. 2010) and a quickly progressing south-to-north front of local extinction (Mazzolli 2008). Little is known about jaguar populations in the Caatinga, but the fact that only 7 % of this biome is under protection highlights the need for conservation that includes non-protected areas to connect protected populations (de Paula et al. 2012). Roques et al. (2014) report genetic signs of isolation from one of the key jaguar populations in the Caatinga. Nonetheless, in view of the logistical difficulties, for these biomes, the selection of corridors for any investment should follow an extremely careful evaluation, considering if the target populations we wish to connect will in fact benefit from this investment.

The Cerrado is in the process of rapid habitat conversion due to agriculture expansion (Klink and Machado 2005), especially for the recent worldwide demand of ethanol from sugar cane (Rocha 2007). Loyola et al. (2009) indicate the Cerrado as one of the ecoregions in the world demanding urgent intervention for carnivore conservation. The fast conversion of habitat has led to an estimated loss of 50 % of the biome's jaguar population (Moraes Jr. 2012). Genetic studies suggest that recent gene flow connected Cerrado jaguars to those in the Amazon and Pananal (Roques personal communication). Continuing development, however, threatens to impact the remaining potential connections among jaguar populations (Silveira and Jácomo 2002). Considering the intermediate impact level on potential corridors in combination

with rapid development, the Cerrado currently appears to be in transition from the low-cost to the high-cost stage of corridor implementation.

The Araguaia river is a graphic example of the pressing need for large scale conservation actions in the Cerrado. With 1,300 miles passing 13 protected areas on its way to the Amazon, this river is one of the largest of central Brazil. It originates in the Cerrado, adjacent to Emas National Park, the largest protected grassland area. The park holds one of the last jaguar population in the southwestern Cerrado, but population density is below 1 individual per 100 km^2 and the park is thought to harbor no more than 10–15 individuals (Sollmann et al. 2011). To maintain the species in this region, connectivity with other populations along the Araguaia river is crucial (Silveira and Jácomo 2002). The area of the Araguaia is still under relatively low human pressure, compared with much of the region, and was identified as holding a key subpopulation of jaguars in the Cerrado (Moraes Jr. 2012). But government-supported infrastructure development, such as the construction of roads and dams, threaten the corridor's functionality (Silveira and Jácomo 2002). The example highlights the need for immediate integration of development and conservation planning in the Cerrado.

We are aware that dispersal behavior of an animal depends largely on its resource requirements (Bélisle 2005; Heinz and Strand 2006). Consequently, the use and movements along corridors by animals are governed by more than the factors considered here, for example the presence and abundance of food resources and other ecological aspects (Johnson 1980). We are also aware that we evaluate corridors based on structural rather than functional aspects, since there are no data about the functional response of jaguars to many of the evaluated characteristics. Further, given the distinct environmental circumstances of the different biomes, and the distinct ecological adaptations of jaguars to these biomes (Astete et al. 2008), it seems unlikely that the species' response to human impacts would be constant across Brazil. We therefore refrain from attempting to develop a single movement model based evaluation of potential corridors (as presented by Rabinowitz and Zeller 2010) throughout Brazil. Rather, we provide an assessment of the degree of disturbance of potential corridors based on existing infrastructure to evaluate the potential for large scale jaguar corridors in Brazil. Functionality is a response to structural aspects of a corridor and we incorporate aspects into our analysis, which, based on what is known about jaguars today, are likely to have a negative impact on corridor functionality. The analysis should be understood as a first step towards actual evaluation of large-scale corridors in Brazil that are potentially viable from the standpoint of existing human infrastructure, and to provide guidance as to where to focus further investigations and conservation efforts.

Future research to determine potential corridors needs to include studies on jaguar dispersal ability and assess the use of designated corridor by the species (Hilty et al. 2006; Noss and Daly 2006; Zeller et al. 2011). In addition, the matrix surrounding a corridor has to be taken into account, since it can contribute significantly to movement between habitat patches (Ricketts 2001; Bender and Fahrig 2005; Vergara 2011). Edge effects of matrix habitat on corridors can cause individuals moving through corridors to have higher mortality due to adverse effects of the matrix (Hobbs 1992), such as increased interactions with humans (Woodroffe and Ginsberg 1998; Kiffner et al. 2012).

All these considerations point towards the fact that the use of corridors as a conservation tool for wide ranging species like the jaguar requires both large scale planning and accounting for regional and local characteristics. Because large scale corridors include anthropogenic land use, political involvement is crucial to the process of implementing such corridors. Human expansion and habitat conversion continue to happen at a fast pace throughout Brazil. If large scale corridors are to play a role in jaguar (and other wildlife) conservation planning, they need to be put on the scientific and political agenda very soon.

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Herpetofauna do Pantanal brasileiro

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Resumo

Abordagens moleculares e probabilísticas, enfocando a evolução de elementos da herpetofauna, têm ocupado cada vez mais as páginas de importantes periódicos científicos internacionais. Até o momento, poucos destes trabalhos envolvendo espécies brasileiras foram realizados no Brasil, sendo a maioria desenvolvida no exterior. Essas abordagens possibilitam inferências que não podem ser acessadas por outros métodos e dizem respeito às relações microevolutivas entre espécies ou populações, podendo indicar processos estocásticos e seletivos. O tamanho ancestral da população ou da espécie, a estruturação genética e magnitude do fluxo gênico entre áreas, o tempo de ancestralidade, entre outros parâmetros genéticos, podem ser estimados e contrastados com árvores filogenéticas e redes de haplótipos, permitindo um estudo mais completo das histórias evolutivas. A interação entre herpetólogos e laboratórios de biologia molecular seria um importante avanço para a formação de grupos de pesquisa que utilizem essas abordagens. As técnicas que possibilitam análises integradas de dados representam uma ferramenta importante para a realização dessa promissora interação.

Palavras-chave: Evolução molecular, Filogenia, Filogeografia, Caracteres contínuos.

Abstract

Molecular and probabilistic approaches focusing on the evolution of the herpetological fauna have been occupying an increasing space in important scientific journals. Until now, few of these studies addressing Brazilian taxa have been developed in Brazilian laboratories. These approaches allow inferences that cannot be accessed by other methods regarding the microevolutionary relationships among species or populations, and may reveal stochastic as well as selective processes. The size of the ancestral population or species, the genetic structure and magnitude of gene flow among areas, the time to the most recent common ancestor, and other genetic parameters can be estimated and contrasted to phylogenetic trees and haplotype networks, leading to a

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more comprehensive study of the group's evolutionary history. The interaction between herpetologists and molecular biology laboratories would be an important advance for the establishment of research groups that use these approaches. Methods that facilitate analyses of integrated data represent an important tool in this promising interaction.

Key-words: Molecular evolution, Phylogeny, Phylogeography, Continuous characters.

Introdução

Planícies de inundação e biota associada

Planícies de inundação (*floodplain wetlands*) consistem em áreas periodicamente inundadas devido ao extravasamento lateral de rios ou lagoas e, eventualmente, também pelo aporte de chuvas ou elevação do lençol freático (JUNK *et al*., 1989). Em alguns desses sistemas hidrológicos, a grande diversidade de hábitats aquáticos, a maturidade e a estabilidade ambiental levaram à radiação evolutiva da herpetofauna aquática, que em alguns casos apresenta grande número de endemismos (e.g. McCOY, 1984).

No Pantanal, entretanto, a despeito da abundância e diversidade de hábitats aquáticos e de suas interfaces com hábitats terrestres, os endemismos de répteis e de anfíbios não são evidentes (veja adiante), indicando pouca persistência do atual cenário ambiental, inexistência de barreiras geológicas e climáticas e colonização recente por elementos faunísticos dos biomas vizinhos. Essa colonização ainda está em curso, principalmente a partir do Cerrado, Chaco, Amazônia e, em menor extensão, da Floresta Atlântica e de Chiquitanos. Assim, é possível que muitas das espécies atualmente conhecidas somente de hábitats elevados no planalto periférico venham a ser encontradas na planície inundável do Pantanal.

Em planícies de inundação como o Pantanal, a alternância e a recorrência de inundações e de secas prolongadas são os fatores ecológicos determinantes dos padrões de diversidade, bem como da maior parte dos processos ecológicos (JUNK *et al.*, 1989; HAMILTON *et al*., 1996; OLIVEIRA & CALHEIROS, 2000; JUNK & WANTZEN, 2004). Ao mesmo tempo em que elementos da biota podem responder individualmente aos pulsos de inundação, por meio de adaptações morfológicas, fisiológicas, fenológicas e/ou comportamentais, comunidades características e distintas são periodicamente estabelecidas e reestruturadas em virtude da alternância entre biótopos terrestres e aquáticos em uma mesma área (JUNK & WANTZEN, 2004).

Primeiras coletas e publicações sobre anfíbios e répteis do Pantanal

As primeiras publicações sobre anfíbios e répteis de localidades no Pantanal datam do final do século XIX e estão baseadas em material coletado durante explorações fluviais dos tributários do rio da Prata e áreas adjacentes, nos anos de 1853 a 1856, sob o comando do capitão Thomas J. Page, da marinha americana. Esse material foi examinado, identificado e publicado por COPE (e.g. 1862;

1863a, b; 1868), que descreveu diversas espécies com base no material colecionado, principalmente, ao longo do Rio Paraguai.

Muitas dessas espécies ainda são válidas, a exemplo das serpentes *Eunectes notaeus*, *Micrurus pyrrhocryptus*, *Sibynomorphus turgidus*, o lagarto *Stenocercus caducus* e os anfíbios *Lysapsus limellus*, *Scinax nasicus* e *S. acuminatus*. Outros táxons, eventualmente tratados como subespécies, possivelmente constituem espécies plenas e poderão oportunamente ser reconhecidas como tal, a exemplo de *Trachycephalus venulosus hebes*, *Phyllomedusa hypocondrialis azurea*, *Leptophis ahaetulla marginatus*, *Liophis poecilogyrus caesius*, *Philodryas olfersii latirostris*.

Coletas subseqüentes de anfíbios e répteis do Pantanal foram feitas em localidades situadas, geralmente, ao longo da Estrada de Ferro Noroeste do Brasil, que entre 1914-1995 ligava Bauru (no centro do Estado de São Paulo) a Corumbá, atravessando a porção sul da planície inundável. Há, assim, informações esparsas sobre anfíbios e/ou répteis das localidades de Miranda (KOSLOWSKY, 1898; LUTZ, 1946) e, principalmente, Corumbá e arredores (PERACCA, 1904; PARKER, 1928; GANS, 1960). Boa parte dos espécimes de serpentes listados por AMARAL (1925) em sua publicação sobre o material obtido pela "Comissão de Linhas Telegráficas", chefiada pelo Marechal Cândido Rondon, é proveniente, também, de localidades ao longo da "Noroeste do Brasil", no trecho entre Campo Grande e Corumbá.

Por um período de aproximadamente trinta anos, após o artigo de GANS (1960) nenhuma outra publicação abordou a composição da fauna local de anfíbios ou répteis de localidades no Pantanal. Mais recentemente, listas locais começaram a ser disponibilizadas, embora com restrita abrangência taxonômica (*e.g.*, GORDO & CAMPOS, 2004 - somente anfíbios do Pantanal da Nhecolândia e dos arredores de Corumbá, Pantanal do Paraguai; STRÜSSMANN & SAZIMA, 1993 - somente serpentes do Pantanal de Poconé).

A primeira compilação sobre os anfíbios e répteis da Bacia do Alto Paraguai (BAP), incluindo as altas cabeceiras de todos os rios que correm para o Pantanal, foi apresentada no relatório final do Plano de Conservação da Bacia do Alto Paraguai (PCBAP) (BRASIL, 1997). A lista de espécies apresentada na ocasião foi elaborada, principalmente, com base em citações bibliográficas consideradas fidedignas (i.e., listas de espécies e revisões taxonômicas com menção a exemplares examinados e localidades de coleta dos mesmos) e no exame de material depositado em pequenas coleções regionais.

O incremento dessas coleções regionais e a oportunidade de reexaminá-las, bem como consultas a coleções de maior abrangência, constituem a base da presente síntese do conhecimento sobre a herpetofauna em diferentes regiões da BAP (que inclui o Pantanal propriamente dito e seu entorno não inundável; veja adiante). Uma lista completa da herpetofauna do Pantanal foge ao escopo do presente trabalho e será disponibilizada oportunamente. Deste modo, foi dada especial ênfase à análise da cobertura geográfica dos registros de anfíbios e répteis em toda a porção brasileira da BAP, com menção às localidades de coleta e sub-regiões do Pantanal (e seu entorno) consideradas como mais bem amostradas do ponto de vista da herpetofauna.

Informações mais gerais, como número de táxons presentes em cada uma das regiões e sub-regiões analisadas, agregam dados extraídos da literatura e de inventários recentes ou em andamento, cujos resultados ainda estão por ser publicados. A presente análise e a lista de espécies apresentada, portanto, estão baseadas no conhecimento ainda incompleto de uma fauna bastante rica, diversa e em constante avanço de colonização para o interior da planície, a partir dos biomas vizinhos.

Área de Estudo

Características do Pantanal brasileiro

A área analisada no presente trabalho inclui tanto a planície inundável ou depressão do Pantanal, com cerca de 138.000km^2 (aproximadamente 400 x 350km; SILVA & ABDON, 1998), como os planaltos e cadeias montanhosas que a circundam, também integrantes da Bacia do Alto Paraguai e onde se situam as cabeceiras dos rios que drenam para o Pantanal. Essas áreas elevadas estendem-se por mais 222.000km^2 e são de origem Cambriana ou Pré-Cambriana, enquanto que a planície do Pantanal é constituída de depósitos do Quaternário (HAMILTON *et al.*, 1996; ASSINE & SOARES, 2004).

O clima na planície é quente, Aw segundo o sistema de Köppen (NIMER, 1979), ou seja, tropical megatérmico, com a temperatura média do mês mais frio superior a 18º C e duas estações bem definidas: a seca, entre maio e setembro, e a chuvosa, que se estende de outubro a abril. A temperatura média é de 25°C, mas pode ultrapassar 40°C nos meses em que o Pantanal está mais seco (agosto a outubro). As temperaturas mínimas verificam-se de maio a setembro, quando podem ocorrer quedas súbitas de temperatura (10°C ou mais), mas de pouca duração (TARIFA, 1986).

A precipitação varia de 1.000 a 1.700 mm anuais, diferindo consideravelmente em diferentes pontos da planície. A ação combinada das chuvas nas cabeceiras dos rios e do pequeno desnível da planície resulta em enchentes periódicas, entre novembro e abril. A profundidade da água na maior parte das áreas inundáveis é inferior a 2,5m e a velocidade de escorrimento é lenta através da planície, podendo haver uma diferença de até dois meses nos períodos de início e final da inundação, entre a porção norte e a porção sul (HAMILTON *et al*., 1996).

Devido à declividade (mais acentuada no sentido leste-oeste e um pouco menor no sentido norte-sul), às feições geomorfológicas de algumas áreas do Pantanal, e à variabilidade climática e edáfica associadas à amplitude latitudinal desse ecossistema, a inundação não ocorre de modo uniforme em toda a planície. Algumas áreas, particularmente nas proximidades da calha do rio Paraguai, são permanentemente inundadas e em outras, o período de inundação é superior a seis meses. A maior parte da planície, entretanto (especialmente as áreas periféricas sob maior influência do Cerrado), fica inundada por períodos mais curtos.

Diferenças locais nos padrões de inundação condicionam a presença de biota distinta em diferentes sub-regiões do Pantanal brasileiro. O número e a denominação dessas sub-regiões variam segundo diferentes autores e critérios de análise.

ADÁMOLI (1981) utilizou aspectos ecológicos e fitogeográficos, enquanto SILVA & ABDON (1998) basearam-se em aspectos fisiomorfológicos (nível de inundação, relevo, solo e vegetação) e geopolíticos na delimitação das sub-regiões na planície. A regionalização aqui adotada é proposta por HAMILTON *et al.* (1996), com base em critérios hidrológicos e geomorfológicos. Segundo esses critérios, são reconhecidos dez "pantanais" ou sub-regiões, com padrões de inundação distintos apresentados na Tabela 1 com suas respectivas áreas totais (incluindo hábitats secos, inundados e inundáveis) e as principais localidades abrangidas por cada um deles.

Mesmo no nível sub-regional, a inundação não é uniforme. Embora o terreno seja plano na maior parte da planície, cuja altitude aproximada é de 90m acima do nível do mar (RATTER *et al*., 1988), pequenos gradientes no micro-relevo (de 0 a 3m) resultam em um intrincado mosaico de hábitats, microhábitats e biota associada, em cada uma das distintas sub-regiões mencionadas acima.

No nível de paisagem, as diferenças entre os distintos pantanais podem ser marcantes. O Pantanal da Nhecolândia, por exemplo, caracteriza-se por apresentar numerosas lagoas ou baías (temporárias ou permanentes) e, em alguns casos, denominadas "salinas", devido sua elevada salinidade, em meio a campos inundáveis entrecortados por "cordilheiras". Estas, a despeito do nome, consistem em paleodiques aluviais baixos e estreitos, recobertos por florestas semidecíduas, cerradão e cerrado (RATTER *et al*., 1988). Também o Pantanal do Corixo Grande consiste em inúmeras lagoas, corixos e baías permanentes, praticamente contíguas ou entremeadas por escassas porções de terra firme.

Somente na Nhecolândia e no Pantanal do

Tabela 1: Denominação e área das sub-regiões do Pantanal (segundo HAMILTON *et al.,* 1986) utilizadas na presente análise sobre a herpetofauna local e principais localidades em cada sub-região

SUB-REGIÃO (ESTADO)	ÁREA TOTAL (km^2)	PRINCIPAIS LOCALIDADES
CORIXO GRANDE (MT)	11479	Rio Corixa Grande, Tremedal
CUIABÁ (MT)	14406	Santo Antônio do Leverger, Pirizal (Nossa Senhora do Livramento), Poconé, Porto Cercado, Rodovia Transpantaneira, Rio Pixaim, Faz. Jofre, Porto Jofre
PIQUIRI (MT)	15996	São Lourenço, Barão de Melgaço, Distrito de Mimoso, Baía de Chacororé, Baía de Sá Mariana, Joselândia, São Pedro, Perigara
PARAGUAI (MT/MS)	16258	Cáceres, Ilha de Taiamã, Descalvado, Porto Conceição, Porto Morrinhos, Baía Uberaba, Morro do Cará-Cará, Parque Nacional do Pantanal, Morraria da Ínsua, Porto Índio, Serra do Amolar, Baía Gaíva, Baía Mandioré, Corumbá, Ladário, Porto da Manga, Albuquerque
RIO TAQUARI (MS)	2927	Rio Taquari, Faz. Caiçara, São Francisco, Paiaguás
LEQUE do TAQUARI (MS)	39344	Morro do Campo
NHECOLÂNDIA (MS)	8623	Nhecolândia, Chatelodo, Campo Dora, Porto Alegre, Nhumirin
MIRANDA (MS)	5035	Agachi, Est. Bodoquena, Carandazal, Estância Caiman, Guaicurus, Jaraguá, Passo do Lontra, Porto Carreiro, Miranda, Salobra, Taunay
AQUIDAUANA (MS)	9197	Aquidauana, Anastácio, Faz. Ipiranga (Rio Negro), Piraputanga, Palmeira
NABILEQUE (MS)	13662	Forte Coimbra, Nabileque, Porto Esperança

Paraguai (este último, situado ao longo da calha principal do maior rio da planície e com lagoas isoladas de grandes dimensões), superfícies de água livre constituem mais de 2% da área total da sub-região (HAMILTON *et al*., 1996). A presença de baías ou outros corpos d'água permanentes é mais restrita em outras sub-regiões do Pantanal, principalmente no Leque do Taquari e pantanais do rio Taquari, do Miranda e de Aquidauna (HAMILTON *et al*., 1996)

Material e Métodos

Foram encontrados, em seis coleções zoológicas, cerca de 8.600 registros de anfíbios e répteis oriundos do Pantanal brasileiro (estados de Mato Grosso e Mato Grosso do Sul). Quatro coleções são regionais: Universidade Federal de Mato Grosso (UFMT), Cuiabá, MT; Coleção Zoológica de Referência, seção Herpetologia (CEUCH), da Universidade Federal de Mato Grosso do Sul, *Campus* de Corumbá, MS; Coleção Herpetológica Arlindo de Figueiredo Béda (CHAFB), Universidade Federal de Mato Grosso do Sul, *campus* de Aquidauana, MT; Coleção de Vertebrados da Empresa Brasileira de Pesquisa Agropecuária - EMBRAPA Pantanal (CPAP), Corumbá, MS. As outras duas coleções examinadas são mais abrangentes e de expressão nacional: Museu de Zoologia da Universidade de São Paulo (MZUSP), São Paulo, SP e Instituto Butantan (IBSP), São Paulo, SP.

A coleção IBSP é composta apenas por serpentes, enquanto que na coleção CPAP, apenas os répteis foram examinados. Os anfíbios desta última são, em sua maior parte, oriundos da Fazenda Nhumirim (Pantanal da Nhecolândia) e da cidade de Corumbá e arredores e foram recentemente listados por GORDO & CAMPOS (2004).

Registros duvidosos foram verificados mediante análise do material-testemunho correspondente, sempre que possível.

Resultados e Discussão

Composição da herpetofauna do Pantanal

A herpetofauna atualmente conhecida para toda a Bacia do Alto Paraguai (BAP) inclui 73 espécies de anfíbios e 179 espécies de répteis. A herpetofauna anotada somente para a planície consiste em 171 espécies, sendo 44 anfíbios e 127 répteis (dois jacarés, quatro quelônios, 31 lagartos, oito anfisbênias e 82 serpentes). Estes valores tendem a aumentar, uma vez que cada novo inventário, seja no Pantanal ou em regiões adjacentes pertencentes a biomas vizinhos, evidencia novos registros e/ou espécies não descritas (e.g., CARAMASCHI & NIEMEYER, 2003; STRÜSSMANN, 2000, 2003; STRÜSSMANN *et al*., 2000; STRÜSSMANN *et al*., no prelo).

O grupo dos quelônios é, certamente, um dos menos conhecidos quanto à sua composição e distribuição na planície inundável do Pantanal. Somente quatro espécies foram registradas: *Geochelone carbonaria*, *G. denticulata*, *Acanthochelys macrocephala* e *Phrynops geoffroanus*. O número de espécimes (n=21) nas coleções examinadas, bem como o de localidades de ocorrência de quelônios na BAP (n=7), são incrivelmente baixos.

Espécies com provável ocorrência na planície incluem *Bufocephala vanderhaegei*,

Kinosternon scorpioides e *Hydromedusa tectifera*, presentes em rios do planalto adjacente que drenam para o interior da planície. O cágado exótico *Trachemys scripta*, originário da América do Norte e introduzido em larga escala no Brasil para abastecer o mercado de animais de estimação, tem sido registrado em hábitats naturais na região de Aquidauana. O mesmo parece ocorrer com *Podocnemis unifilis*, espécie tipicamente amazônica, ameaçada em virtude da exploração como recurso alimentar e comércio ilegal (IUCN 1996). Juvenis de *P. unifilis* têm sido apreendidos pela Polícia Federal e já foram encontrados na natureza, na região de fronteira entre o Brasil e a Bolívia, em Corumbá, MS. Lotes ilegais desses animais possivelmente são libertados para evitar confronto nas barreiras permanentes de fiscalização aduaneira.

Alguns registros de répteis para a planície, constantes na literatura, são duvidosos e precisam ser cuidadosamente checados, antes que sejam incorporados definitivamente à lista de espécies da região. Um exemplo é a serpente *Liophis miliaris orinus*, espécie à qual DIXON (1983) atribuiu um indivíduo procedente de Carandazal (MS), na porção sul da planície. O exemplar não foi localizado na coleção IBSP, à qual supostamente pertence, mas a distribuição conhecida desta subespécie de *L. miliaris* está restrita ao sudeste do Brasil, conforme apresentado em mapa e texto pelo autor (DIXON, 1983).

Outro registro duvidoso refere-se a *Sordellina punctata*. Na redescrição feita por HOGE & ROMANO (1976/77), com base em 25 exemplares, e nos livros de tombo da coleção IBSP, há menção a um exemplar coletado em 1943 no Pantanal sul (Porto Esperança, MS). Nenhum material adicional foi obtido fora das regiões sul e sudeste do Brasil, desde então (M.G. RODRIGUES, com. pess.).

A Tabela 2 traz o número de táxons de anfíbios e de répteis já registrados para a planície do Pantanal e para toda a BAP. Na elaboração dessa tabela, cujos táxons estão ordenados em ordem alfabética, foram atualizados e complementados os dados fornecidos em JUNK *et al*. (no prelo).

Espécies endêmicas: objeto de discussão

Biomas ou ecossistemas que ultrapassam fronteiras políticas internacionais, como o Pantanal, apresentam dificuldade adicional para análises zoogeográficas detalhadas. Em alguns casos, isso faz com que a própria denominação oficial de um mesmo ecossistema, bioma ou ecorregião seja distinta em diferentes países, dificultando análises mais gerais sobre a biota. As regiões conhecidas no Paraguai como "bajo Chaco" e na Argentina como "Chaco oriental" ou "Chaco húmedo" (veja LEYNAUD & BUCHER, 1999), por exemplo, parecem estar sujeita ao mesmo regime de pulso de inundação, por rios integrantes do sistema hidrológico Paraná-Paraguai, que áreas do Pantanal brasileiro e boliviano.

Essa questão parece ser fundamental nas discussões sobre a presença de espécies endêmicas no Pantanal. Já foram consideradas endêmicas (e.g., BROWN, 1986; STRÜSSMANN *et al*., 2000) e, portanto, "emblemáticas", espécies como a sucuri-amarela *Eunectes notaeus*, o cágado-cabeçudo *Acanthochelys macrocephala*, o jacaré-do-Pantanal *Caiman yacare* e a víbora *Dracaena paraguayensis*, todas com hábitos aquáticos ou semi-aquáticos.

Tabela 2: Número de táxons superiores, de famílias, de gêneros e de espécies de anfíbios e de répteis registrados para o Pantanal. Em parêntesis, o número total de gêneros e de espécies atualmente conhecido para toda a Bacia do Alto Paraguai.

Táxons superiores	Famílias	Gêneros (n)		Espécies (n)	
AMPHIBIA					
Anura	Bufonidae	1	(2)	3	(6)
	Hylidae	6	(7)	18	(26)
	Leptodactylidae	6	(7)	17	(30)
	Microhylidae	3	(3)	5	(6)
Gymnophiona	Caecilidae	1	(1)	1	(1)
REPTILIA					
Amphisbaenia	Amphisbaenidae	4	(4)	8	(15)
Chelonia	Chelidae	2	(3)	2	(3)
	Testudinidae	1	(1)	2	(2)
Crocodylia	Alligatoridae	2	(2)	2	(4)
Sauria	Anguidae	1	(1)	1	(1)
	Gekkonidae	5	(5)	5	(6)
	Gymnophthalmidae	5	(5)	5	(9)
	Iguanidae	1	(1)	1	(1)
	Polychrotidae	2	(2)	3	(4)
	Scincidae	1	(1)	3	(3)
	Teiidae	6	(6)	7	(12)
	Tropiduridae	2	(2)	5	(6)
Serpentes	Boidae	3	(4)	4	(5)
	Typhlopidae	1	(1)	1	(2)
	Colubridae	36	(37)	72	(89)
	Elapidae	1	(1)	3	(6)
	Viperidae	2	(2)	3	(4)
Total	21 (27*)	92	(98)	171	(241)

* Famílias com ocorrência exclusivamente anotada, até o momento, para áreas elevadas da Bacia do Alto Paraguai (número de gêneros/número de espécies): Amphibia Dendrobatidae (2/3); Reptilia Sauria: Hoplocercidae (1/1); Serpentes: Aniliidae (1/1); Anomalepididae (1/2); Leptotyphlopidae (1/4).

Outras espécies com distribuição restrita ou estendendo-se pouco além das áreas sujeitas aos pulsos de inundação do rio Paraguai incluem *Clelia bicolor, Liophis jaegeri coralliventris*, *Liophis poecilogyrus caesius*, *Hydrops caesurus* e *Thamnodynastes chaquensis*.

Mais recentemente, a presença de endemismos entre os répteis do Pantanal tem sido

questionada (JUNK *et al.*, no prelo), com base no fato de que a maior parte das espécies acima mencionadas também figura em listas de espécies do Chaco (*e.g.*, LEYNAUD & BUCHER, 1999; VINKE & VINKE, 2001). Adicionalmente, algumas dessas espécies apresentam áreas de distribuição que podem estender-se até latitudes tão elevadas como aquela correspondente à alta bacia de drenagem do rio Mamoré, na Bolívia (onde foi registrada a presença de *A. macrocephala*, veja RHODIN *et al*., 1984) ou próximas ao paralelo 28, limite sul da distribuição de *E. notaeus* (HENDERSON *et al*., 1995).

De qualquer forma, uma ampla discussão sobre o conceito e limites do Pantanal, em conjunto com abordagens que ultrapassem a visão atual do espaço geográfico e incorporem aspectos históricos de sua gênese são essenciais para a compreensão dos eventos evolutivos da herpetofauna dessa região. Esse conjunto de informações, aliado a dados mais precisos sobre distribuição da fauna nos biomas vizinhos, possibilitará julgamento mais adequado sobre a presença de espécies endêmicas, tal como ocorreu em relação à Caatinga e ao Cerrado, onde inicialmente havia a suposição de existirem poucos casos de endemismo (veja COLLI *et al*., 2002; RODRIGUES, 2003).

Cobertura geográfica dos registros de anfíbios e répteis no Pantanal brasileiro

A análise do material nas seis coleções examinadas mostra que há registros documentados de anfíbios e/ou répteis para pelo menos 129 localidades na BAP, das quais 52 situadas na planície do Pantanal (30 em MS e 22 em MT) e 77 nos planaltos do entorno (25 em MS e 52 em MT). A Tabela 3 traz as localidades da BAP representadas em coleções (ordenadas em ordem alfabética) e suas respectivas coordenadas geográficas, as coleções que abrigam material de cada localidade e o número de registros em cada coleção.

Apenas quatro localidades foram aqui consideradas como razoavelmente bem amostradas na planície (aquelas individualmente representadas por mais de 300 espécimes nas coleções examinadas):. Aquidauana (cerca de 30% do total de exemplares oriundos de localidades na planície e depositados em coleções), Cáceres (12%), Estância Caiman (11%) e Taunay (8% do total). Todas estão situadas em áreas limítrofes com o Cerrado adjacente, podendo, portanto, incluir alguns registros de espécies cuja ocorrência está limitada, por exemplo, a morros isolados, serras ou vales entre elas.

Localidades mais interiores na planície e relativamente bem amostradas incluem a porção norte do Pantanal (município de Poconé, Pantanal do Cuiabá), a Base de Pesquisas de Fauna do IBAMA e a Fazenda Santa Inês, e na porção sul (município de Corumbá, Pantanal do Miranda), a Base de Pesquisas da UFMS em Passo do Lontra (Tabela 3).

Cinco localidades dos planaltos do entorno (menos de 7% do total) estão melhor representadas (com mais de 300 exemplares) em coleções. Três dessas localidades estão inseridas no domínio do Cerrado, na borda NE do Pantanal: os arredores do aproveitamento hidrelétrico de Manso (a localidade mais bem amostrada no planalto, correspondendo a 28% dos registros para o planalto da BAP existentes em coleções), Chapada dos Guimarães (inclui arredores da área urbana, o Parque Nacional e sua

Tabela 3: Localidades na Bacia do Alto Paraguai (incluindo a planície inundável do Pantanal e seu entorno não inundável) representadas por anfíbios e répteis em quatro coleções regionais e duas coleções mais abrangentes. Acrônimos: **CEUCH** Coleção de Herpetologia do Departamento de Ciências do Ambiente, Universidade Federal de Mato Grosso do Sul, *Campus* de Corumbá, MS; **CHAFB** Coleção Herpetológica Arlindo Figueiredo Béda, Universidade Federal de Mato Grosso do Sul, *Campus* de Aquidauana, MS; **CPAP** EMBRAPA Pantanal, Corumbá, MS; **IBSP** - Instituto Butantan, São Paulo, SP; **MZUSP** - Museu de Zoologia da Universidade de São Paulo, São Paulo, SP; **UFMT** Coleção de Vertebrados do Instituto de Biociências, Universidade Federal de Mato Grosso, Cuiabá, MT.

PORÇÃO DA BAP E ESTADO		LOCALIDADE	LAT	LONG	COLEÇÃO						Nº total de registros
					CEUCH	CHAFB	CPAP	IBSP	MZUSP	UFMT	
Planície											
MATO GROSSO	1.	Baía Uberaba	17º30'	57º50'	X						2
	2.	Barão de Melgaço	16º11'	55º58'					X	X	16
	3.	Base do IBAMA (Rodovia Transpantaneira, Km 111)	56º59'	17º16'						X	235
	4.	Cáceres	16º04'	57º41'				X	X	X	479
	5.	Faz. Baia das Pombas, Distrito de Mimoso	16º21'	55º48'						X	14
	6.	Faz. Carandá	'	'						X	2
	7.	Faz. Jofre	17º20'	56º49'						X	11
	8.	Faz. Porto Coqueiro, Rodovia Transpantaneira	'	'						X	1
	9.	Faz. Pouso Alegre	'	'						X	4
	10.	Faz. Santa Inês	16º30'	56º45'					X	X	151
	11.	Faz. São Francisco do Perigara	16º54'	56º16'						X	24
	12.	Ilha de Taiamã	16º50'	57º25'					X		54
	13.	Morro do Cará-Cará, Parque Nacional do Pantanal	17º52'	57º27'					X	X	37
	14.	Parque Nacional do Pantanal	17º26'	57º10'						X	31
	15.	Pirizal, Nossa Senhora do Livramento	16º15'	56º22'						X	1
	16.	Poconé (baixada)	'	'					X	X	3
	17.	Porto Jofre	17º17'	58º45'					X	X	34
	18.	Posto de fiscalização, Rodovia Transpantaneira, Km 17	16º25'	56º40'						X	7
	19.	rio Pixaim	16º53'	56º58'					X		18
	20.	Rodovia Transpantaneira	'	'						X	14
	21.	Santo Antônio do Leverger	15º52'	56º04'				X	X	X	36
	22.	Usina de Asfalto, Rodovia Cuiabá-Sto. Antônio do Leverger	'	'						X	1
MATO GROSSO DO SUL	1.	Agachi	20º04'	56º18'				X	X		76
	2.	Albuquerque	19º23'	57º26'	X			X			72
	3.	Anastácio	20º31'	55º48'		X		X	X		42
	4.	Aquidauana	20º28'	55º48'	X	X	X	X	X		1145
	5.	Baía Jacadigo, Corumbá	19º12'	57º45'	X						2
	6.	Baía Mandioré	18º10'	57º45'	X						1
	7.	Carandazal	19º40'	57º10'				X	X		31
	8.	Corumbá	19º00'	57º40'	X			X	X		19
	9.	Estância Caiman	19º57'	56º18'					X		424
	10.	Faz. Gaíva, Serra do Amolar	17º49'	57º41'						X	19
	11.	Faz. Ipiranga, Rio Negro	19º26'	54º59'					X		1
	12.	Faz. Rio Negro, Corumbá	'	'	X						1
	13.	Faz. Xaraés, Corumbá	19º31'	56º57'	X						1
	14.	Forte Coimbra	19º55'	57º47'				X			12
	15.	Guaicurus	20º05'	56º45'				X	X		91

PORÇÃO DA BAP E ESTADO		LOCALIDADE	LAT	LONG	COLEÇÃO						Nº total de registros
					CEUCH	CHAFB	CPAP	IBSP	MZUSP	UFMT	
MATO GROSSO DO SUL	16.	Ladário	19º02'	57º36'	X						1
	17.	Miranda	20º14'	56º22'	X			X	X		147
	18.	Nabileque	20º55'	57º49'				X			4
	19.	Nhecolândia	19º16'	57º04'	X		X	X			43
	20.	Paiaguás, Faz. Caiçara	18º26'	57º02'	X						1
	21.	Passo do Lontra	19º30'	57º00'	X	X		X	X		91
	22.	Piraputanga	20º28'	55º32'				X			1
	23.	Porto Carreiro	19º58'	56º52'				X			1
	24.	Porto Esperança	19º37'	57º27'				X	X		139
	25.	Porto Índio	17º40'	57º47'				X			2
	26.	rio Taquari	'	'				X			9
	27.	RPPN Acurizal, Serra do Amolar (sede)	17º49'	57º33'					X	X	26
	28.	Taunay	20º18'	56º05'				X	X		314
	29.	Faz. Limoeiro, Rio Paraguai	'	'						X	1
	30.	Salobra	20º10'	56º31'				X	X		131
Planalto											
MATO GROSSO	1.	Alto São Lourenço	'	'					X		1
	2.	APM Manso	14º52'	55º48'					X	X	1329
	3.	Baía Rica	15º47'	57º39'						X	6
	4.	Barra do Bugres	15º00'	57º30'				X		X	11
	5.	Bauxi, córrego das Pedras (Jangada)	15º14'	56º29'						X	19
	6.	Boa Vista, rio São Lourenço	16º20'	54º46'					X		1
	7.	Chapada dos Guimarães	15º40'	55º50'				X	X	X	363
	8.	Correntes	17º37'	54º59'				X		X	9
	9	Cuiabá	15º35'	56º05'				X	X	X	320
	10.	Distrito da Guia, Cuiabá	15º21'	56º13'						X	1
	11.	Distrito de Cangas	16º05'	56º34'						X	9
	12.	Dom Aquino	15º38'	54º47'				X			1
	13.	Estação Ecológica Serra das Araras	15º39'	57º13'					X	X	242
	14.	Estrada para Cáceres, Fazenda 3 G, estação repetidora de Sangradouro	'	'						X	1
	15.	Faz. Encomind, Margem esquerda do rio Cuiabazinho	'	'						X	1
	16.	Faz. Martinópolis, Distrito de São Lourenço de Fátima, Juscimeira	16º17'	54º59'						X	2
	17.	Faz. Quilombinho, Chapada dos Guimarães	'	'						X	1
	18.	Faz. Reunidas, rio Sepotuba	15º29'	57º42'						X	2
	19.	Faz. Santo Antônio, Itiquira	'	'					X		1
	20.	Faz. Santo Antônio, margem esquerda do rio Cuiabazinho	'	'						X	1
	21.	Faz. Zortea, próximo a Sete Lagoas, nacente do rio Paraguai	'	'						X	1
	23.	Fazenda às margens do rio Vermelho	'	'						X	1
	24.	Itiquira	17º08'	54º25'					X	X	35
	25.	Jaciara	15º57'	54º58'					X	X	14
	26.	Jangada	15º14'	56º29'						X	1
	27.	Jaraguá	17º09'	55º05'				X			10
	28.	Mirassol D'Oeste	15º45'	58º16'				X			1

PORÇÃO DA BAP E ESTADO		LOCALIDADE	LAT	LONG	COLEÇÃO						Nº total de registros
					CEUCH	CHAFB	CPAP	IBSP	MZUSP	UFMT	
MATO GROSSO	29.	Morro de Santo Antônio	15º46'	56º05'						X	1
	30.	Nossa Senhora do Livramento	15º45'	56º20'				X		X	24
	31.	Poconé	16º30'	56º45'				X	X	X	143
	32.	Porto Esperança, MT-343	15º37'	57º15'						X	13
	33.	Porto Esperidião	15º51'	58º28'					X		248
	34.	Porto Estrela	15º19'	57º13'						X	2
	35.	Reserva do Cabaçal	15º06'	58º29'						X	10
	36.	Ribeirão Jacobina, S de Cáceres	16º15'	57º20'					X		1
	37.	Rio do Peixe	14º55'	58º27'						X	17
	38.	Rio dos Peixes, Chapada dos Guimarães	'	'						X	6
	39.	Rio Sepotuba	15º07'	57º40'						X	107
	40.	Rodovia BR-163 (Cuiabá-Rosário Oeste), Km 12	'	'						X	1
	41.	Rodovia MT-251 (Emanuel Pinheiro)	'	'						X	2
	42.	Rodovia MT-060 (Poconé-Cuiabá)	'	'						X	1
	43.	Rodovia MT-060; Km 23,7	'	'						X	1
	44.	Rodovia MT 351 (para usina de Manso)	'	'						X	1
	45.	Rondonópolis	16º15'	54º51'				X	X	X	155
	46.	Salto do Céu	15º09'	58º08'				X			1
	47.	São Lourenço	16º32'	55º02'					X		1
	48.	São Vicente	15º49'	55º25'					X	X	25
	49.	Tangará da Serra	14º04'	57º03'				X		X	23
	50.	UHE Jauru	15º14'	58º44'						X	11
	51.	UHE Juba	14º45'	58º06'						X	8
	52.	Várzea Grande	15º38'	56º07'					X	X	5
MATO GROSSO DO SUL	1.	Amolar	18º02'	57º29'	X						1
	2.	Aquidauana	20º28'	55º48'		X					1
	3.	Baía do Castelo/Baía Vermelha	18º25'	57º34'	X						18
	4.	Barranco Branco	22º10'	57º26'				X			1
	5.	Bodoquena	20º30'	56º40'		X	X	X	X		70
	6.	Bonito	21º00'	56º30'	X	X		X	X	X	45
	7.	Corguinho	19º53'	54º52'				X			1
	8.	Corumbá	19º01'	57º40'	X		X	X	X		396
	9.	Coxim	18º30'	54º45'				X	X		90
	10.	Faz. Gaíva, Serra do Amolar	17º48'	57º40'						X	3
	11.	Faz. Mandioré, Serra do Amolar	17º55'	57º37'						X	19
	12.	Guia Lopes da Laguna	21º27'	56º06'				X	X		6
	13.	Jardim	21º28'	56º08'		X					1
	14.	Ladário	19º02'	57º36'	X		X			X	23
	15.	Morro Bocaina, Corumbá	19º14'	57º50'	X						1
	16.	Morro do Azeite, Buraco das Piranhas	19º40'	57º10'	X						1
	17.	Morro do Sargento	18º56'	57º35'	X						2
	18.	Nioaque	21º08'	55º48'				X	X		21
	19.	Porto Murtinho	21º42'	57º52'		X		X	X		65
	20.	Rio Verde de Mato Grosso	18º56'	54º52'	X			X			3
	21.	RPPN Acurizal, Serra do Amolar (Fundão)	17º51'	57º33'					X	X	504

PORÇÃO DA BAP E ESTADO	LOCALIDADE	LAT	LONG	COLEÇÃO						Nº total de registros
				CEUCH	CHAFB	CPAP	IBSP	MZUSP	UFMT	
22.	Santa Luzia	17º57'	54º56'					X		53
23.	Sonora	17º34'	54º45'						X	36
24.	Taquari	18º30'	54º45'				X			1
25.	Urucum	19º19'	57º35'	X				X		87
TOTAL DE LOCALIDADES REPRESENTADAS EM CADA COLEÇÃO:				**23**	**8**	**5**	**44**	**49**	**69**	Total de registros: **8663**

zona de amortecimento; 8% dos registros para o planalto) e Cuiabá (7%). As outras duas localidades, a área urbana de Corumbá (9% dos registros para o planalto) e a Reserva Particular do Patrimônio Natural (RPPN) Acurizal (11%), estão situadas na borda oeste do Pantanal, em abrupta transição com ambientes inundáveis da planície.

Em Manso e na RPPN Acurizal, as coletas de anfíbios e répteis resultam de inventários faunísticos específicos e recentes, que envolveram o emprego de armadilhas e a participação de coletores/pesquisadores-residentes. Nas demais localidades do planalto mencionadas acima, os registros são oriundos, principalmente, da colaboração esporádica de terceiros ao longo de mais de oito décadas, muitas vezes como resultado do escambo de serpentes por antivenenos, praticada no país por muitos anos.

O conhecimento sobre os conjuntos herpetofaunísticos em cada um dos distintos "pantanais" brasileiros é, portanto, bastante desigual. No geral, as informações são um pouco melhores para os pantanais da porção sul da planície servidos pela estrada de Ferro Noroeste do Brasil (pantanais de Aquidauana, do Miranda e do Paraguai) e, na porção norte, para o Pantanal do Cuiabá.

Algumas sub-regiões do Pantanal jamais foram alvo de qualquer coleta de material herpetológico que tivesse como destino final o depósito em coleções regionais ou em coleções mais representativas como a do MZUSP e do IBSP (Fig.1). Uma dessas regiões situa-se na porção norte da planície, o Pantanal do Corixo Grande e a outra, na porção sul, Pantanal do Leque do Taquari. Essas regiões podem ser consideradas, portanto, como prioritárias para a execução de inventários da herpetofauna, não só devido à total desinformação que temos sobre as mesmas, mas, também, pelo risco de serem descaracterizadas, antes mesmo que sejam conhecidas.

Também estão pouco representados por material herpetológico em coleções os pantanais da Nhecolândia, do Rio Taquari e do Nabileque. Este último possivelmente abriga grande número de espécies tipicamente chaquenhas, muitas delas cuja presença em território brasileiro ainda é totalmente desconhecida. A coleção de serpentes do Butantan é a que mantém maior proporção de registros do Pantanal do Nabileque (10% das cerca de 1400 serpentes oriundas da área da BAP), de três localidades distintas.

Dados não publicados de inventários em curso complementam consideravelmente os registros baseados em literatura e em material anteriormente colecionado. Entre os táxons cuja presença no Pantanal pode ser assegurada por registros fidedignos, mas que

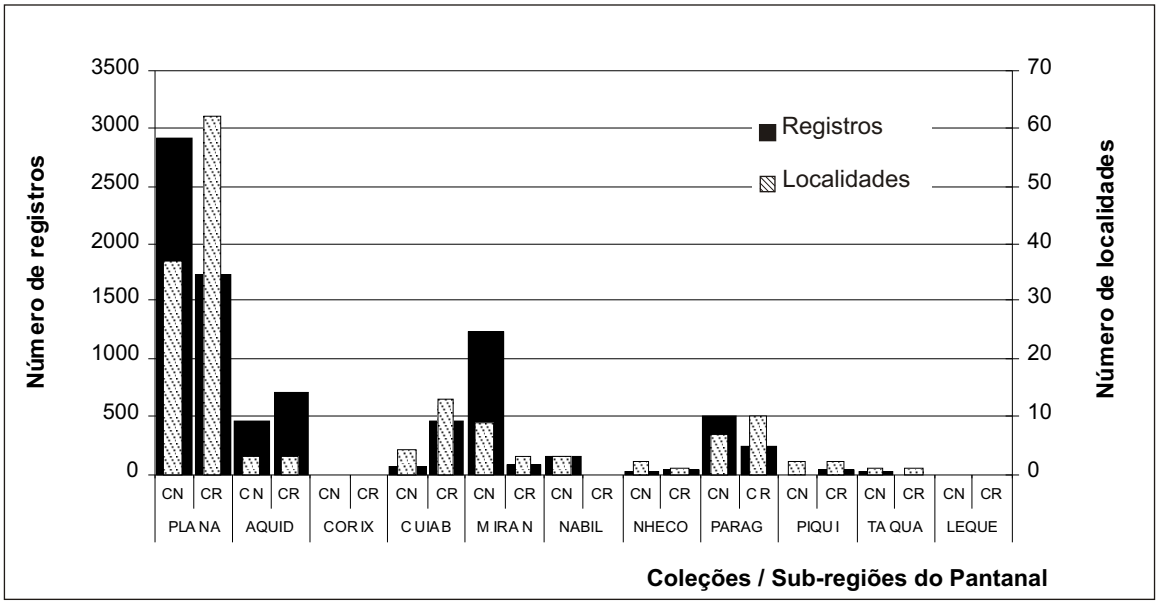

Figura 1: Localidades e número de registros de anfíbios e répteis depositados em quatro coleções regionais ("CR", incluindo UFMT, CHAFB, CEUCH e CPAP, veja texto) e duas coleções nacionais de maior abrangência ("CN", incluindo MZUSP e IBSP), em diferentes sub-regiões do Pantanal (PLANA Planalto; AQUID Aquidauana; CORIX Corixa Grande; CUIAB Cuiabá; MIRAN Miranda; NABIL Nabileque; NHECO Nhecolândia; PARAG Paraguai; PIQUI Piquiri, TAQUA Rio Taquari; LEQUE Leque do Taquari).

ainda não estavam representados por material-testemunho nas coleções que examinamos até a conclusão deste trabalho, há espécies nos gêneros *Cercolophia*, *Leptotyphlops* e *Apostolepis* (na planície inundável), *Atractus* e *Pseustes* (na BAP).

Afinidades biogeográficas

Em uma das primeiras análises zoogeográficas sobre a fauna de répteis do Pantanal, ALHO *et al.* (2001) evidenciaram que pelo menos 25% das espécies ocorrentes na porção norte da planície eram ubíquas, estando presentes em pelo menos cinco biomas distintos (florestas Amazônica e Atlântica, Cerrado, Caatinga e Chaco). Como exemplos dessas espécies amplamente distribuídas podem ser citados o jabuti-piranga *Geochelone carbonaria*, o sinimbu *Iguana iguana,* a cobra-de-duas-cabeças *Amphisbaena alba* e serpentes como *Boa constrictor*, *Liophis almadensis* e *Mastigodryas bifossatus*.

Ainda segundo ALHO *et al.* (2001), os répteis registrados para toda a "diagonal de formações abertas" da América do Sul (que inclui, do nordeste para sudoeste a Caatinga, o Cerrado, o Pantanal e o Chaco) compreendiam 24% das espécies do Pantanal norte, proporção que se elevava para mais de 50% quando formas restritas a partes dessa diagonal (e.g., espécies somente ocorrentes no Pantanal e no Cerrado) também eram consideradas. Apenas 17% dos répteis do Pantanal norte, segundo os mesmos autores, eram mais frequentemente registrados em biomas florestados (ALHO *et al*., 2001).

Essas análises, aliadas ao tamanho, proximidade e influências do Cerrado sobre outros elementos da biota do Pantanal, faziam prevalecer a idéia geral de que aquele deveria ser o bioma que mais compartilhava espécies da herpetofauna com a planície inundável (à semelhança do registrado por RODRIGUES *et al*., 2002, para os mamíferos da

planície). Em número de espécies conhecidas, o Cerrado e o Pantanal efetivamente se equivalem: o número total de espécies de répteis listados para a BAP é semelhante ao registrado por COLLI *et al*. (2002) para a totalidade do Cerrado (113 espécies de anfíbios, 185 de répteis), o segundo maior bioma Sul-Americano, com quase dois milhões de km^2.

A atualização das bases de dados utilizadas por ALHO *et al.* (2001) evidenciou novo arranjo zoogeográfico para as espécies da herpetofauna na totalidade da planície inundável do Pantanal (JUNK *et al*., no prelo). Entre os répteis, as espécies ubíquas continuaram a representar a maioria das formas amplamente distribuídas na planície, mas entre aquelas com distribuições mais restritas ou periféricas, 35% são próprias do bioma Amazônia. Entre os anfíbios, a maior parte das espécies (45% das amplamente distribuídas e 43% das com distribuições mais restritas ou periféricas) é oriunda do Chaco e apenas 13% das espécies amplamente distribuídas na planície foram consideradas ubíquas (JUNK *et al*., no prelo).

Apenas 10% das espécies de anfíbios com ampla distribuição na planície e 14% daquelas com distribuições pontuais ou periféricas são próprias do Cerrado (veja lista de espécies endêmicas desse bioma em COLLI *et al*., 2002). Entre os répteis, 15% das espécies amplamente distribuídas na planície e apenas 4% das espécies com distribuição pontual ou periférica são oriundas do Cerrado (JUNK *et al*., no prelo).

Estas proporções tendem a modificar-se continuamente, à medida que aumenta o conhecimento sobre a composição de faunas locais no Pantanal. A instabilidade das proposições acerca de relações biogeográficas da herpetofauna do Pantanal pode ser creditada, não só, a novos registros, descoberta de espécies adicionais com distribuição restrita na planície ou à descoberta de espécies novas para a ciência, mas também ao aumento do conhecimento e da cobertura geográfica dos estudos em biomas vizinhos.

Padrões de distribuição e de uso do substrato

A maior parte da herpetofauna do Pantanal (incluindo todas as espécies aquáticas) tem ampla distribuição na planície inundável. É o caso de anfíbios como *Leptodactylus chaquensis*, *L. podicipinus*, *Physalaemus albonotatus*, *Scinax nasicus* e *S. acuminatus*, de répteis como o jacaré-do-Pantanal *Caiman yacare* e de serpentes como *Clelia bicolor*, *Thamnodynastes chaquensis* e *Eunectes notaeus*.

A presença de espécies com distribuições restritas no interior da planície é responsável pela ocorrência de conjuntos herpetofaunísticos distintos em cada uma das diferentes sub-regiões. Provavelmente há, também, diferenciações no nível sub-regional, em particular nas situações em que, como em Aquidauana, Corumbá, Cáceres e na região da Serra do Amolar, entre outras, há maior diversidade topográfica. Adicionalmente, os padrões de abundância das espécies com mais ampla distribuição na planície podem variar em cada sub-região, mas nenhum destes aspectos foi ainda avaliado adequadamente.

Os dados de coleções, de bibliografia e de estudos de campo ainda não publicados sugerem que entre 30-35 espécies de anuros, 20-25 lagartos, três a cinco anfisbênias e pelo menos 40 espécies de serpentes podem ser encontrados em um mesmo sítio (JUNK *et al*., no prelo), nas localidades do

Pantanal consideradas como qualitativamente melhor amostradas. Essas localidades, em geral, foram alvo de inventários específicos ou de coletas no longo prazo, a exemplo de Corumbá, Aquidauana, Cáceres, Serra do Amolar, Parque Nacional do Pantanal.

Quanto ao uso do substrato, JUNK *et al.* (no prelo) mencionam que 52% das espécies de répteis do Pantanal são terrícolas, 22% são arborícolas ou semiarborícolas, 13% são aquáticas ou semiaquáticas e 13% são criptozóicas. Quando a herpetofauna total da BAP é considerada, esses valores são essencialmente semelhantes: 52% das espécies são terrícolas (entre os anuros, todos os Bufonidae, Leptodactylidae e Dendrobatidae), 26% são arborícolas ou semiarborícolas (praticamente todos os Hylidae), 12% são fossórios ou criptozóicos e 10 % são aquáticos ou semiaquáticos (entre os anuros, somente *Lysapsus limellus* e *Pseudis paradoxa* podem ser considerados como tal).

Embora a herpetofauna total do Pantanal seja comparativamente pobre em espécies com hábitos aquáticos ou semiaquáticos, assembléias locais podem apresentar proporções mais elevadas desses táxons especializados do que outros sítios já estudados na região Neotropical, como registrado por STRüSSMANN & SAZIMA (1993) para as serpentes de uma área do Pantanal do Cuiabá. Em outras áreas, entretanto, como aquelas da borda oeste do Pantanal, chama atenção a elevada proporção de serpentes com hábitos fossoriais ou semifossoriais. Em um inventário recente na RPPN Acurizal, Serra do Amolar (extremo norte de Mato Grosso do Sul, Pantanal do Paraguai), essa categoria ecológica correspondeu a 25% das espécies (43 no total) e 35% dos indivíduos registrados (308 no total) (C. Strüssmann, R.A.K. Ribeiro e V.T. Carvalho, dados não publicados).

Conservação

As espécies da herpetofauna do Pantanal consideradas vulneráveis devido aos níveis atuais de comercialização (legal e ilegal) de espécimes e/ou seus subprodutos restringem-se àquelas constantes no Apêndice II da Convenção sobre o Comércio Internacional de Espécies da Fauna e Flora Silvestre Ameaçadas (CITES): os Testudinidae (*Geochelone carbonaria*, *G. denticulata*), os Crocodylia (*Caiman yacare*, *Paleosuchus palpebrosus*), os lagartos *Iguana iguana*, *Dracaena paraguayensis*, *Tupinambis* spp., todas as serpentes da família Boidae e os Colubridae *Clelia clelia* e *Hydrodynastes gigas*. O *status* dessas espécies na planície, entretanto, é melhor do que em qualquer outra parte de suas áreas de distribuição, devido à baixa pressão de predação antrópica sobre essas espécies e mais baixas perspectivas de conversão de hábitats no Pantanal, em relação ao que ocorre nos planaltos do entorno ou, mesmo, em outros biomas.

Ameaças latentes a elementos mais especializados da herpetofauna do Pantanal, entretanto, não faltam. Espécies piscívoras como *Helicops leopardinus* podem acumular mercúrio oriundo de garimpos de ouro na periferia da planície (veja LEADY & GOTTGENS, 2001); espécies aquáticas, em geral, serão muito afetadas por quaisquer medidas que venham a reduzir a área ou período de inundação, como assoreamento excessivo, construção de diques e aterros, retificações de leitos de rios, etc. O mesmo acontecerá em relação a espécies cujos nichos

fundamentais estejam situados nas proximidades junto à linha de contato entre biótopos terrestres e aquáticos (o "*moving littoral*", sensu JUNK *et al*., 1989).

A conservação da biota do Pantanal requer, necessariamente, melhor conhecimento dos conjuntos de fauna e flora em distintas sub-regiões, por meio da realização de inventários em maior número de localidades; a delimitação e efetiva proteção de novas unidades de conservação, representativas das distintas unidades de paisagem existentes na região. Mais do que tudo, entretanto, é necessário envidar esforços para garantir a manutenção dos processos ecológicos que mantém o regime hidrológico na planície, a maior parte deles originados ou dependentes de eventos com origem fora da planície, nas regiões de cabeceiras situadas nos planaltos do entorno.

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Assessing the umbrella value of a range-wide conservation network for jaguars (*Panthera onca*)

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Abstract. Umbrella species are employed as conservation short-cuts for the design of reserves or reserve networks. However, empirical data on the effectiveness of umbrellas is equivocal, which has prevented more widespread application of this conservation strategy. We perform a novel, large-scale evaluation of umbrella species by assessing the potential umbrella value of a jaguar (*Panthera onca*) conservation network (consisting of viable populations and corridors) that extends from Mexico to Argentina. Using species richness, habitat quality, and fragmentation indices of ~1500 co-occurring mammal species, we show that jaguar populations and corridors overlap a substantial amount and percentage of high-quality habitat for co-occurring mammals and that the jaguar network performs better than random networks in protecting high-quality, interior habitat. Significantly, the effectiveness of the jaguar network as an umbrella would not have been noticeable had we focused on species richness as our sole metric of umbrella utility. Substantial inter-order variability existed, indicating the need for complementary conservation strategies for certain groups of mammals. We offer several reasons for the positive result we document, including the large spatial scale of our analysis and our focus on multiple metrics of umbrella effectiveness. Taken together, our results demonstrate that a regional, single-species conservation strategy can serve as an effective umbrella for the larger community and should help conserve viable populations and connectivity for a suite of co-occurring mammals. Current and future range-wide planning exercises for other large predators may therefore have important umbrella benefits.

Key words: *conservation network; habitat quality; jaguar; mammal;* Panthera onca; *surrogate; umbrella species.*

Introduction

The use of surrogate species is a commonly applied strategy in conservation and management (Caro and O'Doherty 1999, Caro 2010). "Surrogate species" is a blanket term that encompasses several different concepts, including indicator species, umbrella species, keystone species, and flagship species, among others. Surrogates are used as short-cuts for monitoring biodiversity and ecosystem health, or for prioritizing areas for conservation, and thus are a key component of conservation efforts of a variety of organizations (Caro 2010). Despite their widespread usage, the effectiveness of the surrogate species strategy is contentious and faces theoretical (Saetersdal and Gjerde 2011) and empirical (Andelman and Fagan 2000, Bifolchi and Lodé 2005, Fleishman and Murphy 2009, Che-Castaldo and Neel 2012) challenges. This lack of certainty in the efficacy of surrogate species may contribute to the criticism of single species conservation efforts and increasing interest in more holistic ecosystem management approaches (Simberloff 1998, Mac Nally et al. 2002, Lindenmayer et al. 2007). Thus, there is a pressing need for more rigorous analyses of how surrogate species might be used to measure the success of conservation approaches and the circumstances under which such approaches will be most effective.

Umbrella species are intuitively appealing examples of a surrogate species. The umbrella species concept suggests that conservation planning based on the needs (e.g., habitat area and connectivity) of one species may benefit co-occurring species (Roberge and Angelstam 2004, Branton and Richardson 2010). Typically, umbrella species are organisms with large area requirements and/or specialized habitat needs (Caro 2010; but see Fleishman et al. [2001] and Branton and Richardson [2010] for other possible characteristics of umbrella). Therefore, a

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protected area or reserve network that is designed to conserve viable populations of a particular umbrella species will simultaneously conserve viable populations of many other co-occurring species. However, echoing limitations of the surrogate species approach more generally, the utility of umbrella species as conservation tools remains poorly understood (Roberge and Angelstam 2004, Caro 2010). Results from studies examining umbrella species effectiveness are equivocal in terms of the utility of umbrellas as both tools for reserve selection (Andelman and Fagan 2000, Bifolchi and Lodé 2005, Branton and Richardson 2010, Sattler et al. 2013) and the maintenance of connectivity between reserves (Minor and Lookingbill 2010, Epps et al. 2011, Cushman and Landguth 2012, Brodie et al. 2014).

Two potential factors may contribute to variability in umbrella effectiveness. The first is spatial scale; most studies of umbrella effectiveness compare species richness in one or several reserves (or corridors) that contain an umbrella, with one or several that do not (Branton and Richardson 2010). However, umbrella species may be most useful as conservation tools at larger scales, for example, at regional scales or across an entire reserve network (Noss et al. 1996, Carroll et al. 2001, Rondinini and Boitani 2006). The second factor is the response variable used to determine the effectiveness of umbrellas. In many previous studies, the response that is measured is richness of co-occurring species (Branton and Richardson 2010, Caro 2010). However, other types of response may be more important, given that the goal of an umbrella is to maintain viable populations of co-occurring species. These other measures of umbrella efficacy include population size and habitat quality of co-occurring species (Branton and Richardson 2014), or degree of conservation network overlap (Rondinini and Boitani 2006). Different patterns in umbrella effectiveness may emerge depending on the type of response analyzed (Branton and Richardson 2014).

Large carnivores are often employed as umbrella species due to their substantial area needs and general sensitivity to human disturbance, but little is known about their actual umbrella value (Sergio et al. 2006, 2008). Several recent attempts at range-wide conservation planning for large carnivores have been conducted (Sanderson et al. 2002, IUCN 2006, Rabinowitz and Zeller 2010), which provide an opportunity to examine the umbrella-value of carnivores at large spatial extents. Moreover, recently developed global datasets on habitat suitability and fragmentation for mammals (Crooks et al. 2011, Rondinini et al. 2011) provide the ability to examine not only how carnivores function as umbrellas for conserving species richness of co-occurring mammals, but perhaps more importantly, how they serve as umbrellas for maintaining high-quality, core habitat for sympatric mammals.

The goal of our study was to examine the potential umbrella effectiveness of a conservation network designed to meet the needs of a single species, the jaguar (*Panthera onca*). This range-wide network (Fig. 1) extends from Mexico in the north to Argentina in the south and consists of viable jaguar populations (Jaguar Conservation Units; JCUs) and jaguar movement corridors that connect those populations. We ask the questions: (1) To what extent can the JCUs and jaguar

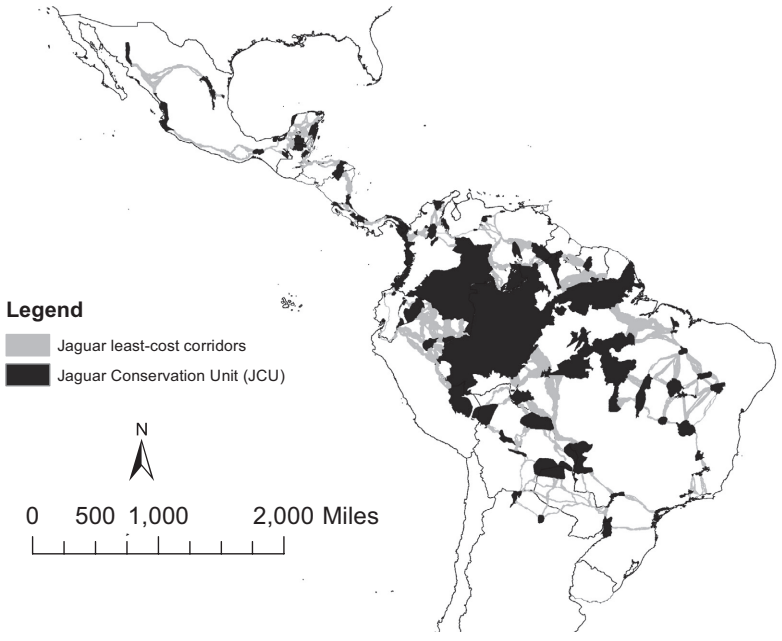

FIG. 1. A map of the jaguar conservation network for the Americas. The network consists of Jaguar Conservation Units (JCUs; in black), which maintain viable populations of jaguars, and jaguar corridors (in gray), linking the JCUs.

corridors act to maintain species richness and high-quality habitat for co-occurring Latin American mammals? (2) How well might jaguar corridors act to conserve connectivity (e.g., areas of low fragmentation) for co-occurring mammals? (3) How well can JCUs and corridors function as umbrellas when compared to a random selection of reserves or corridors?

Materials and Methods

Modeling Jaguar Conservation Units and corridors

The process of developing a range-wide conservation plan for the jaguar began in 1999 when the Wildlife Conservation Society (WCS) and the Universidad Naciónal Autonoma de México, Mexico City, Mexico, convened 35 jaguar experts to implement a rigorous planning exercise (Sanderson et al. 2002). The knowledge of these experts was pooled to determine the geographic distribution of jaguars, point observations of occurrence, and most importantly, core populations of jaguars. These core populations, termed Jaguar Conservation Units (JCUs), were defined as (1) areas with stable prey community that contained a population of at least 50 breeding jaguars or (2) areas with fewer than 50 breeding jaguars but with sufficient habitat and prey base such that jaguar populations could increase under favorable conditions (Sanderson et al. 2002). Only ~28% of JCU area overlaps with existing protected areas. This planning process was updated in 2006 and resulted in a range-wide map of 90 JCUs (Zeller 2007), which has been further modified to result in the most recent final map of JCUs (Fig. 1). We acknowledge that the model of JCUs we use in this paper may not be completely accurate in identifying the exact spatial location of all viable jaguar populations and that local-level refinements are and will continue to occur (e.g., De Angelo et al. 2013). However, the JCU network we employ does provide a consistent, expert-validated, range-wide model with which to evaluate the broad-scale umbrella value of jaguars, and provides a good template for what may occur with other range-wide planning exercises.

An important component missing from the initial range-wide plan, and its subsequent refinement, was an evaluation of potential jaguar movement, or dispersal, between JCUs and their likely routes of movement. Accordingly, Rabinowitz and Zeller (2010) predicted corridors between JCUs via least-cost path modeling (Adriaensen et al. 2003). In this approach, resistance values, indexing travel costs for a particular species, are assigned to different environments on a landscape (e.g., habitat types; Beier et al. 2008). Then, modeling algorithms are used to determine the path of least resistance between two populations; this pathway defines the corridor with the lowest cost of movement and highest probability of survival and can be used to focus conservation efforts for that species. Given a lack of empirical information on how jaguars disperse across landscapes, expert opinion was used to derive the resistance values for the creation of jaguar least-cost corridors. Resistance maps were created by having 15 jaguar experts assign resistance values to movement according to six factors: land cover type, percent tree and shrub cover, elevation, distance from roads, distance from settlements, and human population density (Rabinowitz and Zeller 2010). Resistance values were summed for each 1-km^2 pixel across the jaguar's range, and least-cost pathways between the JCUs were developed using Cost-Distance and Corridor functions in ArcGIS (Rabinowitz and Zeller 2010). The end result of this analysis was a map representing landscape resistance to jaguar movements and identification of least-cost corridors linking JCUs (Fig. 1; note this is slightly modified from Rabinowitz and Zeller 2010; see Materials and Methods: Overlap with co-occurring mammals).

Overlap with co-occurring mammals

To analyze how the JCUs and jaguar corridors can function as umbrellas for species richness and habitat quality of co-occurring mammals, we used ArcGIS to overlap the JCUs and corridors with habitat suitability models for ~1500 mammals inhabiting Latin America. We emphasize that our analysis does not compare how well jaguars perform as umbrellas to other potential umbrella species, but rather analyzes the umbrella value of a range-wide conservation strategy designed around the needs of a single species. The habitat suitability models were created by Rondinini and co-authors (Rondinini et al. 2011) for almost all terrestrial mammals globally. Briefly, for each mammal species, habitat suitability models (at 300-m resolution) were developed that indicated areas of high-, medium-, and low-quality habitat. Suitability was based on habitat preferences and elevational restrictions given in the IUCN Red List species descriptions, and utilized global land cover, elevation, and hydrologic maps. The suitability models were restricted to the known range of each species to avoid extrapolating species presence beyond their known limits. High-quality habitat corresponded to preferred habitat for the species, medium-quality habitat corresponded to habitat where the species could be found, but not persist in the absence of primary habitat, and low-quality (unsuitable) habitat corresponded to habitat where the species would rarely or never be found (see Rondinini et al. 2011 for details). We used ArcGIS to extract the areal extent of high-, medium-, and low-quality habitat contained within JCUs and jaguar corridors for each mammal species. We also determined the number of different species that had at least some amount of habitat (of any quality) that fell within JCUs and corridors. This latter index corresponds to the typical umbrella species analysis, where range maps of co-occurring mammals are used to determine the species richness contained within a conservation network (e.g., Carroll et al. 2001). We analyzed Mexico/Central America and South American separately due to faunal distinctiveness in the two regions, as well as structural

differences in the jaguar network (Mexico/Central America having much smaller JCUs on average than South America). For South America, we excluded the large Amazonian JCU (the largest JCU in Fig. 1) from the analysis, as we did not feel it was appropriate to include such a massively large JCU (2278098 km^2) in the umbrella analysis. This JCU would unduly bias our analysis toward finding a positive umbrella effect, and it represents too large of an area to be feasibly targeted as part of a protected area network.

Although gaining an understanding of the mammalian species richness and areal extent of habitat contained within the jaguar conservation network is useful in understanding its umbrella value, we also wanted to determine the proportion of the total available habitat for each species that was contained within the JCUs and corridors. We defined the total amount of habitat available for each co-occurring mammal using two scenarios, one more conservative and one less conservative for assessing the umbrella value of jaguars. For the more conservative method, we assumed that amount of habitat available to be conserved for each co-occurring mammal was equivalent to the total amount of identified habitat within all of Latin America (Mexico through Argentina) for that species. Any habitat for mammals that fell outside that range (e.g., habitat in the USA for certain wide-ranging species) was not included in the calculation of available habitat. In this way, we were assessing the umbrella value of jaguars for Latin American mammals more generally, even for mammals that have all or part of their habitat falling outside the current range of the jaguar, which does not extend throughout all of Latin America. For the less conservative method, we assumed that the amount of habitat available to be conserved for each co-occurring mammal was equivalent to the total amount of habitat within the outer boundaries of the jaguar's current range in Latin America (Appendix S1: Fig. S1). We excluded habitat (or species) that fell outside of this outer boundary. This second analysis therefore represents the umbrella value of jaguars for those mammals within the overall planning area for the jaguar reserve network. Note that even this second method is still fairly conservative, as we are including in the analysis co-occurring mammals that could never be contained within a jaguar network because they fall outside current jaguar habitat (e.g., high elevation species) but still fall within the outer boundaries of jaguar range. Once the total amount of habitat available for each co-occurring species was defined, we divided the amount of high-, medium-, and low-quality habitat for each species contained within JCUs and corridors by the total amount available. This calculation provided an estimate of the proportion of the total available high-, medium-, and low-quality habitat for each co-occurring mammal that was contained with JCUs and jaguar corridors.

For the jaguar corridors, we performed a second overlap analysis with fragmentation models for all ~1500 co-occurring mammals. For each species, the fragmentation models indicate the value of the GISfrag metric, which gives the average Euclidean distance of all cells within a high-quality habitat patch to the nearest edge of the patch (see Crooks et al. 2011 for details). High values of the GISfrag metric therefore indicate more interior habitat (or lower degree of fragmentation), whereas low values indicate less interior habitat (or higher degree of fragmentation; Crooks et al. 2011). We calculated the mean value of the GISfrag metric for each mammal species within jaguar corridors as a measure of how well jaguar corridors conserved interior, core habitat for co-occurring mammals.

Comparison with random models

We compared how well JCUs and jaguar corridors performed as potential umbrellas for co-occurring mammals with randomly selected protected area networks and randomly generated least-cost corridors. To generate a random protected area network to compare with the JCUs, we randomly selected protected areas within the study region from the World Database of Protected Areas (see Fig. 2 for an example). We excluded marine reserves and randomly selected protected areas until the total area within the reserve network was approximately the same as within the JCUs. Because only ~28% of JCU area falls within the protected area network of the study region, this random selection of protected areas resulted in a spatially distinct network from the JCUs for comparison of umbrella value (i.e., there was only partial overlap of the JCUs with the random protected area networks). The JCUs themselves were not included in the random selection. We created 10 randomly generated networks for both Mexico/Central America and South America to compare with the JCUs. We then overlapped these randomly generated networks with the Rondinini et al. (2011) habitat suitability models as described previously for the JCUs. Because the random reserve networks and JCUs were not equivalent in area, to compare their efficiency in conserving high-, medium-, and low-quality habitat for co-occurring mammals and for species richness more generally, we divided the areal extent of overlapping habitat and the number of species protected by the total area of the network. This value (which we term the "protected area efficiency") indicates the proportion of the network that contains high-, medium-, and low-quality habitat for each co-occurring mammal, or the average number of species protected per unit area of the network. We summarized data by mammalian order and across all mammals, with each randomly generated network representing a separate sampling occasion. We then determined if the protected area efficiency value for JCUs was higher than the 95% confidence interval for the randomly generated networks, which would indicate that the JCUs were better than random networks in protecting species richness and habitat quality of co-occurring mammals.

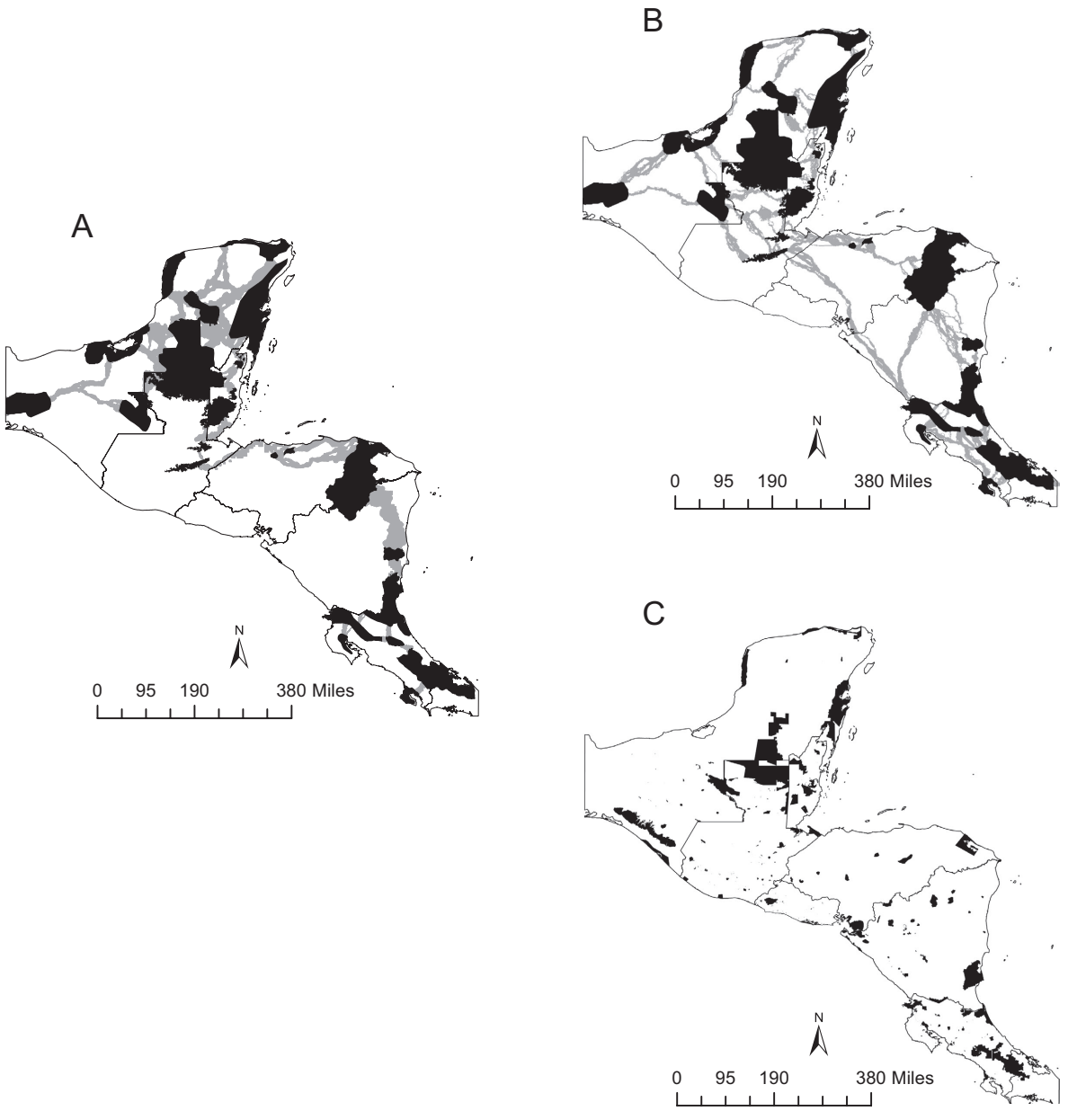

FIG. 2. Example comparison of jaguar network with random networks. Panel (A) is a map of actual JCUs (black) and modeled jaguar corridors (gray) for a section of Mexico/Central America, (B) a map of random generated corridors (gray) linking JCUs, and (C) a map of randomly selected protected areas (black) from the World Database of Protected Areas. Note that 10 corridor networks, and 10 protected area networks, were generated for comparison with the actual jaguar network.

To generate random least-cost corridor linkages between JCUs, we randomly permutated the jaguar cost-surface used to create the jaguar corridor network. The cost-surface values were randomly sampled without replacement and the original cost-surface was reclassified to reflect the order of the randomly sampled cost values. Corridors were modeled between all JCUs across the random cost-surface using Cost-Distance and Corridor functions in ArcGIS. Note that for South American corridors, we used an earlier version of the jaguar corridor network than shown in Fig. 1. This earlier version was used to maintain consistency in the use of coarse-scaled environmental layers for generation of the real vs. random corridors.

We repeated the process of randomly generating corridors 10 times (see Fig. 2 for an example) for Mexico/Central America and South America. Because the random corridor networks and jaguar corridors were not exactly equivalent in area, we repeated the process described for JCUs of dividing the amount of overlapping mammal

habitat, as well as the number of species protected, by the total area of the network. This value (which we term the "corridor efficiency") indicates the proportion of the network that contains high-, medium-, and low-quality habitat for each co-occurring mammal or the average number of species protected per unit area of the network. We examined if the jaguar corridors had a better efficiency value for mammalian orders, and across all mammals, by comparing corridor efficiency values for jaguar corridors with 95% confidence intervals of the 10 randomly generated corridor networks.

Results

Overlap with co-occurring mammals

We focus the results on how well the jaguar network overlapped high-quality habitat for co-existing mammals. Additional results on how the jaguar network protected low- and medium-quality habitat are in Appendix S2 (Fig. S1). Using our more conservative method to define available habitat, of the 583 mammal species with at least some high-quality habitat in all of Mexico/Central America, 423 (73%) had some of that habitat contained within JCUs. Using our less conservative method to define available habitat, 81% of mammals with high-quality habitat available within the jaguar's range in Mexico/Central America have at least some of that habitat within JCUs. Jaguar corridors in Central America overlapped high-quality habitat for 45% and 50% of co-occurring mammal species, for more and less conservative estimates of availability, respectively. JCUs conserved a substantial proportion of the total available high-quality habitat for co-existing mammal species. The average proportion (± SD) of high-quality habitat that overlapped with JCUs was 0.22 (0.27) and 0.25 (0.26) across all species, for the more and less conservative estimates of available habitat, respectively. A substantial amount of variability in the proportion of high-quality habitat falling within JCUs occurred across mammalian orders, with average proportion ranging from 0.09 to 0.52 (Fig. 3; see Appendix S2: Fig. S2 for inter-order results based on the more conservative estimate of available habitat and Fig. S3 for inter-order results based on total area of the range in square kilometers contained within JCUs). In terms of total areal extent, JCUs conserved an average of 42018 km^2 of high-quality habitat for co-occurring mammals in Mexico/Central America and jaguar corridors an additional 19327 km^2.

Similar patterns are seen in South America. JCUs overlapped high-quality habitat for 70% and 81% of co-occurring mammal species for more and less conservative estimates of availability, respectively. In addition, jaguar corridors overlapping high-quality habitat for 67% and 75% of species for more or less conservative estimates, respectively. The average proportion of high-quality habitat conserved within JCUs in South America was slightly lower than in Mexico/Central America, with averages of 0.15 (0.19) and 0.18 (0.20) across all species, for the more and less conservative definitions of available habitat. Again, substantial inter-order variability in the proportion of high-quality habitat overlapping JCUs was present, with average proportion ranging from 0 to 0.30 (Fig. 3; see Appendix S2: Fig. S2 for inter-order results based on the more conservative estimate of available habitat, and see Fig. S3 for inter-order results based on total area of the range in square kilometers contained within JCUs). In terms of total areal extent, JCUs conserved an average of 168198 km^2 of high-quality habitat for co-occurring mammals in South America and jaguar corridors an additional 51107 km^2.

Comparison with random models

JCUs in Mexico/Central America were less efficient than randomly generated protected area networks at overlapping absolute numbers of species. The number of species with at least some low-, medium-, or high-quality habitat overlapping JCUs (1.69 species/1000 km^2) fell below the 95% CI of the random networks (2.74 ± .05 species/1000 km^2). However, JCUs were more efficient than random protected area networks at protecting high-quality habitat for co-occurring mammals. JCU efficiency was greater than random networks across all species and for 10 of 11 mammalian orders (i.e., the efficiency value fell outside the 95% confidence interval of the efficiency value for the random networks; Fig. 4A). In contrast, JCU efficiency generally fell within, or just barely outside, the 95% CI of random networks for low- and medium-quality habitat (Appendix S2: Fig. S1). Similar overall patterns are seen for JCU efficiency in comparison to random networks for South America, with JCUs significantly less efficient in protecting species richness (0.60 species/1000 km^2) compared to random networks (0.86 ± 0.05 species/1000 km^2), but more efficient in protecting high-quality habitat than random networks across all species. Moreover, JCUs in South America were more efficient at overlapping high-quality habitat for 10 of 13 orders (Fig. 4B).

Jaguar corridors in Mexico/Central America were more efficient than randomly generated corridor networks at protecting a larger number of species within networks. The number of species with at least some low-, medium-, or high-quality habitat overlapping jaguar corridors (3.78 species/1000 km^2) fell above the 95% CI of the random networks (3.5 ± 0.05 species/1000 km^2). Jaguar corridors were also more efficient than random corridor networks at protecting high-quality habitat across all species and for 10 of 11 mammalian orders (Fig. 4C). Moreover, jaguar corridors conserved more high-quality habitat within interior core (i.e., less fragmented) patches across all species, and for 10 of 11 orders, than random corridors (Fig. 5A). In South America, jaguar corridors were less efficient at protecting species richness (species richness within jaguar corridors, 0.35 species/1000 km^2; species richness random

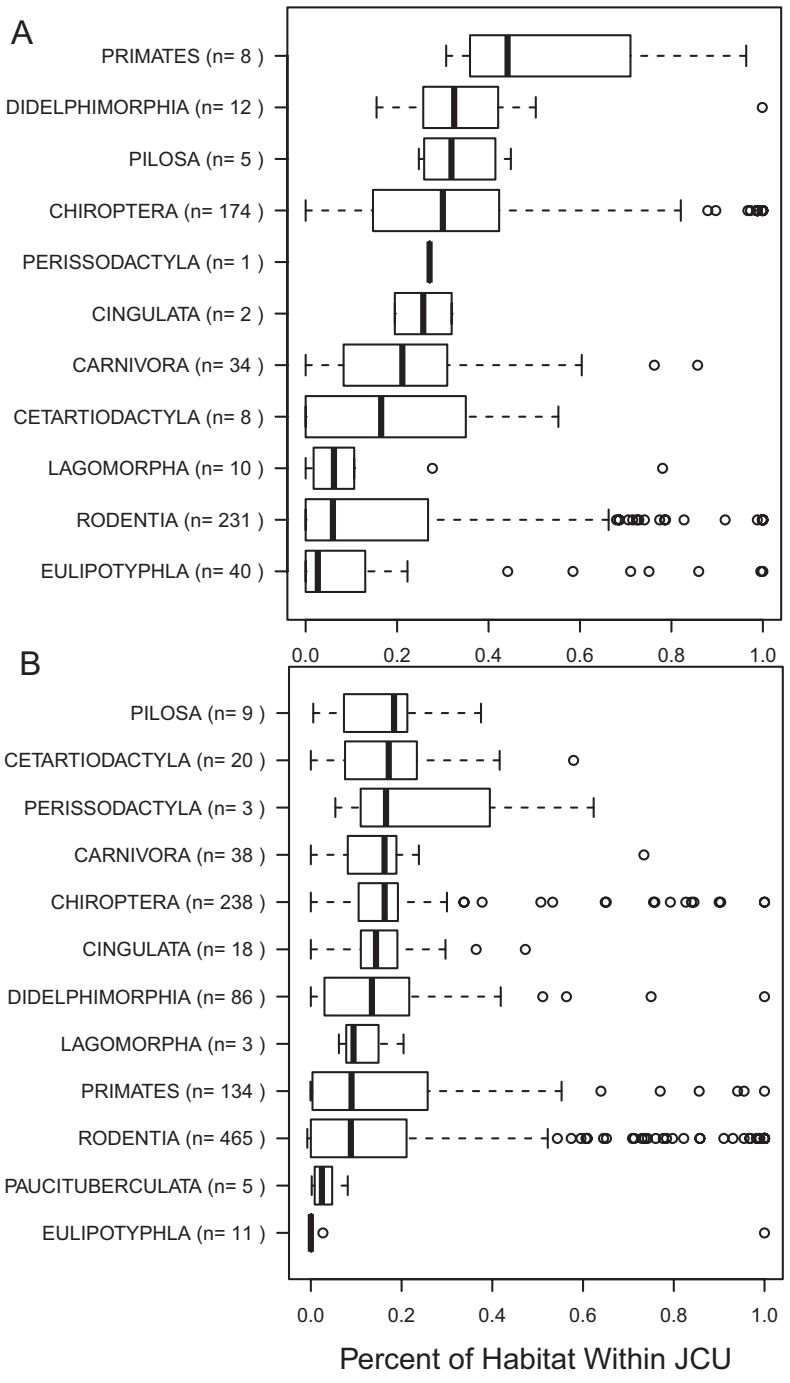

FIG. 3. Boxplots of the proportion of available high-quality habitat of co-occurring mammals contained within JCUs. Boxplots show the median (vertical black lines), upper and lower quartiles (open boxes), and variability outside those quartiles (whiskers). Panel (A) shows results from an analysis of Mexico/Central America, and (B) results from an analysis of South America. Available high-quality habitat was defined as the total amount of high-quality habitat of each species that fell within the outer boundary of the jaguar's range. Boxplots based on defining available high-quality habitat as all high-quality habitat within Latin America can be found in Appendix S2: Fig. S2.

corridors, 0.38 ± 0.02 species/1000 km^2). However, South American jaguar corridors were more efficient in protecting high-quality habitat than random corridors across all species and for 9 of 13 orders (Fig. 4D). South American jaguar corridors were also more efficient in protecting intact high-quality core habitat (Fig. 5B).

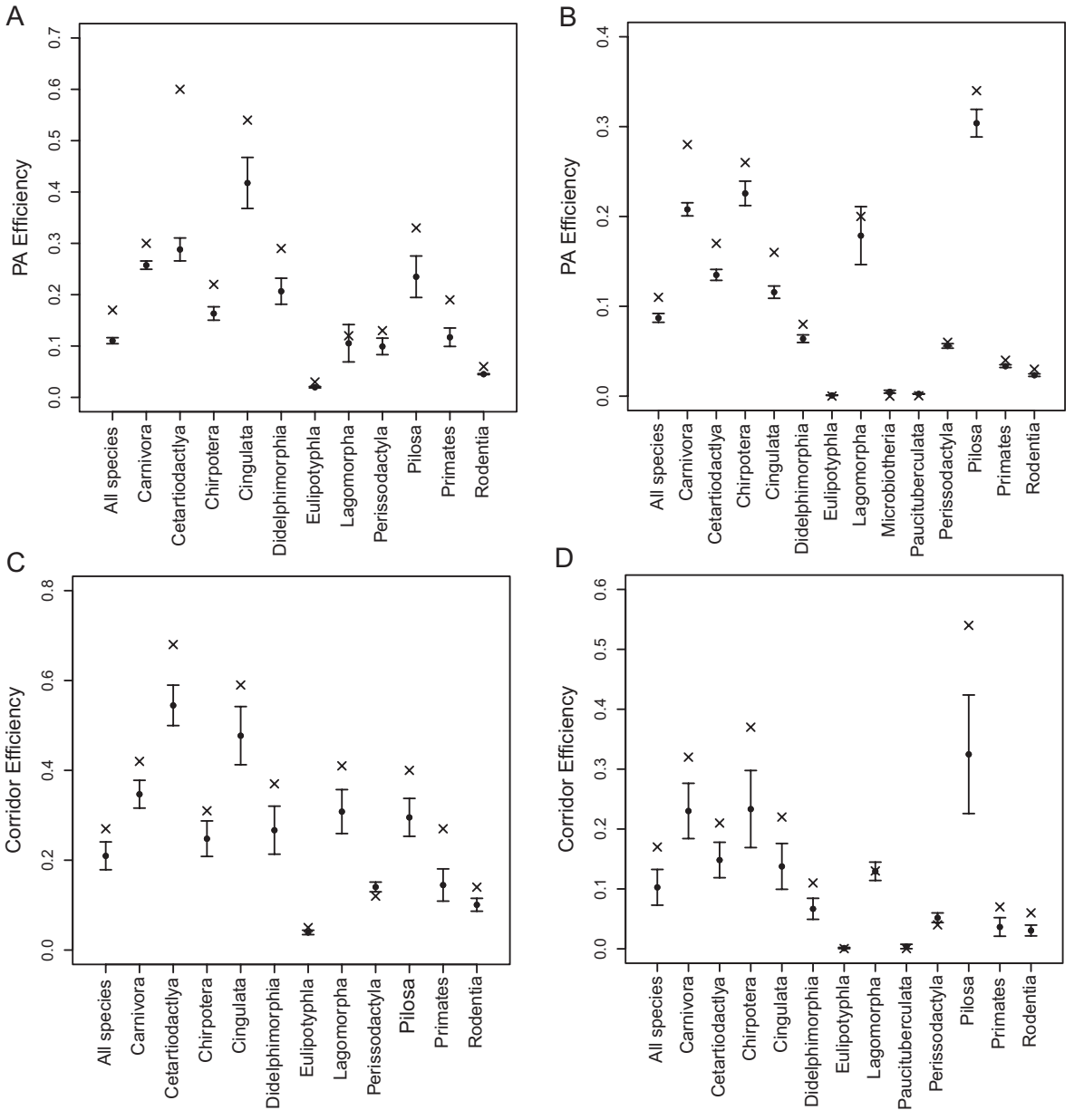

FIG. 4. Comparison of the efficiency of the jaguar network (JCUs and jaguar corridors) and random networks in containing high-quality habitat of co-occurring mammals. Protected area (PA) efficiency and corridor efficiency were calculated as the amount of high-quality habitat for each mammal contained within the network (protected areas or corridors), divided by the total area of the network. Thus, higher values indicate more efficient networks in overlapping high-quality habitat for co-occurring species. Mean and 95% CI of 10 random networks indicated by solid circles and whiskers; mean value of actual JCU or jaguar corridor network given by the "x". Panel (A) shows a comparison of JCUs in Mexico/Central America with 10 randomly generated protected area networks, (B) a comparison of JCUs in South America with 10 randomly generated protected area networks, (C) a comparison of jaguar corridors in Mexico/Central America with 10 randomly generated corridors, and (D) a comparison of jaguar corridors in South America with 10 randomly generated corridors. Results from an analysis of low- and medium-quality habitat can be found in Appendix S2: Fig. S1.

CONCLUSIONS

A conservation strategy designed around the needs of a single species, the jaguar, can serve as an effective umbrella for conserving high-quality habitat of co-occurring mammal species in Latin America. To our knowledge, this analysis represents one of the first quantitative evaluations of the umbrella value of a single-species, multinational conservation plan and is one of the largest in terms of spatial extent that has been conducted to date. Our ability to analyze data for all co-occurring mammals across the entire range of the jaguar strengthens confidence in our

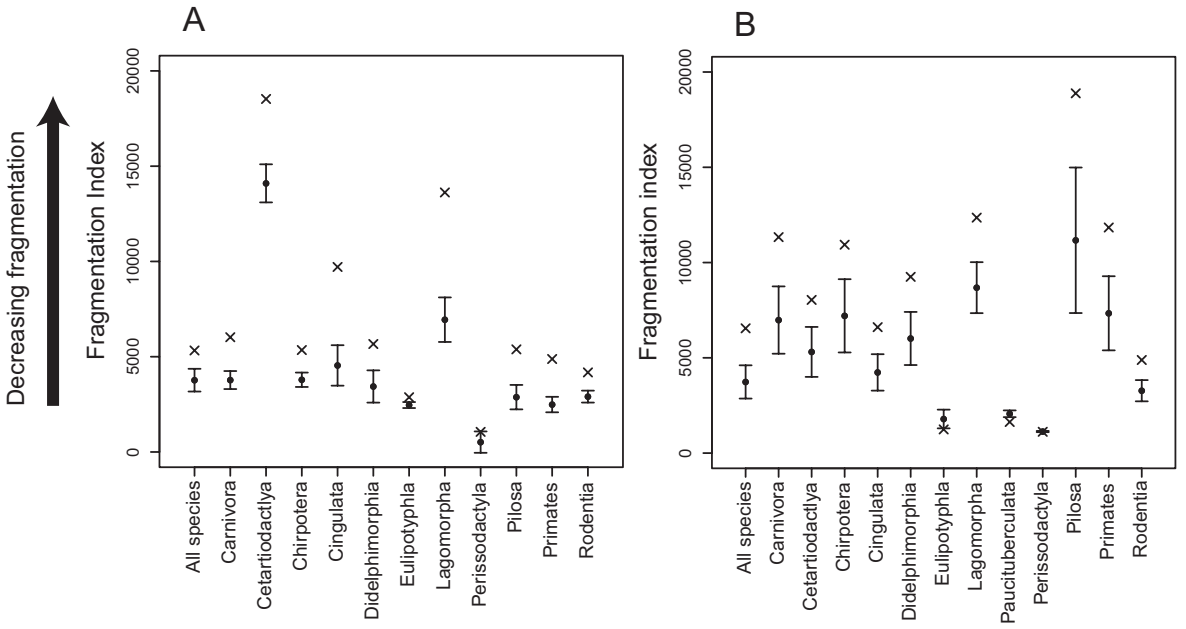

FIG. 5. Comparison of performance of jaguar corridor and random corridors in containing interior, core habitat for co-occurring species. Fragmentation index indicates average distance within high-quality habitat patches to patch edge, thus, greater values indicate less fragmentation. Mean and 95% CI of 10 random networks indicated by solid circles and whiskers; mean value of actual jaguar corridor network given by the "x". Panel (A) shows a comparison of jaguar corridors in Mexico/Central America with 10 randomly generated corridors, and (B) a comparison of jaguar corridors in South America with 10 randomly generated corridors.

conclusions. Moreover, because the models developed by Rondinini et al. (2011) measure area of occupancy and habitat quality rather than extent of occurrence, we were able to quantitatively assess umbrella effectiveness at a finer level than simple range limits.

Our results show that the jaguar network outperformed random networks in protecting high-quality habitat for co-occurring mammals. JCUs also conserved a substantial amount and percentage of high-quality habitat; indeed, the percentage of available high-quality habitat of co-occurring mammals that was contained within the JCUs alone was greater than 10% for virtually all mammalian orders (sometimes substantially so), which is an oft-cited, yet controversial, target threshold for adequate representation of conservation features within a network (Pressey et al. 2003, Brooks et al. 2004, Rondinini et al. 2005). Given the positive (but not necessarily monotonic; Torres et al. 2012) relationship between habitat quality and population density and persistence across a range of scales (Pöyry et al. 2009, Schooley and Branch 2011, Oliver et al. 2012, Robles and Ciudad 2012), and the substantial areal extent of the JCUs (average JCU size ~25000 km^2), the jaguar network may conserve large populations of many co-occurring mammals. Large population size increases the chance that these populations of co-existing mammals will be viable in the long-term, which is one of the major goals of the umbrella strategy (Caro 2010). In addition, jaguar corridors, due to their substantial width and length, contained additional high-quality habitat, including relatively intact core patches, for mammals outside of JCUs. This pattern suggests that jaguar corridors should facilitate movement for numerous species across the fragmented Latin American landscape. Connectivity is important to ameliorate the effects of habitat loss and fragmentation on co-occurring mammals, and to provide adaptive potential and range shifting in the face of climate change (Groves et al. 2002, Crooks and Sanjayan 2006, Heller and Zavaleta 2009).

Our findings contrast with several studies that have found umbrella species an ineffective conservation strategy (Andelman and Fagan 2000, Roberge and Angelstam 2004, Bifolchi and Lodé 2005, Gardner et al. 2007), including when using wide-ranging species such as large carnivores as umbrellas (Andelman and Fagan 2000, Carroll et al. 2003, Beier et al. 2009, Minor and Lookingbill 2010). We suggest several reasons for this discrepancy. First, and perhaps most importantly, our use of multiple measures of effectiveness was necessary to develop a better understanding of the value of jaguars as an umbrella species. Had we merely investigated species richness as our measure of umbrella effectiveness, using extent of occurrence range maps for mammals as is typically done, we would have concluded that jaguars were not particularly effective umbrellas (except for jaguar corridors in Central America). Random networks performed as well or better at overlapping the ranges of co-occurring mammals. Only upon examination of

habitat quality of co-occurring mammals did we see the potential value of jaguars as umbrellas. Multiple measures, and metrics that relate more strongly to population viability, may thus be necessary to evaluate the effectiveness of umbrellas in protecting the larger community (Branton and Richardson 2014). Second, the large-scale nature of our assessment likely increased our power of inference. The typical study design for evaluating umbrella effectiveness is relatively small scale, where one or a few reserves occupied by an umbrella are compared with one or a few reserves that are unoccupied. Such studies have revealed mixed results in terms of support for the effectiveness of umbrellas (Branton and Richardson 2010). We suggest that the efficacy of umbrellas should be most evident at larger scales, when guiding the design of the entirety of large conservation networks that will naturally accommodate the needs of many species at regional scales and above. Indeed, several other larger scale studies of umbrella effectiveness revealed support for umbrellas in terms of the number of co-occurring species and amount of those species' range that was contained within an overall conservation network (Noss et al. 1996, Carroll et al. 2001, Rondinini and Boitani 2006, Thorne et al. 2006, but see Andelman and Fagan 2000). Third, we focused our analysis solely on co-occurring mammals, which were taxonomically similar to our umbrella species (also a mammal). Taxonomic relatedness may positively influence conclusions regarding umbrella effectiveness, but this idea is debatable (Fleishman et al. 2001, Hurme et al. 2008, Branton and Richardson 2010). Related to the previous point, a common positive response to tree cover for jaguars and numerous Latin American mammals may be contributing to our results. However, the jaguar network was developed based on consideration of numerous layers in addition to tree cover, including elevation and human disturbance (e.g., hunting pressure, distance to roads and settlements), and therefore, this possibility does not appear to be a sufficient explanation. We also emphasize that while a common response to tree cover may be important, it does not lessen the value of using the jaguar to define the necessary size of protected areas and corridors.

Despite the jaguar network serving as an effective umbrella for mammals in Latin America, the efficacy of the network varies substantially across mammalian orders. Inter-order variability in jaguar umbrella effectiveness was evident for both Mexico/Central America and for South American mammals, although more pronounced for Mexico/Central America. The jaguar network performed better as an umbrella for larger mammals than smaller ones, perhaps due to a better match in scale and type of habitat selection between species of similar size (Wiens 1989). Not surprisingly, the jaguar network conserves a substantial amount of high-quality habitat for carnivores and is more effective in conserving high-quality habitat than random networks. The jaguar network also is efficient in conserving high-quality habitat for other mammalian orders, including Cetartiodactyla (even-toed ungulates), Chiroptera (bats), Cingulata (armadillos), Pilosa (anteaters and sloths), and Primates. However, the jaguar serves as a less effective umbrella for mammalian orders such as Rodentia, Lagomorpha (hares and rabbits), and Eulipotyphla (moles and shrews). Numerous species in these last three orders are endangered or threatened due to small range size (~17% of species listed as vulnerable, endangered, or critically endangered by IUCN). This finding stresses the need for complementary conservation strategies for these groups. Moreover, although randomly selected networks performed as good as or better than the jaguar network for these mammalian orders, levels of high-quality habitat contained within these random networks were still relatively low, suggesting that additional selection of conservation areas for these particular species-rich mammalian orders is urgently needed.

Inter-order variability in the effectiveness of jaguar corridors in conserving interior, high-quality habitat for co-occurring mammals was also pronounced; however, with the exception of Eulipotyphla, Paucituberculata, and Perissodactyla, jaguar corridors performed better than random corridors. This finding is consistent with two other studies in tropical zones that suggest that large mammals can effectively predict connectivity for other mammalian orders (Epps et al. 2011, Brodie et al. 2014). Our findings, however, contrast with studies in temperate zones that have found limited ability of carnivores to predict connectivity for other mammalian orders (Beier et al. 2009, Minor and Lookingbill 2010, Cushman and Landguth 2012), perhaps because temperate carnivores tend to be highly generalist. Although jaguars are relatively generalized in habitats and diet, they do display a preference for forest cover and aversion to human disturbance, which may increase their ability to predict connectivity for other mammals. In addition, our focus on habitat suitability and fragmentation for sympatric mammals, rather than strict overlap between high connectivity areas or modeled corridors (sensu Beier et al. 2009 and Minor and Lookingbill 2010), or our use of the full co-occurring mammal community in our analysis, may have contributed to our more positive result.

Given our use of large-scale models to assess the effectiveness of jaguars as umbrellas, our results must be approached with a modicum of caution. Our use of random models to compare with the jaguar network may be imperfect but serves as an important starting point for understanding umbrella value of jaguars in comparison to other possible networks. Another approach would be to actually design reserve networks (e.g., Rondinini and Boitani 2006) and corridors to meet the needs of co-occurring mammals and determine the degree of match between the jaguar network and these other networks. However, in addition to the difficulties of such an analysis, particularly for identifying least-cost corridors of other species in a rigorous manner on very

limited data, the jaguar network was built on expert opinion and includes substantial area outside the world protected area system, making comparisons between networks problematic. We also must be cautious in terms of the relevance of our modeling results to real patterns on the ground. In particular, areas of high-quality habitat based on the Rondinini et al. (2011) models may be impacted by factors not considered in the modeling process (e.g., hunting) that would alter overall quality for numerous mammals (Torres et al. 2012). Also, the jaguar network is a proposed network that is not yet fully realized, and thus, our analysis should be seen as evidence of the potential umbrella value of this modeled network. However, the jaguar network is being actively implemented and refined with field-based ground-truthing and is thus more than a hypothetical model of a reserve network (e.g., Zeller et al. 2010, Petracca et al. 2013, Rabinowitz 2014). This suggests that field-based analysis of the effectiveness of jaguars as umbrellas would be a useful complement to our analysis and should be possible with current data. For example, a substantial amount of camera-trapping data exists that could evaluate species richness or occupancy of co-existing mammals in areas with or without jaguars, or areas of low vs. high jaguar density (sensu Brodie and Giordano 2013). Jaguar camera-trapping has occurred across the jaguar range (Tobler and Powell 2013), and thus, a meta-analytical approach to the umbrella question should result in a larger scale analysis than typical field-based evaluations of umbrella species.

Recent calls for an ecosystem-based approach to conservation planning have suggested that single-species conservation efforts are ineffective (Simberloff 1998, Mac Nally et al. 2002, Hughes et al. 2005). Lack of convincing data regarding the efficacy of surrogate species has contributed to these calls (Mac Nally et al. 2002). Others have suggested that single-species and ecosystem-based (or habitat-based) efforts can provide complementary biodiversity conservation strategies (Lindenmayer et al. 2007, Caro 2010). Our findings support this latter conclusion, as we document that the jaguar conservation network can provide substantial, but not complete, umbrella coverage for the co-existing mammal community. This suggests that other range-wide planning exercises for large carnivores may have benefits well beyond protection of a single species. We stress that we do not address the question of whether jaguars are the ideal umbrella species for neotropical or Latin American mammal communities; such an analysis would require that we compare the jaguar network to range-wide conservation strategies developed for several additional threatened species (e.g., white-lipped peccaries, *Tayassu pecari*), which to date do not exist. While the ideal umbrella species would be an interesting question to address, it might also be a moot point. The jaguar's ability to attract conservation funding and tourism and garner local support will ensure that it is a focus of conservation efforts. Our research indicates that this focus, while somewhat limited, can have far-reaching positive benefits for the entire Latin American mammal community.

Acknowledgments

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Original Research Article

The numbers of the beast: Valuation of jaguar (*Panthera onca*) tourism and cattle depredation in the Brazilian Pantanal

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ABSTRACT

Large carnivores fascinate people because of their beauty and potential as human predators and have therefore become focal species for the ecotourism industry. Wildlife tourism has grown exponentially and has often been used as a financial argument for species conservation. However, carnivores depredate livestock, leading to a direct economic conflict with rural livelihoods, often resulting in lethal retaliation action. Here we show that jaguar ecotourism represents a gross annual income of US$6,827,392 in land-use revenue across a representative portion the Brazilian Pantanal, the world's largest wetland. Considering the aggregate costs of jaguar depredation on livestock within the same area, we estimate that the resident jaguar population would induce a hypothetical damage of only US$121,500 per year in bovine cattle losses. This large discrepancy between economic gains and losses reinforces the importance of wildlife tourism as a conservation tool in boosting tolerance of jaguars in private ranches. We also evaluate the partnership between ecotourism and cattle ranchers, in which cattle losses induced by jaguars could be compensated by a system of voluntary donations from tourists, ensuring that both traditional livestock husbandry and ecotourism can co-exist within the same ranches, thereby promoting landscape-scale jaguar conservation.

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1. Introduction

Wildlife tourism is often extolled as a critical tool for species conservation (Tisdell, 2012; Gossling, 1999). This type of tourism is a rapidly growing economic activity, especially in emerging economies, where it can generate substantial revenues for rural entrepreneurs, local communities and local governments, which trickle down into the wider service industry (Gossling, 1999; Curtin and Kragh, 2014). However, this economic argument can only hold in public policy negotiations if local revenues generated by wildlife within a given area can be materialized, even if overall estimates of financial benefits are not completely accurate. Assessments of local income generated by wildlife ecotourism activities represent a far more persuasive argument for wildlife conservation compared to, for example, ethical or existential values (Chardonnet et al., 2002).

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Large cats represent some of the most charismatic species appealing to a wide audience, and are therefore of great value to wildlife tourism activities (Skibins et al., 2013). Consequently, traditional communities involved with ecotourism are typically more tolerant of large cats (Hemson et al., 2009). Lions (*Panthera leo*), leopards (*Panthera pardus*) and cheetahs (*Acinonyx jubatus*) are among the most sought-after species by national park visitors in South Africa (Lindsey et al., 2007). Direct contributions of ecotourism to the conservation of large cats in sub-saharan Africa include habitat expansion and restoration, anti-poaching enforcement and patrols, improved livestock husbandry, well-designed livestock compensation, and predator conservation incentive programs (Mossaz et al., 2015). Still, conservation outcomes effectively depend on several factors, including local community participation and appropriate local financial trickle-down (Mossaz et al., 2015). In India, wildlife tourism has grown by 15% annually (Bindra and Karanth, 2013) and the main reasons for visiting protected areas are opportunities to see nature in general, tigers (*Panthera tigris*), and scenic beauty (Karanth and DeFries, 2011; Karanth et al., 2012). In fact, there is an urgent need to establish and enforce regulations to manage ecotourists, resource use, and land-use change around Indian protected areas (Karanth and DeFries, 2011). In 2012, lack of control in tiger tourism resulted in India's Supreme Court temporarily banning tourism access to core areas of tiger reserves. However, this measure generated much criticism, such as increasing the risk of tigers being killed by poachers and reducing tourism revenue for park management (Buckley and Pabla, 2012). In South America, jaguar (*Panthera onca*) tourism is a relatively recent activity (<20 years) that occurs primarily in protected areas and private cattle ranches of the Brazilian Pantanal (Hoogesteijn et al., 2015; Tortato and Izzo, 2017) and a single protected area in Central Amazonia (Nassar et al., 2013). Jaguar tourism has become increasingly governed by state-level directives, including specific regulations in the Pantanal, but the lack of management plans in protected areas remains a barrier to the development of this industry (Tortato and Izzo, 2017).

Even though jaguar tourism is potentially a high profitable activity, local people still engage in the persecution and killing of large cats like jaguars and pumas. Killing is often induced by cultural factors that goes back several generations (Marchini and MacDonald, 2012; Treves and Bruskotter, 2014; Porfírio et al., 2016). However, the single most important driver of hunting and persecution of large cats is livestock depredation, resulting in economic losses to local ranchers and farmers, a conflict that generates retaliatory culls (Treves and Karanth, 2003), often through professional bounty hunters (Michalski et al., 2006). In fact, over 75% of all felid species worldwide are persecuted and killed because of their real or perceived threats to livestock (Inskip and Zimmermann, 2009). Assessing the potential or realized costs and benefits involved in large carnivore conservation is an intractable task to be integrated into land management (Dickman, 2010), but benefits accrued from tourism can clearly help compensate the costs of co-existing with large apex predators (Walpole and Leader-Williams, 2002). Therefore, ecotourism that singles out particular flagship species should enable the creation of conservation offset programs that compensate for losses for traditional ranchers, thereby providing financial support to mitigate human-wildlife conflicts (Hemson et al., 2009; Dickman, 2010; Hazzah et al., 2014; Bauer et al., 2017).

Wildlife is highly visible and abundant in the Brazilian Pantanal, the world's largest sheet-flow continental wetland. Indeed, the Pantanal is widely considered to be the most important wildlife tourism epicenter in Latin America (Chardonnet et al., 2002), comparable to the best protected parks in East African savannas. Illegal hunting is the main threat to the population viability of jaguars in the Pantanal (Quigley and Crawshaw Jr. 1992; Crawshaw Jr. 2002), and is mainly driven by supposedly economic losses induced by jaguars on cattle herds in private ranches (Zimmerman et al., 2005; Boulhosa and Azevedo, 2014). These losses are proportionately low compared to the complete inventory of cattle herd size of any given ranch or farm, but ranges widely, for example, from U$350 to U$22,400 per year within a single ranch in the Pantanal (Tortato et al., 2015). Therefore, any benefits brought about by jaguar tourism to ranches with a mixed financial portfolio must also take into account cattle losses from jaguar depredation.

Wildlife valuation studies usually consider “non-use values” through different methodologies such as contingent valuation (Nijkamp et al., 2008). Here, we consider “use values” as market prices to measure the positive economic impact that a jaguar population can represent in terms of annual revenues derived from tourism, compared to livestock casualties induced by jaguars on the basis of the same spatial scale in the Brazilian Pantanal. We also valuate the potential for this tourism industry to create a compensation scheme for cattle losses through voluntary donations. We therefore discuss the operational feasibility of this compensation scheme, and the overall importance of tourism as a conservation tool for the highest-density jaguar population anywhere on Earth.

2. Methods

2.1. Study region

The Pantanal biome — the world's largest floodplain — is located in the central portion of South America and is widely recognized by its wildlife abundance, the main attraction for thousands of tourists who visit the region each year. The Brazilian Pantanal covers an area of 140,000 km^2, only 2.5% of which is officially protected under the categories of national park, state park and private reserve (Harris et al., 2005). This study was conducted in the Encontro das Aguas State Park (hereafter, EASP) and its surrounding landscape. The EASP encompasses an area of 108,000 ha, located in the municipal counties of Poconé and Barão de Melgaço, more precisely in the locality of Porto Jofre, state of Mato Grosso, Brazil. Land-use revenues in this region were traditionally based on extensive, low-yield cattle ranching, but sport fishing and wildlife-oriented tourism have gradually increased over the two last decades. Jaguar tourism within the EASP and neighbouring areas occurs primarily along rivers and streams (Tortato and Izzo, 2017) (Fig. 1). Porto Jofre is a major ecotourism destination, within which field

Fig. 1. An adult male of Jaguar (*Panthera onca*) along the margin of the Três Irmãos River, in the Encontro das Águas State Park. Photo credit: Rafael Hoogesteijn.

observation of jaguars is the most established attraction. Other wildlife fills in the background scenario, but has a secondary role in the choice and marketing of this destination (FRT, unpublished data). Traditional ranching of adapted cattle breeds has been the most important economic activity in the Pantanal for over 250 years (Wilcox, 1992), and occupies over 80% of the biome (Seidl et al., 2001), including all ranches around the EASP area. Comparing these two main economic activities of the Pantanal, wildlife tourism is potentially more widespread because it can occur in both strictly protected areas and private landholdings (Hoogesteijn et al., 2015; Tortato and Izzo, 2017). Cattle ranching is legally prohibited in formal protected areas, such as EASP.

2.2. Calculating minimum revenues from jaguar tourism

The daily earnings from seven tourism lodges were used to calculate the minimum revenue originating from jaguar tourism. Although other lodges outside this area may also offer customer-designed packages for jaguar observation, these packages are relatively unstable and unpredictable. Therefore, we opted for a conservative approach in considering only lodges that work specifically with jaguar tourism within the EASP and surrounding region. This minimum revenue was obtained by multiplying the per guest daily values (DV) of room and board for each lodge, the total number of visiting tourists in 2015 (NT) and the minimum daily occupation rate (MD). The values that the local jaguar population represents for each lodge were then summed across all lodges.

Information relating to daily revenues and number of tourists in 2015 was obtained through direct interviews with the owners and/or managers of each lodge. Minimum daily revenues were based on packages exclusively designed to observe jaguars, offered by leading tour operators working in the study area, which were standardized as a minimum package duration of 3 days. For the purposes of this paper, we restricted our revenue estimates to those generated by packages from established lodges only, thereby ignoring additional revenues from more independent tourists who arranged their own customized tours with free-lance local guides and services. In addition, we deliberately excluded other minor tourist expenditure, including the purchases of crafts, restaurant meals, trips or other local services. The total value of these incidentals are far more difficult to estimate, even if they contribute to local service chains. We therefore simply assume that revenues estimated here could be severely conservative, but are reliable and stable, and our estimates can be easily reproduced by other studies.

2.3. Spatial scale of jaguar tourism and livestock damage

Defining a spatial scale of tourism economics is important to compare the gains and losses related to a flagship species such as jaguars, rendering the evaluation replicable and robust. The spatial scale considered in this study was based on 349 known GPS locations where tourists observed jaguars along the main rivers and streams of EASP and the neighbouring landscape. These locations were obtained from geographic coordinates obtained in situ and provided by tour guides. Considering the extreme localities along the whole catchment, the entire stretch of rivers used by tourists was defined as the potential jaguar tourism area. Considering the mean maximum distance moved by any given adult jaguar within their home

ranges in this area (Devlin, 2017), we created a buffer area of 5850 m from any riverbank, which resulted in a total area of 81,000 ha, corresponding to the approximate total area where all jaguars observed by all tourists likely maintain their territories (Fig. 2). Considering this area only, we used a carrying capacity (or stocking density) estimate of 0.2 cattle heads or animals per hectare, which is a realistic estimate for the ranches neighbouring the EASP area, and consistent with grazelands at other tropical wetlands with natural grasses (Hoogesteijn and Chapman, 1997; Sarmiento and Pinillos, 1999; Hoogesteijn and Hoogesteijn, 2010). We therefore established that the maximum size of the bovine herd in a similar area at this carrying capacity would be ~16,200 animals.

In the Pantanal, cattle losses caused by jaguars vary widely both spatially and temporally (Azevedo and Murray, 2007; Cavalcanti and Gese, 2010; Tortato et al., 2015). We therefore consider annualized loss estimates within the context of the EASP region. To obtain an estimate of the total number of domestic animals killed by jaguars, we searched for published and unpublished data within the wider EASP area. A hypothetical estimate of damage caused by jaguars was obtained by multiplying the annualized proportional loss reported in the literature and by individual ranch managers by the estimated maximum number of cattle that the area could support. We then multiplied this number by the market value of each animal (estimated at US$300 per head averaged for all sex/age classes) obtained from all updated livestock auction websites (e.g. http://www.noticiasagricolas.com.br/cotacoes/boi). In summary, we first defined the total area used by all jaguars observed by tourists within the study area and then created a hypothetical scenario in which realistic rates of annual cattle depredation by jaguars were estimated for an area of the same size within the wider EASP landscape. We could then assess the costs and benefits of coexisting with a wild jaguar population at a comparable spatial scale. We could then assess both the hypothetical cattle damage induced by jaguars and the minimum value of tourism revenues that are directly attributed to jaguar tourism.

Finally, we interviewed the owners of all seven major ecotourism lodges within the study area for information on the scale and growth of jaguar tourism activity. During these interviews, we specifically obtained information on the absolute and relative seasonal occupation rate (rooms and beds) over the last 6 years (2010–2015), and annualized the data accordingly. Additionally, we interviewed most of the tour guides operating in the study area ($N = 30$) and asked them when (which year) they started working with jaguar tourism.

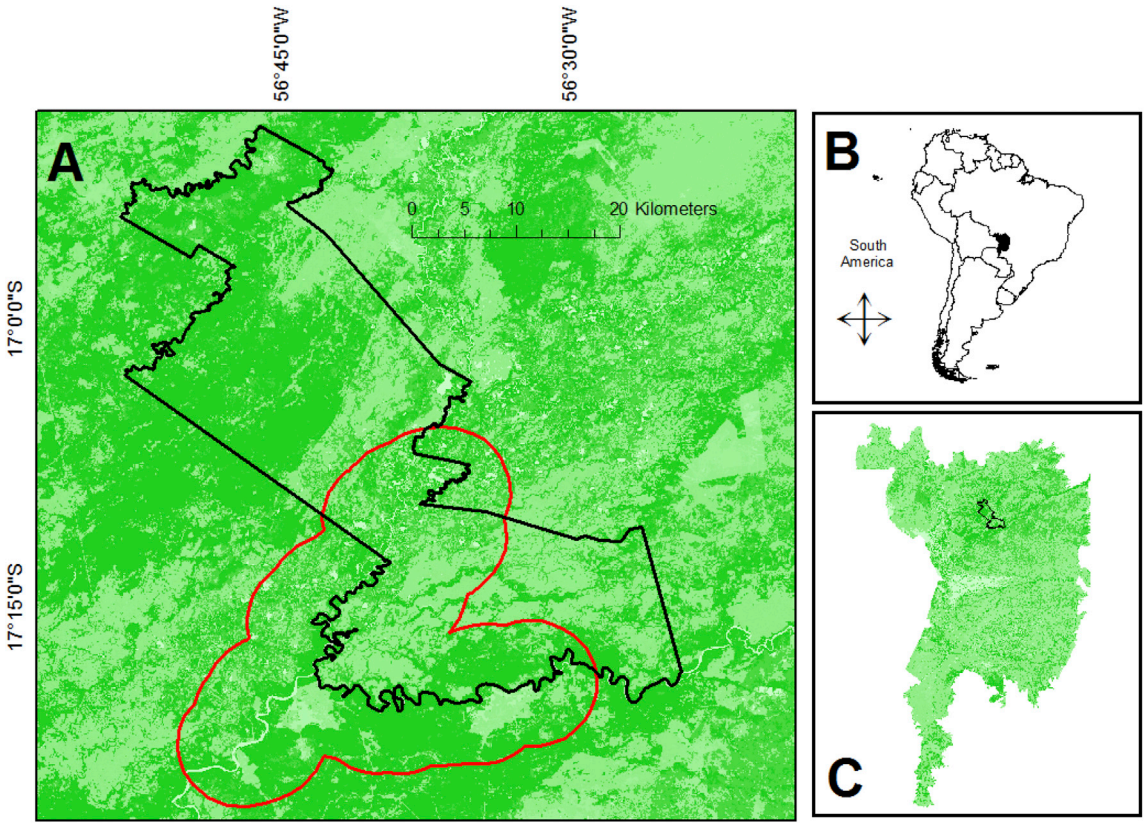

Fig. 2. Map of the wider study landscape centered at the Encontro das Águas State Park (EASP) (black line polygon in panel A), including the park and surrounding landscape within private cattle ranchers delineated by a tourism buffer zone (red line polygon), which represents the total projected area used by the jaguar population under observation by ecotourists. Upper inset map of South America shows the Brazilian Pantanal biome (solid black area in B). Lower inset map (C) shows the entire Brazilian Pantanal region and the location of the EASP reserve (black polygon). Dark and light green areas (in A and C) indicate forest and grassland habitats, respectively, which are typical of the landscape mosaic of the Pantanal.

2.4. Compensation system through jaguar tourism

To evaluate the financial viability of a compensation scheme for livestock losses caused by jaguars, we further deployed a willingness-to-pay questionnaire, which was systematically applied to all tourists at the time of their final-day checkout from all major hotels and lodges across the entire study area from 1 August to 30 October 2015. The issues addressed by this questionnaire involving the compensation scheme were:

1) Jaguars attack cattle and other domestic species. This leads ranchers to persecute and kill this species. Compensation systems are alternatives to minimize this conflict.
   Do you agree that these losses should be compensated financially?
   ( ) Yes; ( ) No
2) Can jaguar tourism be a source of funds for this compensation system?
   ( ) Yes; ( ) No
3) How much in relation of your daily accommodation rate (%) would you be prepared to donated for this compensation system? ( ) 1%; ( ) 2%; ( ) 3%; ( ) 4%; ( ) 5%; ( ) 6%; ( ) 7%; ( ) 8%; ( ) 9%; ( ) 10%. Another value (%) ____.

The results of questions 1 and 2 are presented as percentages, whereas question 3 was defined as the average daily percentage available for the compensation scheme.

3. Results

3.1. Minimum revenues from jaguar tourism

The total annual revenue that jaguars represented for seven local lodges across the Brazilian Pantanal in 2015 was US$6,827,625, and values per lodge ranged from US$81,000 to U$$3,105,000 (Table 1).

3.2. Livestock damage caused by jaguars

We estimated a total herd size of 16,200 animals grazing on the same 81,000-ha area defined here as supporting the regional scale jaguar tourism. In addition, we considered an annual mortality rate of 2.5% from jaguar depredation of this overall herd size, based on a study carried out in an area bordering the EASP (Hoogesteijn et al., 2015). Considering this herd size and annual loss rate, this yields an annual hypothetical loss of US$121,500. Subtracting this hypothetical cost due to jaguar damage incurred to cattle from the total minimum value of jaguar revenue would result in a total minimum net benefit of US$6,706,125 for the study area in 2015.

3.3. Development of jaguar tourism

Lodge owners did not have accurate data on the exact number of tourists they serviced in their lodges over the past few years. However, they provided indirect data that clearly shows an increase in jaguar-tourism activities in the region. First, they confirmed that the demand for room and board services increased over the last 5 years and will continue to increase in 2017 and 2018, with only a few booking vacancies left in the high season between August and October. In addition, they carried out marked structural refurbishments to their hotels to accommodate the growing demand for beds, which recently increased by 20% from 184 beds in 2010 to 221 beds in 2016.

In a second approach, we assessed the daily accommodation rates of four hotels that provided detailed financial data for 2015 and 2016. These data show a mean increase of 24.5% in transaction daily rates, or well above the Brazilian inflation rate over the same period (~10.7%). Interviews with 30 tour guides that specialized on jaguar tourism showed that half of them

Table 1
Minimum value generated by jaguar-based nature tourism in 2015 for seven lodges (named anonymously, A to G) in the Porto Jofre area, Pantanal of Poconé, Mato Grosso, Brazil. The minimum staying period was defined as 3 days at all lodges. Even when in several cases, the total length of packages (days) was longer, we use this minimum staying time for our estimates.

Lodges	Daily value (US$)	No. of tourists (2015)	MJV[a] (US$)
A	450	400	540,000
B	430	1745	2,251,050
C	900	1150	3,105,000
D	300	470	423,000
E	200	500	300,000
F	135	315	127,575
G	150	180	81,000
Total			**US$ 6,827,625**

[a] Minimum transaction value of jaguar tourism per lodge.

began this activity 10 years earlier. Therefore, there has been a gradual increase in the lodging capacity available to tourists, per capita daily rates charged, and the number of tour guides allocated to jaguar tourism, all of which clearly reinforces the overall evidence of increasing demand for jaguar-oriented tourism in the Pantanal.

3.4. Financial compensation from jaguar tourism

During the months of August, September and October 2015 we interviewed a total of 137 tourists who visited the EASP region. Having been informed of the existence of a conflict between jaguars and cattle ranchers, tourists became aware that observed jaguars can take both wild and domesticated prey outside the park, with 96% agreeing that a compensation scheme would be required to cover the costs of jaguar depredation on livestock. In fact, 95% of all informants believed that jaguar tourism could be a tangible source of revenues for this compensation scheme and 80% agreed to, on average, donate an additional 6.8% (SD ± 3.9%) of the value of their all-inclusive daily rates to be allocated to this compensation scheme. Considering the average daily lodging costs per tourist of US$412, these 6.8% would represent a daily average of US$ 28 ± 15 per tourist in willingly paid fees to support the jaguar compensation program.

4. Discussion

Our study provides the first transaction estimates of the minimum monetary value of jaguar-based tourism anywhere in the Americas in relation to livestock losses through jaguar depredation. Realistic estimates of costs and benefits were expressed in terms of monetary values (Tortato et al., 2015). Positive monetary values represent a powerful counter-argument to safeguard populations of large carnivores and other 'problem species', thereby upholding the main justification for a jaguar conservation program. Similar estimates have already been used for other flagship species, such as sharks (Anderson and Waheed, 2001; Gallagher et al., 2015), macaws (Munn, 1992) and lions (Thresher, 1981), but these assessments typically consider animal values per individual and have been criticized for lacking data on population demography and spatial requirements, thereby inflating the degree of uncertainty of estimates per unit area (Catlin et al., 2013). In this study, we consider an entire operational jaguar population to circumvent the problems described by Catlin et al. (2013). For example, there are individuals within any population that, because of their behaviour or location of their territories, can be more easily observed than others, and therefore have an intrinsically higher value for observational tourism. In addition, prey selection even within a single jaguar population can be widely variable (Cavalcanti and Gese, 2010), so that livestock depredation costs vary significantly across different individual jaguars

In terms of observed costs and benefits of providing safe habitat to a jaguar population, the benefits accrued from tourism far outweighed the costs of cattle losses in private ranches. From our viewpoint, this statement reinforces one of the many arguments that can be used to justify jaguar conservation. In fact, the monetary argument is no more powerful than an ecological or the moral argument, but it can reach a wider societal audience and can easily sway even the most hostile stakeholders to facilitate benign policy decisions that can achieve unanimous consensus (Brauer, 2003). In addition, in our estimates of gross financial income we considered only the direct revenues obtained from the daily accommodation rates from the seven lodges included in this study. This value is clearly low and highly conservative, and underestimates the total amount and distribution of tourism revenues, since it does not consider many other ancillary expenses, including travel costs, wages and tips for guides, and other elements of the service industry such as purchases in restaurants and craft markets. Thus, notwithstanding the fact that the value of jaguar in this study was underestimated and is valid only at a landscape scale, jaguars could still generate a revenue of nearly US$7 million for an 81,000 ha area in 2015. This is equivalent to a minimum crude revenue of US$84.3 per hectare, which is approximately three-fold higher than the approximate land-use revenue from traditional bovine cattle ranching estimated for a typical farm across the Brazilian Pantanal (Moraes, 2008) (Fig. 3). Again, this is a conservative estimate since the growing demand for wildlife tourism, particularly in the Pantanal, will accelerate even faster in years to come.

One could argue against the long-term reliability of jaguar tourism in footing the bill of Pantanal conservation over the years. However, as our data show, the current perspective is a rapidly escalating value. If we consider the total number of jaguar-seeking tourists in our study landscape in 2015 ($\approx$4760) and extrapolate the average increase in per capita lodge prices between 2015 and 2016, the ~US$6.83 million value in 2015 likely increased to ~ US$8.47 million in 2016.

One problem that remains to be solved is the sheer asymmetry in costs and benefits by different stakeholders in the Pantanal. This is particularly expressed as the growing conflict between the tour operators, who capitalize on profits from a high-density jaguar population, and the landowners outside the protected area, whose land help support the jaguar population but occasional incur costs in cattle depredation by the same jaguars. To add insult to injury, local landowners in the cattle business do not receive any financial benefit from any level of jaguar tolerance. In our study area, tour operators do not actually own any land, but promote river-based observation tours of jaguars that may be preying on cattle on neighbouring cattle ranches, which clearly support critical habitat and a natural prey base for jaguars. This could be feasibly solved by a compensation scheme for cattle losses. Compensation schemes have often been proposed to mitigate human-wildlife conflicts (Schwerdtner and Gruber, 2007). In its most common form, it includes the quid pro quo reimbursement of private parties for damage induced by wild species to personal property or livestock (Wagner et al., 1997; Nyhus et al., 2005). A critical bottleneck in implementing these systems, however, is to raise funds to make offset payments possible, often through conservation initiatives from NGOs, private funds or government agencies (Wagner et al., 1997; Nyhus et al., 2005; Bulde and

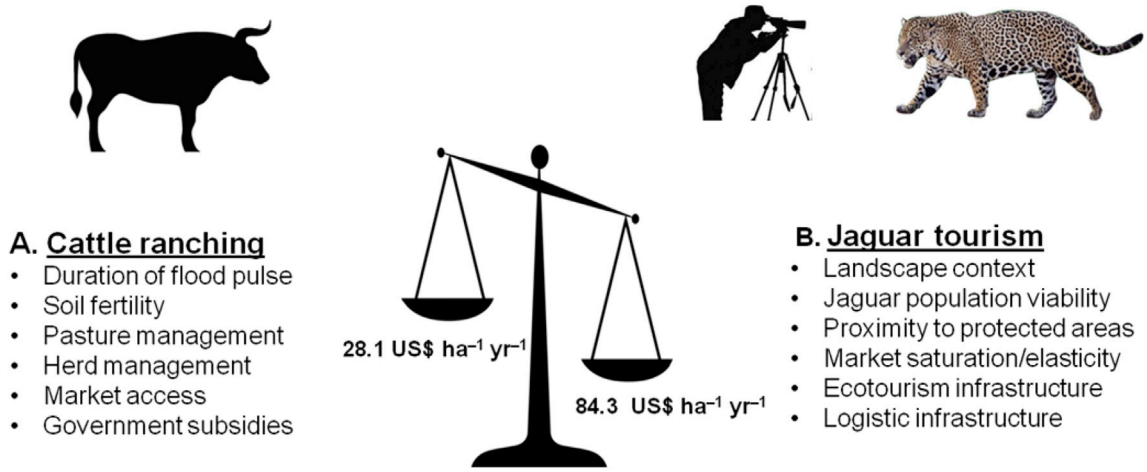

Fig. 3. Schematic representation of key determinants of the balance of land use revenues for Pantanal ranches based on the (A) traditional bovine cattle ranching economy; (B) jaguar tourism economy; or both. Data on cattle revenues from Moraes (2008).

Rondeau, 2005). Obviously, given the glaring inequality observed between the revenue generated from tourism and inevitable losses to livestock producers, a logical solution would be for tour operators to raise much needed funds to fuel compensations. Our results show that 80% of all tourists visiting our study area would be happy to donate additional funds to this compensation scheme. Considering the willingness-to-pay fraction of the minimum number of tourists who paid for room and board across our study area in 2015, it would require each of these 3808 tourists to voluntarily donate only U$32 as a one-off payment for all the hypothetical landscape-scale damage inflicted by jaguars on the cattle herds. Four fifths of all tourists suggested that they would be willing to donate on average of US$84 over a 3-day stay, which far exceeds the value of this payment. Our results therefore demonstrate the financial feasibility of a relatively doable compensation scheme through wildlife tourism, which would create a 'win-win' scenario for both of these main economic activities.

Most cattle ranchers (94%) in the Brazilian Pantanal, agreed that they would like to receive assistance for jaguar livestock depredation issues, yet only 20% accrued any benefits from ecotourism that may include jaguar observation (Zimmerman et al., 2005). We propose that before creating a compensation scheme through wildlife tourism, it would be necessary to put into practice best management practices, including the implementation of anti-depredation strategies in terms of livestock management (e.g. Michalski et al., 2006; Hoogesteijn and Hoogesteijn, 2014; Quigley et al., 2015). This is because a sufficiently tempting compensation scheme can encourage a decrease in efforts to prevent damage in the first place (Bulde and Rondeau, 2005). A proposal between 'best-management' practices and a tourism-based compensation scheme has already been implemented in Africa (Mossaz et al., 2015), where the total amount to be compensated depended on the context in which any animal was killed (Bauer et al., 2017). For example, livestock killed by lions in well-managed landholdings received higher compensation values (Bauer et al., 2017). The large-scale management of cattle herds in the Brazilian Pantanal, where individual farms frequently contain large pasture areas (>3000 ha) and large bovine herds (>1000 animals), makes it difficult to control for losses and, consequently, the operational viability of a compensation system such as implemented in African pastoral systems (Hemson et al., 2009; Hazzah et al., 2014; Bauer et al., 2017). Our solution to mitigate losses dictate that a stable compensatory partnership from tourism operators to livestock ranchers should be considered as a reward to ranchers for, first and foremost, protecting jaguars within their properties, rather than simply as a payment for incidental cattle losses to jaguars (Hoogesteijn et al., 2005). Furthermore, to ensure that ranchers are unable to overestimate losses caused by jaguars, it would be appropriate to consider the annual loss percentages already available for portions of the Pantanal (eg. Azevedo and Murray, 2007; Cavalcanti and Gese, 2010; Tortato et al., 2015; Hoogesteijn et al., 2015), whereby the amount to be rewarded per ranch is already pre-determined but can be reviewed on an annual or biannual basis.

5. Conclusions

In this study we demonstrated for seven tour operators in a typical region of the Brazilian Pantanal, that jaguars represents an annual revenue 56 times higher than the annual hypothetical damage caused within cattle ranches with an area equivalent to that required to support a jaguar population under conditions of frequent human contact. We also showed that regional losses caused by jaguars on cattle herds could be rewarded by a system of voluntary payments from willing tourists, and the implementation viability of anti-depredation strategies by ranchers, ensuring that traditional livestock and tourism activities can coexist side by side. In summary, our results demonstrate that the ecotourism industry should be explicitly considered by government agencies as a major revenue generator in the Pantanal, with added advantage of operating as an environmental conservation tool not only for jaguars, but also for the entire ecosystem.

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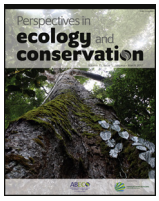

Policy Forums

Advances and barriers to the development of jaguar-tourism in the Brazilian Pantanal

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ABSTRACT

Wildlife tourism has grown in recent years and in many countries represents a major economic activity. The observation of wildlife in Brazil, despite its great biodiversity potential, is underexploited. Here we discuss the importance of jaguar-tourism as an economic and ecological activity, contributing to the jaguar conservation in the Pantanal, a region with abundant fauna and recognized as an important ecotourism destination in Brazil. We argue that the absence of management plans for protected areas in the Pantanal are impeding the development of this activity.

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Tourism based on natural areas, or ecotourism, is an industry with social, economic and environmental consequences (Buckley, 2010) and is growing rapidly in many parts of the world (Gossling, 1999; Kepe, 2001). This activity is an important source of revenue for many countries, such as Kenya, where approximately 10% of its territory has been set aside for wildlife conservation and promotion of nature-based tourism (Akama, 1996). In Latin America, ecotourism is an activity that is on the increase. The importance of ecotourism on a given country's economy varies a lot, but an example of how ecotourism can be important to a country's economy is Costa Rica, where the number of tourists increased from 435 thousand in 1987 to 1.1 million in 2000. In this country, the travel & tourism industry accounted for 7.9% of the gross domestic product (GDP) (Gouvea, 2004). Nature-based tourism is mainly associated with protected areas such as national parks (Levin et al., 2015). On a global scale, the protected areas received 8 billion tourists a year, the majority being in Europe and North America (80%) (Balmford et al., 2015). In South America, there are good examples, such as the Galapagos National Park in Ecuador, which in 1992 generated a total revenue of U$ 32,000 from tourism and in 1997 received 62,800 visitors (Chardonnet et al., 2002). Another example is the Monteverde Cloud Forest Reserve in Costa Rica, a protected area of 10,000 hectares, which in 1994 received 49,793 visitors (Aylward et al., 1996). In Brazil, the average of the annual visitor rate from 1998 to 2007 ranged from 100 visitors in Serra do Divisor National Park to 737,039 visitors in Tijuca National Park (Balmford et al., 2015). Within all of the possibilities of attraction in ecotourism, wildlife-focused tourism has a great potential for conservation, because in several cases it is focused on charismatic species (Skibins et al., 2013) such as large predators, among which are sharks (Gallagher et al., 2015), African big cats (Mossaz et al., 2015) and tigers (Karanth et al., 2012). As predators need large home range, there is a consequent demand for large areas for their conservation.

Brazil is considered megadiverse in relation to its fauna and flora (Mittermeier and Werner, 1990) but wildlife-tourism is under explored and under developed. One reason may be the absence of a so-called charismatic mega fauna such as the African savannas (Lindsey et al., 2007), but it can be suggested that the lack of specific laws and government incentives (Gouvea, 2004) is an important factor discouraging wildlife-tourism. From the 53 National Parks in Brazil, only 20 are open to the public to visit (Silva, 2005). A region with abundant wildlife and ecotourism potential in Brazil is the Pantanal, the largest continental wetland in the world (Chardonnet et al., 2002; Harris et al., 2005). This biome harbours one National Park, three State Parks, one Ecological Station, two Road Parks and several private reserves. The Transpantaneira Road Park is situated in a global hotspot of recreational visitation (Levin et al., 2015) and two of these protected areas: Encontro das Águas State Park and the SESC Pantanal Private Natural Heritage Reserve are situated around this hotspot of recreational visitation (Levin et al., 2015; Tortato and Izzo, 2016). Among the public protected areas of the Pantanal, only the Pantanal Matogrossense National Park has a management plan, which establishes the rules for public use (IBAMA, 2003).

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Ecotourism is an activity that began more than 30 years ago in the Pantanal (Alho et al., 1988). Wildlife observation represents one of the main attractions, especially birdwatching. In this essay, we discussed the activity of observing jaguars (*Panthera onca*) in nature in the Pantanal. We call this activity as jaguar-tourism and discuss the advances and barriers to its development. Jaguar-tourism is an activity which is on the rise in the Pantanal (Hoogesteijn et al., 2016) and occurs in two distinct regions. In the northern region it consists of searching for jaguars in rivers and streams, with outboard boats, without involving the partnership of cattle ranches and jaguars are usually observed on the riverbanks and beaches formed in the dry season (June–November). In the southern Pantanal, jaguar-tourism is generally developed in cattle ranches associated with hotels (Hoogesteijn et al., 2016) and the search for jaguars occurs with the use of adapted trucks, similar to those used in safaris in Africa and in some ranches with outboard boats in internal streams. As in northern Pantanal, the jaguars are usually observed during the dry season.

Jaguar-tourism is a recent activity if compared to the tourism involving big cats in Africa. There, this activity occurs in many countries and represents an important tool for big cats conservation, that contributes for example to habitat protection, mitigates human–cat conflicts through jobs, education and compensation of losses provoked by these species on the livestock (Mossaz et al., 2015). The development of jaguar-tourism in the Pantanal needs to use de African examples to transform this economic activity in a conservation tool.

The partnership between cattle ranching and jaguar-tourism on the same property in the Pantanal creates an ambiguous situation. The jaguar can represent economic losses by predating the herd (e.g. Tortato et al., 2015) but represents a profit for being one of the main attractions for ecotourism. Many ranchers already see the jaguar as a source of income (Harris et al., 2005). Fazenda San Francisco in the municipally of Miranda, southern Pantanal, is a great example, where the profits from the jaguar-tourism can be 25 times greater than the losses caused by this species on their herd (Concone and Azevedo, 2012). With the majority of protected areas located in the northern Pantanal (Harris et al., 2005) the cattle ranches of the southern region, where the jaguar represents a source of income, can be considered private refuges and an advancement for jaguar conservation.

In addition to private areas, jaguar-tourism also occurs in two protected areas in the state of Mato Grosso: the Taiamã Ecological Station in the Municipality of Cáceres and the Encontro das Águas State Park in the municipalities of Barão de Melgaço and Poconé. These protected areas do not have management plans to regulate their public use. Despite the lack of management plans for protected areas, the jaguar-tourism activity is regulated in the Pantanal. In the State of Mato Grosso this activity is regulated through CONSEMA, resolution – 85/11 (Diário Oficial de Mato Grosso, 19 de Agosto de 2011) which established rules for the observation of big cats by tourists. This vanguard resolution is a keystone advance to regulating wildlife tourism activity in Brazil and served as an example for the establishment of rules for wildlife tourism in other states, such as the neighbouring state of Mato Grosso do Sul (Diário Oficial n. 8912. SEMADE Resolution n. 08 of April 28, 2015).

The CONSEMA resolution – 85/11 features 11 articles, which establish rules for the observation of big cats in the wild, such as the maximum observation time, the number of boats and minimum distance between the tourists and the observed animal. However, after five years of existence, some articles of this resolution continue to generate conflict between managing agencies such as the State Department of the Environment (SEMA-MT) and tourism operators, including Article 8, which prohibits the tourism activity inside or in buffer zones of protected areas (e.g. Encontro das Águas State Park), requiring the regulation of the activity through the management plan or by the agency responsible for the administration of the protected area. The Encontro das Águas State Park does not have a management plan; even so, in 2015 more than 4800 foreign tourists (Tortato, unpublished data) visited this protected area. Based on Article 8 of CONSEMA resolution – 85/11 we can consider that all activity developed in this protected area is illegal. The Encontro das Águas State Park was created in 2004 through Decree. N° 4881 and its Article 3 establishes the maximum period of five years to prepare its management plan, under the responsibility of SEMA. Regarding Taiamã Ecological Station, which was created in 1981 (Decree N°. 86061), only in 2015 did it start the preparation of its management plan. Thus, the absence of management plans of protected areas is a clear barrier to the development of the jaguar-tourism in the Pantanal. Most jaguar-tourism activities in the northern part of the Pantanal are around or near protected areas, and with it, though regulating the activity, CONSEMA resolution – 85/11 has little effectiveness.

Another problem involving wildlife tourism in Pantanal is the act of feeding the jaguars. It is a practice prohibited by CONSEMA resolution – 85/11 and SEMADE Resolution n. 08. The act of feeding wildlife has become a popular way for tourists to have a guaranteed contact with the target species in nature, but can represent negative impacts on the species observed, such as changing the natural behaviour, aggression and habituation to humans, increases risk of disease and making them more vulnerable to predators (Orams, 2002). The consequences of feeding wild animals can be fatal for humans, as the death of a tourist in the Fraser Islands, Australia, caused by dingo (*Canis lupus dingo*) attacks (Burns and Howard, 2003). Habituate jaguars with humans through feeding them is a serious risk to tourists and according to Neto et al. (2011) has been linked to attacks on humans near Taiamã Ecological Station. Besides the jaguar, there are feeding cases of other species in the Pantanal for tourism purposes, such as caiman (*Caiman yacare*), ocelot (*Leopardus pardalis*), crab-eating-fox (*Cerdocyon thous*), maned wolf (*Chrysocyon brachyurus*), giant otter (*Pteronura brasiliensis*), capuchin monkey (*Cebus cay*) and tapir (*Tapirus terrestris*). The act of feeding wildlife in Brazil represents a conflict with some aspects of environmental legislation, ecotourism concepts and functions of Protected Areas (Alves et al., 2013). We can say that, nowadays, the jaguar feeding activity is currently avoided by the majority of the tour operators in northern Pantanal, but in the past, this activity was used to increase the chances of tourists observing jaguars in nature. The fact that the tour operators do not feed jaguars is not due to the action of SEMA agents, but to their own initiative and self-regulation. This self-regulation was induced by the awareness of the problem and if one tour operator feeds the jaguars, the others will immediately rebuke him because this attitude can discredit the entire local tourist trade. On the other hand, in the southern Pantanal the rules against feeding jaguars are more recent (SEMADE Resolution n. 08, 2015). In this region, there are recent records of jaguars being fed by fishing tourists (e.g. http://g1.globo.com/bom-dia-brasil/noticia/2014/10/turistas-ignoram-risco-de-ataque-e-alimentam-oncas-no-pantanal.html). Therefore, the implementation of resolutions and state surveillance measures and education of tour guides can help create a self-regulatory condition, as noted in the northern part of the Pantanal.

We conclude that despite the potential, the Pantanal needs actions to expedite the implementation of a management plan process in its protected areas, enabling its public use and the creation of specific legislation at the federal level that regulates the activity of wildlife tourism and thus assisting in the development of wildlife tourism in Brazil. The Pantanal represents a good example of how this economic activity can contribute to the valuation of wildlife and therefore its conservation. With these measures,

the Pantanal can increase its global representation on this specific economic activity that integrates man with nature.

Conflict of interest

The authors declare no conflict of interest.

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Cattle and Environment in the Pantanal of Mato Grosso, Brazil, 1870–1970

ROBERT WILCOX

In recent years international attention has focused on threats to the Brazilian tropical rain forest. Extensive road building, mining, hydroelectric projects, agribusiness, and waves of land-hungry peasants, encouraged by government developmental interests, have contributed to considerable environmental degradation in the Amazon Basin over the last few decades. A major element in this drama has been the role of cattle ranching, decried by the international community and Brazilians alike.

The story is well-known and has been told eloquently by a number of observers. Over the last 30 years, ranching has been considered a major culprit in causing widespread deforestation, erosion, subsequent dessication and soil sterility, and atmospheric pollution from burning. Public outcry has spurred the present Brazilian government to take measures to reduce environmental destruction in the basin.[1]

Yet ranching in Brazil has not been restricted to the Amazon. One important region which is beginning to attract attention is the Pantanal, a fluvial flood plain in the west of the country along the Bolivian border. An area of seasonal flooding, the Pantanal is considered one of the planet's ecologi-

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1. See Susanna B. Hecht, "Cattle Ranching in Amazonia: Political and Ecological Considerations," in *Frontier Expansion in Amazonia,* eds. Marianne Schmink and Charles H. Wood (Gainesville: University of Florida Press, 1984), 366–98, passim; Douglas R. Shane, *Hoofprints on the Forest: Cattle Ranching and the Destruction of Latin America's Tropical Forests* (Philadelphia: Institute for the Study of Human Issues, 1986), 62–63, 71; John Hemming, ed., *Changes in the Amazon Basin* (Manchester: Manchester University Press, 1985); John O. Browder, "The Social Costs of rainforest destruction," *Interciencia* 13/3 (1988): 115–20.

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cal marvels. It is one of the largest natural bird habitats in the world, and host to many species of mammals, reptiles, and fish. It also has supported an important regional ranching industry for over a century. Concern has been expressed, however, over recent incursions by mechanized agriculture and mining. This, and the relatively traditional character of local ranching has led to popular interest in the region, as represented by the ecological-erotic soap opera aired on primetime Brazilian television between March and November 1990. Broad camera sweeps of striking natural beauty, actor testimonials of "returns to the native," and romantic portrayals of ranching life have contributed to a belief that the cattle industry has "saved" the Pantanal from uncontrolled growth.

It is curious that an industry that has been blamed for extensive ecological degradation in one region could be considered a savior of the environment in another. The purpose of this paper is to explore the relationship between cattle ranching and the environment in this particular locale, the Pantanal, and to examine the contention that ranching has protected that environment from encroaching development.

The Pantanal is a geological depression of the Paraguay River measuring 450 kilometers by 250 kilometers and occupying a total of 139,000 square kilometers. It makes up 17 percent of the combined surface area of the modern states of Mato Grosso and Mato Grosso do Sul, 28 percent of the latter. It is bordered by hills in Bolivia to the west, by other hills (*serras*) to the east, the Paraguayan Chaco in the south, the savanna plateau near the city of Cuiabá to the north, and by equatorial forest in the northwest.[2]

The region is drained by a number of rivers and streams, by far the most important being the Paraguay River. This strategic and economically important waterway flows north to south some 1250 kilometers through the Pantanal to the Paraguayan border. Elevation drop has been estimated at no more than 40 to 50 meters. The Paraguay receives the outflow of a number of rivers, mainly running from east to west. Most are partially navigable by shallow draft boats. This hydrological system ensures an abundance of water to the Pantanal, particularly during flood season.[3]

Considered the region of widest flooding in South America, the Pan-

2. Antonio C. Allem and José F. M. Valls, *Recursos forrageiros nativos do Pantanal matogrossense* (Brasília: EMBRAPA, 1987), 3–4; Orlando Valverde, "Fundamentos Geográficos do Planejamento Rural do Município de Corumbá," *Revista Brasileira de Geografia,* 34/1 (Jan.–Mar. 1972): 59; Brazil, Ministério das Minas e Energia, Secretário-Geral, *Projeto Radambrasil, levantamento de Recursos Naturais, vol. 27, corumbá* (Rio de Janeiro: Min. das Minas e Energia, 1982), 110–11; Brazil, Ministério dos Transportes, *Síntese do estudo do sistema rodoviária coletor do Pantanal Matogrossense* (Brasília: Min. dos Transportes, 1974), 7; Afonso Simões Corrêa, "Pecuária de corte em Mato Grosso do Sul", unpublished report delivered at Encontros Regionais de Pecuária de Corte, 27 November 1984, Brasília, 1. My thanks to the author for making this available to me.

3. Valverde, "Fundamentos," 80, 82.

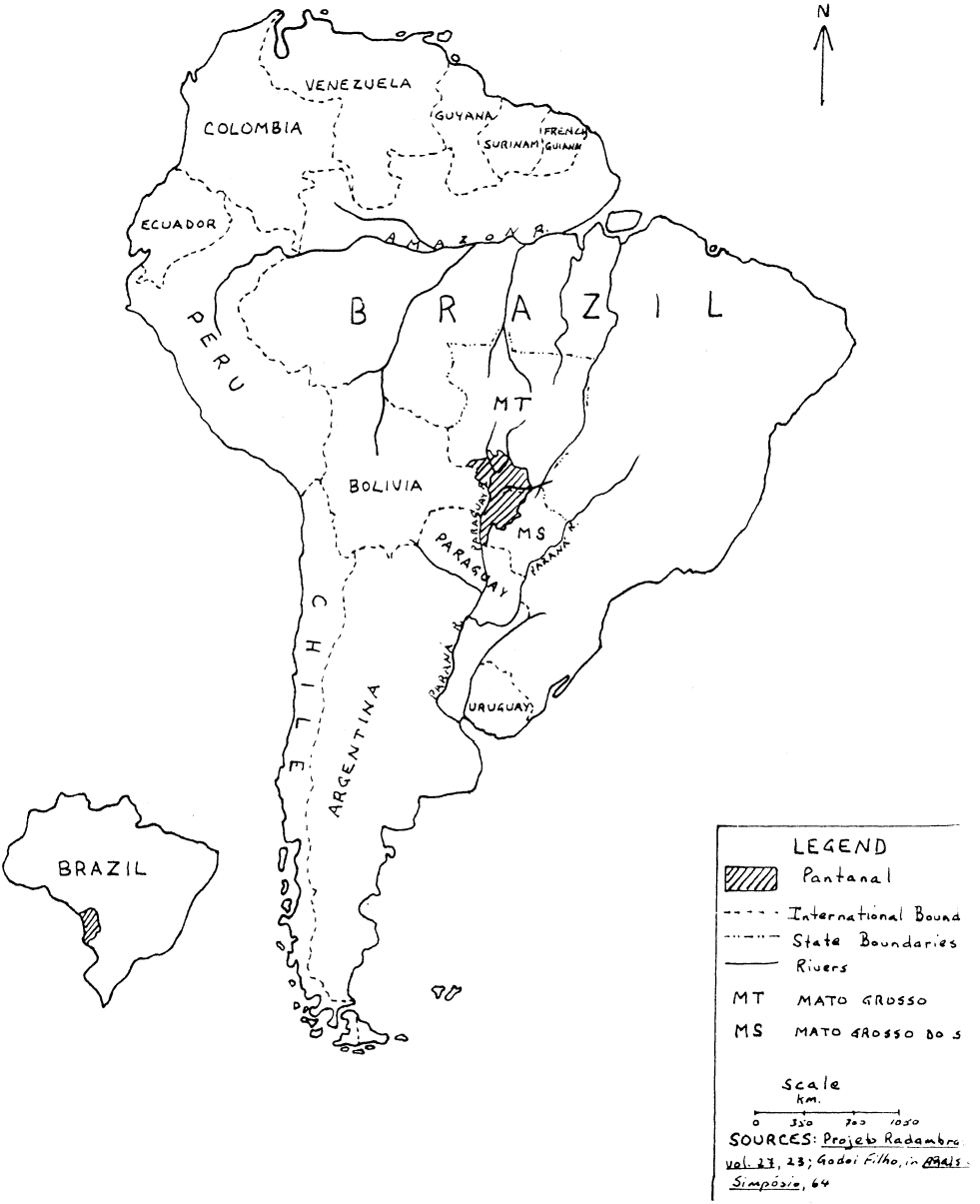
tanal is subject to seasonal rains and river overflow that transform the area into a shallow inland sea for six to eight months of the year. A tropical floodable savanna, Pantanal topography gradually rises from west to east, away from major rivers and streams. Elevations vary between 80 and 150 meters above sea level. The Pantanal is characterized by such geomorphological features as fresh and salt water lagoons (*baías* and *salinas*) and elevations or hillocks called *cordilheiras*. These are important in cattle raising.[4]

Baías are sweet water lagoons formed largely by land depressions, although also influenced and transformed by dunes that block outflow after significant floods, and animal action, which has helped to deepen the depressions, especially with the introduction of beef cattle. They are generally rounded and are most common in the lower western and central areas of the Pantanal. Salinas have formed in much the same manner, but contain high concentrations of salts (mostly sodium chloride) due to local soil type. As water evaporates, salt deposits accumulate along the shores. Should a salina dry up completely, the resulting salt lick is given the name *barreiro.* These are a natural salt source for the wild and domesticated animals of the region, and are most noticeable in the higher elevations to the east. Cordilheiras, between 3 to 5 meters high, are scattered throughout the Pantanal, usually with forest thickets, and escape regular flooding. It is here where ranch houses are built and where animals retire when flood waters cover lower elevations. In the east, the importance of cordilheiras in ranching diminishes with the gradual rise in elevation.[5]

Climate in the Pantanal is determined by two major seasonal weather systems. In the summer (November to March) a hot and humid tropical continental air mass from the north dominates the region, bringing seasonal rains and high temperatures. Mean annual rainfall is between 1000 and 1500 millimeters (1 millimeter = .04 inch), one-half to two-thirds in these months. Average temperatures range between 21 and 35 degrees centigrade (70 to 95 degrees fahrenheit), with highs of 40 degrees C. not uncommon. During the winter (June to September), a dry tropical Atlantic air mass from the east covers the region, signalling a season of dry weather and winds, locally called a drought. Mean temperatures range between 15 and 27 degrees C. During these months, however, the region is occasionally subject to short-lived cold fronts from the south, brought by the polar Atlantic air mass. In the intermediate seasons (Spring and Autumn), the tropical Atlantic air mass tends to dominate, although it is

4. Allem and Valls, *Recursos,* ix; Brazil, *Projeto Radambrasil, vol. 27,* 190; Valverde, "Fundamentos," 55, 71, 85.

5. Valverde, "Fundamentos," 60; Brazil, Projeto *Radambrasil, vol. 27,* 190–91.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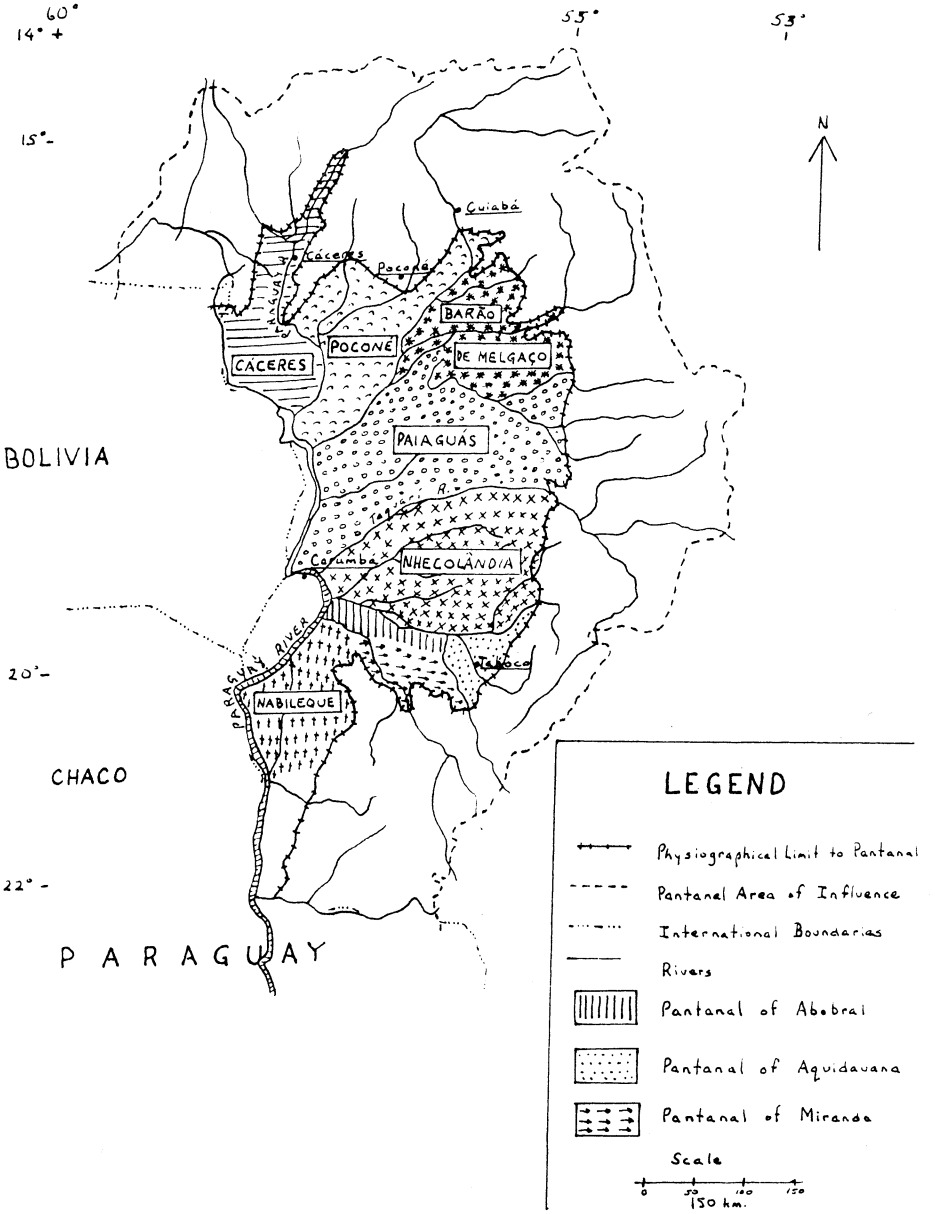

SOURCES: José Domingues Godoi Filho, "Aspectos geológicos do Pantanal Matogrossense e de sua área de influência", in Anais do 1º Simpósio, 65; Allem and Valls, 29.

periodically affected by the entrance of either a tropical continental or a polar system. Temperatures and rainfall are moderate.[6]

The length and severity of flooding in the Pantanal varies, not only from year to year, but also from subregion to subregion. These subregions, though superficially similar, differ in degree of flooding, soil types, elevation, and natural grasses available as pasture. Allem and Valls have divided the Pantanal into nine wetlands or *pantanais,* differentiating them in terms of water courses, soil types, and the nature of historical occupation. Though all possess similar characteristics, each is distinct in the degree to which specific features affect human occupation. The most important in terms of cattle raising is Nhecolândia (23,574 square kilometers) to the south, though during the years before the Paraguayan War (1864–1870), the northern pantanais of Cáceres (40,376 sq. km.) and Poconé (15,800 sq. km.) were important ranching regions. While there is considerable variability throughout the Pantanal, for the sake of relative brevity only the abovementioned wetlands and their direct relationships with ranching will be examined.[7]

Flooding is the result of regional fluvial overflow and local rainfall during the summer season. Heavy rains fall in the tropical upper regions of the Paraguay River beginning in October or November, swelling streams and rivers and taking approximately 15 to 20 days to affect the Pantanal. Locally, this time sequence depends on proximity to the north and regional rainfall. Rainfall varies from area to area, increasing the amount of flood water in the west and south-west as it combines with fluvial flooding to cover extensive territory. In the east, which neighbors the semi-arid savanna (*cerrado*), flooding is almost exclusively local. As a result, there is significant seasonal and regional variation, so that zones in the north flood sooner and dry earlier than those in the extreme south, while the east generally suffers more from drought than elsewhere. On the whole, however, it can be said that the rains fall from late November to March or April, and widespread flooding extends from January–February to May–June. The driest months are August to October.[8]

Weather conditions are anything but predictable or constant, as ranchers and farmers everywhere emphasize. In the Pantanal rains can be especially heavy and lengthy, while the dry period can extend over several months and even years if air masses are delayed or diminished due to

6. Valverde, "Fundamentos," 71–79; Brazil, Projeto *Radambrasil, vol. 27,* 203.

7. Allem and Valls, *Recursos,* 17–18, 31–60. See the appended maps for locations of the pantanais considered by Allem and Valls.

8. Jorge Adámoli, "A dinâmica das inundações no Pantanal", in *Anais do 1° Simpósio sobre Recursos Naturais e Sócio-Econômicos do Pantanal,* Corumbá, MS, 28 November to 4 December, 1984 (Brasília: Min. da Agricultura, EMBRAPA, 1986), 53, 56; Valverde, "Fundamentos," 84–87.

conditions beyond the region. This has led to such extremes as years of excessive flooding followed by several more years of minimal seasonal flooding and subsequent drought. The effects these variations have had on human settlement are significant, and help explain why agriculture is still a negligible activity in the Pantanal, while ranching has proved successful, within limits.

Soils in the Pantanal are of two types—alluvial clays in the lower elevations, and permeable sandy soils in areas of less regular flooding. Products of alluvial deposit, clay soils are highly fertile. Due to minimal permeability, in the lower elevations these soils trap water, causing regular flooding. But they are also the source of nutrients for vegetation, especially grasses, that flourish with the receding of flood waters. With each year's flooding, soil is replenished by minerals carried by river waters from the north. Sandy soils are generally found in the higher and eastern regions of the Pantanal, have high saline concentrations, and sometimes carry inordinate amounts of aluminum. They are less fertile, contain less humus, and are more permeable, permitting permanent human occupation. But these are also the areas subject to serious drought if local rainfall is too low to permit sufficient water storage in natural aquafers. The water table is considerably deeper than in other areas, forcing the digging of wells if baías dry up. Salinas are more common here, due to constant leaching. This variation in soil types suggests that there is a diversity of vegetation, particularly grasses, which determines the character and extent of human occupation, above all ranching.[9]

For this study, the most important vegetation in the Pantanal is vegetation of transition, which includes mixed forest and grassland (prairie), and mixed grassland and scrub forest characteristics of the cerrado. Cattle ranching is and was undertaken primarily on this transitional vegetation. The bulk of open fields, water holes and resting areas are located in areas of natural prairie and forest, occasionally including less palatable scrub.[10]

Mixed forest and grassland share terrain with cordilheiras covered in decidious forests, usually no larger than two or three hectares (1 hectare = 2.47 acres), and often located near baías. The baías are ringed by two or more grass species, and are frequently invaded by semi-aquatic plants and grasses, at least in the margins. Prairies include a variety of grass species, periodic bushes, and the occasional palm or dyewood tree. Human occupation, above all neo-European, has tended to alter this landscape somewhat over the years, particularly in eliminating trees in favor of

9. Allem and Valls, *Recursos,* 19–21, 31–60; Valverde, "Fundamentos," 95–98; Brazil, *Projeto Radambrasil, vol. 27,* 272–79.

10. Valverde, "Fundamentos," 90–98.

grasses by the use of fire. Mixed forest and grassland make up close to one-third of the pantanal of Nhecolândia, due to a longer period of permanent occupation.[11]

Determined by sandy soils of poor fertility, cerrado-type vegetation is very much the same as that found in the true cerrado of the central Brazilian plateau. Scrub forest consisting of woody trees and bushes adapted to semi-drought conditions, and tough, unpalatable grass species dominate the area. All vegetation has adapted to the environment by developing extensive and deep root systems in order to survive periodic drought. Cerrado comprises yet another one-third of Nhecolândia.[12]

The most common vegetation in the Pantanal is grass. However, a relatively small number of grasses found throughout the region are regularly grazed by cattle, though no one grass monopolizes the diet of cattle. The most popular grazing areas have always been near water courses after flood waters recede, and by baías. Major grasses found in these areas must be able to survive a minimum of two to three months totally submerged. Over time, certain species show the highest adaptability and tend to force out less hardy grasses, leading to the predominance of two or three species in areas normally grazed by cattle. By far the most common are several varieties of *capim mimoso* (Axonopus purpusii, Reimarochloa brasiliensis and R. acuta, and Hemarthria altissima). Mimosos are found throughout the Pantanal, though most often in regions subject to annual flooding. Able to withstand long periods under water and a significant length of time in semidrought conditions, their growth is also stimulated by cattle trampling, thus ensuring survival and eventual dominance of any area frequented by cattle. For ranching, mimosos are important because they are highly nutritious for cattle, especially when young and tender after flood waters have receded.[13]

By far the most common of other grasses is *capim carona* (Elyonurus muticus), a hardy invader with a tight root system that dies off with flooding but easily returns when soil dries out. Carona is most common in the higher areas and in Nhecolândia, covering up to 10–20 percent of the surface of some ranches. Allem and Valls speculate that carona's frequency in Nhecolândia is due to greater pressure on pasture than in other

11. Valverde, "Fundamentos," 95–98; José de Barros Maciel, *A pecuária nos pantanaes do Matto Grosso. These apresentada ao Terceiro Congresso de Agricultura e Pecuária, 1922* (São Paulo: Imp. Methodista, 1922), 12–13.

12. Valverde, "Fundamentos," 98; Barros Maciel, *A pecuária,* 12–13.

13. Allem and Valls, *Recursos,* 78–82; S. Cardoso Ayala and Feliciano Simon, *Album Gráphico do Estado de Matto-Grosso* (Corumbá/Hamburgo: n.p., 1914), 286–88; João Leite de Barros, "A Pecuária em Corumbá," *Anuário de Corumbá, 1939* (Corumbá:, n.p., 1939), 8–11.

pantanais. It is a plague to ranchers because of its coarseness and low nutritional value. In the past, it was often used by locals to stuff furniture.[14]

Other grasses are found under various conditions and survive depending on the local environment. Of the nine most important species, six, including two mimosos, are recognized as native to the Pantanal, with three considered colonial imports. This is significant, for it highlights the unique environment of the Pantanal and the abilities of its local species to withstand outside encroachment within such an environment, at least as long as man's intervention is limited.[15]

The far eastern areas of the Pantanal are less part of this specific ecosystem, bordering as they do on the cerrado, and tend to host grass species common to the cerrado habitat—woody, coarse, low nutritional value, barely palatable to cattle. Carona is also found here. It is primarily for this reason that the area was the last to be settled by ranchers, and the first to experiment with planted pasture. Exotics had been of limited success, however, as they demand constant control and investment, requirements difficult for eastern Pantanal ranchers to satisfy, especially in the past. And most are incapable of invading the natural cerrado and Pantanal, being limited to soils heavily altered by human action, such as agricultural fields and roadsides. The result has been that the Pantanal as a whole is dominated by native grasses, estimated in 1974 at 74 percent of total territory, with planted pastures occupying a paltry 2 percent (forest 24 percent, agriculture insignificant). Legumes, though found, are insignificant in the cattle regime of the region, as they are not normally consumed by cattle, nor considered by ranchers.[16]

Before the arrival of Europeans in the sixteenth century, the Pantanal was inhabited by semi-nomadic indigenous tribes engaged in hunting and fishing. Once the white man introduced cattle into the region, probably toward the end of the seventeenth century, some tribes became ranchers themselves. Native ranching practiced no breeding control, and replenishment of stock relied on rustled Spanish cattle from what is today Paraguay. With the exception of the Jesuit missions in the lowlands of present-day Bolivia, which lasted from the 1660s until Jesuit expulsion in 1767, neo-European ranching in the region did not begin until the mid-eighteenth

14. Allem and Valls, *Recursos,* 31–60, 78–82, 155, 158; Barros, "A Pecuária," 8–11; Brazil, Ministério da Agricultura, Industria e Commércio, Serviço de Inspecção e Fomento Agrícola, *Estudo dos Factores da Producção nos Municípios Brasileiros e Condições econômicas de cada um. Estado de Matto Grosso, Município de Corumbá* (Rio de Janeiro: Min. da Agricultura, 1924), 9.

15. Allem and Valls, *Recursos,* 78–82.

16. Allem and Valls, *Recursos,* 78–82, 115, 164; Brazil, Ministério dos Transportes, *Síntese de estudo do sistema rodoviário coletor do Pantanal Matogrossense* (Brasília: Min. dos Transportes, 1974), 2.

century, in the northern Pantanal. The decline of gold mining in the Cuiabá region forced several merchant families to seek land grants and to establish rudimentary cattle ranches on the lush fields of Poconé and Cáceres. Loyal to the Portuguese king, they were rewarded with political and economic favors, and when strong nativist movements developed throughout Brazil after Independence, they became victims of anti-Portuguese riots in the Cuiabá district and sought refuge in the southern region of the Pantanal. By the time of the Paraguayan War, several ranches were thriving in the region, trading jerked beef and hides upriver to Cuiabá and to the Brazilian military garrisons along the Paraguay River. The war caused great disruption in the region, as Paraguayan and Brazilian troops requisitioned cattle and ranch property, forcing the bulk of the population to flee north to Cuiabá. After the war, the former settlers or their relatives returned to begin anew, rebuilding stocks by introducing new cattle, or rounding up remaining feral steers.[17]

Beef cattle ranching throughout the Americas, and including the United States until recently, has been extensive. This means the pasturing of steers on open range, with little use of fencing and minimal care taken by the rancher. Over time, the provision of salt and mineral supplements, fencing—at first used to separate properties, then in pasture rotation—and the controlled productivity of animals, has come to dominate most ranching in the Western Hemisphere. This is less so in the tropical regions, including the Pantanal. Most of the cattle in the Pantanal became semi-feral, and round-up amounted to organized "hunting" of the animals. The use of salt, and fencing to separate properties, is common in the area today, as is selective breeding but, during most of the period under study, little attention was paid to the rare call for "rationalization." To a certain extent, this was the product of entrenched traditionalist views, but was more a consequence of isolation, as transportation costs and market return did not justify such investment, except among the larger and richer ranchers. As a result, ranching in the Pantanal to this day has relied on native grasses, and is dependent on climatic regularity.[18]

Certain regions of the Pantanal lend themselves more easily to settlement than others. This is due to climatic and hydrographic conditions and access to the outside world. For this reason, with reconstruction after the Paraguayan War, Nhecolândia became the most important ranching zone in the Pantanal, which is still the case today.

17. Uacury Ribeiro de Assis Bastos, *Expansão territorial do Brasil colônia no vale do Paraguai (1767–1801)* (Boletim No. 4, Departamento de História No. 3, Universidade de São Paulo, 1978), 124–35; James C. Jones, "Native Peoples of Lowland Bolivia," in *Frontier Expansion in Amazonia,* 62–82; Renato Alves Ribeiro, *Taboco—150 anos: Balaio de Recordações* (Campo Grande: n.p., 1984), 23–28, 41–49.

18. Virgílio Corrêa Filho, *A propósito do Boi pantaneiro* (Rio de Janeiro: Pongetti e Cia., 1926), 50–52.

During the final decades of the nineteenth century, a few large ranches were scattered around the Pantanal. Nhecolândia at the start of the twentieth century was settled by no more than a dozen families, raising probably as many as 100,000 head. By 1920, there were some 80 ranches in Nhecolândia with nearly 200,000 animals. The Brazilian census of that year counted 700,000 head throughout the Pantanal. By the mid-1950s the number of ranches in Nhecolândia totalled about 100, with a human population of five to six thousand and an average of three to five thousand animals per ranch. In the early 1970s, some 3,500 ranches were counted throughout the Pantanal, carrying over five million head. Nearly one-half were found in Nhecolândia.[19]

Ranches varied in size, but were on the whole large. Property was held either through title or by right of long-term occupation. In the 1890s, the largest holdings in the Pantanal ranged between 100,000 and 400,000 hectares each. One ranch visited at the end of the war was said to extend over a million hectares. By the 1920s, some ranches had subdivided among family members while others had expanded, though more than half could be measured at over 100,000 hectares each. In the 1950s, Nhecolândia ranches varied between 8,700 and 65,000 hectares. By the 1970s, infrastructural changes throughout the Pantanal left 70 percent of all properties between 1,000 and 10,000 hectares, covering 43 percent of the region, while just over 11 percent (405 properties) were ranches of over 10,000 hectares, 56 percent of total area. Subdivision had increased the number of medium-sized ranches, but had neither eliminated large ranches nor permitted any significant expansion of small properties that could be exploited in mixed farming. This gradual subdivision and growth in cattle population guaranteed that ranching's relationship with its environment would change over time.[20]

19. Barros, "A Pecuária", 8–11; Barros Maciel, *A pecuária,* 14–18; Brasil, Ministério da Agricultura, Industria e Commércio, *Synopse do recenseamento realizado em 1 de setembro de 1920; População pecuária* (Rio de Janeiro: Min. da Agricultura, 1922), 26; *Terra e Gente* (Rio de Janeiro) 1 (January 1956): 92–93; Bento de Souza Porto, "Programa de desenvolvimento da pecuária no Pantanal," in Estado de Mato Grosso, *Pantanal, Nova Fronteira Econômica, I Encontro do Prodepan (Programa de Desenvolvimento do Pantanal), Conferências, Proposições e Subsídios* (Corumbá: Secretária da Agricultura, 1974), 102–03. Nhecolândia as a separate unit was not conceived until the 1930s. Populations for the region before this date are extrapolated from those of the municipality of Corumbá, which covered more territory than the Nhecolândia of today. The bulk of cattle were found in Nhecolândia, however.

20. Virgílio Corrêa Filho, *Fazendas de gado no pantanal Mato-Grossense,* Documentário da vida rural, No. 10, (Rio de Janeiro: Ministério da Agricultura, 1955), 20, 22; Otavio Domingues and Jorge de Abreu, *Viagem de estudos à Nhecolândia* (Rio de Janeiro: Instituto de Zootecnica, Ministério da Agricultura, 1949), 21; *Terra e Gente* 1 (January 1956): 92–93; Souza Porto, "Programa," 103. In the past, most land areas were quoted either in square leagues (1 square league = 4356 hectares) or in *alqueires paulistas* (1 alqueire paulista = 2.42 hectares). My figures have been standardized to hectares from these measurements. Today, all land measure-

Flooding is by far the most decisive influence on the Pantanal ranching industry. Annual deposit of rich silt and subsequent rejuvenation of native grasses have provided a regular and excellent diet for animals, domestic and wild, with minimal effort on the part of the rancher. But raising cattle in the Pantanal is not so simple. The feeding cycle for cattle, as in every ranching regime where confinement is not employed, has been one of several months of fattening followed by a lean period. In the tropics, the dry season deprives animals of easily accessible forage, while fattening occurs during the rainy season. In the Pantanal, however, it is just the opposite. In some regions, cattle do indeed lose weight during the dry period, but in most they thrive, with only minimal stress occurring in August and September, when grasses lose nutritional value due to reduced moisture. It is an anomaly of ranching in the Pantanal that the rainy season brings the most stress to cattle, as rising flood waters restrict access to forage.[21]

Ranchers must know their ranch and local conditions, in order to move the cattle at the beginning of the season from areas of regular flooding. Otherwise, they would have to devote a good deal of time and expense in swimming stranded animals from isolated dry areas to safer ones nearer ranch headquarters. Though flood waters seldom rise high enough to drown cattle, often they have been extensive enough to force animals to stay put and eventually exhaust local forage. This also has an environment impact, as available grasses are overgrazed, reducing their ability to regenerate after the waters recede. In addition, the high waters can prevent animals from lying down to rest. Eventually, they die of exhaustion, even where sufficient feed is available.[22]

Though excessive floods are uncommon, precisely for this reason over the years many ranchers have been caught unprepared. According to modern study, floods usually come in cycles that last roughly five years. Ranches located closest to major water courses such as the Paraguay River, and subject to annual flooding over a large area of their territory, have been devastated by extensive floods. The disastrous flood of 1905, for example, claimed some 30,000 head in one region, while a single ranch allegedly lost 10,000 animals. There was a temporary decline in ranching

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ments are in hectares. By comparison, in Texas the famous Matador and King ranches measured over 330,000 hectares (800,000 acres) and 520,000 hectares (1,250,000 acres), respectively. Lewis Nordyke, *Great Roundup: The Story of Texas and Southwestern Cowmen* (New York: William Morrow & Company, 1955), 261; P. Rossi, " 'King Ranch', a maior fazenda de criar do mundo e a raça bovina Santa Gertrudis," *Revista de Indústria Animal* (São Paulo) Ano VIII, 2/1 (January 1939): 163.

21. Allem and Valls, *Recursos,* 183–87.
22. Allem and Valls, *Recursos,* 180–87.

in the Pantanal as a result. Another 160,000 head throughout the Pantanal died in the 1910 floods, and during the severe floods of 1920–1923, some municipalities lost up to 50 percent of their herds, while one rancher alone counted some 20,000 head drowned. Many small ranchers were ruined. And even as late as 1973–1974, flooding combined with drought took the lives of over 80,000 head, double expected losses.[23]

Flooding determined the character of ranching in other ways. For a period of three to six months each year, many ranches were incommunicado, at least before the arrival of radio. Several ranchers used this period to send their families to the city, while engaging in building and fencing repairs. This also tends to be breeding season, as animals congregate together, although there was no really distinct season until the arrival of wire fencing. At any rate, between May and November more calves are born, thus they are at most a few months old when waters begin to rise. As might be expected, this is a time of high calf mortality, not only due to floods, but also because of insect infestation, a problem in some areas. And under severe flood conditions, miscarriages rise dramatically.[24]

Insects have not been a major problem for cattle in the Pantanal, and in fact, the low incidence of insect-related disease or parasitism, compared to other ranching regions of Brazil, has been attributed to seasonal flooding. It is said that the tick and bot or warble fly cannot survive in the Pantanal as a result. This is less the case in the higher, more arid regions of the eastern Pantanal. However, it seems that there was one serious disease that usually appeared at the end of flood season.[25]

Mal das cadeiras or *peste de cadeiras* is a disease of horses and mules that is fatal if not treated immediately. Isolated in 1905 in Paraguay, *Tripanosomosa equinum* (surra) is transmitted by a fly vector and strikes animals weakened by the natural conditions of the Pantanal, when forage is scarce, and extra effort required simply to get around. Apparently, the disease was first noticed on the island of Marajó in the

23. Empresa Brasileira de Pesquisa Agropecuária, Centro de Pesquisa Agropecuária do Pantanal, *Aspectos Hidrológicos do Pantanal do Mato Grosso (1900–1978),* Foleto A 570 (Campo Grande: EMBRAPA—CNPGC, 1978), 8–9; Miguel Arrojado Ribeiro Lisboa, *Oeste de São Paulo, Sul de Mato-Grosso; Geologia, Industria Mineral, Clima, Vegetação, Solo Agrícola, Industria Pastoril* (Rio de Janeiro, Typ. do "Jornal de Commercio", 1909), 149; Esther de Viveiros, *Rondon conta sua vida* (Rio de Janeiro: n.p., 1958), 195; Econ. J. Monserrat and Carlos A. Gonçalves, *Observações sobre a pecuária no Brasil Central: Relatório de viagem apresentado ao Ilmo. Sr. Dr. Manoel Corrêa Soares, D.D., Presidente do Instituto Sul Rio Grandense de Carnes, em 8 de agosto de 1953* (Porto Alegre [?]: n.p., 1954), 53; Brasil, *Estudo dos Factores,* 15; José de Barros, *Lembranças para os meus filhos e descendentes* (São Paulo: n.p., 1987 [?]), 65; Allem and Valls, *Recursos,* 184.

24. Allem and Valls, *Recursos,* 12, 175–87.

25. Author's interview with Dr. Arnildo Pott, Empresa Brasileira de Pesquisa Agropecuária—Centro de Pesquisa Agropecuária do Pantanal (EMBRAPA—CPAP), Corumbá, Mato Grosso do Sul, 7 June 1990.

Amazon delta in 1828, spread up the river into Peru and Bolivia, and entered Mato Grosso and Paraguay in the 1850s. As reported by commanders, the disease was one factor in limiting Paraguayan troop movements during the early stages of the Paraguayan War. Until the 1930s, there was no effective medicine and ranchers regularly had to import their horses from the safe environment of the cerrado, or use steers as saddle mounts. The most serious epidemics followed extensive flooding. From the 1930s, awareness of the disease vector and widespread application of an effective treatment, reduced incidence of the disease considerably, so much so that by the mid-1950s ranchers believed it had been eliminated. Nevertheless, until that time horses could not be raised safely in the Pantanal, requiring an annual drain on income as they were bought or bartered for cattle with ranchers to the east or in Paraguay and Argentina (one horse was worth ten yearling steers in 1900, two to five adult steers). This was a serious limitation on the expansion of the cattle industry in the Pantanal.[26]

Periodic drought was almost as influential on ranching in the Pantanal, especially in the higher elevations, where ground water levels are considerably deeper than areas nearer permanent water courses. Ranchers, depending on resources and understanding of local conditions, could take advantage of a prolonged dry spell. Property improvements could be made, pasture expanded, size and productivity of herds increased, communications extended, prompting the prediction: "dry year, rich year." Rancher Renato Ribeiro mentions that the droughts of the 1930s helped to develop the Pantanal, since the lack of water forced ranchers to dig wells, providing a regular system of water supply and ensuring that herds would congregate closer to human habitation, which made care much easier. An extended drought between 1962 and 1973 created a boom period in the Pantanal cattle industry, coming at a time of economic expansion through-

26. Corrêa Filho, *Fazendas de gado,* 44–45; For accounts during the war, see several reports found in the Colección Rio Branco, I-30, in the Archivo Nacional de Asunción, Asunción, Paraguay [Hereafter ANA]; C. Pereira and W.F. de Almeida, "Observações sobre parasitologia humana e veterinária em Mato Grosso," *Memória do Instituto Oswaldo Cruz* (Rio de Janeiro) 36, No. 3 (1941): 301–9; Estado de Matto Grosso, *O Estado de Matto Grosso (Brasil); Notas e apontamentos úteis aos immigrantes e industrias europeas* (Cuyabá: n.p., 1898), 23; Barros, *Lembranças,* 48–51; Foreign Office of Great Britain, Diplomatic and Consular Reports, No. 5220, *Paraguay. Report for the Year 1912 on the Trade of Paraguay* (London: Foreign Office, 1913), 10; Ribeiro, 29–30; Dolor F. Andrade, *Mato Grosso e a sua pecuária* (São Paulo: n.p., 1936), 11; *Terra e Gente* 1 (January 1956): 92–93. Though there has been no recorded outbreak of the disease for many years, rancher and former Secretary of Agriculture for the state of Mato Grosso, Paulo C. Machado, emphasized that without continued prophylactic action surra could still be devastating. Author's interview in Campo Grande, Mato Grosso do Sul, 22 May 1990; also, Paulo Coelho Machado, "História das ruas de Campo Grande, A rua 26 de Agosto; Artigos publicados no Jornal da Cidade, 1981/82" (Campo Grande: unpublished), 67–68. My thanks to the author for providing this to me.

out Brazil. Ranchers used more of their territory, increased outside investment flowed into the region, and a number of ranches were established in areas that in the past had been considered risky for year-round ranching. Beef sales to the voracious market of São Paulo soared. There was, however, another side to this apparent advantage.[27]

Drought cycles are less predictable than those of floods, and often have worked in tandem with flooding to wreak havoc on unwary ranchers. While improvements occurred on many ranches during the droughts of the 1930s, lack of capital for investment in windmills and deep well excavation caused the failures of many small ranchers in the eastern Pantanal. In addition, prolonged droughts created conditions for ruin among many ranchers, as they expanded herds and pastures into marginal areas, leaving themselves vulnerable to extensive floods, which inevitably return. This was the case during the dry period of 1962–1973, when expansion and increase in herd size led to greater than normal losses in 1973–1974 from drought and flood combined, while disrupting marketing when animals could not be rounded up. This would have been even more serious were it not for early warning from meteorologists.[28]

So far, I have been discussing natural occurrences that have influenced ranching in the Pantanal. Flooding and drought undoubtedly have regulated modern human existence in the region, yet humans have introduced ranching practices that have had a profound impact on the region, and eventually on the structure of cattle raising itself.

One of the most important aspects of ranching is the number of animals pastured in a given area. At first glance, it may seem that the Pantanal's vastness and the annual renewal of native grasses would ensure few problems of over or underpasturing. This appears to be confirmed by the ratio of animals to land area recorded throughout the period. Observers at the beginning of the twentieth century reported a ratio of one head to between 2.2 and 3 hectares. At the same time in Argentina, the proportion was 1.8 hectares per animal. The Pantanal ratio was essentially constant throughout the period, increasing to 3.3 hectares per head in the early 1970s. These figures suggest two possible trends: as cattle population has grown, the amount of land in use as pasture has increased at a slightly higher rate, or the average number of head per hectare has decreased, possibly due to a gradual decline in native pasture productivity, or because, as ranching expands, it moves onto marginal land. Probably both trends have been at work. These fig-

27. Ribeiro, *Taboco,* 28, 30–31.

28. Ribeiro, *Taboco,* 28, 228; Author's interview with Dr. Cassio Leite de Barros, Corumbá, 9 June 1990; Allem and Valls, *Recursos,* 183.

ures also raise the question of the estimated capacity of native grasses in the Pantanal.[29]

Antonio Allem and José Valls have done the most exhaustive recent study of this subject, and while their conclusions are not definitive (as they admit), the data is significant. They believe that the Pantanal today cannot support more than between one head for 2 or 3 hectares, although one animal to 2 hectares may be too much pressure, since weed growth has been increasing. But as we know, the Pantanal is not uniform in terrain, soils, grasses, and human exploitation. In fact, some pantanais have been considered overgrazed while others have not, and certain areas within a pantanal have revealed greater evidence of pasture degradation than others. For example, in Poconé, weed growth was estimated in 1974 at 15 percent per year, a trend that predicted some 3 million hectares covered in weeds by 1984, nearly 25 percent of total natural pasture in the region. Reasons for this include recent diking of the region, which has permitted hardy cerrado vegetation to invade areas no longer affected by annual flooding; the excessive number of cattle to available pasture, especially as cattle tend to congregate in areas of the most palatable species; and unstable water levels, forcing animals to stay close to ranch headquarters for a prolonged period of time.[30]

The regular concentration of cattle in any one area always creates problems for local pasture survival. This is particularly the case around the baías and ranch headquarters. Near ranch buildings, many years of cattle trampling and excrement collection causes the soil to become impermeable to water, as the undersoil gradually hardens, while the ground level rises several centimeters. This restricts the penetration of floodwaters that in the past reached closer to living spaces. When there is excessive concentration at the baías for an extended period, these natural watering holes soon become unusable, as the shores become so muddy and dangerous that other drinking sources must be found. On the other hand, in the higher and drier areas, regular transit by cattle makes a swampy area passable, due to combined weight over time steadying the surface. However, excessive compacting of the soil deprives grasses of oxygen for survival, and helps to introduce species exotic to the region, and to eliminate, at the extreme, some native grasses. In part, this explains the predominance of the mimosos and carona, though again, more study is re-

29. Lisboa, *Oeste,* 145–150; Rodolpho Endlich, "A criação do gado vaccum nas partes interiores da América do Sul," *Boletim da Agricultura* (Rio de Janeiro) 4/2 (1903): 82–84 (This was a series of articles that appeared in seven continuous issues through 1902 and 1903.); Souza Porto, "Programa," 102.

30. Allem and Valls, *Recursos,* 226–27; Frederik A.B. Mayerson, *O aproveitamento e proteção do Pantanal, (Análise crítica do "Estudo de desenvolvimento integrado da Bacia do Alto Paraguai")* (Brasília: SEMA/MINTER, 1981), 13.

quired to determine the long term ecological effects of the mimosos as native invaders. But such transformation would be less complete without the influence, if comparatively small, of regular pasture burning.[31]

In ranching throughout the world, fire has played a critical role. This is especially the case in regions where annual drought cycles are experienced, as in tropical and semi-tropical savanna. To the rancher, regular annual burning serves to eliminate excess vegetation, renew grasses that have grown tough with age and animal cropping, keep the incidence of noxious weeds down, and limit insects and parasites harmful to cattle. But fire also contributes to the impoverishment and hardening of the soil, and the gradual displacement of indigenous plant species by fire-hardy grasses and woody species. In the long run, these invaders take over from palatable grasses and eventually force greater rancher intervention and expense if the pasture is to remain economically viable. However, there is debate among scientists over the degree of ecological disturbance caused by regular burning on the savanna, especially if fire is controlled. To date, the issue is unresolved, though no one questions the harmful effects of widespread uncontrolled burning.[32]

In the Pantanal, fire was, and is, less important than in the cerrado. However, it was used periodically for over a century, largely in the eastern drier region, and has had some local impact. Burning appears to have started virtually with the introduction of cattle to Mato Grosso, though only became common in the years following the Paraguayan War. This was most apparent in the northern sectors of the Pantanal, where population pressure was greatest, and where government-owned ranches had once existed. Many new ranchers, during the period of postwar reorganization, set fires in an attempt to round up the unbranded feral cattle of abandoned government ranches. In the southeastern Pantanal, some burning was common during initial occupation of the territory, in order to clear land of bush and trees to construct ranch buildings, and for easier pasturing. Ribeiro relates how his ancestors set fires in the 1840s and 1850s that lasted weeks and covered hundreds of hectares. Once established, it appears burning was employed regularly in this region, not only to renew grasses, but also in hunting jaguars, a constant threat to cattle.[33]

31. Virgílio Corrêa Filho, *Pantanais Matogrossenses (Devassamento e Ocupação)* (Rio de Janeiro: IBGE, 1946), 128; Corrêa, *Fazendas de Gado,* 9–10; Endlich, "A criação," *Boletim da Agricultura* 4/1 (1903): 24–27.

32. See Ana Primavesi, *Manejo Ecológico de Pastagens em Regiões Tropicais e Subtropicais* (São Paulo: Nobel, 1986), 45–46; William Sandford and Elizabeth Wangari, "Tropical grasslands: dynamics and utilization," *Nature and Resources* 21/3 (July–Sept. 1985): 13.

33. Luiz D'Alincourt, "Resultado dos trabalhos e indagações statísticas da província de Mato-Grosso, 1828," *Anais da Biblioteca Nacional* 3 (1877–78): 256; João Severiano da Fonseca, *Viagem ao Redor do Brasil: 1875–1878* 2 vols. (Rio de Janeiro: Biblioteca do Exército Editora, 1986 [1880]) 1: 169; Ribeiro, *Taboco,* 27, 102.

In the western and southern sectors, where flooding was more widespread, burning was much less common. With the exception of regular burning in the *carandá* palm stands (Copernicia alba) near the Paraguayan Chaco, which has been going on since at least the 1930s, the introduction of large-scale burning in the west has been attributed not to ranchers at all, but to rubber collectors, who were permitted by the patriarch of Nhecolândia, Joaquim Eugênio Gomes da Silva (Nheco), to enter the region in 1899. Apparently, the burning of brush aided these tappers to find the widely-scattered *mangabeira* (Hancornia speciosa) trees, from which they extracted latex. Nheco later regretted his decision, as the collectors disrupted the ecosystem of the Pantanal with their fires and indiscriminate hunting of wild animals. They also represented the end of an era, as their accounts of the richness of wildlife in the Pantanal attracted many more outsiders to the region.[34]

For the most part, however, burning in the western Pantanal was done only to remove scrub where cattle had not grazed, and at times of emergency need for pasture, such as during an excessive flood year or if frost killed existing grasses. In the cerrado regions, burning was employed as the cheapest and most effective means of rejuvenating pasture, regardless of its detrimental effects. In most of the Pantanal, however, flooding did this for the rancher. Thus, ranchers tended to be a little more cognizant of the effects of fire, especially as this was a different ecosystem to that of the upland regions of Mato Grosso. It was recognized, for example, that burning produced a great deal of ash that then entered the river system, disrupting the aquatic life cycle, particularly harmful to fish. For a time, it was believed that excessive potassium from the ash killed fish directly, as many thousands of dead fish were observed after burning had occurred. It appears, however, that more likely deaths were due to extensive growth of aquatic vegetation, which formed floating islands and a decomposition process that released high levels of hydrosulphuric gas into the water, depriving the fish of oxygen. Locally called *diquada,* this has been a recurrent problem in the northern Pantanal. Ranchers also saw the effects of potassium in their animals when they ingested ash with the new grasses, while at the same time maintaining a low salt diet. This caused nutritional deficiency, as potassium chlorate combines with sodium chlorate in the blood to eliminate sodium through the urine.[35]

34. Allem and Valls, *Recursos,* 189–190; Barros, *Lembranças,* 45.

35. Domingues and Abreu, *Viagem,* 11; Arnildo Pott, *Pastagens no Pantanal* (Corumbá: EMBRAPA, CPAP, 1988), 25: Antonio Carlos Simões da Silva, *Cartas Mattogrossenses* (Rio de Janeiro: n.p., 1927), 72; Carolina Joana da Silva, "Nota prévia sobre o significado biológico dos termos usados no Pantanal Matogrossense I—Batume e Diquada," *Universidade, Revista da Universidade Federal de Mato Grosso* (Cuiabá) 4, No. 2 (May–Aug. 1984): 30–35; F. Iglesias, "O Toque," *Brasil Agrícola* (Rio de Janeiro) 1/11 (Nov. 1916): 346.

Recently, more intense pressure on the land has led to greater use of fire, with predictable detrimental effects. Allem and Valls have documented that in the upper Pantanal soils are deteriorating and invader species common. These invaders are usually carona and *barba de bode* (Aristida pallens), the same invaders seen in the plateau cerrado to the east. This reinforces the opinion that the upper region of the Pantanal is an extension of or at least in transition between cerrado and the lower humid areas. Several more years of observation are necessary, however, in order to determine whether the area is part of a process of cerrado expansion, or a more or less permanent transition zone.[36]

The planting of artificial pasture has never been very significant in the Pantanal, even today. In fact, it was rare in Brazil until the first decade of the twentieth century and was not seriously undertaken in Mato Grosso until the 1920s. Nevertheless, where exotic pastures were deliberately introduced, they have had local influence on the ecosystem. Most artificial pasture has been introduced into the Pantanal only since the 1970s, though some isolated experiments were undertaken as early as the 1940s, generally short-lived. This was in the drier eastern sector of the region, and in occasional patches in the cordilheiras. Planted pasture has always been used for fattening of steers for market, and while traditional extensive ranching practices still predominate in the region, they have been modified by an increase in fattening as improved transportation permits, which signals the likelihood of a new era in cattle ranching in the eastern Pantanal.[37]

Until the 1980s, the grasses chosen for cultivation were *jaraguá* (Hyparrhenia rufa) and *colonião* (Panicum maximum), both of African origin and used throughout the center-west of Brazil, especially in São Paulo, where most cattle were (and are) fattened before being processed in refrigerated slaughter houses. These grasses were appreciated for their nutritive value, ease of care, rapid growth, and resistance to fire. Planting appears to have been determined by environmental factors. Extensive flooding reduces available pasture, and if this goes on for a period of time, or if animal losses to floods are sufficiently high, the natural response is to seek a form of future security through cultivation. This was the case after the floods of 1974. The result has been a gradual degradation of pasture in certain regions, especially as fire and diking are part of the planting system, and even more serious deforestation in the upper Pantanal regions, with all the

36. Allem and Valls, *Recursos,* 189–190.

37. Joaquim Carlos Travassos, *Monographias agrícolas* (Rio de Janeiro: Sociedade Nacional de Agricultura, 1903), 23–26; Campo Grande, Matto Grosso, *O município de Campo Grande em 1922; publicação da intendencia municipal* (São Paulo: Cia. Melhoramentos, 1923), 48.

attendant residual effects this brings to the rest of the region. One study has concluded that this has created a form of "disclimax" in some areas of the Pantanal, as woody species displace native grasses.[38]

Fencing has had a longer history in the Pantanal than the introduction of exotics. The main use was to separate properties, a process that increased significantly over time. The rotation of pastures was not practiced, and is hardly recognized today. At the beginning of the twentieth century it was believed by outside observers that fencing would lower the cost of managing cattle by limiting their range, but it soon became clear that the cost of a horse and rider (roughly 1 mounted horse to 100 steers) under extensive ranching conditions was cheaper than that of fencing wire. And as easily-accessible trees were few, labor expenditure to cut and carry wood for posts or cross beams was not justified financially unless land rights were in question among ranchers.[39]

Such concepts of land jurisdiction came slowly to the Pantanal for obvious reasons. The region was replete with natural barriers, principally water courses, many ranches were immense, and relations among neighbors, many of whom were relatives, cooperative. Wealth was determined by number of cattle, not size of ranches. Only as the changes of the 1920s began to affect all of the state, did ranchers in the Pantanal consider fencing. In the rest of the southern part of Mato Grosso, the arrival of the railroad led to soaring land values and widespread speculation. The Pantanal experienced very little of this, due to the region's isolation, though some ranchers began to fence in the hopes that by doing so their land would increase in value and the work load diminish. Nhecolândia was the first area where fencing was established in any significant manner, as this was the region that experienced the first wave of subdivisions. By the 1930s, fencing there was widespread, at least in comparison to the rest of the Pantanal, and more common than not by the 1940s.[40]

At first, fences were made from trees: carandá palm near the Paraguay River, harder woods in the higher regions. When wire came into use, it was usually smooth, though today it is mostly barbed. Fence posts are still of local wood, however, particularly carandá. Besides dividing property, fences were used in corrals. Also, fences were employed to restrict access of neighboring cattle to one's property. This was especially so during

38. Monserrat and Gonçalves, *Observações,* 53; Pott, *Pastagens,* 49; Mayerson *O aproveitamento,* 13; Allem and Valls, *Recursos,* 287–288.

39. Virgílio Alves Corrêa, "Aos Fazendeiros," *Revista da Sociedade Matto-Grossense de Agricultura* (Cuiabá) 1 (May 1907): 28–31; Endlich, "A criação," *Boletim da Agricultura* 4, No. 3 (1903): 131–132.

40. Corrêa Filho, *A propósito,* 46–52; Carlos Vandoni de Barros, *Nhecolândia* (Mato Grosso [sic]: n.p., 1934), 32–33; "O Gado de Nhecolândia," *O Observador econômico e financeiro* (São Paulo [?]) 10 (October 1945): 124.

attacks of mal das cadeiras, when some ranchers closed off their ranches to neighboring horses. Nevertheless, environmental damage caused by the concentration of animals was minimal, with the exception of some soil destruction leading to erosion near water holes and around ranch houses. Deforestation for posts was probably significant, though the carandá is ubiquitous in some areas, and grows rapidly.[41]

The impact of ranching on local fauna has generally depended on the type of ranching practiced, and the degree of competition between cattle and wildlife for finite resources. Impressionistic accounts from the years of initial occupation noted an impressive amount and variety of wildlife, particularly birds and fish. Fish were important to the ranches, since they provided food and oil, the latter for lamps and in the crude curing of hides. Professional fishermen were an integral part of the Pantanal ranch work force during the formative years. Wildcats, particularly jaguars, were cited as a constant hazard to the ranch animals. These predators, sensing an easy meal, would approach corrals and ranch buildings, demanding constant vigilance from ranch hands at certain times of the year. The jaguar hunt became a necessary part of ranch life, and acted as an arena for cowboy manhood rituals, as well as a welcome diversion from daily routine. The cowboys and their bosses did not normally hunt, however, for a variety of reasons, including a general conservationist attitude, distaste for game meat, restricted opportunity, and the expense of ammunition. Exceptions were the wildcats, when dangerous, and feral pigs. The latter, introduced in the nineteenth century with the first ranchers, cause problems to ranchers and disrupt the local environment, since they dig up the ground around baías with their snouts in search of food, restricting pasturing and endangering horses. In this way, they have also contributed to modify vegetation. Cowboys have dealt with them partially by creating a sport in which immature males are caught, castrated and marked, to be hunted when adults, or captured for fattening on the ranch. They are not in danger of extinction. Poisonous snakes, dangerous to both humans and animals, and armadillos, which burrow in the grasslands, putting horses at risk, occasionally had bounties placed on them by ranchers in an attempt to diminish ranching risks. Recent studies have noted population declines among both, though it appears greater cattle concentrations rather than the bounties have contributed to this.[42]

Although most ranchers now support conservation, thanks to generations of coexistance with local fauna, and try to protect wild animals,

41. Domingues and Abreu, *Viagem,* 13, 21–22; Barros Maciel, *A pecuária,* 27.

42. Corrêa Filho, *Fazendas de Gado,* 12–13; Corrêa Filho, *Pantanais,* 70; Ribeiro, *Taboco,* 199–200; "O Gado da Nhecolândia": 126; Antônio de Pádua Bertelli, *O paraíso das espécies vivas: pantanal de Mato Grosso* (São Paulo: Cerifa, 1984), 253–254.

certain species of wildlife are fast disappearing in the Pantanal, particularly wildcats, South American caimans (*jacarés*), several species of monkey, otter, and the giant anteater. These have all suffered from hunting by professionals from outside of the region and by poachers. Some birds, including several parrot species, also have shown declining populations in recent years. Such persecution has increased lately, particularly as the world market for skins and especially live animals for collectors has attracted smugglers into the region, often linked to the illicit drugs trade. Nevertheless, during the 1910s one traveller reported "piles" of jaguar and deer skins on the property of the large U.S. ranching and beef bouillon factory, Brazil, Land and Cattle Company, on the Paraguay River. This was in the northern Pantanal, where he estimated as many as 1,000 animals were being killed annually. Another observer noted in 1916 that herons were being hunted for their feathers. The market was paying $1,000 U.S. a kilogram, and he estimated it was necessary to kill 200 birds to collect that weight in feathers. In the 1930s, deer, *capivara* (Hydrochoerus hydrocoeris), the largest rodent in the world, and giant toads were hunted for their skins. All declined in number in specific localities, especially where easily accessible, such as along the margins of rivers. Herons, capivaras and toads no longer are hunted, due to a weak market, though deer skins are still sought illegally.[43]

Travellers' reports throughout the period constantly refer to the impressive number of jacarés (Caiman yacare) found basking in the sun along riverbanks, oblivious to the presence of man and his river steamers. Unfortunately, such apparent indifference was fatal in many cases, as travellers and ship's crew often used the defenseless reptiles for target practice, a "sport" eagerly engaged in to alleviate the tedium of long river journeys. Birds were victims as well. Still, this was not a consequence of ranching, but of the opening of Mato Grosso to the world and its "civilizing" influences. On the ranches, jacarés and birds were seldom disturbed, primarily because they did not harm the cattle nor hinder ranch activities or expansion.[44]

Other animals, however, have felt the direct impact of ranching. Capivaras, important elements in the life cycle of the Pantanal, are herbivores. Yet the rodents do not compete with cattle for forage, as they are very

43. Bertelli, *O paraíso,* 245–54; Pereira da Cunha, *Descrições de viagens* (n.p., n.d.), 90; Otto Willi Ulrich, *Nos sertões do Rio Paraguay* (São Paulo: n.p., 1936), 99–102; Author's interview with Dr. Arnildo Pott, EMBRAPA—CPAP, Corumbá, 7 June 1990. The price for heron feathers was quoted in *pesos oro argentinos,* one peso oro roughly equivalent to one dollar U.S. Bertelli also noted that herons, particularly young chicks, were slaughtered for their feathers and meat "in the hundreds" as early as the 1860s: Bertelli, *O paraíso,* 281.

44. Annibal Amorim, *Viagens pelo Brasil; do Rio ao Acre, aspectos da Amazônia, do Rio a Matto Grosso* (Rio de Janeiro: Garnier, 1913 [?]), 474.

adaptable, easily consuming aquatic vegetation, and thus are able to change grazing habits with the seasons. However, they do suffer from disease introduced with cattle. Capivaras are especially susceptible to mal das cadeiras, and in years of high equine mortality, the same was noticed in the rodents. Study of this phenomenon is still in its infancy, but the introduction of effective vaccines for the horses does not seem to have had any effect on outbreaks among the capivara, suggesting the disease has become endemic among the rodents. Yet due to the cyclical nature of the disease and to a high birth rate, capivaras are still ubiquitous in the Pantanal.[45]

Another disease, hoof-and-mouth (*febre aftosa*), has claimed victims among the deer of the eastern Pantanal. First noticed in the 1930s, aftosa became endemic in certain areas, with prophylactic action taken only in subsequent decades. Ranchers at the time noticed the immediate decline of deer populations in their regions, a situation that has yet to be reversed. Today, it is still a serious problem for cattle, with an infection rate of 40 percent. Deer and possibly other animals are considered to be hosts. This has been one of the reasons why all four species of deer native to the Pantanal are on the endangered species list.[46]

Many ranchers today claim that attention paid to wildlife in recent years has led to increases in several species populations, including capivara, some armadillos and even deer. One rancher wrote in the early 1980s that he had not seen so much wildlife on his ranch in 65 years. One reason posited is that since 1974 climatic conditions have been ideal in the Pantanal, with adequate rainfall, no excessive flooding, and no drought. Certainly, this could be a factor, for as we have seen, survival in the Pantanal is determined as much by climate as by human intervention. However, little past study was made of the region's wildlife, making it extremely difficult yet to draw conclusions on the long-term impact of ranching. Nevertheless, it appears that in certain areas at least, ranching has displaced local fauna, cattle have competed for resources, and there has been disruption of wildlife stocks, especially where disease and predatory hunting have been introduced. Yet, the degree to which ranching is responsible for this is still difficult to determine with certainty, and more scientific study is required before definitive conclusions can be drawn.[47]

45. Cleber José Rodrigues Alho, "Manejo da fauna silvestre," in *Anais do 1º Simpósio,* 190–92.

46. Ribeiro, *Taboco,* 200–205; *Programa nacional de pesquisa do pantanal* (Corumbá: EMBRAPA, CPAP, 1990), 33; Alho, "Manejo": 194.

47. Ribeiro, *Taboco,* 200–5; Author's interview with Dr. Cassio Leite de Barros, Corumbá, 9 June 1990.

In examining the Pantanal flood plain, it becomes clear how varied and complex the region is. Predictable climatic seasonality causes transformations in terrain, vegetation, wildlife, and accessibility, yet often there is considerable difference among sectors of the Pantanal. Seasonal fluvial and pluvial flooding fosters the growth of luxuriant and nutritious natural grasses, not only providing ideal conditions for the raising of beef cattle, but limiting the scope of ranching as well. Sites for ranches have had to be chosen carefully, to avoid excessive animal losses in times of abnormally high floods. Ranchers have learned this by trial and error. And flooding, coupled with periodic drought, has caused suffering among ranchers unprepared for occasional extremes in weather and the disruption of expected environmental conditions.

This was especially the case when extensive ranching was the norm. Ranchers with large properties and herds could afford some losses, while small ranchers almost inevitably were ruined. In many ways, such constraints determined the structure of ranching more than the ranchers themselves. But gradually ranches subdivided as families grew and more immigrants, often relations, entered the region. In some senses, this made it difficult to engage in other activities, though considerations such as transportation, access to markets, and costs of production were undoubtedly more important. Most critical, however, was the nature of the Pantanal itself, which limited the kinds of activities that could survive with minimal capital inputs. Extensive ranching seems to have been the only possible alternative under the circumstances.

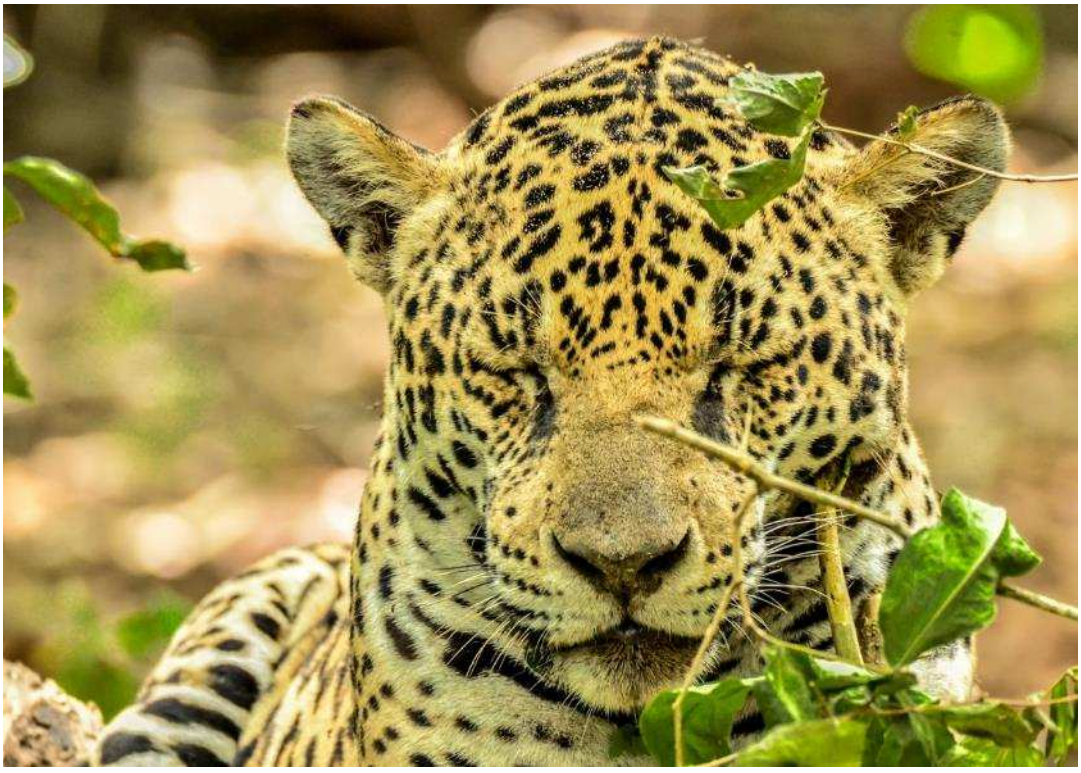
Ranching was not some benign partner coexisting with its environment, however. The entry of tens of thousands of large, voracious herbivores, and the economic inputs necessary for their guided survival, had an impact. Competition for space with wild animals, introduction of disease, gradual vegetation change, and disruption of habitat for certain species are all directly attributable to domesticated ungulates. The introduction by humans of fire, fencing, exotic forage grasses, if on a limited scale, has taken its toll on local ecosystems, as has the very presence of humans and their communications systems, permitting the entry of poachers, rubber tappers, placer miners, and even uncontrolled tourism in recent years. The numerous Pantanal faunal species on the rare and endangered lists attests to that.

Ranching has not "saved" the Pantanal. That it does not seem to have had as negative an impact as in the Amazon, is probably due to the environmental conditions of the Pantanal itself. And the argument that ranching has prevented the entry of agricultural and mining interests due to previous occupation of the land, has less weight for the past than it may

have today. If anything, the Pantanal has saved itself, as capital costs, including building dams and canals, not to mention all-weather roads, simply were too high to justify the investment. Over the years there was always another, more accessible region to which to turn, rather than undergo the uncertainties of this seasonal floodplain.

INSTITUTO CHICO MENDES DE CONSERVAÇÃO DA BIODIVERSIDADE

DIAGNÓSTICO DOS ASPECTOS SOCIOAMBIENTAL DA PROPOSTA DE CRIAÇÃO DO MOSAICO DE UNIDADES DE CONSERVAÇÃO NO PANTANAL NORTE.



2018

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1. Introdução

O Pantanal, uma das maiores extensões de áreas alagadas do mundo, situa-se na planície da Bacia do Alto Paraguai. Esta Bacia ocupa uma área total de quase 600.000 Km^2, dos quais 363.000 Km^2 localizadas em território brasileiro, 110.000 Km^2 no Paraguai e 121 Km^2 na Bolívia. O Pantanal se estende por uma área de 138.183 Km^2 em território brasileiro, 35% dos quais localizados no estado do Mato Grosso e 65% no estado do Mato Grosso do Sul. É uma área de alta diversidade biológica, revestindo-se de grande importância para a conservação. O Pantanal foi declarado Patrimônio Nacional pela Constituição Federal de 1988, Reserva da Biosfera Mundial e Patrimônio Natural da Humanidade pela UNESCO; e algumas áreas específicas foram declaradas "sítios Ramsar" no âmbito da Convenção Ramsar de Zonas Úmidas.

Em um estudo realizado por Mattar e cols. (2018), os quais fazem uma análise das unidades de conservação federais no Brasil, foi verificado que, proporcionalmente e desconsiderando as RPPNs, o Pantanal é o Bioma que menos possui área protegida para a conservação da biodiversidade no país, com apenas 0,98 % do bioma protegidos por UCs federais (apenas duas: Estação Ecoógica de Taiamã e Parque Nacional do Pantanal Matogrossense, ambas criadas em 1981). Ao considerar as unidades de conservação federais, estaduais e municipais de todas as categorias, obtem-se um total de 5,46% do bioma protegido, da quais 2,36% correspondem a UCs de proteção integral e 3,1% a UCs de uso sustentável (15 RPPNs e uma APA) (Silva *et al*., 2009).

Desta forma, diante da baixa porção do Pantanal protegido, e considerando que o Brasil é signatário do tratado internacional da Convenção sobre Diversidade Biologica (CDB) desde fevereiro de 1994, fica evidente a necessidade de ampliação das áreas protegidas no bioma Pantanal.

Neste contexto, o presente documento tem por objetivo apresentar um diagnóstico dos aspectos socioambiental da proposta de criação do mosaico de unidades de conservação no pantanal norte.

2. Análise da Representatividade

O bioma Pantanal é o resultado da grande influência biogeográfica dos biomas vizinhos, como o Cerrado a leste, a Amazônia ao norte e o Chaco a sudoeste. Da vegetação, que já têm catalogadas cerca de 2.700 plantas, pode-se dizer que é composta predominantemente por formações típicas do Cerrado, mas com características marcantes de ecossistemas amazônicos, de Mata Atlântica e de formações chaquenhas, onde sobrevive uma fauna exuberante. As aves se destacam, tendo sido catalogadas 660 espécies. Além disso, o Pantanal é parada obrigatória de aves migratórias que chegam à região na época da vazante a procura de peixes. A região possui um número considerável de espécies de peixes (262), 162 espécies de répteis, 95 espécies de mamíferos e anfíbios.

A região é bastante favorável à apreciação da fauna, por apresentar uma fitofisionomia de vegetação esparsa, com predominância de gramíneas e com a vegetação de porte alto se concentrando em áreas de relevo um pouco mais elevado, formando as chamadas “cordilheiras”, que são protegidas das constantes inundações. Segundo estudos da Embrapa, o estado de conservação da vegetação é bom e cerca de metade de sua área permanece em estado natural. Porém, sua situação vem se agravando, sobretudo em algumas áreas críticas.

O crescente desmatamento, proporcionado, sobretudo pelas pastagens cultivadas, pelo carvoejamento e pelo assentamento humano em áreas impróprias estão contribuindo para a perda de habitats. A redução das áreas de florestas implica na eliminação de espécies dependentes. Outros fatores que contribuem para a sua devastação são a caça predatória, responsável pela diminuição e desaparecimento de espécies importantes como a onça-pintada e o lobo guará, e a remoção das matas ciliares, especialmente para permitir o acesso do gado aos cursos d’água, contribuindo para o assoreamento e a diminuição da vazão hídrica, prejudicando toda a bacia do rio Paraguai.

No Pantanal, segundo estudo realizado por Silva et al. (2010), foi analisado a evolução do desmatamento do Pantanal e seu entorno no Brasil nos últimos 32 anos (até 2008) sendo que o desmatamento na planície do Pantanal atingiu 12,14% de sua área, enquanto que no planalto havia atingido 58,90%. Os percentuais atuais apontam que se não houver áreas de controle efetivas, a vegetação natural da região pode· ser suprimida até o ano de 2050.

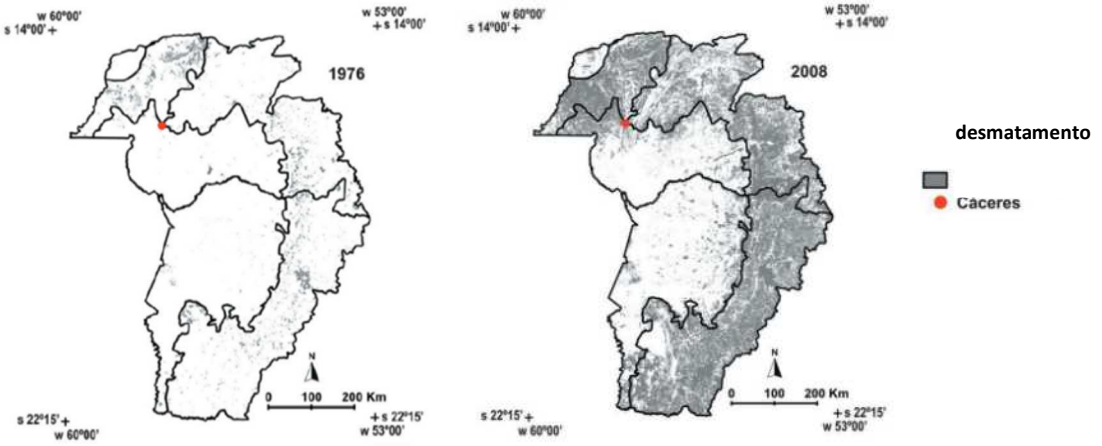


Figura 1 - Desmatamento da Bacia do Alto Paraguai (BAP) e Biomas no período de 1976 e 2008. (Fonte: Silva et al., 2010.)

Apenas 5,46% do Pantanal é protegido por unidades de conservação (federais, estaduais e municipais), dos quais 2,36% correspondem a UCs de proteção integral e 3,1% a UCs de uso sustentável (15 RPPNs e uma APA, até o momento). Entretanto, existem apenas duas unidades de conservação federais de proteção integral neste bioma.

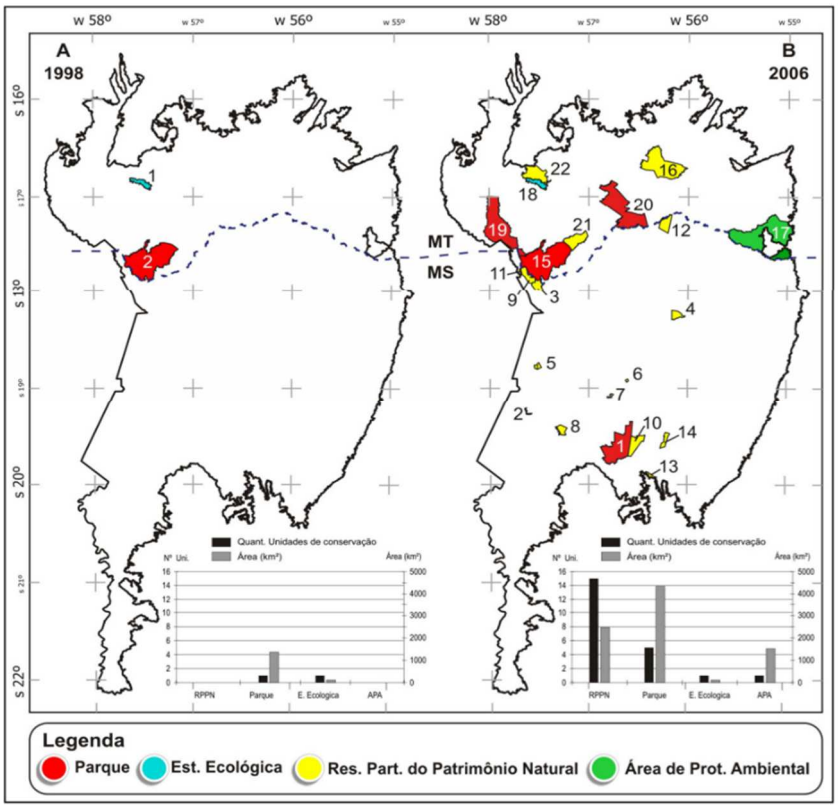


Figura 2 - Bioma Pantanal e unidades de conservação federais e estaduais nos anos de 1998 e 2006. (Fonte: Silva et al., 2009).

2.2 A Reserva da Biosfera do Pantanal

Em 1968 a Unesco criou o Programa Homem e a Biosfera (MaB – *Man and the Biosphere*), durante a Conferência da Ciência e Cultura, o qual fomenta a pesquisa cooperativa, a conservação do patrimônio natural e cultural e a promoção do desenvolvimento sustentável, formando uma rede mundial para proteger áreas expressivas da biosfera.

Para tal são previstas a criação de reservas da biosfera em áreas prioritárias e com boa representatividade de ecossistemas, a fim de cumprir os objetivos de aprofundamento direcionado das pesquisas científicas, para o conhecimento dos efeitos do aumento progressivo da degradação ambiental no planeta, gerando instrumentos de planejamento para combater os efeitos dos processos de degradação e promover a conservação da natureza e o desenvolvimento sustentável.

As reservas da biosfera são áreas em que são experimentados, aperfeiçoados e introduzidos os objetivos de conservação da biodiversidade, desenvolvimento sustentável e manutenção dos valores culturais, em associação com o desenvolvimento científico de ecossistemas protegidos. Elas podem, também, representar instrumentos de gestão e manejo sustentável integrados.

Atualmente, o Programa conta com mais de 239 reservas, localizadas em 83 países, cobrindo uma área total superior a 218 milhões de hectares. No Brasil, a primeira reserva da biosfera, criada em 1992, teve como objetivo proteger os remanescentes de Mata Atlântica. O Pantanal Mato-Grossense foi declarado pela Unesco, no dia 9 de novembro de 2000, como Reserva da Biosfera Mundial. A EE de Taiamã e o Parque Nacional do Pantanal Matogrossense são considerados áreas núcleo desta reserva da Biosfera.

O responsável pela implantação do Programa no Brasil, desde 1999, é o Comitê Brasileiro do Programa MaB (Cobramab), um colegiado interministerial, coordenado pelo Ministério do Meio Ambiente (MMA)

2.3 Reserva do Patrimônio Mundial

A Unesco prevê a designação de áreas de valor universal como Reserva do Patrimônio Mundial. Essas Reservas devem preencher um ou mais dos seguintes critérios:
- Conter exemplos significativos dos principais estágios da evolução da Terra;
- Conter exemplos significativos de processos geológicos, evolução biológica e interação humana com o ambiente natural;
- Conter únicos, raros ou superlativos fenômenos naturais e formações de excepcional beleza;
- Conter habitats nos quais populações de espécies raras ou ameaçadas de extinção possam ainda sobreviver.

O Parque Nacional do Pantanal Mato-Grossense foi reconhecido pela Unesco como Patrimônio Natural da Humanidade, juntamente com o Parque Nacional do Jaú, em 29 de novembro de 2000.

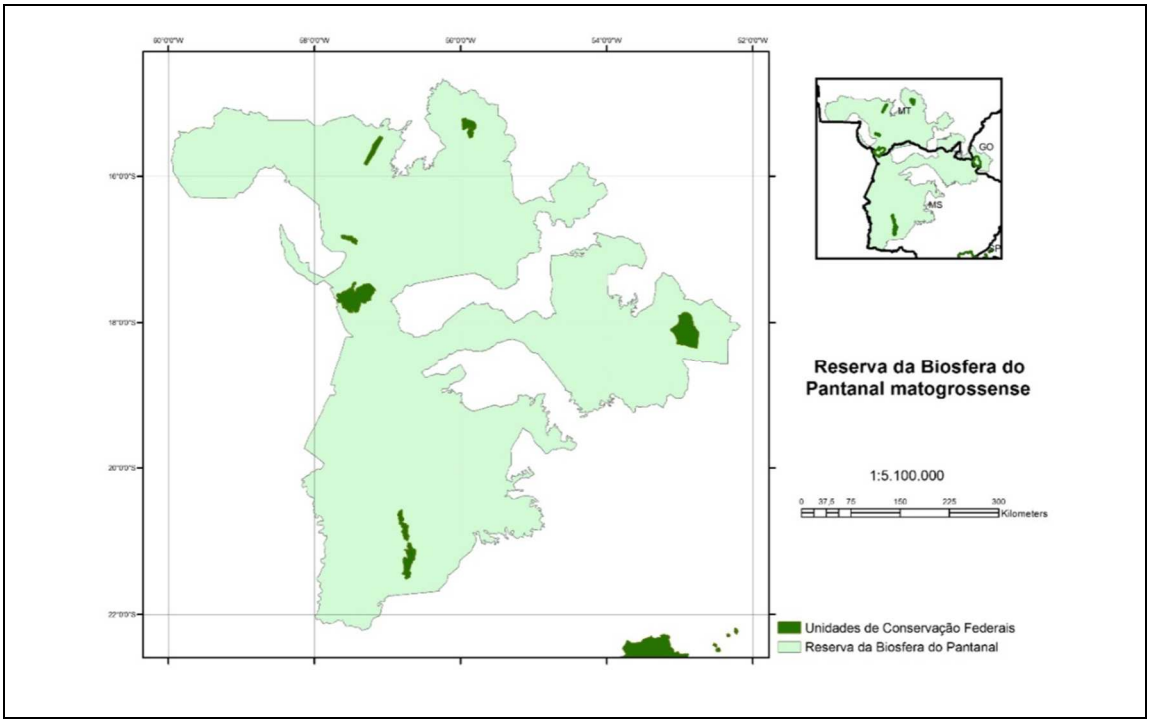


Figura 3- A Reserva da Biosfera do Pantanal

2.4. Sítio Ramsar

Esta convenção não está vinculada a uma agência internacional reguladora e não impõe nenhum tipo de restrição ou condição que afete a soberania dos países. As Partes Signatárias da Convenção de Ramsar participam de um processo destinado a identificar, em seus territórios, os sítios que podem ser classificados como Zonas Úmidas de Importância Internacional, com o objetivo de prestar especial atenção a sua conservação e ao uso sustentável.

Segundo a Convenção, os países signatários devem promover o uso sustentável dos sítios declarados, mediante a adoção de políticas e legislações apropriadas e de atividades de formação e pesquisas destinadas a incrementar a consciência pública sobre o valor das zonas úmidas.

O Parque Nacional do Pantanal Mato-Grossense foi reconhecido como Sítio Ramsar em 24 de maio de 1993 e representa a maior concentração de fauna do neotrópico, por incluir várias espécies de mamíferos, aves, répteis e peixes, ameaçados de extinção. Pela Convenção, outro ganho para o Brasil foi a declaração de Parques-Parceiros, estabelecida em 1997 entre os Parques Nacionais do Pantanal Mato-Grossense e o *Everglades National Park* (EUA), ambos signatários da Convenção Ramsar sobre Zonas Úmidas de Importância Internacional.

3. MOSAICO DE UNIDADES DE CONSERVAÇÃO DO PANTANAL NORTE

As áreas propostas para criação e ampliação de unidades de conservação no Pantanal abrangem os municípios de Cáceres e Poconé, no sudoeste do estado de Mato Grosso. Estes dois municípios possuem duas unidades de conservação federais a Estação Ecológica do Taiamã e o Parque Nacional do Pantanal Mato-grossense e duas unidades de conservação estaduais, o Parque Estadual Guirá e o Parque Estadual Encontro das Águas. A proposta de criação e ampliação propostas conecta as áreas já existentes formando um corredor biológico entre elas.

A proposta de ampliação da Estação Ecológica de Taiamã abrange uma área de exclusão de pesca, estabelecida pela Resolução CEPESCA/MT 02/2018.

Entre a proposta de ampliação da Estação Ecológica de Taiamã e o Parque Nacional do Pantanal mato-grossense, na região conhecida popularmente como “brejão”, local onde foi verificada a presença da atividade pesqueira está sendo proposta a criação da Reserva de Fauna do Pantanal, categoria que permite e fomenta o uso ecocômico dos recursos pesqueiros.

Além disso, está sendo proposta a ampliação do parque nacional do pantanal mato-grossense em áreas que aumentam o número de ambientes protegidos e em áreas que facilita o processo de fiscalização e proteção da unidade.

Entre o parque nacional do pantanal mato-grossense e o parque estadual do encontro das águas, na região onde se tem uma das maiores concentrações de onça pintada do mundo, esta sendo proposta a criação do refúgio de vida silvestre da onça pintada, categoria que permite a conciliação das atividades agropecuárias com a conservação ambiental.

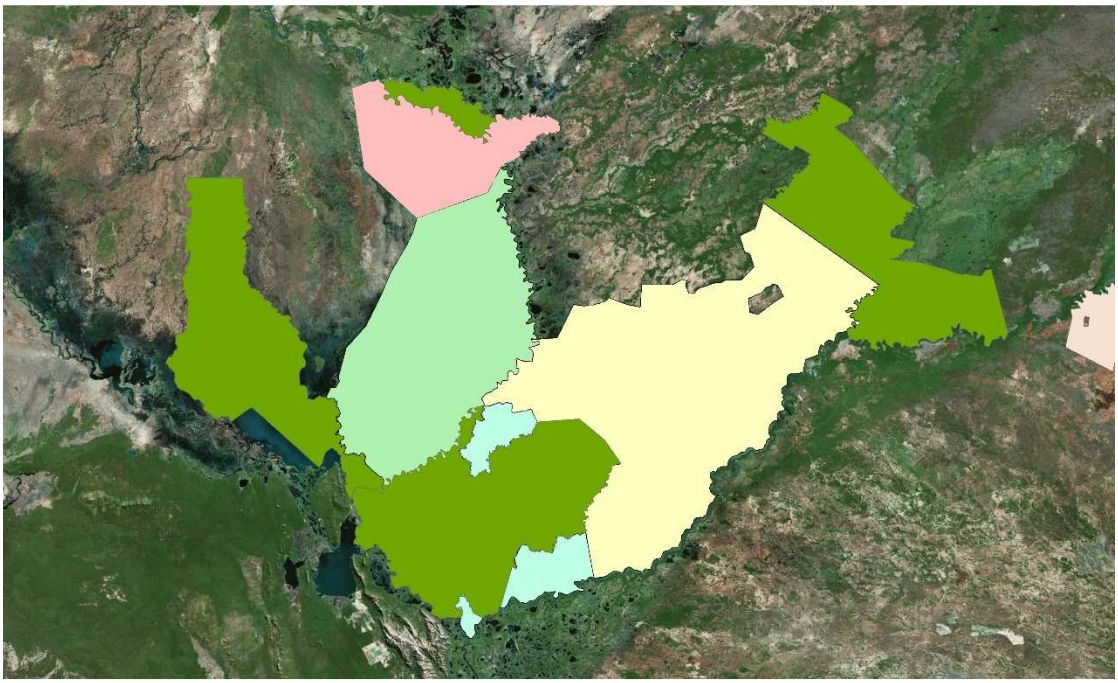


Figura 4. Mapa com os polígonos propostos pelo ICMBio para Ampliação da Estação Ecológica de Taiamã em vermelho; Reserva de Fauna do Pantanal em verde claro; Refúgio de Vida Silvestre da Onça-pintada em amarelo; Ampliação do Parque Nacional do Pantanal Mato azul claro Em verde escuro são as unidades de conservação, federais e estaduais, já existentes na região.

3.1 Proposta de ampliação da Estação Ecológica de Taiamã

Nome da Área	**Estação Ecológica de Taiamã**
Área Atual	11.555 hectares
Área proposta	75.927 hectares
Prioridade de Conservação segundo MMA 2007	Alta, Extremamente Alta
Ato de criação	Decreto Nº 86.061, de 2 de Junho de 1981
Objetivo	A preservação da biodiversidade e a realização de pesquisa científica nas inúmeras lagoas que servem como refúgio reprodutivo e de desenvolvimento para muitas espécies de peixes e aves.
Município	Cáceres/MT e Poconé/MT

3.2 O que é uma Estação Ecológica:

A Estação Ecológica é uma unidade de proteção integral com o *objetivo a preservação da natureza e a realização de pesquisas científicas*".

§ 1o A Estação Ecológica é de posse e domínio públicos, sendo que as áreas particulares incluídas em seus limites serão desapropriadas, de acordo com o que dispõe a lei.

§ 2o É proibida a visitação pública, exceto quando com objetivo educacional, de acordo com o que dispuser o Plano de Manejo da unidade ou regulamento específico.

No entorno da EE de Taiamã, existe uma Reserva Natural do Patrimônio Natural (RPPN), unidade de conservação localizada em área privada, gravada em caráter de perpetuidade, com o objetivo de conservar a diversidade biológica. A RPPN JUBRAN, criada em 2001 com 35.531 hectares, possui parte de seus limites em áreas adjacentes à Estação Ecológica de Taiamã. Somando-se a área das duas UC, obtém-se 47.086 hectares.

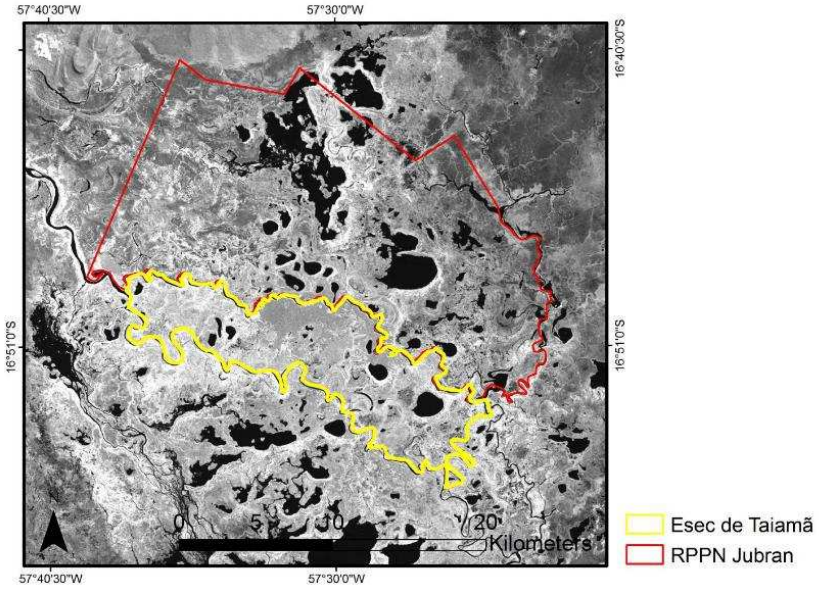


Figura 5 - Mapa da EET e RPPN Jubran.

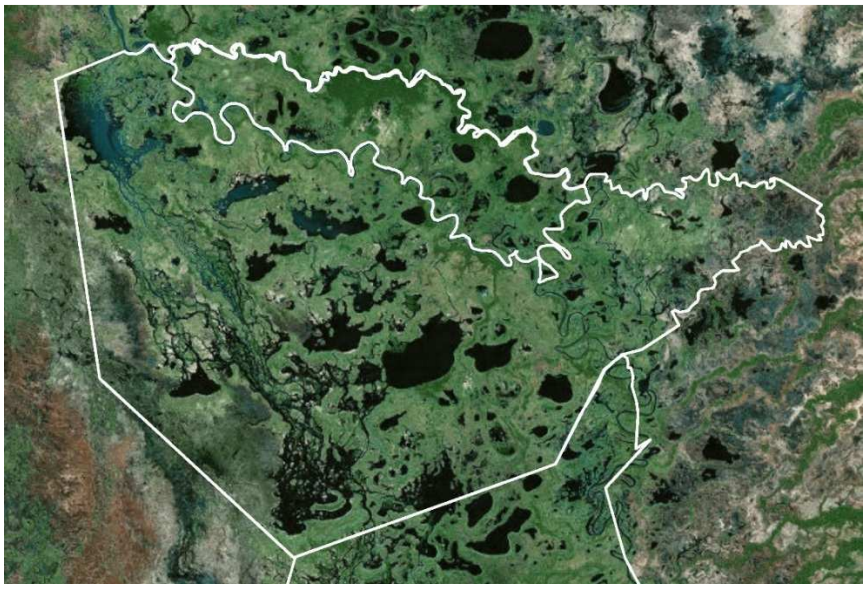


Figura 6 - Mapa da EET e a proposta de ampliação.

3.3 Proposta de Criação da Reserva de Fauna do Pantanal

Nome da Área	**Reserva de Fauna do Pantanal**
Área proposta	164.766 hectares
Prioridade de Conservação segundo MMA 2007	Alta
Objetivo	Manejo econômico da Pesca.
Município	Cáceres/MT

3.4 O que é uma Reserva de Fauna?

A Reserva de Fauna *é uma área natural com populações animais de espécies nativas, terrestres ou aquáticas, residentes ou migratórias, adequadas para estudos técnico-científicos sobre o manejo econômico sustentável de recursos faunísticos".*

§ 1o A Reserva de Fauna é de posse e domínio públicos, sendo que as áreas particulares incluídas em seus limites devem ser desapropriadas de acordo com o que dispõe a lei.

§ 2o A visitação pública pode ser permitida, desde que compatível com o manejo da unidade e de acordo com as normas estabelecidas pelo órgão responsável por sua administração.

§ 3o É proibido o exercício da caça amadorística ou profissional.

§ 4o A comercialização dos produtos e subprodutos resultantes das pesquisas obedecerá ao disposto nas leis sobre fauna e regulamentos.

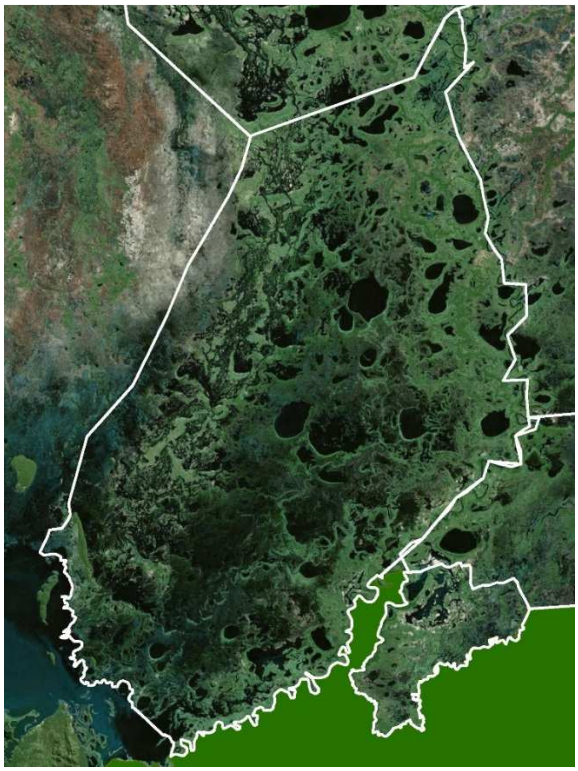


Figura 7 - Mapa da proposta de criação da Reserva de Fauna.

3.5 Proposta de ampliação do Parque Nacional do Pantanal Mato-grossense

Nome da Área	**Parque Nacional do Pantanal mato-grossense**
Área Atual	135.606 hectares
Área da Ampliação	32.440 hectares
Prioridade de Conservação segundo MMA 2007	Alta, Muito Alta e Extremamente Alta
Ato de criação	Decreto Nº 86.392/1981
Objetivo	proteger e preservar amostras de ecossistemas pantaneiros, bem como a sua biodiversidade, mantendo o equilíbrio dinâmico e a integridade ecológica dos ambientes
Município	Poconé/MT

3.6 O que é um Parque Nacional?

O Parque Nacional tem como objetivo básico a preservação de ecossistemas naturais de grande relevância ecológica e beleza cênica, possibilitando a realização de pesquisas científicas e o desenvolvimento de atividades de educação e interpretação ambiental, de recreação em contato com a natureza e de turismo ecológico.

§ 1º O Parque Nacional é de posse e domínio públicos, sendo que as áreas particulares incluídas em seus limites serão desapropriadas, de acordo com o que dispõe a lei.

§ 2º A visitação pública está sujeita às normas e restrições estabelecidas no Plano de Manejo da unidade, às normas estabelecidas pelo órgão responsável por sua administração, e àquelas previstas em regulamento.

§ 3º A pesquisa científica depende de autorização prévia do órgão responsável pela administração da unidade e está sujeita às condições e restrições por este estabelecidas, bem como àquelas previstas em regulamento.

No entorno do Parque Nacional do pantanal mato-grossense existem quatro Reserva Natural do Patrimônio Natural (RPPN). A RPPN Doroche, com aproximadamente 33 mil hectares; a RPPN Acurizal, com aproximadamente 11 mil hectares; a RPPN Penha, com aproximadamente 12 mil hectares e a RPPN Rumo Oeste, com aproximadamente mil hectares. Somando a área de todas as RPPN obtém-se mais de 58 mil hectares que agregam proteção à região.

A proposta de ampliação está indicada no plano de manejo do parque elaborado em 2005 e ainda são de grande relevância para a consolidação da gestão do PARNA Pantanal Matogrossense em áreas estratégicas para Uso Público da UC, em especial nas áreas da Fazenda Boa Esperança e da Fazenda Belica.

Na Fazenda Boa Esperança está localizada parte do Morro do Caracará, no limite com o PARNA Pantanal Matogrossense, sendo este um dos principais atrativos de visitação da UC. O acesso à trilha do Morro do Caracará é feito pela sede da Fazenda Boa Esperança. O acréscimo desta área garante ao Parque Nacional o acesso e controle da trilha, a proteção do Morro do Caracará, que é considerado um complexo arqueológico com ocorrência de diversos sítios de arte rupestre e é ameaçado pela exploração clandestina de pedras semipreciosas (ametista). A área também abrange a Baía do Morro, que além de estar incluída na Zona de Uso Extensivo, possui conectividade direta com o interior da UC, representando área estratégica para a proteção e controle dos acessos.

Figura 8 - Mapa com a relação do parque nacional do Pantanal Matogrossense e as RPPN do seu entorno

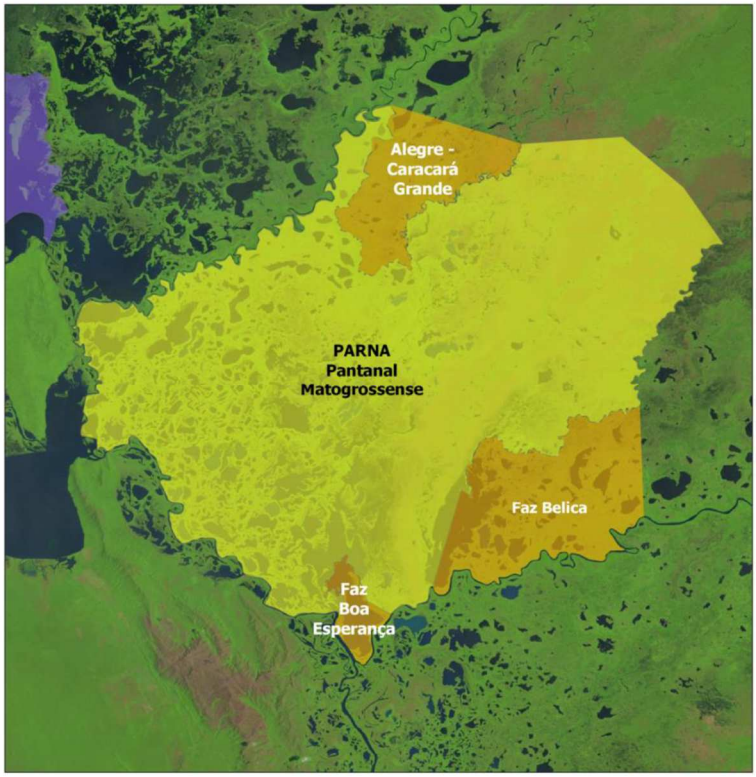


Figura 9. Mapa das áreas propostas para ampliação do parque nacional do pantanal mato-grossense

3.7 Proposta de Criação do Refugio de Vida Silvestre da Onça-Pintada

Nome da Área	**Refugio de Vida Silvestre da Onça-Pintada**
Área proposta	270.391 hectares
Prioridade de Conservação segundo MMA 2007	Alta e Muito Alta
Objetivo de criação	proteger ambientes naturais onde se asseguram condições para a existência ou reprodução da Onça Pintada.
Município	Poconé/MT

3.8 O que é um Refúgio da Vida Silvestre?

Segundo a lei 9.985/2000 o RVS tem como objetivo proteger ambientes naturais onde se asseguram condições para a existência ou reprodução de espécies ou comunidades da flora local e da fauna residente ou migratória.

→ Pode ser constituído por áreas particulares, desde que seja possível compatibilizar os objetivos da unidade com a utilização da terra e dos recursos naturais do local pelos proprietários.

→ Havendo incompatibilidade entre os objetivos da área e as atividades privadas ou não havendo aquiescência do proprietário às condições propostas pelo órgão responsável pela administração da unidade, a área deverá ser desapropriada.

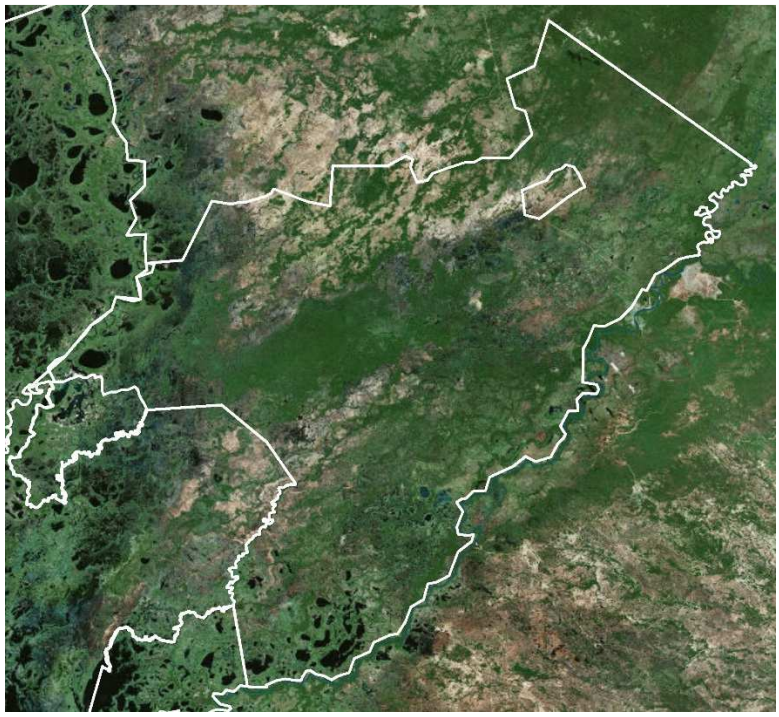


Figura 10 - Mapa da proposta de criação do Refúgio de Vida Silvestre.

4. Áreas Prioritárias para a Conservação da Biodiversidade Brasileira

Partindo do princípio que “é preciso conhecer para se gerenciar”, a conservação e o uso da biodiversidade devem ser identificados, mapeados e monitorados visando tanto conhecer a sua dinâmica e seu potencial de uso, bem como, deve-se caracterizar as pressões antrópicas que ameaçam a continuidade de sua existência. Estas informações devem estar disponíveis para todos os setores e níveis de Governo, bem como, para todos os cidadãos de forma a orientar as tomadas de decisão sobre o uso das terras, da biodiversidade e das águas. Foi com esse objetivo que o Ministério do Meio Ambiente coordenou um amplo esforço regional de consultas, tanto a especialistas quanto instituições públicas e privadas, sobre o estado do conhecimento dos grupos biológicos e dos diversos aspectos socioeconômicos. Para tal, foram realizadas diversas reuniões com pesquisadores, tomadores de decisão, representantes da sociedade civil e dos governos estaduais e federal para definir as áreas e ações prioritárias para a conservação e uso sustentável da biodiversidade. O papel do Ministério do Meio Ambiente é o de alertar, sobre as áreas geográficas mais importantes para a conservação e uso sustentável da biodiversidade brasileira, e de construir, junto a todos os setores de governo e da sociedade civil, novos caminhos que permitam a geração de recursos e manutenção das riquezas originárias. Estas "Áreas Prioritárias para a Biodiversidade" também devem orientar e auxiliar nas propostas de criação de novas Unidades de Conservação pelo Governo Federal e pelos Governos Estaduais, bem como na elaboração de novos projetos para a conservação, uso sustentável e recuperação/restauração da biodiversidade brasileira.

Neste contexto a região apresenta setores classificados como de PRIORIDADE DE CONSERVAÇÃO MUITO ALTA, segundo o “Mapa das Áreas Prioritárias para conservação, uso sustentável e repartição de benefícios da biodiversidade dos biomas Cerrado e Pantanal – 2ª atualização”, publicado em 2016 pelo Ministério do Meio Ambiente.

5. Aspectos populacionais e socioeconômicos da região

Os dois municípios abrangidos pelas propostas são Cáceres e Poconé ambas no Estado do Mato grosso. A principal cidade que possui relação com a Estação Ecológica de Taiamã, e sua área proposta de ampliação, é Cáceres. Atualmente 100% da área da UC está neste município, porém a proposta de ampliação se sobrepõe aos municípios de Cáceres (87%) e Poconé (13%).

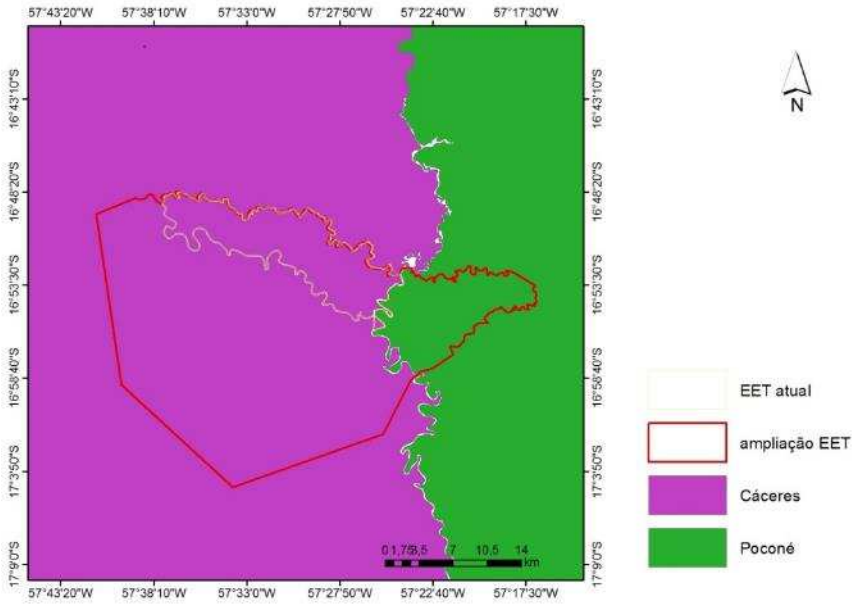


Figura 11 - Proposta de ampliação da Estação Ecológica de Taiamã e os municípios relacionados.

Mesmo com a ocorrência de uma pequena área da proposta de ampliação no município de Poconé, a relação dos usuários do rio Paraguai na região e também da própria gestão da UC são com a cidade de Cáceres, visto que o rio Paraguai passa nesta última antes de chegar a EET. Não há praticamente nenhum contato entre os gestores da UC ou usuários da região com a cidade de Poconé.

Com relação à criação da Reserva de Fauna, como o limite da proposta é o rio Paraguai, a proposta está totalmente inserida no município de Cáceres, se relacionando principalmente com a cidade de Cáceres.

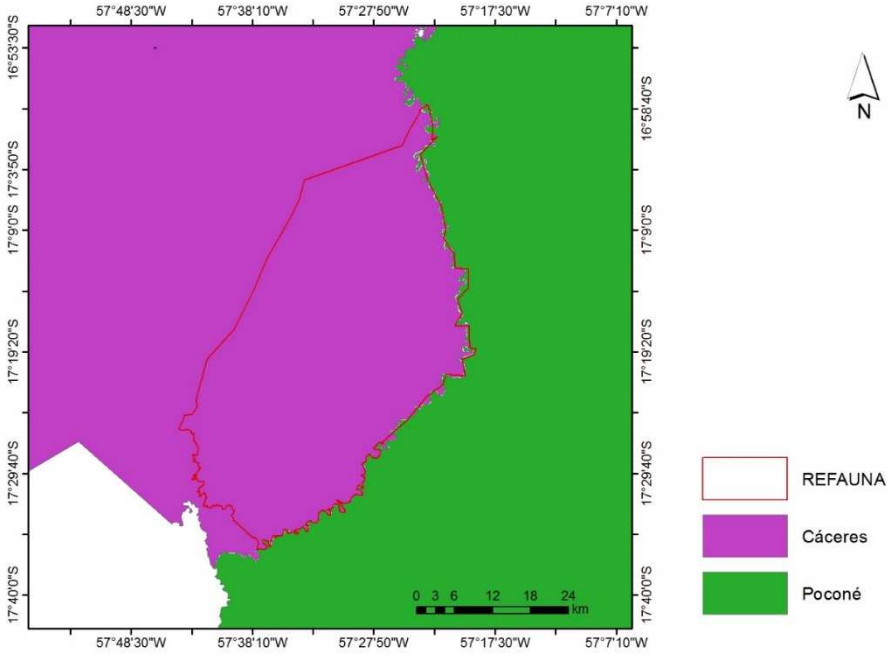


Figura 12 - Proposta de criação da Reserva de Fauna e os municípios relacionados.

A ampliação do parque nacional do Pantanal mato-grossense e a criação do refúgio de vida silvestre da onça pintada estão totalmente inserida no município de Poconé. Tendo grande parte de suas ações relacionadas com a sede deste município.

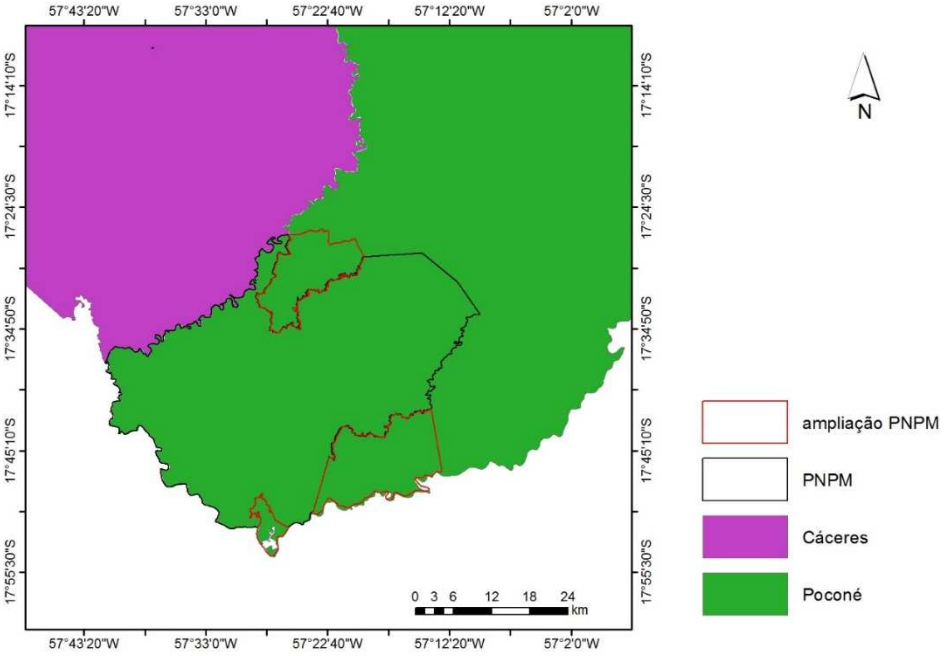


Figura 13 - Proposta de ampliação do Parque Nacional do Pantanal Matogrossense e os municípios relacionados.

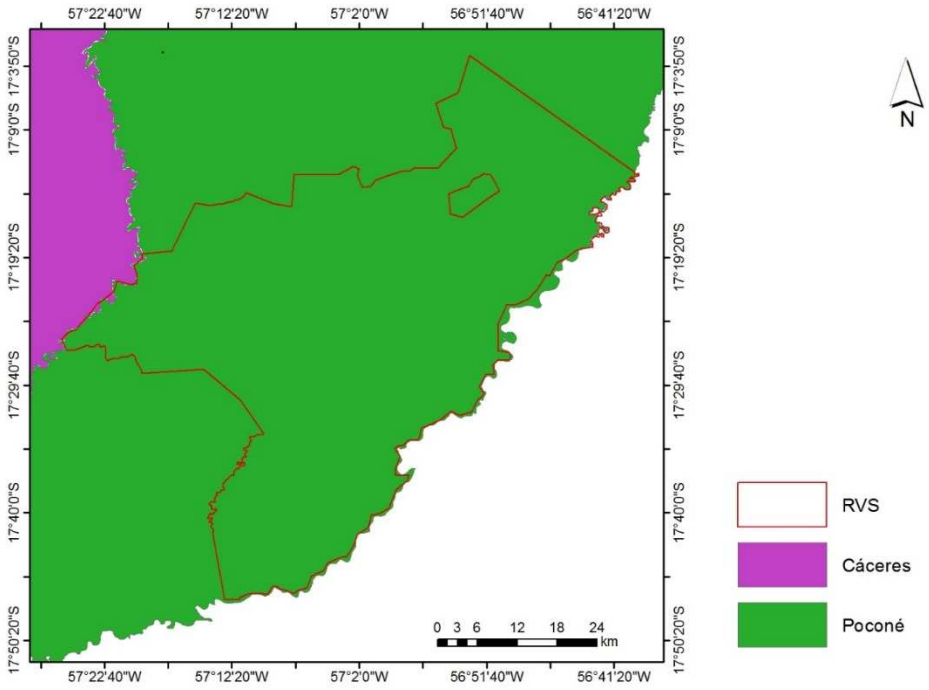


Figura 14 - Proposta de criação do Refugio de Vida Silvestre e os municípios relacionados.

Tabela 1: Dados do município de Cáceres

Dependência Genealógica	O município de Cuiabá deu origem ao município de São Luíz do Paraguay, depois São Luíz de Cáceres e finalmente Cáceres.
Denominação dos habitantes	Cacerense.
IDH	0,737 (SEPLAN/2000)
Eleitores	55.270 (TRE/2006)
Distrito	Sede, Bezerro Branco, Caramujo e Horizonte do Oeste.
Limites	Mirassol d'Oeste, Barra do Bugres, Nossa Senhora do Livramento, Poconé, Porto Esperidião, Lambari d'Oeste, Glória d'Oeste e República da Bolívia.
Altitude	118 m.
Distância da Capital	209,70 km.
Extensão Territorial	24. 398 km^2 (IBGE)
Localização Geográfica	Mesorregião 130: Centro-sul mato-grossense. Microrregião 535 : Alto Pantanal.
Bacia Hidrográfica	Grande Bacia do Prata.

Fonte: PORTALMT

Tabela 2: Dados do município de Poconé

Histórico	Poconé foi fundada em 1777 com a descoberta do ouro na região
Denominação dos habitantes	poconeano
IDH	0,679
Habitantes	32.241
Eleitores	22.902
Distrito	Distrito de Cangas e Distrito de N. Senhora Aparecida do Chumbo
Limites	Barão de Melgaço-MT, Cáceres-MT, Nossa Senhora do Livramento-MT, Corumbá-MS
Altitude	142 m
Distância da Capital	100 km
Extensão Territorial	17 260,861 km²
Localização Geográfica	A mesorregião do Centro-Sul Mato-Grossense é uma das cinco mesorregiões do estado brasileiro de Mato Grosso. É formada pela união de dezessete municípios agrupados em quatro microrregiões.
Bacia Hidrográfica	Grande Bacia do Prata

A formação dominante da população de Cáceres é de origem indígena, notadamente do povo Chiquitano, que habitou historicamente o território boliviano, assim como a divisa deste país com o Brasil. As etnias Guató e Umutina, também compõem o conjunto gênico e cultural da conformação da população cacerense.

Está registrada em trecho da Ata de Fundação de Vila Maria, a composição da população inicial desta localidade: “Neste distrito do Rio Paraguai e margem oriental dele, para com o efeito de fundar, erigir e consolidar uma Povoação civilizada aonde se congregasse todo o maior número de moradores possível compreendidos todos os casais de índios castelhanos proximamente desertados por estes domínios portugueses da Província de Chiquitos, que fazem o numero de setenta e oito indivíduos de ambos os sexos que ajuntando-se todo o outro numero das mais pessoas congregadas para o dito fim faz o total de cento e setenta e um indivíduos de ambos os sexos” (Arquivo Público de Mato Grosso. Lata 1778C. citado por Siqueira , 2002).

Inicialmente constituída por militares e indígenas a população de Cáceres passou por um acréscimo de diversidade em sua constituição em momento mais recente de sua história, a partir dos anos de 1950, quando as grandes

obras de interligação do país, facilitaram o processo de migração espontânea para a região, e com grande intensidade à partir do governo militar, que implementou programas estatais para colonização dirigida às regiões centro-oeste e amazônica. A partir de então a região sudoeste de Mato Grosso recebeu migrantes de todas as regiões do Brasil, com destaque para as regiões sul e sudeste.

Poconé é um Município da região metropolitana do Vale do Rio Cuiabá, distante da Capital 100 KM. Município histórico com 228 anos, conta com uma população de 32.241 pessoas sendo 24.417 na zona urbana e 7.788 na zona rural. O Município conta com 14 bairros, 05 vilas, 02 distritos (Distrito de Cangas e Distrito de N. Senhora Aparecida do Chumbo), 72 comunidades (Zona Rural) e 11 Assentamentos.
Suas principais atividades econômicas são: Pecuária, Mineração, Agricultura e com grandes potencialidades no Turismo, pois o Município de Poconé é o Portal de entrada do Pantanal Matogrossense, sendo inúmeras as Pousadas e hotéis no decorrer da Rodovia Transpantaneira (Rod. Zelito Dorileo), que diariamente recebem grande fluxo de Turistas de várias partes do Brasil e do Mundo, querendo conhecer as nossas belezas naturais, fluxo esse que aumenta de ano em ano, o que nos dá a certeza que em um futuro bem próximo o Município de Poconé, estará sendo um dos mais procurados quando se tratar na questão Turismo/Ecologia.

Poconé foi descoberta por Luiz de Albuquerque de Melo Pereira e Cáceres, em 1777, após ouro ter sido descoberto. Seu primeiro nome foi *Beripoconé*, nome proveniente de uma tribo indígena que habitava a região,". Em 21 de janeiro de 1781, sob ordens de Luís de Albuquerque de Melo Pereira e Cáceres, Antonio José Pinto de Figueiredo criou a *Ata de fundação do Arraial de São Pedro d'El Rey*. O nome *Arraial de Beripoconé* não foi usado pelo gentílico ser considerado bárbaro, que derivando do gentio significa "habitou nesta paragem". Em 25 de outubro de 1831, o Decreto Geral do governo regencial criou o município, junto com seus limites políticos atuais, de Villa de Poconé, o último nome sendo uma modificação do nome original. O de 1831, criou o município, com a denominação de Villa de Poconé, voltando o nome antigo, pouco modificado. Neste decreto, ocorreu pela primeira vez a designação de limites em ato de criação de município em Mato Grosso. Em 1 de julho de 1863, Poconé recebeu o estatuto de cidade via Lei Provincial.

A taxa de crescimento populacional nos municípios nos últimos anos não foi tão expressiva, como podemos analisar na tabela 2. A base econômica dos municípios não proporciona grandes aumentos na quantidade de postos de trabalho e alguns distritos se desmembraram e formaram novos municípios nesse período. O comércio local é bem expressivo, impulsionado também pela grande quantidade de servidores públicos que são lotados no município (municipal, estadual e federal), em especial pela presença em Cáceres do batalhão de fronteira do exército brasileiro, que possui grande quantidade de militares servindo na região.

Tabela 3: Evolução populacional de Cáceres e Poconé/MT

Ano	Cáceres	Poconé	Mato Grosso	Brasil
1991	77.540	29.856	2.027.231	146.825.475
1996	73.004	30.595	2.208.665	156.032.944
2000	85.857	30.773	2.504.353	169.799.170
2007	84.175	31.110	2.854.642	183.987.291
2010	87.942	31.779	3.035.122	190.755.799

Fonte: IBGE

Ainda nos dias atuais, a principal atividade econômica desses municípios é a pecuária, possuindo um dos maiores rebanhos bovinos do Brasil, mas conta também com a agricultura familiar e turismo.

Em consonância com o movimento da maioria dos municípios brasileiros de concentração populacional na área urbana, Cáceres apresenta a distribuição de 76.568 (87,10%) de sua população na área urbana e 11.374 pessoas (12,9%) na área rural do município, por outro lado, como mencionado anteriormente Poconé apresenta uma população de 32.241 pessoas sendo 24.417 na zona urbana e 7.788 na zona rural. (IBGE, 2010). Certamente o pulso de inundação do Pantanal influencia significativamente nesse padrão, visto que no período de cheia as áreas habitáveis desses municípios reduzem consideravelmente devido ao alagamento desse bioma.

O município de Cáceres recebe repasse de ICMS ecológico por conter em seu território área parcial ou total das unidades de conservação: Estações Ecológicas Serra das Araras e de Taiamã, ambas federais; Parque Estadual do Guirá e RPPN Jubran, reconhecida pelo governo federal. Este repasse representou, em média, 1,5% do total do ICMS recebido pelo município no período de 2002 a 2009, sendo que em 2014 foram repassadas ao município de Cáceres 287.746,40 reais de ICMS ecológico e o município de Poconé recebeu em 2014 652.689,96 reia de ICMS ecológico (SEMA/MT, 2013 e). A criação e ampliação das unidades de conservação certamente representaria um significativo aumento na arrecadação de ICMS.

O turismo vem crescendo nos últimos anos, especialmente devido à pesca esportiva muito explorada no município (IBGE, 2010). Esta atividade turística encontra-se implantada no corredor fluvial do rio Paraguai e do rio Cuiabá e seus principais afluentes e também da rodovia transpantaneira, os quais geram emprego e renda para diversos segmentos econômicos, benefícios sociais e também problemas de ordem ambiental. O turismo de pesca, realizado nesse espaço geográfico, acontece através de pequenas embarcações, barcos-hotéis, hotéis-pesqueiros, hotéis, pousadas, campings e ranchos de pesca. O

turismo no Pantanal do Mato Grosso está quase inteiramente relacionado à pesca esportiva e ao turismo de contemplação, modalidades que usufruem toda a infraestrutura hoteleira da região pantaneira, incluindo as pousadas e hotéis ao longo do rio Paraguai, Cuiabá e afluentes, bem como na rodovia Transpantaneira.

No período em que é permitida a pesca no estado, podemos verificar a presença de acampamentos em locais fixos de pescadores profissionais no entorno da EET e na proposta de criação da reserva de fauna, às margens do rio Paraguai, principalmente quando as águas do rio estão mais baixas. Aproximadamente 50 pescadores profissionais frequentam o entorno da unidade, na área onde está sendo proposta a criação da Reserva de Fauna, categoria que permite esta atividade. Além destes, empresas que exploram o turismo de pesca amadora e de observação de fauna também frequentam esta área, com barcos-hotéis, mas sem ponto fixo. A maioria dos barcos-hotéis descem o rio Paraguai até o entorno da EET com o objetivo de realizar pesca amadora, levando em média 20/25 pessoas, entre turistas e tripulantes, e permanecem no entorno da unidade de 3 a 4 dias por viagem. Em alguns períodos vários barcos-hotéis (5 ou 6) se aproximam, simultaneamente, da região da UC. São poucas as semanas em que, durante o período em que a pesca é liberada no rio Paraguai, não há barcos-hotéis e pescadores amadores no entorno da EET. Durante o período de defeso dos peixes (piracema) (entre outubro e janeiro, anualmente) a população no entorno da unidade às margens do rio diminui significativamente, chegando a zerar. Não existe morador ribeirinho na região da unidade, sendo que os pescadores que exploram o entorno da UC tem suas residências na zona urbana do município.

Figura 15 - Imagens de acampamentos de pescadores profissionais no entorno da EET.

. A pesca no entorno da Unidade é regulamentada (Resolução CEPESCA/MT 02/2018), com objetivo de causar um mínimo impacto aos seus recursos e proteger uma região de grande importância ictiológica. Os principais locais de pressão de pesca estão indicados na figura abaixoFigura 16.

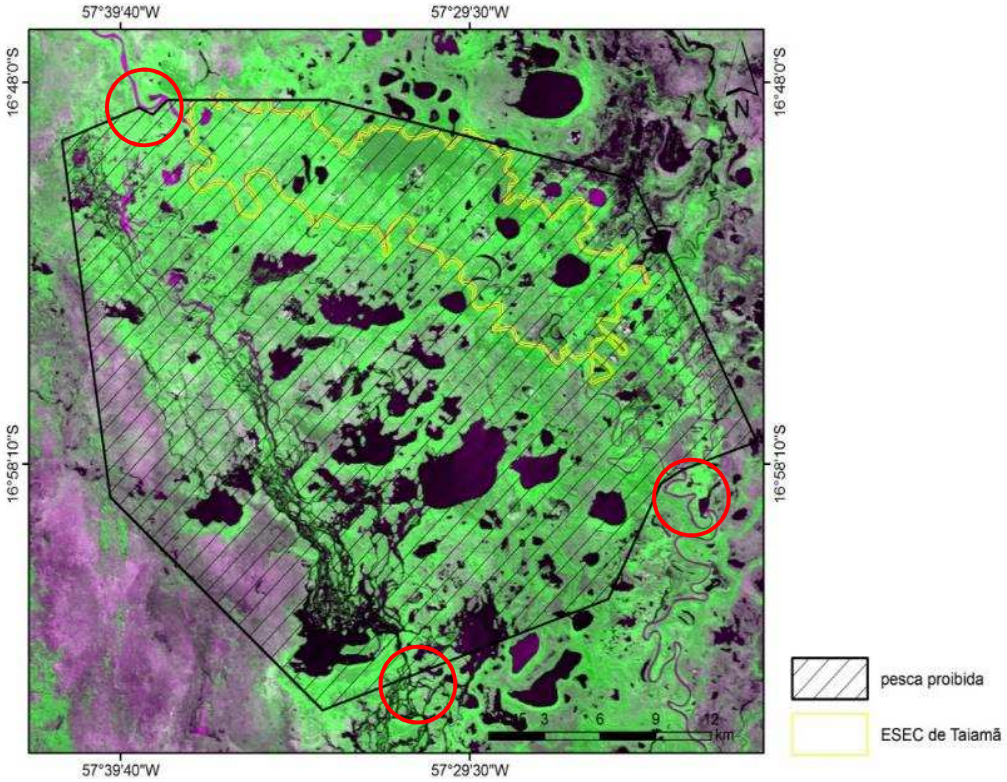


Figura 16 - EE de Taiamã e região da Resolução CEPESCA 02/2018, com principais locais de pressões de pesca.

Além da pesca, o turismo de observadores da natureza vem se intensificando nos últimos anos. Essa atividade se apresenta como alternativa de desenvolvimento econômico sustentável. Nos últimos anos, alguns barcos-hotéis que trabalhavam exclusivamente com turismo de pesca já possuem pacotes para turismo de observação, em especial a onça-pintada. A tendência em longo prazo é o aumento deste tipo de atividade na região.

6. Envolvimento dos grupos sociais com a Unidade de Conservação

6.1 Grupos sociais de interesse:

6.1.1. Pesca Amadora

Os pescadores amadores que utilizam o entorno da EE de Taiamã e da Resolução CEPESCA 02/2018, chegam, em sua maioria, através de barcos-hotéis e em menor proporção oriundos de pousadas existentes no rio Paraguai. A maioria dos barcos-hotéis e pousadas próximos da área do entorno da unidade são representados por uma associação privada, a Asatec - Associação Ambientalista Turística e Empresarial de Cáceres – MT. Esta instituição atua

como parceira da Estação Ecológica de Taiamã há muitos anos, visto que a mesma tem cadeira no Conselho Consultivo da Estação e que já foram desenvolvidas várias atividades em conjunto.

Em todas as reuniões do conselho que a Asatec participou, ficou claro que a EE de Taiamã, segundo seus representantes, tem papel fundamental na conservação da biodiversidade do Pantanal Norte. A citada associação adota em seu discurso o papel decisivo que teve ao apoiar a elaboração e implementação da IN 09 IBAMA e da RESOLUÇÃO CEPESCA 02/2018, que determina uma série de normas para a exploração dos recursos pesqueiros na área de entorno da EE de Taiamã, a qual atinge o segmento de pesca amadora de forma significativa.

Em outra deliberação do conselho consultivo da Estação, onde foi proposta a exigência de autorização direta pela Estação Ecológica de Taiamã para empresa/barco-hotel/chalana/pousada/hotel que queira trazer pescador amador para pescar nas proximidades do limite da área do acordo de pesca (IN IBAMA 09/2009), teve adesão da Asatec. Esta proposta tem por base a necessidade de normatização de atividades que afetem as unidades de conservação federais, suas zonas de amortecimento ou áreas circundantes não sujeitas ao licenciamento ambiental previsto na Resolução CONAMA n◦ 237/97

Através da Resolução 001/2009 do Conselho Municipal de Defesa do Meio Ambiente do Município de Cáceres (Condema), ficou estabelecido a diminuição da cota de pesca para pescadores amadores e proibição de captura do dorado (*Salminus brasiliensis*) por medida de precaução, visto que a população da espécie estava em provável declínio e que é uma espécie de grande valor para a pesca recreativa no Pantanal. A Asatec, como integrante do referido conselho do ICMBio, apoiaram tal ação. Esta diminuição da cota máxima de pescado por turismo representou uma diminuição significativa da quantidade de peixe extraído das proximidades da EE de Taiamã.

As atividades de educação ambiental em parceria entre Asatec e EE de Taiamã já ocorreram com o objetivo de sensibilizar tripulação e proprietários de barcos-hotéis e pousadas sobre a importância da conservação da Estação, da bacia do rio Paraguai e do bioma Pantanal, com o intuito de instruir sobre a necessidade da continuidade do recurso pesqueiro, principal benefício da unidade para a população de Cáceres/MT.

Ainda com relação à Asatec, há alguns anos surgiu um novo formato de turismo adotado pelos empresários da região, o de observação da natureza, o qual obviamente possui como um de seus objetivos a conservação da natureza. Os guias, turistas e demais envolvidos no processo, além de realizar ações de observação de belezas naturais, também inibem a ação de possíveis infrações ambientais. Contudo, este novo formato corresponde a uma pequena parte do total de turistas que vão ao Pantanal na região de Cáceres/MT.

6.1.2. Pesca Profissional

A pesca tem grande importância para a população de Cáceres-MT, pois é a base econômica para muitas famílias de baixa renda que utilizam as águas da bacia do alto rio Paraguai. A Colônia de Pescadores Z-2 de Cáceres-MT foi criada através da Portaria nº 046 da Confederação Nacional dos Pescadores, em 03 de junho de 1982, estando situada às margens do Alto Paraguai, na zona urbana da cidade de Cáceres. A Colônia conta com aproximadamente 800 associados, sendo que uma pequena porção, talvez 50 pescadores, realmente se instalam em acampamentos no entorno próximo da EE de Taiamã.

Como entidade organização dos/as pescadores/a de Cáceres, existe também a Associação dos Pescadores Profissionais de Cáceres – APPEC.

De acordo com o levantamento de dados realizado por Bezerra *et al*, (2005 e 2006), é possível apresentar preliminarmente, o perfil dos pescadores artesanais de Cáceres. No momento da realização desta pesquisa a maioria (69,62 %) dos pescadores da Colônia Z-2 é de Mato Grosso, sendo alguns oriundos de outras localidades, mas predominam pessoas nascidas em Cáceres. De acordo com Bezerra (2009) cerca de 78,48% têm casa própria; 16,45% ainda pagam aluguel e 5,07%, vivem "de favor" em casa de parentes e filhos. Conforme o mesmo autor 3,79 % dos pescadores envolvidos com a pesca no rio Paraguai possuem idade entre 16 a 30 anos, ressaltando-se que esses são filhos e sobrinhos de pescadores profissionais mais velhos. Pescadores com idades entre 31 a 50 anos correspondem a 46,85 % e, em maior número, constituindo quase a maioria, estão os pescadores com idade entre 51 a 73 anos (49,36 %). Há muitos que se aposentaram, mas continuam pescando. Existem 93,6% de homens nessa atividade e apenas 6,4% de mulheres. Em relação ao tempo que pescam, 40,5% iniciaram a atividade há até 10 anos; 30,3 % têm de 21 a 30 anos na pesca; 17,8% já estão há um longo tempo de vida pescando; 8,8% estão entre 31 a 40 anos na pesca profissional e 2,6% não informaram. Verificou-se que 49,5 % têm de um a quatro filhos; 36,8 % de cinco a nove filhos; 3,9% de 10 a 13 filhos; e, 10% não têm filhos ainda. Em relação a renda obtida com a atividade, 68,3% dos pescadores, alcançam um salário mínimo; 29,1 % atingem dois salários e 2,6 % mais de três salários. Com relação ao grau de escolaridade, observa-se as seguintes relações: de pescadores analfabetos 25,4 %; 1° grau incompleto 60,7%; concluíram o 1° grau 7,6%; 2° grau completo 5%, superior completo 1,3%. (Bezerra *et al*, 2005).

Da mesma forma que a Asatec, a participação da Colônia de Pescadores no Conselho consultivo da EE de Taiamã sempre foi fundamental, de forma a apoiar as ações em prol da conservação da biodiversidade, como o apoio à criação e implementação da IN09/2009 IBAMA e sua revisão, a adesão às políticas do conselho de solicitação de autorizações diretas por parte das embarcações de pesca amadoras citadas anteriormente, dentre outras participações de grande valor.

São realizadas eventualmente, durante o período de defeso, reuniões com os pescadores profissionais da Colônia de Pescadores Z-2, com objetivo de sensibilizar esse público sobre a importância de ações de conservação no bioma Pantanal. Normalmente são abordados temas como características do Pantanal, legislação de pesca, formas de fortalecimento da categoria e aspectos específicos da EE de Taiamã.

6.1.3. Entrevistas com pescadores profissionais da colônia de pescadores Z-2

Com o intuito de verificar a percepção dos pescadores profissionais da colônia de pescadores sobre a Estação Ecológica de Taiamã, foi realizada no segundo semestre de 2014 uma pesquisa através de entrevistas, a qual foi conduzida pela pesquisadora Cláudia de Pinho, uma importante personalidade local representante das comunidades tradicionais. Participaram da pesquisa 31 pescadores profissionais filiados à colônia, com idades entre 38 e 84 anos. Os gestores da UC optaram por não participar do processo para evitar qualquer tipo de influência nas respostas dos entrevistados.

Importante ressaltar que os pescadores profissionais consideram a área da RESOLUÇÃO CEPESCA 02/2018, área da ampliação, como se fosse parte da EET, visto que nas duas áreas a pesca é proibida, e quem faz a gestão da região são os gestores da Estação.

As perguntas foram divididas em quatro temas principais: (1) opinião sobre a UC (a qual reflete importância e significância), (2) relação com os gestores, (3) atividades que colaboram com a UC e (4) fiscalização.

Em todas as entrevistas as respostas referentes ao primeiro tema (31 – 100% dos entrevistados) são positivas. A leitura das respostas foi interpretativa, visto que ocorreram vários tipos de comentários, porém todos, de alguma forma, estavam avaliando positivamente a importância da UC. Os resultados obtidos demonstram claramente a boa percepção que os pescadores profissionais entrevistados possuem sobe o papel da UC na conservação regional da biodiversidade, principalmente com relação à ictiofauna.

Como exemplo de respostas ao tema inicial, seguem algumas considerações feitas pelos entrevistados:

- “Acho importante ter a reserva aqui”;
- “A reserva é muito importante para nós”;
- “A reserva é um bom lugar no pantanal, precisa ter ela lá, primeiro pela beleza dela, depois por causa dos bichos, peixes”;
- “precisa zelar para não deixar acabar”;
- “É muito importante, ela é o berço do criadouro, todo peixe que sai para o pantanal, sai dali”;

- “A reserva é bom para os peixes, nós pescadores temos que ajudar a preservar lá também, é para nós mesmos, para agora e para o futuro”;
- “Ela é importante, se não tivesse a reserva não tinha mais peixe nesse rio”;
- “Acho que ela é boa para todo mundo. Tem muito peixe nela, porque eles sabem que lá estão seguros”.

No segundo item das entrevistas, relação com o gestor, a maioria das respostas foi positiva (25 entre 31 entrevistados, ou 80,65%). Somente um dos pescadores (3,22 % do total) avaliou negativamente este item. Em cinco entrevistas (16,13%) não foi possível interpretar a resposta como positiva ou negativa. Novamente é importante frisar que a leitura e análise das respostas ocorreu de forma interpretativa. Os resultados apontam que de uma forma geral a relação dos pescadores profissionais com os gestores da Estação Ecológica de Taiamã é positiva. Novamente seguem alguns tipos de resposta obtidas no estudo:

- “Se tem algum problema, nós falamos com o chefe da reserva. Nossos problemas são vários, mas com gente do nosso meio”;
- “Não tenho o que falar, ele sempre tratou bem a gente, pede com educação”
- “Nunca tive problema com o pessoal de lá, eles fazem o seu trabalho e eu faço o meu direito”;
- “No passado não tinha contato com eles de lá da reserva, hoje eles explicam a lei, e também aplicam a lei”;
- “Ele trabalha com cuidado, dá orientação, explica tudo certinho. Eles não são fiscais que inventa moda, nada. O pessoal é gente boa, conhece a gente e conversa”;
- “Nunca tive problemas com o pessoal, de vez em quando eles até passam no acampamento e conversa com todo mundo. Acho que tem que ser assim, ninguém é melhor do que ninguém, apenas temos trabalho que complementa um ao outro”;
- “Hoje o que tenho que reclamar é que de repente o pessoal da reserva chega no pescador, mexe no isopor e a gente chega até a perder o gelo”;
- “Precisa ter mais conversa com quem está no rio, com o pescador”.

O terceiro tema das entrevistas - atividades que colaboram com a UC, referente às ações que os entrevistados exercem em consonância com os objetivos da EE, gerou apenas uma resposta que se repetiu diversas vezes (13 entre 31 entrevistados), que foi o transporte de lixo encontrado no rio Paraguai em regiões próximas da Estação para a cidade de Cáceres. Outros tipos de respostas foram poucas vezes repetidas.

O último item pesquisado foi referente às ações de fiscalização de combate à pesca ilegal que ocorrem na região da EE. A resposta mais frequente

observada no relatório (18 entre 31, ou 58,06%) foi a necessidade de realização de ações de fiscalização com maior frequência. Seguem abaixo alguns depoimentos:

- "Acho só que deveria aumentar a fiscalização, ter mais gente deles fiscalizando";
- "A fiscalização faz o papel deles, acho pouca ainda, precisava ter mais consciência";
- "A fiscalização é sempre boa, mas deveria ser mais, ou dividir o pessoal, pois as vezes o pessoal vem para a cidade e já ficam sabendo que eles estão vindo, então ficam sabendo que pode ir até lá, principalmente nos fins de semana";
- "A fiscalização ainda é pouca, precisa de mais gente para ajudar o Daniel, o outro menino e a japonesa";
- "Falta mais um pouco de fiscalização, tem poucos funcionários, precisa de mais gente para fiscalizar dentro e fora da reserva";
- "Nunca tive problema com o pessoal que fiscaliza, eles pedem para ver o pescado a gente mostra e eles vão embora";
- "Pois a noite é que o pessoal aproveita para entrar e fazer o que não deve, lá do outro lado";
- "Precisa mais fiscalização para conservar o rio e os peixes. Se tivesse mais fiscalização teria mais peixe".

7. Características Físicas

7.1. Clima

O clima no Pantanal é tropical, com temperaturas elevadas e amplitude térmica maior que a de outras regiões do Brasil. Possui estações bem diferenciadas: o clima regional assemelha-se ao do Brasil Central, com médias térmicas anuais de 25 °C e chuvas entre 1.000 e 1.400 mm. As chuvas estacionais concentram-se nos meses de dezembro, janeiro e fevereiro, com 45% da precipitação total anual. O clima na região pode ser dividido em quatro estações distintas: seca (de julho a setembro), enchente (de outubro a dezembro), cheia (de janeiro a março) e vazante (abril a maio).

A região de estudo, segundo Köppen, se enquadra na categoria Aw. A letra A corresponde à zona tropical úmida, ocupada pela categoria florística de megatermas, caracterizada por vegetação tropical e temperaturas e umidade relativa do ar sempre elevadas. A temperatura média do mês mais frio é superior a 18°C, temperatura crítica para a flora tropical. A letra w corresponde,

na região, a uma precipitação anual entre 1000 e 1500 milímetros (mm), com total médio do mês mais seco inferior a 40 mm.

7.1.1. Precipitação

A precipitação média anual apresenta um gradiente do oeste do Pantanal em direção nordeste, leste e sudeste. No oeste, a precipitação é inferior a 1000 mm e a máxima é de cerca de 1300 mm. No leste este gradiente é mais suave chegando a 1600 mm no limite da bacia do Alto Paraguai. Já no norte da bacia, estes valores ultrapassam os 2000 mm. A concentração de precipitação durante os meses mais chuvosos ocorre no leste e, principalmente, no norte da bacia do Alto Paraguai. Embora o clima no Pantanal e arredores caracterize-se pela sucessão de invernos secos e verões chuvosos, parece haver um gradiente de norte para sul. Ao norte do Pantanal, em Cuiabá e Cáceres, por exemplo, o período chuvoso é mais curto e a seca, no inverno, mais severa. Já no Pantanal Sul, o período chuvoso tem sua precipitação distribuída ao longo de um período maior que no norte, com volume de precipitação total similar, evidenciando uma transição em direção ao sul para os climas sem estação seca (Hasenack et al., 2003).

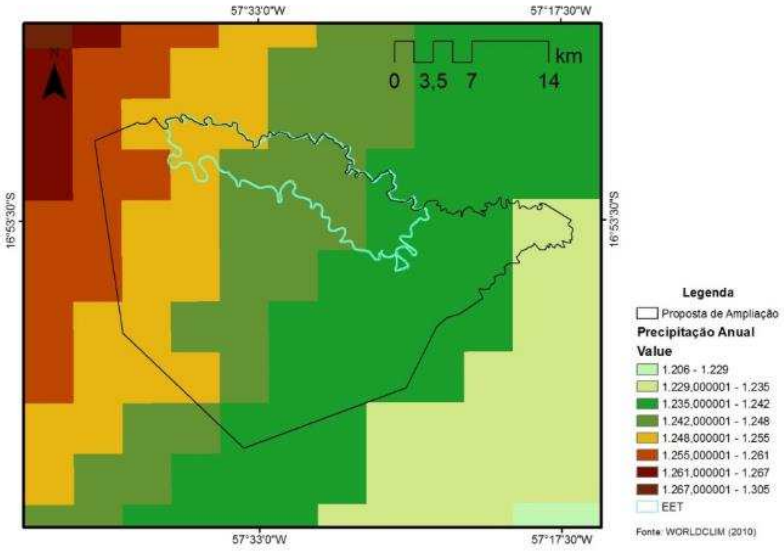


Figura 17 - Precipitação em milímetros na região da EET.

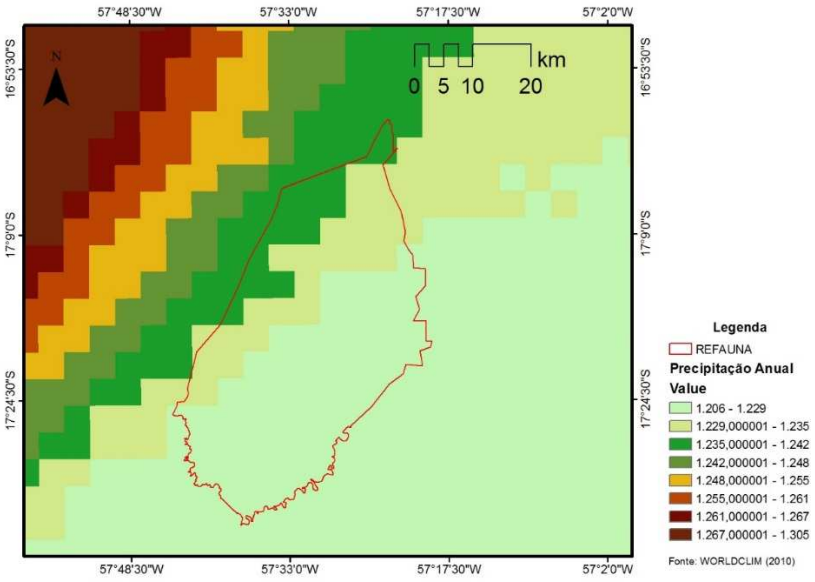


Figura 2 - Precipitação em milímetros na região da Reserva de Fauna.

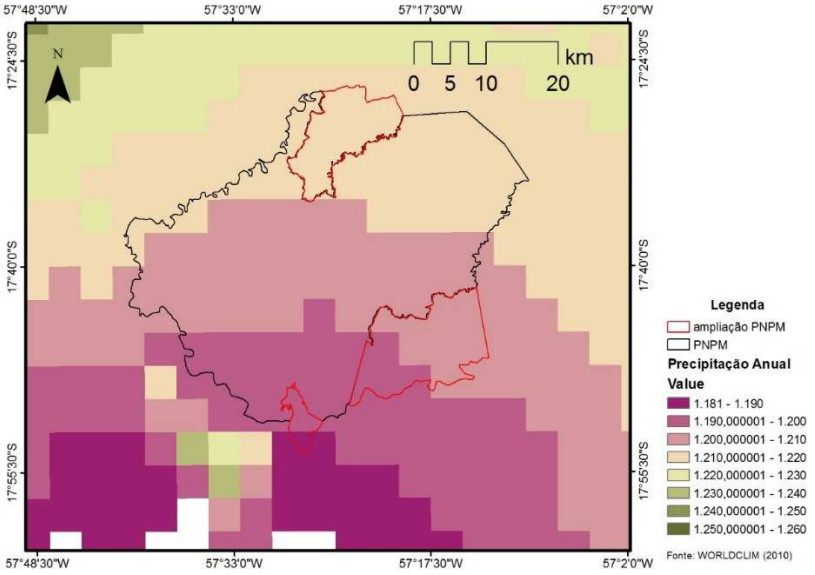


Figura 3 - Precipitação em milímetros na região do Parque Nacional do Pantanal Matogrossense.

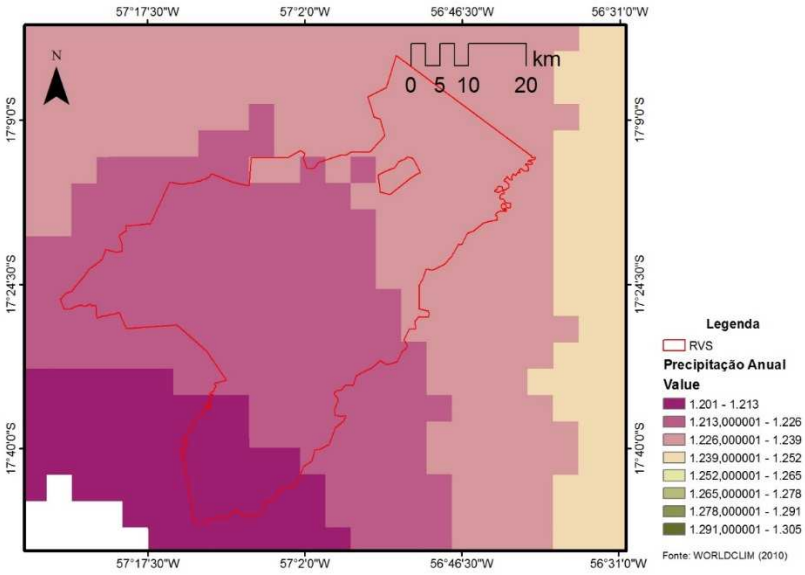


Figura 4 - Precipitação em milímetros na região do Refúgio de Vida Silvestre.

7.1.2. Temperatura

As temperaturas médias mensais na região do Pantanal oscilam no verão (Janeiro) entre 26°C nas porções mais elevadas e 29°C nas porções mais baixas, ao centro e no extremo sul do Pantanal. No inverno (Julho), as temperaturas médias mensais variam entre 20°C na borda leste e sul e 23°C no centro e no norte. O sul do Pantanal apresenta amplitude térmica superior ao norte do Pantanal (8°C e 5°C, respectivamente), provavelmente devido à latitude mais elevada.

A temperatura media anual não muda muito na região das propostas de criação, com temperatura média aproximada de 26,0°C na região sul e aproximadamente 26,3°C na região norte do limite proposto (Worldclim, 2010).

7.1.3 Umidade Relativa

A umidade relativa é bastante alta, superior a 80% na maior parte do ano, porém entre agosto e novembro a umidade relativa pode baixar um pouco do valor citado (INPE).

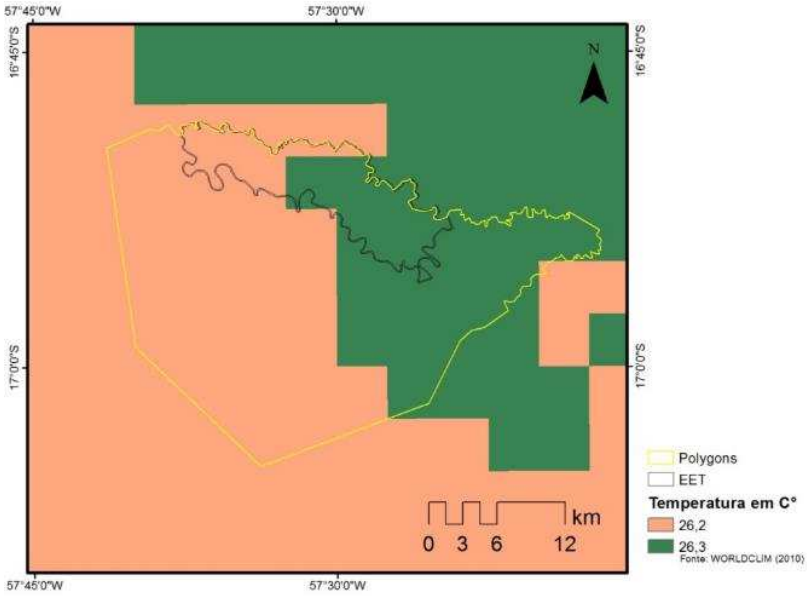


Figura 5 - Temperatura média anual na região da Estação Ecológica de Taiamã.

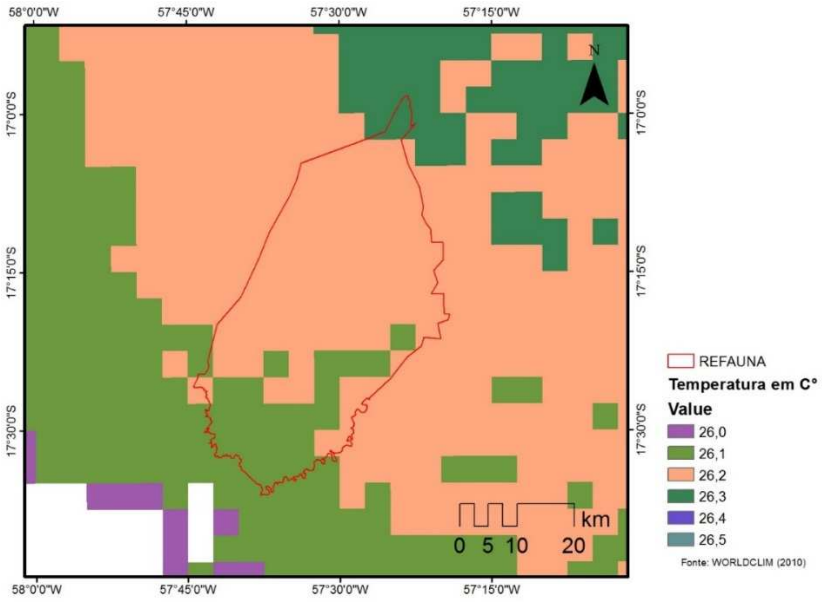


Figura 22 - Temperatura média anual na região da Reserva de Fauna.

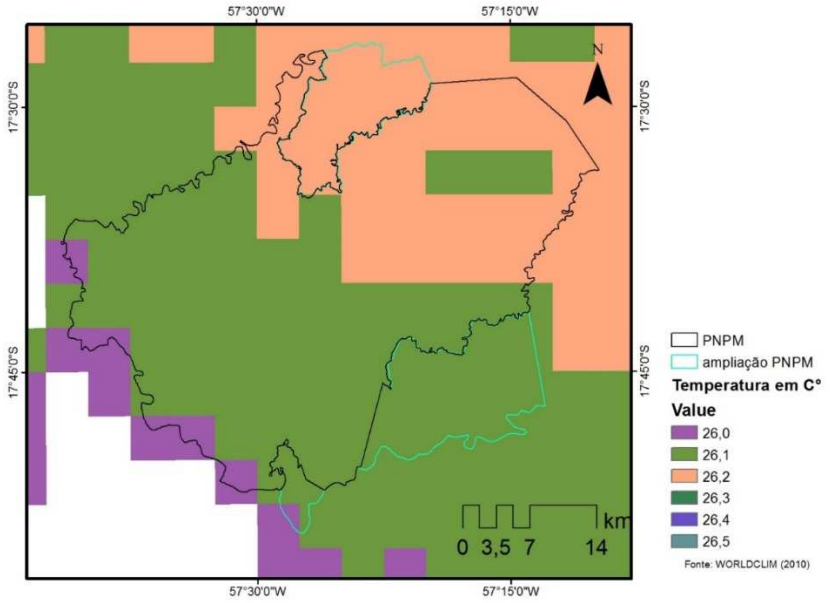


Figura 6 - Temperatura média anual na região do Parue Nacional do Pantanal MatoGrossense.

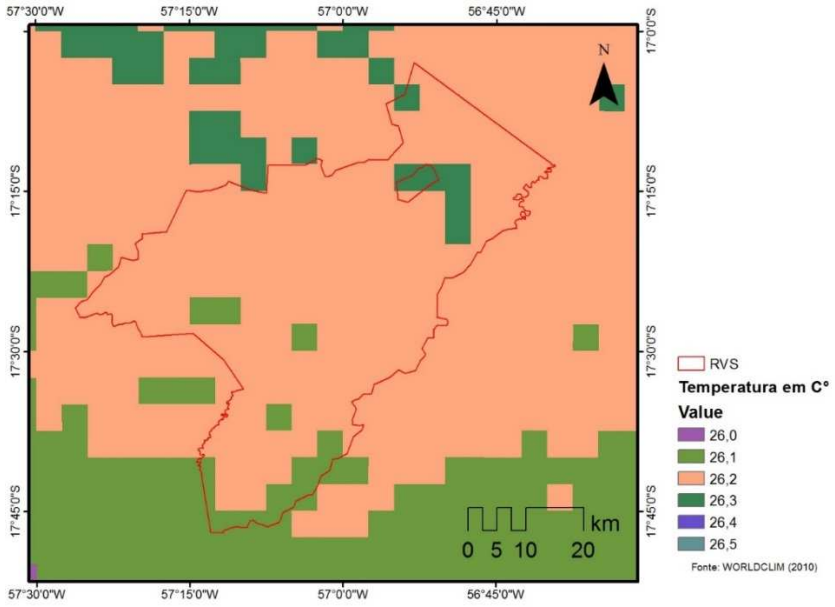


Figura 24 - Temperatura média anual na região do Refúgio de Vida Silvestre.

7.2. Geologia

Ab'Saber (1988), em um extenso trabalho sobre a origem do Pantanal Matogrossense, desenvolve a idéia de que o que hoje é uma depressão teria sido no passado uma vasta abóbada de escudo, que funcionava como área de fornecimento detrítico para as bacias sedimentares do Grupo Bauru (Alto Paraná) e Parecis.

A vasta abóbada de escudo existente até o Cretáceo comportou-se depois como anticlinal esvaziada, de grande amplitude regional. Isto teria acontecido porque durante o soerguimento pós-cretácico de conjunto teriam ocorrido nela falhamentos importantes facilitando seu desventramento.

Hoje o Pantanal Matogrossense se caracteriza por extensas planícies de acumulação, com cotas inferiores a 200 metros. Sua evolução pretérita, atual e futura está submetida às condições das áreas elevadas que o rodeiam, pois estas constituem sua fonte de água e sedimentos (Godói Filho, 1986).

7.2.1. Formação Pantanal

É formada por sedimentos aluviais dominantemente argilosos, argilo-arenosos, sílticos, arenosos e areno-conglomeráticos (camadas inferiores da seqüência) semiconsolidados e inconsolidados de idade Pleistocênica/Quaternária. É relacionada aos depósitos fluviais e lacustres de áreas periodicamente inundáveis ou sujeitas a inundações ocasionais.

Essa unidade foi descrita por Oliveira e Leonardos (1943) para denominar as formações sedimentares existentes na Depressão do Rio Paraguai, e nas planícies e nos pantanais mato-grossenses. Apresenta espessura variável que pode atingir até 200 m (Del' Arco et al., 1982), em virtude da irregularidade do seu substrato (presença de sistemas de horsts e grabens) e de estar em franco processo de desenvolvimento.

Seus depósitos recobrem localmente acumulações quaternárias mais antigas (Formação Xaraiés e Depósitos Detríticos) com relações de contato transicional (mudança de fácies). Possui registros fósseis muito escassos e bem pouco estudados, sendo que a maioria não se presta à cronoestratigrafia.

Sua idade mínima deve ser posterior à abertura da Depressão do Rio Paraguai (área de Relevos Denudacionais, de acordo com o mapa geomorfológico ora elaborado), ou seja, concomitante ou imediatamente após a formação do pediplano de idade Pliopleistocênica. Sua ocorrência na área se restringe a pequena exposição a sudoeste da Lagoa Negra.

A descrição dos sedimentos da Formação Pantanal é dificultada pela ausência de afloramentos em face da topografia plana e da cobertura vegetal.

Ao longo dos rios encontram-se algumas barrancas exibindo aqueles sedimentos, constituindo os únicos afloramentos naturais.

Formações geológicas contantes nos limites propostos para as unidades propostas são:

Q1p2 - Fácies depósitos aluvionares: sedimentos argilo-síltico arenosos.

Q2a - Depósitos Aluvionares: areia, areia quartzosa, cascalho, silte, argila e localmente turfa. Ambiente continental fluvial.

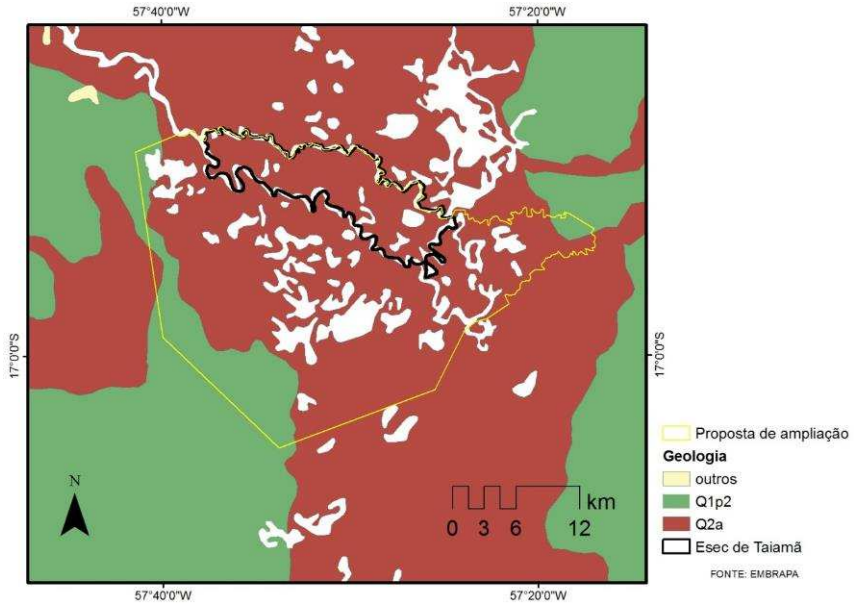


Figura 25 - Formações geológicas na região da EET.

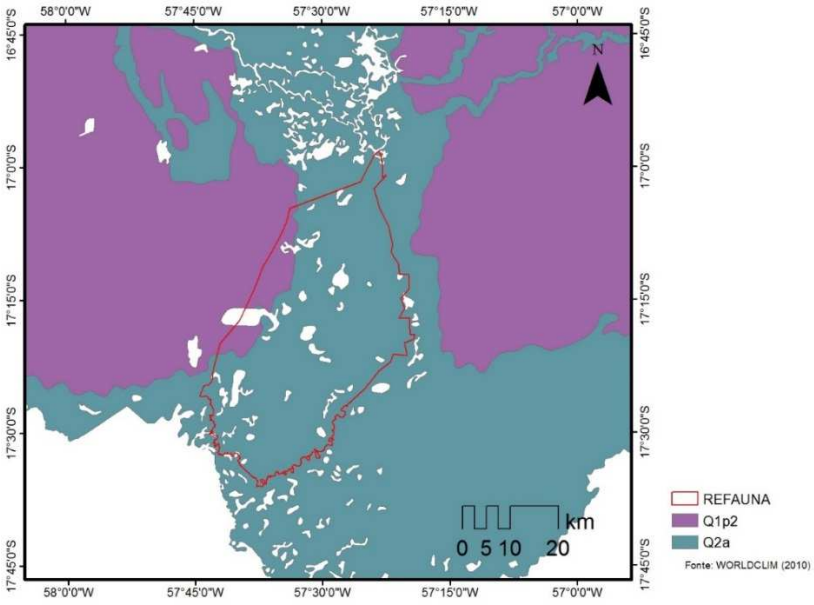


Figura 26 - Formações geológicas na região da Reserva de Fauna.

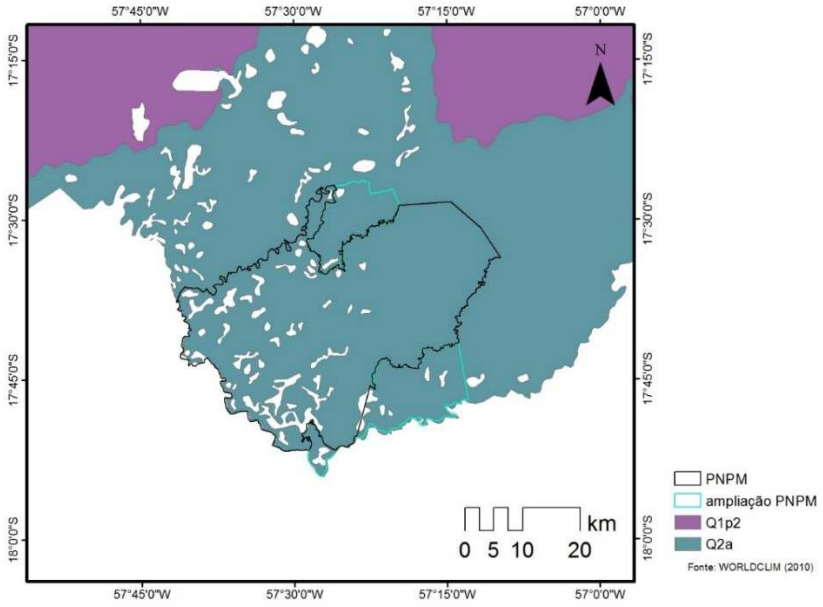


Figura 7 - Formações geológicas na região do Parque Nacional do Pantanal Matogrossense.

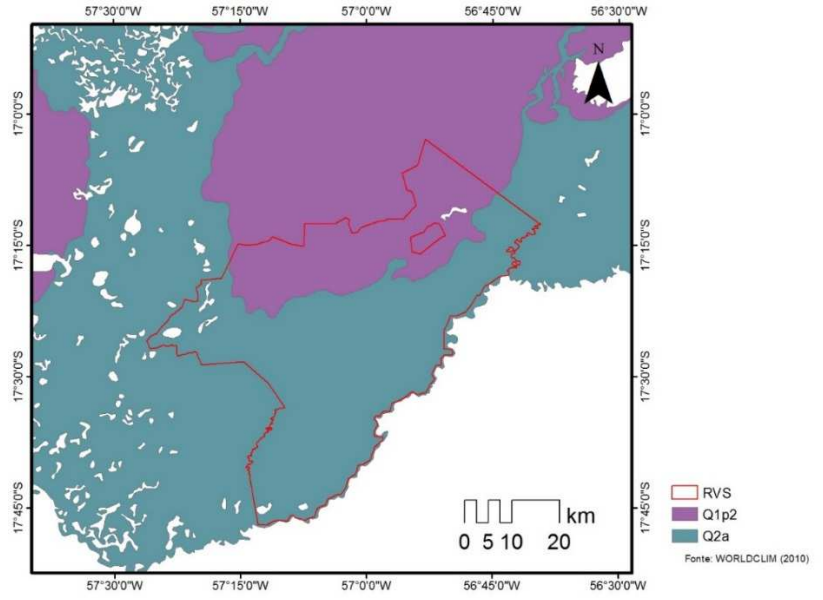


Figura 27 - Formações geológicas na região do Refugio de Vida Silvestre.

7.3. Geomorfologia

Ao longo dos trabalhos de mapeamento geomorfológico realizados através do Projeto RADAMBRASIL (Franco e Pinheiro, 1982) foram identificadas nove unidades geomorfológicas na região, destacando-se a unidade denominada Planícies e Pantanais Matogrossenses, que os autores descreveram como sendo um enorme anfiteatro voltado para oeste. Esta unidade foi subdividida

em oito Pantanais, individualizados por suas características morfogenéticas (altimetria relativa, litologia e pedologia) e botânicas: Pantanal do Corixo Grande-Jauru-Paraguai, do Cuiabá-Bento Gomes-Paraguaizinho, do Itiquira-São Lourenço - Cuiabá, do Taquari, do Negro, do Miranda-Aquidauana, do Jacadigo-Nabileque, e de Paiaguás. Toda a discussão relativa à incorreção do uso do termo Pantanal (uma vez que não se trata de uma área com características pantanosas) e às diferentes propostas de sub-divisões da região foi extensamente relatada por da Silva e Abdon (1998). O principal fato é que embora toda a área esteja submetida a uma gênese comum, caracterizada pelo processo de acumulação, a diferente disposição dos sedimentos confere características distintas a cada subunidade.

O trabalho mais recente sobre subdivisões no Pantanal (Mioto et al., 2012), divide o bioma em 18 sub-regiões. A nomenclatura das regiões foi obtida observando-se os nomes clássicos de estudos anteriores. É importante ressaltar que o limite de Pantanal adotado ultrapassou o limite territorial brasileiro, ou seja, não se atentou somente à delimitação do Pantanal brasileiro e sim até a região do Nabileque/Chaco, adentrando a Bolívia e o Paraguai. A região onde encontra-se a EE de Taiamã é a denominada Tuiuiú, a qual corresponde a 6% da área do Pantanal (considerando o limite adotado por Mioto et al. (2012)). A área proposta para ampliação da ESEC ocupa predominantemente a sub-região Tuiuiú, além de Cáceres e Poconé.

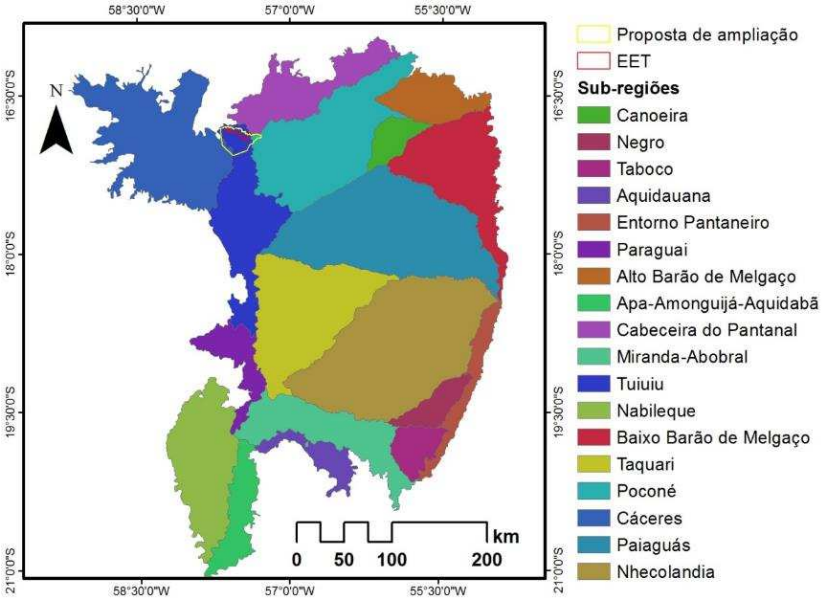


Figura 28 - Sub-regiões do Pantanal, com destaque para a ampliação da Estação Ecológica Taiamã (Mioto et al., 2012).

A área proposta para ampliação do Parque ocupa somente a sub-região Tuiuiú, e a área proposta para criação da reserva de fauna ocupa predominantemente a sub-região Tuiuiú, além de uma pequena porção da formação Cáceres e a proposta de criação do refúgio ocupa predominantemente a sub-região Poconé com parte da formação Tuiuiú.

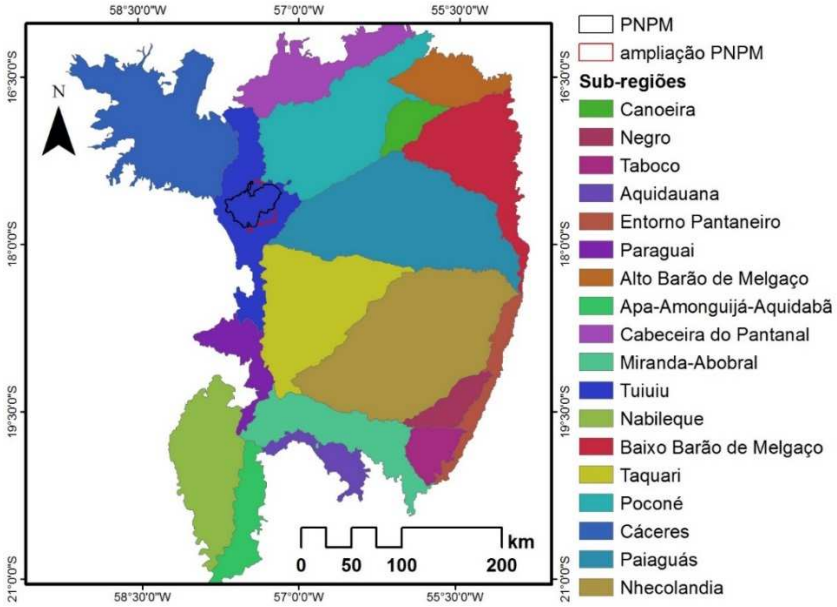


Figura 29 - Sub-regiões do Pantanal, com destaque para a ampliação do Parque Nacional do Pantanal Matogrossense (Mioto et al., 2012).

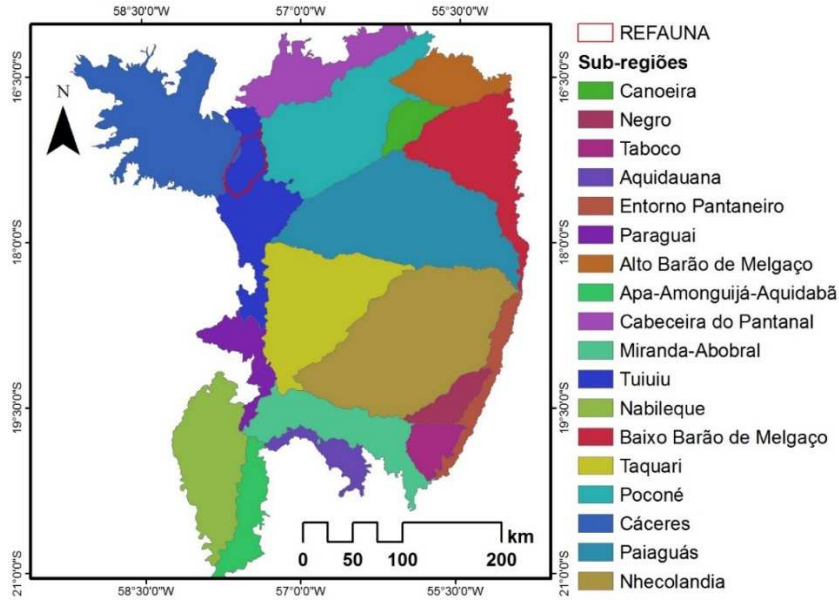


Figura 30 - Sub-regiões do Pantanal, com destaque para a criação da Reserva de Fauna do Pantanal (Mioto et al., 2012).

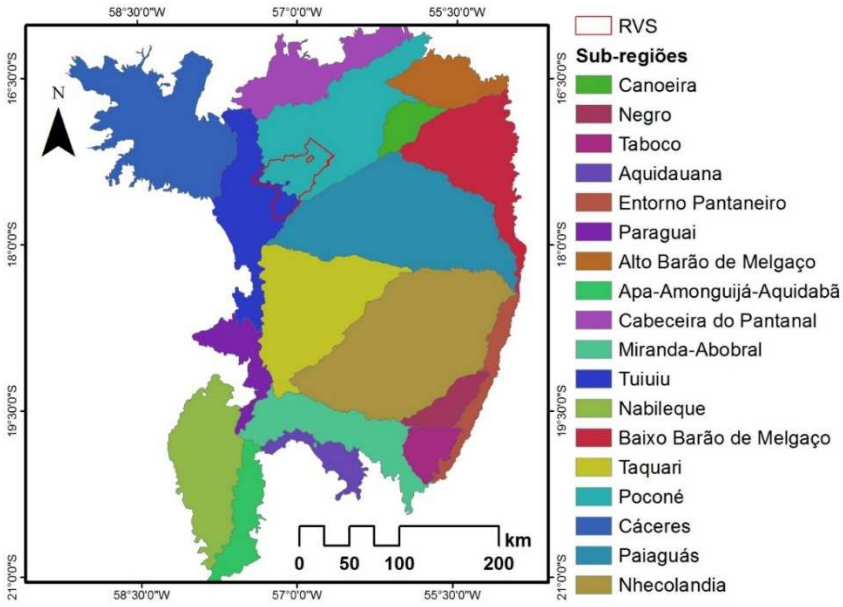


Figura 31 - Sub-regiões do Pantanal, com destaque para a criação do Refugio de Vida Silvestre da Onça Pintada (Mioto et al., 2012).

Segundo Silva (2007), o curso do rio Paraguai em sua extensão no Município de Cáceres pode ser compartimentado, de montante para jusante, em quatro segmentos: I (da foz do rio Seputuba até a foz do rio Jauru), II (da foz do rio Jauru até a Baia das Éguas), III (da Baía das Éguas até a proximidade do Castelo de Areia) e IV (a partir da localidade conhecida como Castelo de Areia)Figura . Tais segmentos apresentam distintas características geomorfológicas, expressadas em termos de diferentes elementos morfológicos e de processos fluviais atuantes. Os dois segmentos superiores apresentam como característica comum o fato de a planície encontrar-se embutida em um vale entrincheirado em depósitos mais antigos, com terraços marginais que decrescem para jusante.

O segmento I possui extensão de 71 km, planície de inundação com largura média de 1700 m. Neste segmento o rio Paraguai apresenta largura média de 150 m e sinuosidade de 2,2. Nesta porção, o rio apresenta barras em pontal e lagoas em meandros abandonados. O segmento II, com extensão de 35 km e planície de inundação com aproximadamente 3000 m de largura, o rio apresenta largura média de 200 m e sinuosidade de 1,1. Nesta área o canal é retilíneo, apresentando barras alternadas e várias ilhas fixas. Já a planície de inundação apresenta canais menores com alta sinuosidade, de natureza reliquiar, mas ainda ativos durante as cheias.

Os outros dois segmentos apresentam características completamente distintas, uma vez que a planície de inundação não está condicionada pela presença de terraços, e as águas de inundação se espraiam de forma divergente em relação ao canal, já na planície do Pantanal.

O segmento III tem 51 km de extensão e seu início é marcado pela deflexão do rio para leste. O canal possui largura média de 250 m e índice de sinuosidade de 1,6, sendo comuns trechos com meandros abertos e a presença de ilhas e barras vegetadas. O compartimento IV inicia-se nas proximidades do ponto conhecido como Castelo de Areia, onde ocorre bifurcação do canal (Limite norte atual da EE de Taiamã). Os dois canais distributários apresentam alta sinuosidade, podendo ser classificados como canais meandrantes. Este compartimento representa o principal sítio de sedimentação. Ao longo do compartimento a descarga fluvial decresce para jusante devido à perda d'água para a planície que se alarga, tanto por transbordamento durante as inundações quanto por rompimento de diques marginais, compondo com a planície aluvial do Cuiabá uma paisagem repleta de lagoas, sazonalmente inudáveis, típica do Pantanal mato-grossense. Após delinear a área da atual Estação Ecológica de Taiamã, os dois canais voltam a se unir.

Toda a região possui um terreno predominantemente plano, havendo domínio de águas no período das cheias. Nas pequenas elevações há quebra de monotonia da paisagem, existindo ainda depressões que recebem a denominação de "baías".

A região do limite proposto para a ampliação está localizada na planície fluvial não confinada (compartimento IV).

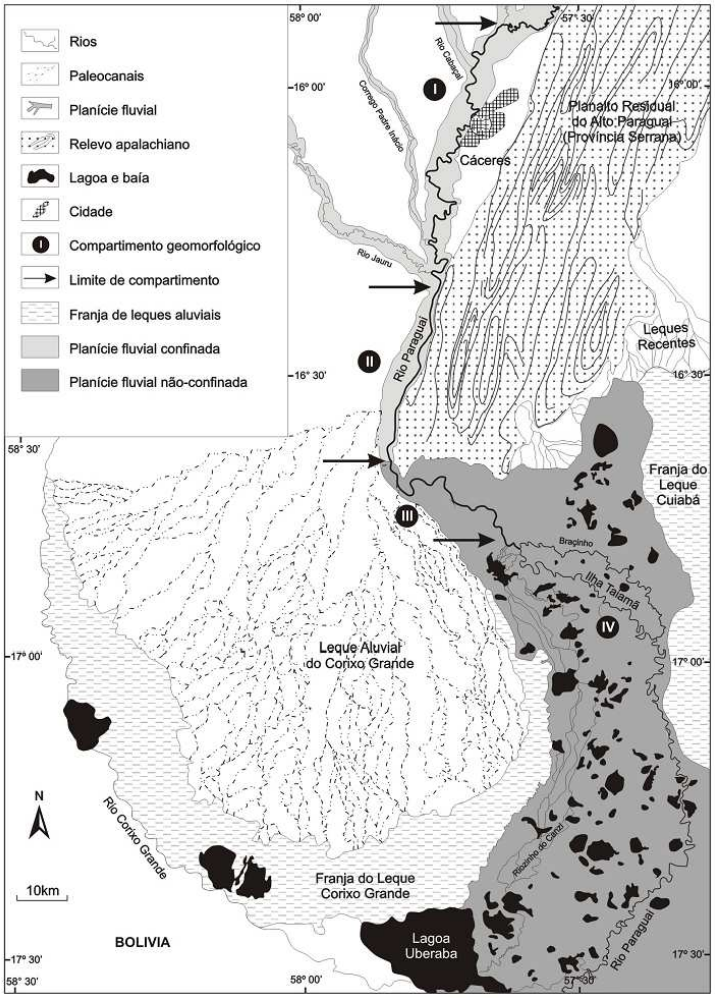


Figura 32 - Geomorfologia (Modificado de Silva et al., 2007).

O relevo da região é predominantemente plano, com amplitude da ordem de 18 metros e altitudes entre aproximadamente 93 e 111 m (topographic-map, 2018).

7.4. Solos

A área de estudo apresenta basicamente 3 classes de solos. As classes de solos foram identificadas segundo o volume Diagnóstico dos Meios Físico e Biótico do Plano de Conservação da Bacia do Alto Paraguai (PCBAP) (1978): Planossolo, Vertissolo, Plintossolo.

7.4.1. Descrição das Características Físicas dos Solos (PCBAP, 1997)

Planossolo

Esta classe compreende solos minerais, geralmente hidromórficos, com horizonte B textural e mudança textural abrupta, de tal forma marcante que, no solo seco, forma-se uma fratura de separação entre esse e o horizonte A, ou mais tipicamente E, sobrejacente. No horizonte B, de densidade relativamente elevada e em geral policrômico, observa-se a ocorrência de cores de redução, evidenciando drenagem ruim ou imperfeita. (Camargo et al*.,* 2007)

São solos típicos de relevo plano e ocorrem em todo o Pantanal Mato-grossense, desde o norte até o sul, desenvolvidos de depósitos sedimentares da Formação Pantanal. Apresentam horizonte A do tipo moderado, em geral seguido de horizonte E, bastante espesso, que alcança até 120 cm de profundidade. No horizonte B, bastante impermeável, são comuns feições relacionadas à alta umidade, como presença de mosqueados e cor cinza, que evidenciam condições redutoras. Em alguns casos, apresentam caráter plíntico e concrecionário.

A pouca disponibilidade de nutrientes, a acidez naciva nos solos distróficos e álicos, a elevada concentração de sódio de caráter solódico, a drenagem imperfeita e o regime de alagamento no período chuvoso a que estão submetidos restringem o aproveitamento desses solos ao uso como pastagem natural.

Plintossolo

Esta classe compreende solos minerais, hidromórficos ou não, sujeitos a condições de forte restrição à percolação de água. Apresentam horizonte plíntico dentro dos 40 cm superficiais, ou a maiores profundidades quando subjacente a horizonte E ou a horizonte(s) com coloração variegada ou com mosqueados abundantes, ou com o predomínio de cores pálidas ou pouco cromadas indicando ambiente de redução por excesso de água.

A maior ocorrência desses solos é verificada nas planícies e pantanais mato-grossenses, sobre sedimentos quaternários da Formação Pantanal, principalmente ao norte do rio Piquiri, e em pequena área na Depressão do Rio Paraguai, ao sul.

São solos álicos, distróficos ou eutróficos, com predomínio dos distróficos e álicos, com argila de atividade baixa ou alta. Verifica-se também a ocorrência de solos com caráter solódicos, considerados para fins de elaboração de legenda como grupo distinto. Apresentam textura arenosa/média ou média/argilosa e caráter abrupto ou não, destacando-se a ocorrência expressiva de solos com horizonte E álbico.

Em virtude do regime de inundação a que estão sujeitos, do acentuado distrofismo e das condições de má drenagem, o pastejo sobre gramíneas nativas constitui por certo a melhor opção de uso.

Vertissolo

Esta classe compreende solos minerais hidromóficos ou com sérias restrições à percolação de água, contendo 30% ou mais de argila e quantidades apreciáveis de minerais de argila do grupo das esmesctitas (argilo-minerais

2:1) e sequência de horizontes A, C (Camargo et al., 1987). Apresentam pronunciada mudança de volume com a variação de teor de umidade, tendo como feições morfológicas características a presença de fendas de retração largas e profundas, que se abrem desde a superfície, nos períodos secos, superfícies de fricção (*slickensides*) em seções mais internas do solo e unidades estruturais grandes e em forma de cunha. Ocasionalmente, microrrelevo gilgai pode delinear a superfície dos terrenos de alguns solos.

Apresentam horizonte A moderado ou chernozêmico e caráter carbonático, cálcico e solódico, neste último caso considerado como grupo distinto para fins de elaboração de legenda de solo.

Embora possuam boa disponibilidade de nutrientes para as plantas, grandes restrições à utilização são determinadas por suas propriedades físicas, como o endurecimento e fendilhamento acentuado quando secos e o rápido encharcamento quando molhados, que dificultam sobremaneira a mecanização, além de causar danos às raízes. Acresce-se a isto o regime de inundação a que estão submetidas.

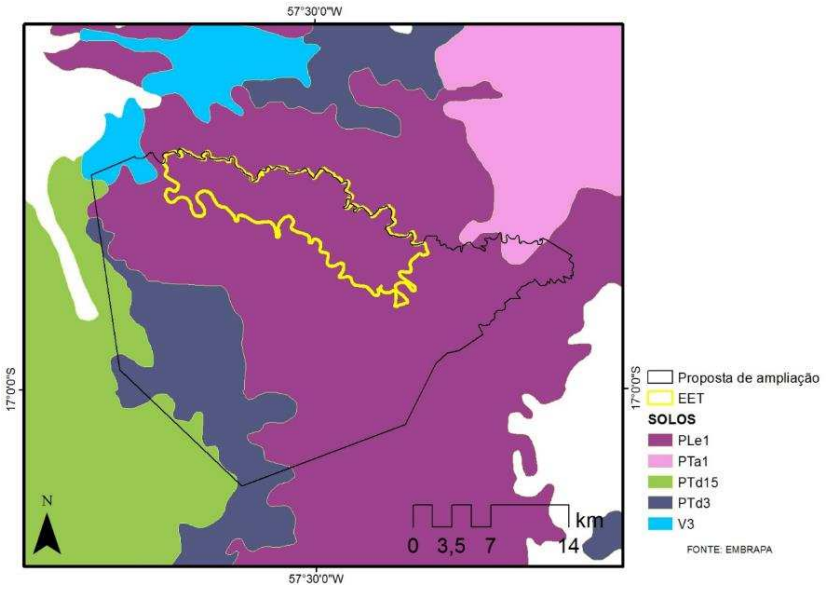


Figura 33 - Solos da região da EET.

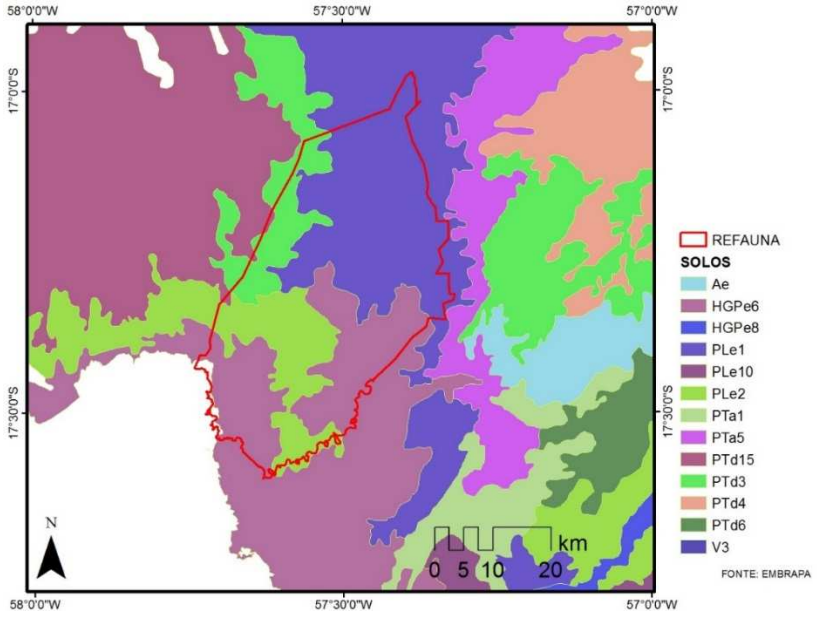


Figura 34 - Solos da região da Reserva de Fauna.

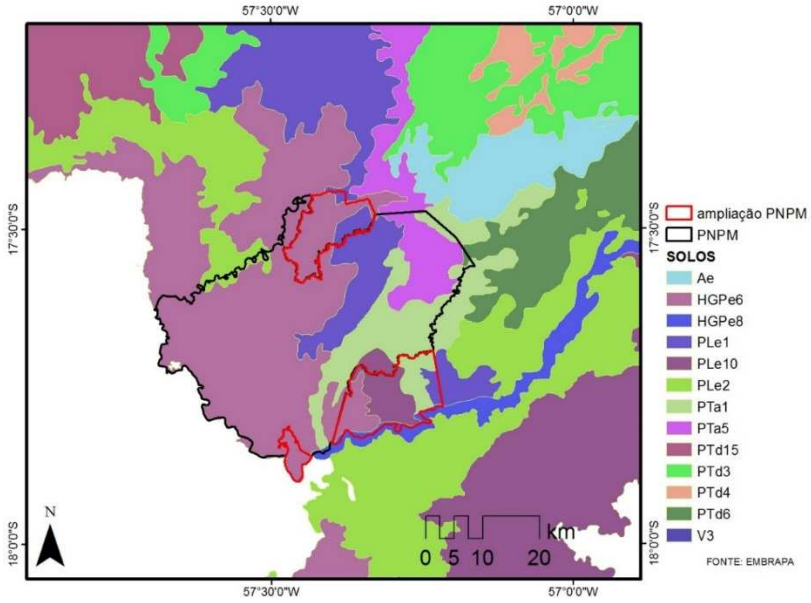


Figura 8 - Solos da região do Parque Nacional do Pantanal Matogrossense.

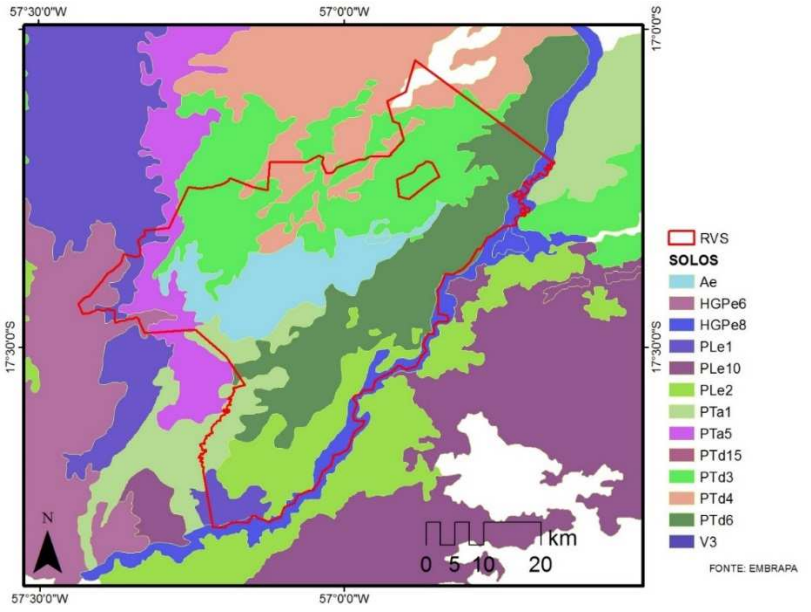


Figura 36 - Solos da região do Refugio de Vida Silvestre.

7.5. Hidrografia

O rio Paraguai possui 2.612 km de extensão, nasce no Planalto Central, na Serra do Araporé (conhecida por Serra das Pedras de Amolar) e deságua no rio Paraná próximo a Corrientes, na Argentina. Sua bacia de drenagem totaliza 1.095.000 km², compreende os Estados de Mato Grosso e Mato Grosso do Sul e parte dos territórios da Bolívia, do Paraguai e da Argentina (ANA, 2004). O rio e seus afluentes percorrem uma extensa área de planície e são extremamente importantes na manutenção das características dos pantanais matogrossenses.

Mesmo sendo um rio de planície, o rio Paraguai pode ser dividido em quatro segmentos distintos: Paraguai Superior, Alto Paraguai, Médio Paraguai e Paraguai Inferior, de acordo com o IBGE (1977).

Os principais tributários do rio Paraguai são, em sua margem direita, os rios Jauru, Cabaçal e Sepotuba e, na margem esquerda, o São Lourenço (com seu afluente Piquiri), Taquari, Negro e Miranda (com seu afluente Aquidauana) e mais ao sul, o rio Apa.

As altitudes em toda a bacia variam de 1.000 m a menos de 100 m, sendo as altitudes acima de 200 m consideradas como parte alta da bacia. As terras mais baixas, com altitudes inferiores a 80 m, formam extensa planície do Pantanal MatogGrossense.

A fraquíssima declinação do Pantanal (3 a 4 cm/km no sentido Norte-Sul e 25 cm/km na direção Leste-Oeste, resultando num escoamento mais rápido no sentido Leste-Oeste) provoca um barramento no escoamento das águas do Paraguai e como conseqüência o alagamento da área (Carvalho, 1986).

Os fatores de ordem natural que causam as enchentes periódicas e ou excepcionais com certa ciclicidade são as chuvas periódicas anuais regulares que caem na bacia do rio Paraguai, principalmente nos seus afluentes superiores, a uniformidade topográfica, os fracos desníveis de relevo e a predominância de litologias sedimentares recentes (Alvarenga et al., 1993).

O trimestre mais chuvoso no alto curso do rio Paraguai é janeiro/fevereiro/março. As lagoas e áreas inundadas pelo rio Paraguai funcionam como reservatórios que liberam a água lentamente para o leito principal, fazendo com que a mesma massa d'água demore até seis meses para alcançar o final da bacia, na parte brasileira. Como visto, além dos ciclos de cheia/seca anuais ocorrem os ciclos plurianuais, de 10 a 13 anos. Desde 1974 o Pantanal encontra-se em um grande período de cheias mais expressivas (Galdino e Clarke, 1995).

Em Mato Grosso, as cheias no rio Paraguai, ocorrem durante o período mais chuvoso, ou seja, de Janeiro a Abril, e atingem a cidade de Corumbá (MS), em Abril, Maio e Junho, após cessar as chuvas, devido à lenta drenagem do Pantanal.

Devido ao regime de inundações periódicas ocorre a formação de corpos d'água denominados "corixos e baias". Os corixos são cursos d'água perenes que ligam uma baia a outra. Na época de cheias, as espécies da fauna costumam abrigar-se em faixas de terreno que separam uma baia da outra, denominadas "cordilheiras" (Guarim-Neto, 1983).

Na região da Estação Ecológica de Taiamã rio Paraguai delimita a unidade, pois na região da UC ele se bifurca em dois canais distributários. O reencontro dos canais delimita a área da unidade de conservação. A denominação local para os dois canais citados é rio Bracinho (esquerda) e rio Paraguai (direita). Importante observar a grande quantidade de corpos d'água na área proposta para ampliação daESEC e da área da proposta da Reserva de Fauna e no

interior dos limites atuais da Estação Ecológica de Taiamã. Durante o período de cheia, quase a totalidade da área da EE fica alagada devido ao transbordamento da água dos rios da bacia do rio Paraguai e afluentes na região da UC.

Segundo FROTA et al. (2017), dentre os 56 macrohabitats descritos na área úmida do Pantanal Matogrossense de acordo com o Sistema de Classificação e Delineamento das Áreas Úmidas Brasileiras (Brasil/MMA, 2015), seis foram identificados na área de estudo, sendo eles (1) Floresta com Monodominância de *Erythrina fusca* (Abobral), (2) Arbustais e Florestas Pioneiras ao Longo de Rios, (3) Campo Inundado, (4) Partes Centrais dos Canais, (5) Lagos de Depressão e (6) Pântanos Flutuantes - Batumes. O macrohabitat Pantanos flutuantes corresponde a 48% da área da UC, fato que demonstra a característica alagada da Estação mesmo no período da estiagem (período de amostragem do estudo de FROTA et al., 2017).

Se por um lado a Estação Ecológica, a proposta de reserva de fauna e o Parque nacional do Pantanal mato-grossense apresentam a sua dinâmica de cheias relacionadas ao rio Paraguai, a proposta de criação do refúgio de vida Silvestre além de ter influência do rio Paraguai também tem influência do rio Cuiabá/São Lourenço.

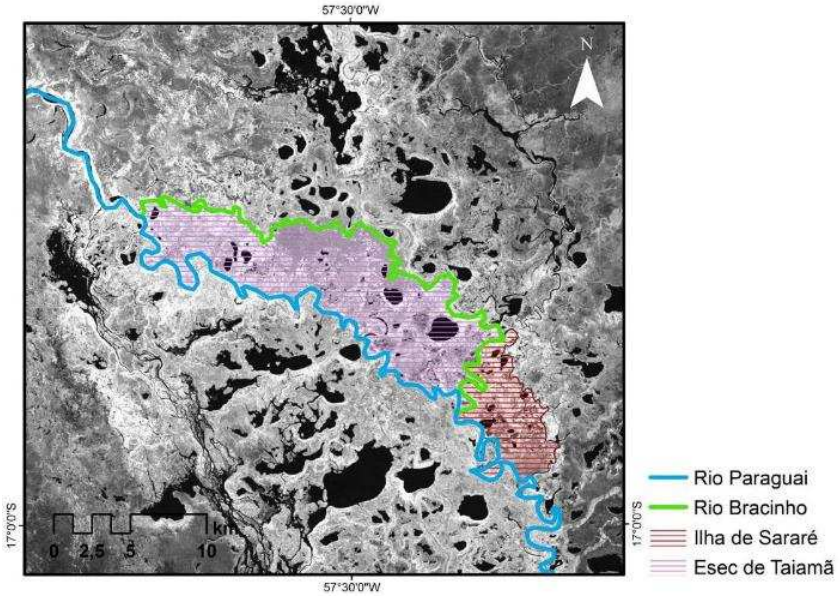


Figura 37 - Região da EET e rios que circundam a UC. As formas em preto são corpos d´água.

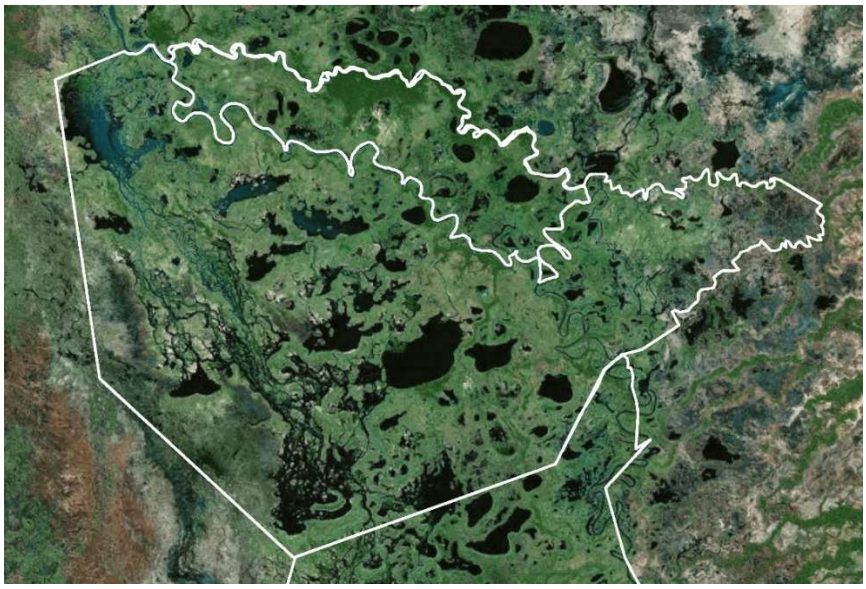


Figura 38 - (A) Imagem de satélite da Ampliação da ESEC Taiamã. As regiões escuras são corpos d'água.

B

Figura 39 - Foto aérea da região proposta de ampliação da Estação.

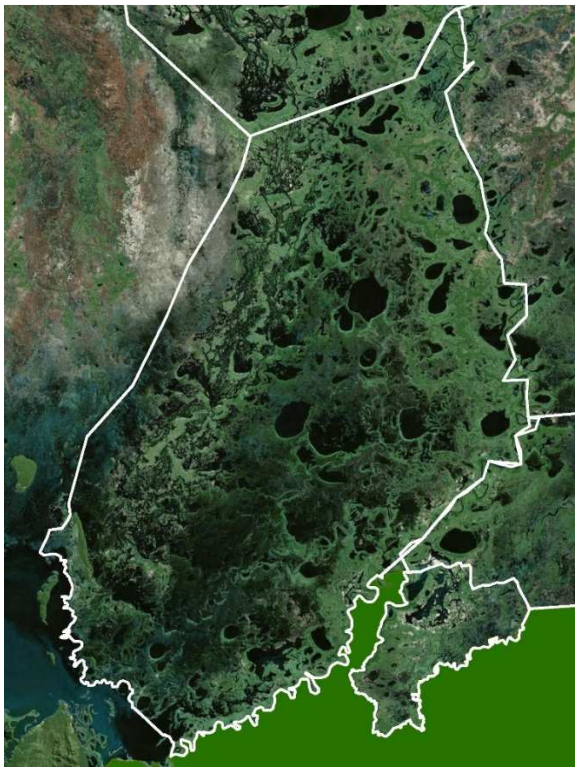


Figura 40 - Imagem de satélite da Reserva de Fauna. As regiões escuras são corpos d'água

Figura 41 - Foto aérea da região proposta de criação da Reserva de fauna.

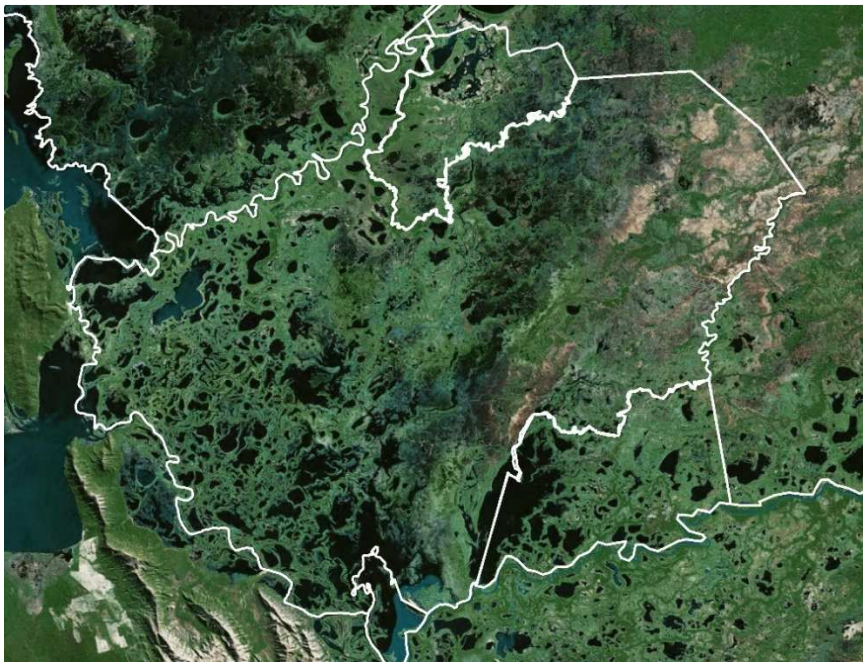


Figura 42 - Imagem de satélite da ampliação do parque nacional do pantanal matogrossense

Figura 43 - Foto aérea da região do parque nacional do pantanal matogrossense

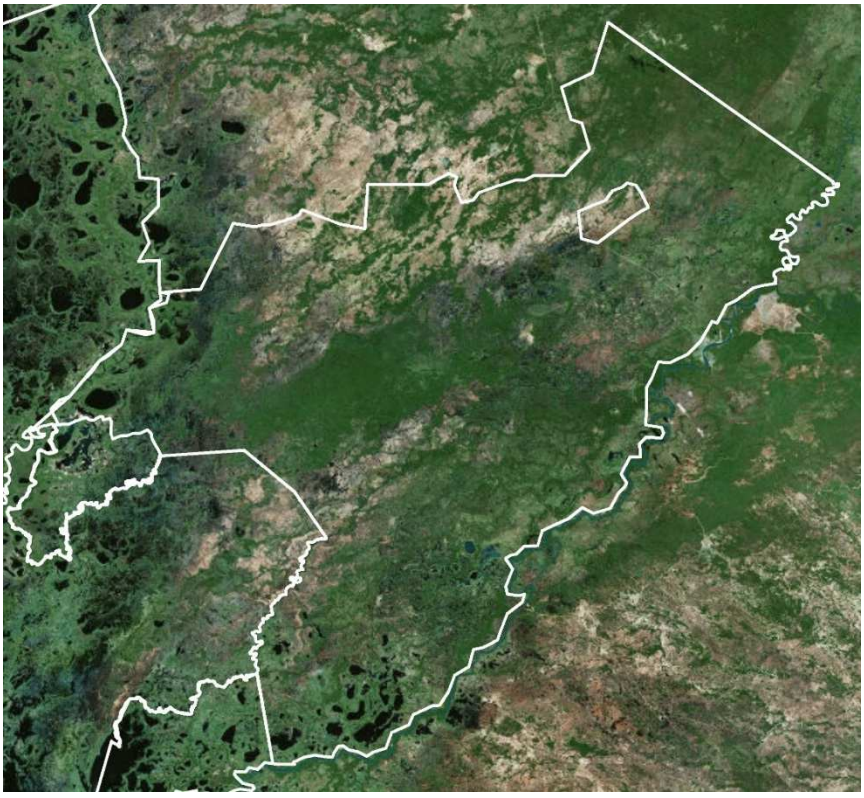


Figura 44 - Imagem de satélite do Refúgio de Vida Silvestre

Figura 45 - Foto aérea da região proposta de criação do refúgio de vida silvestre.

No Pantanal, o regime das inundações determina os principais processos bióticos e abióticos, bem como as composições específicas das unidades da

paisagem (Adamoli, 1995). Todo o bioma é influenciado pelas alterações no regime de inundações, causando mudanças na cobertura vegetal.

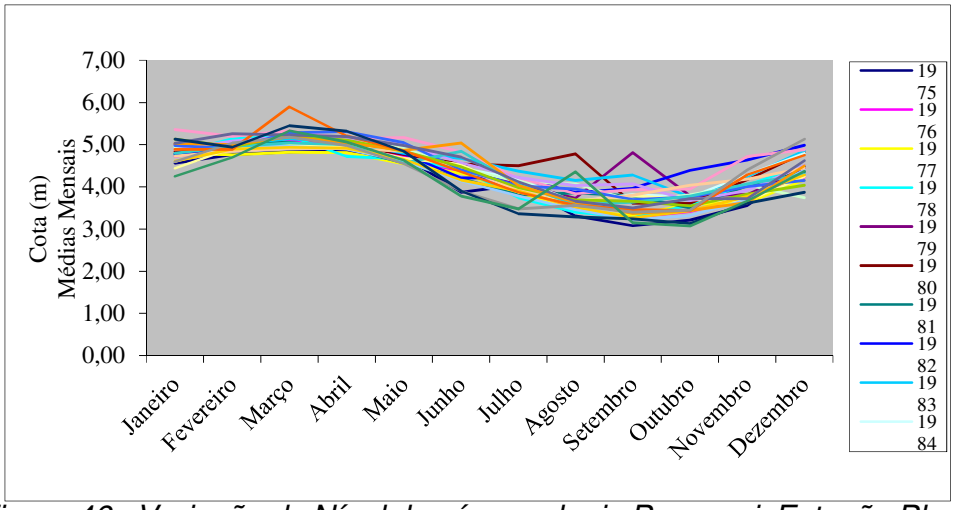


Figura 46 - Variação do Nível das águas do rio Paraguai. Estação Pluviométrica de Descalvado (1975-1999). Fonte: ANA – Agência Nacional de Águas.

Outra característica interessante é a presença de uma região alagada nas proximidades do rio Paraguai que se inicia na Estação Ecológica de Taiamã e termina na região do Parque Nacional do Pantanal Matogrossense abrangendo toda a região da Reserva de Fauna proposta.

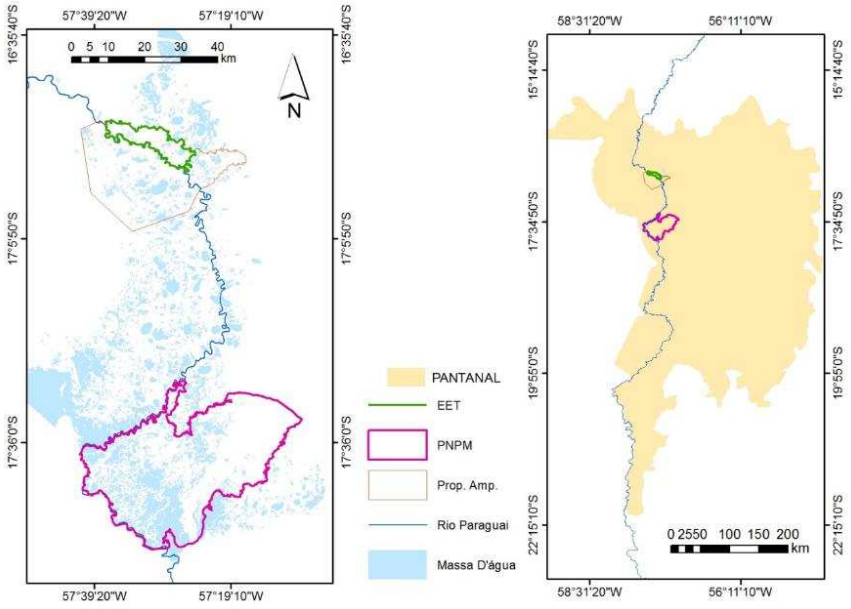


Figura 47 - EET e PNPM e localização da massa dágua entre as UCs.

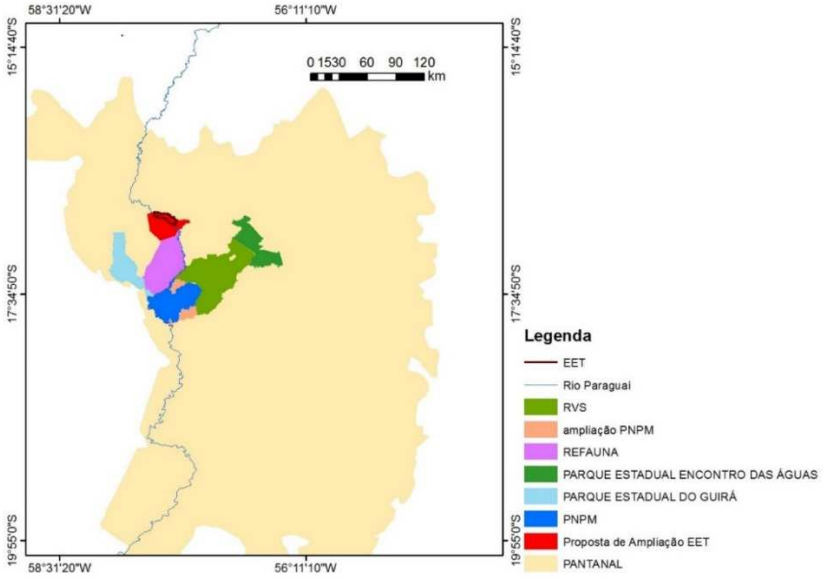


Figura 48 – Propostas de criação e a planície pantaneira

8. Características Biológicas

8.1. Algas

Levantamentos fitoplanctônicos realizados durante um período de 14 anos na região da Estação Ecológica de Taiamã revelaram que nesta área existe uma pronunciada sucessão sazonal da comunidade de algas decorrente dos períodos de cheia e seca que ocorrem anualmente. Geralmente, durante o período das águas, a microflora fica esparsa, sendo que a riqueza de espécies é dominada por algas verdes da ordem Desmidiales, as quais são notáveis povoadoras de locais pobres em minerais. Durante a estação seca, a rápida diminuição dos níveis de água aumenta drasticamente as concentrações de minerais, favorecendo o aumento populacional de algas da divisão Chlorophyta e Euglenophyta. As épocas de enchente e vazante não são claramente distinguíveis, sendo caracterizadas por uma mistura da flora, contendo elementos típicos da cheia e da seca. Cabe aqui explicitar que é praticamente impossível prever seqüências cronológicas precisas de quais espécies deverão se suceder ao longo do ano, fato que se deve principalmente às variações climáticas de ano para ano e também às diferenças que ocorrem num mesmo corpo d'água de um ano para o outro, sendo um corpo dominado durante um determinado ano por espécies de *Microcystis*, por exemplo, e em outro ano por espécie do gênero *Euglena* (De-Lamônica-Freire e Heckman, 1996) .

As macrófitas aquáticas do Pantanal influenciam profundamente as comunidades de algas de duas formas. (1) Elas monopolizam os nutrientes disponíveis durante seus períodos de desenvolvimento, eliminando muitas algas por competição. A devolução destes nutrientes quando da morte das macrófitas possibilitam uma explosão maciça de algas. (2) A segunda relação decorre da necessidade por substrato das algas, na época das chuvas. Nesse momento, juntamente com o grande fluxo d'água, ocorre um aumento de organismos que são potenciais consumidores de algas, como por exemplo o camarão *Macrobrachium amazonicum*, os quais acompanham as macrófitas (De-Lamônica-Freire e Heckman, 1996).

Uma característica das comunidades de algas do Pantanal é a completa dominância de espécies cosmopolitas ou circuntropicais.

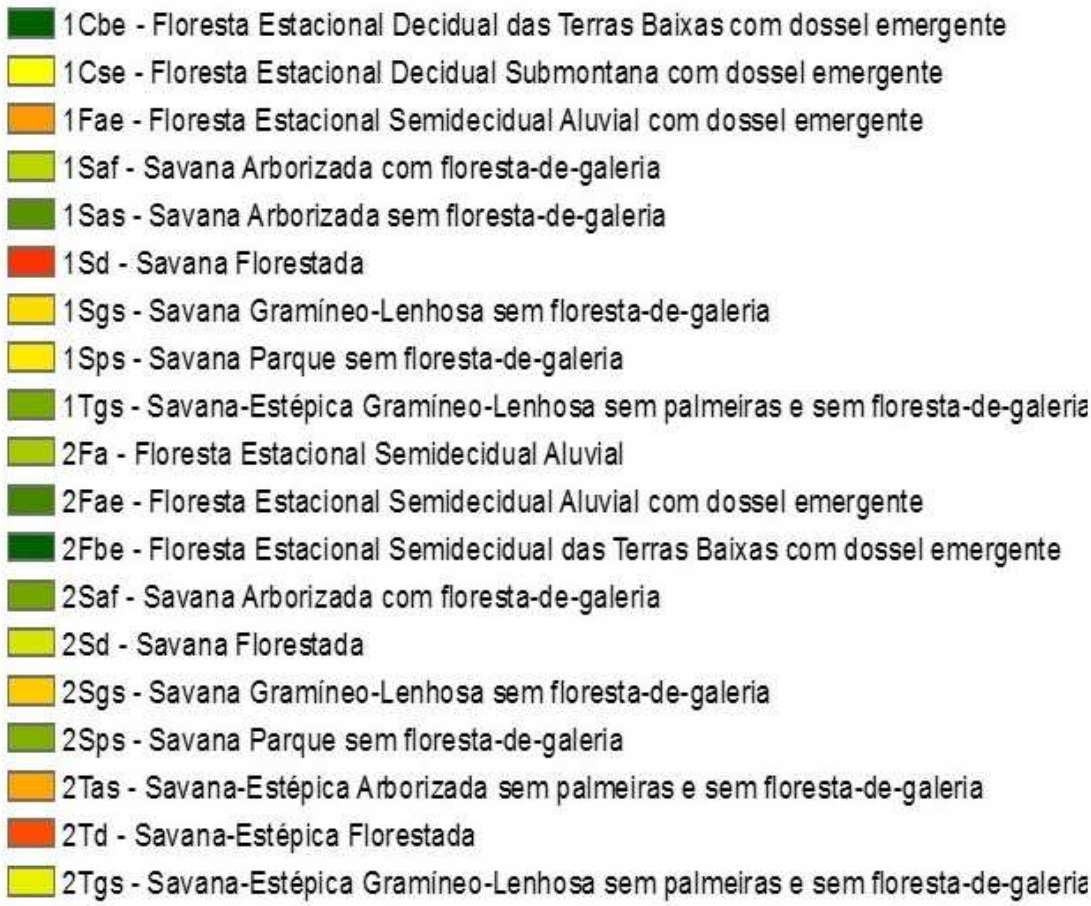
8.2. Vegetação

8.2.1. Contextualização

Não se observam no Pantanal, grandes áreas contínuas de um único tipo de vegetação, o que o torna naturalmente fragmentado. O Pantanal é composto pela interseção de quatro grandes regiões fitoecológicas regionalmente conhecidas por Mata Decídua, Mata Semidecídua, Cerrado e Chaco. Além dessas quatro regiões, em várias porções do Pantanal observa-se a ocorrência de contatos florísticos entre as regiões fitoecológicas e vegetação pioneira, que são aquelas influenciadas pelo alagamento dos rios e das baías, formando os campos alagados e brejos. Mesmo sendo o Pantanal ocupado há mais de 250 anos, suas fitofisionomias formam um imenso mosaico abrigando uma grande diversidade de espécies de plantas e animais adaptados a dinâmica definida

pelo clima e pelos pulsos de inundação da região. Segundo ABDON et al. (2007), o bioma Pantanal ainda é bastante conservado, pois apresentava 88,46% de cobertura natural, contra 11,54% de área antrópica até 2002.

Com relação à vegetação, de acordo com o mapa de vegetação do IBGE na região de estudo foram identificadas três unidades fitoecológicas, sendo elas: Floresta Estacional Decidual, Floresta Estacional Semidecidual e Savana, sendo que estas apresentam uma série de variações.



Segundo o IBGE (1991), entre duas ou mais regiões ecológicas ou tipos de vegetação, existem sempre, ou pelo menos na maioria das vezes, comunidades indiferenciadas, onde as floras se interpenetram, constituindo as transições florísticas ou contatos edáficos. O primeiro caso se refere ao “mosaico específico” ou ao próprio ecótono de Clements (1949). O segundo case se refere ao “mosaico de áreas edáficas”, onde cada encrave guarda sua identidade ecológica sem se misturar. Neste caso, o contato entre tipos diferentes de vegetação com estruturas fisionômicas semelhantes fica muitas vezes imperceptível. Torna-se necessário então o levantamento florístico de cada região ecológica para delimitar a área do ecótono.

As informações sobre a vegetação da região estão de acordo com o volume Diagnóstico dos Meios Físico e Biótico do Plano de Conservação da Bacia do Alto Paraguai (PCBAP) (1978) e com os estudos realizados na região.

8.2.2. Formações fitoecológicas

No PCBAP, a caracterização dos ecótonos não foi realizada, porém os ecótonos listados para toda a região da Bacia do Alto Paraguai podem ser caracterizados através das informações descritas para cada tipo de vegetação. Nestas formações compostas (ecótonos) a formação que aparece em primeiro lugar refere-se àquela de maior predomínio na categoria (Tabela 03).

Savana Florestada

Regionalmente, esta fisionomia pode ser reconhecida como cerradão, ou genericamente, cerrado.

Formação com fisionomia florestal, ocorrendo em terreno não inundável e clima tropical eminentemente estacional. Apresenta sinúsias lenhosas de micro e nano fanerófitos tortuosos, em circunferência raramente ultrapassando 01 metro, com ramificação irregular providos de macrófitos esclerófitos perenes e semidecíduos, ritodoma esfoliado corticoso rígido ou cortez maciamente suberoso, com órgão de reserva subterrâneo ou xilopódio. Não apresenta sinúsia nítida de caméfitos, mas relvado hemicriptofítico, de permeio com plantas lenhosas raquíticas e palmeiras. As árvores apresentam-se dispostas de maneira mais ou menos ordenada, com copas irregulares, podendo se tocar. A composição florística é heterogênea.

Eiten (1983) cita que o estrato arbóreo do cerradão possui alturas predominantemente em torno de 07 metros, com ocorrência de árvores possuindo até 16 metros, sendo a cobertura deste dossel de até 30%. Ribeiro e colaboradores. (1983) consideram que a altura média do estrato arbóreo no cerradão é de 08 a 15 metros, com dossel predominantemente contínuo e cobertura arbórea que pode oscilar de 70 a 100%, proporcionando condições de luminosidade que favorecem a formação de estratos arbustivo e herbáceo diferenciados.

Dentre as áreas estudadas pelo Plano de Conservação da Bacia do Alto Paraguai, a área de Cerradão em Cáceres apresentou 36 espécies arbóreas, sendo *Callisthene major*, *Byrsonima crassifólia*, *Magonia pubecens, Anadenanthera colubrina* v. *cebil, Diptychandra* cf. *aurantiaca* as mais importantes.

Savana (Cerrado) Gramíneo-Lenhosa

Prevalecem nesta fisionomia, quando natural, os gramados entremeados por plantas lenhosas raquíticas, que ocupam extensas áreas dominadas por hemicriptófitos e que, aos poucos, quando manejados através do fogo ou pastoreio, vão sendo substituídos por geófitos que se distinguem por apresentar colmos subterrâneos, portanto mais resistentes ao pisoteio do gado e ao fogo. A composição florística é bastante diversificada, sendo as plantas lenhosas seus ecotipos mais representativos as plantas lenhosas *Andira humilis* (Angelim-do-cerrado), *Cassia* spp.(canafístula), *Byrsonina* spp. (murici), *Bauhinia* spp. (unha-de-vaca), *Attalea* spp. (palmeiras), *Orbignya eichleri* (coco-de-guriri), *Allagoptera campestris* (coco-de-raposa). As principais

herbáceas são plantas graminóides *Axonopus* spp. (grama-de-cerrado), *Andropogon* spp. (capim-do-cerrado), *Aristida* spp. (capim-barba-de-bode), *Tristachya* spp. (capim-flechinha), *Paspalum* sp., *Hemarthria* sp., *Digitaria* sp., *Panicum* sp., *Brachiaria* sp., além de muitos subarbustos (nanofanerófitas) raquíticos das famílias *Compositae, Myrtaceae, Melastomataceae* e *Malvaceae*, de menor expressão fisionômica.

Regionalmente esta fisionomia pode ser reconhecida como Campo, Campo Limpo, Campo Sujo, Caronal, Campina ou Campo Alagado.

Savana Arborizada

Formação natural ou antropizada que se caracteriza por apresentar fisionomia nanofanerofítica rala e hemicriptofítica graminóide contínua, sujeito ao fogo anual. Estas sinúsias dominantes formam fisionomia raquítica em terrenos degradados. A composição florística, apesar de semelhante à da Savana Florestada, apresenta ecotipos dominantes que caracterizam o ambiente de acordo com o espaço geográfico.

Espécies características: *Curatella americana* ((lixeira), capitão-do-campo (*Terminalia argêntea*), araticum (*Annona crassifólia*), barbatimão (*Stryphnodendron* sp.), açoita –cavalo (*Luehea paniculata*), faveiro-do-campo (*Dimorphandra mollis*), jatobá-do-cerrado (*Hymenaea stigonocarpa*), ipê-do-cerrado (*Tabebuia caraiba*), araticum (*Annona coriacea*), pequizeiro (*Caryocar brasiliensis*), mangaba (*Hancornia speciosa*), lixeirinha (*Davilla elliptica*), colher-de-arara (*Salvertia convallariaeodora*), lixeira (*Curatella americana*), pau-santo (*Kielmeyera* sp), pau-terra (*Qualea* sp), muricis (*Byrsonima* sp), entre outras. A ocorrência de lianas não se dá de forma agressiva, sendo a maioria herbácea ou semilenhosa.

Floresta Estacional Semi-decidual

O conceito ecológico deste tipo de vegetação está condicionado pela estacionalidade climática tropical, com época de intensas chuvas de verão seguidas por estiagens acentuadas.

É constituída por fanerófitos com gemas foliares protegidas da seca por escamas (catafilos ou pelos), tendo folhas adultas coriáceas ou membranas caducas. Em tal tipo de vegetação, a porcentagem das árvores em relação ao conjunto florestal, e não das espécies, quem perdem as folhas situa-se entre 20 e 50%. Ao fim da estação seca, o chão fica recoberto de folhas. As áreas ocupadas por esta região fitoecológica apresentam solos férteis e têm relevância na economia regional.

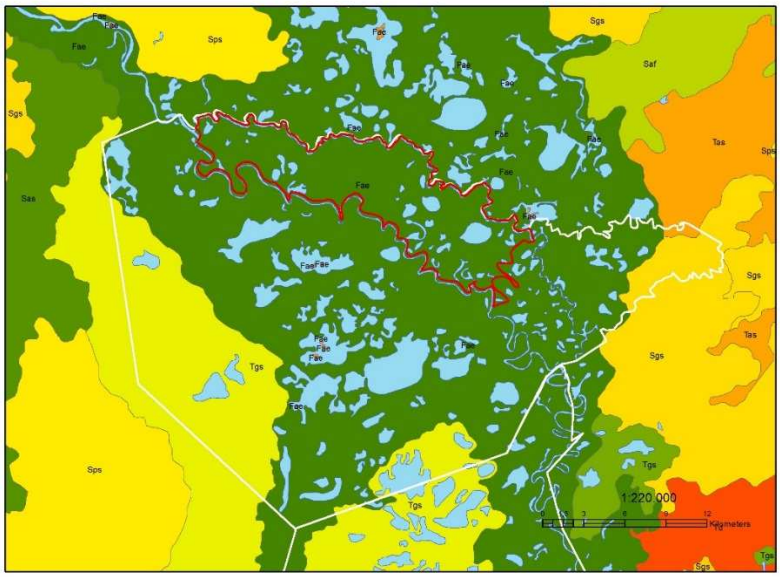


Figura 9 - Tipos de vegetação na região da ESEC de Taiamã.

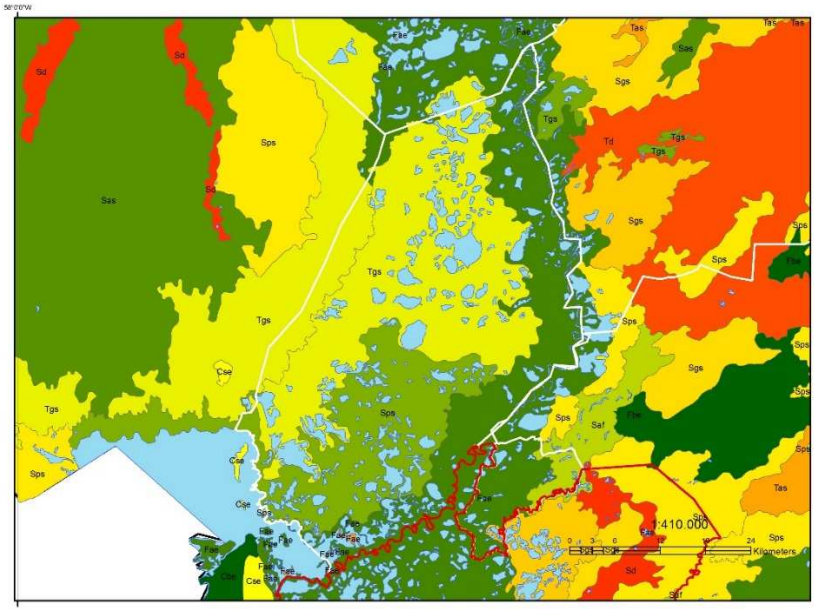


Figura 50 - Tipos de vegetação na região da Reserva de Fauna.

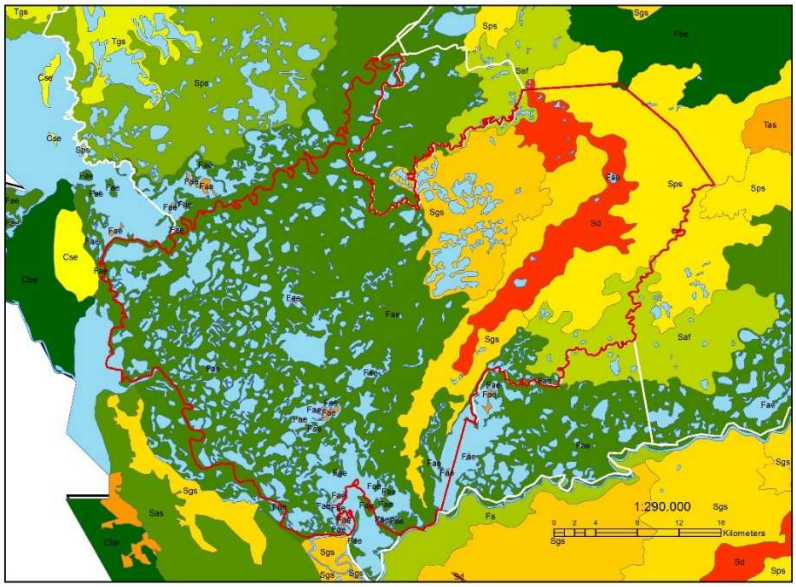


Figura 10 - Tipos de vegetação na região do parque nacional do Pantanal matogrossense.

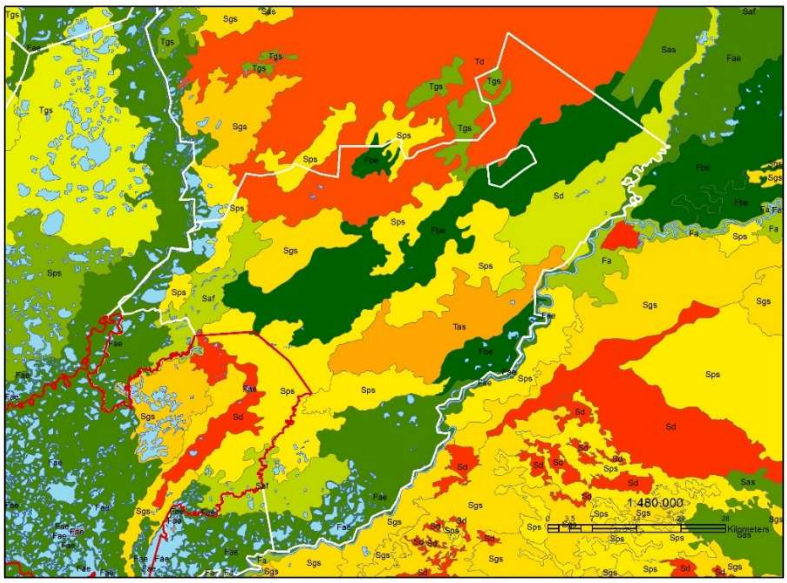


Figura 511 - Tipos de vegetação na região do Refúgio de Vida Silvestre.

O pantanal caracteriza-se por apresentar diversos tipos de corpos d'água, o que favorece o crescimento de muitas plantas aquáticas. Estas são importantes ao equilíbrio de ecossistemas aquáticos, pois servem direta ou indiretamente de alimento e abrigo para muitos organismos que ali vivem, como larvas de insetos, peixes, aves, entre outros. Os brejos agem como importantes filtros, removendo nutrientes e sedimentos, fornecendo água limpa para os habitats

rio abaixo. Sintetizando informações da literatura conclui-se que o Pantanal da área de estudo são caracterizados pelos principais habitats apresentados a seguir:

a) Macrófitas aquáticas: os tipos de ambientes aquáticos são rios, corixos, vazantes, lagoas permanentes e temporárias com vegetação aquática. As águas podem ter origem de chuvas locais e dos rios da Bacia do Alto Paraguai, sendo que a origem, ou respectivo teor de nutrientes, e o tipo de corpo d´água influenciam sobre a flora macrofítica.

A vegetação de macrófitas aquáticas varia com o estágio sucessional e com a energia (corrente, ondas) do corpo d´água, ou seja, as amplas superfícies são pobres em cobertura e riqueza de macrófitas, ou totalmente sem, enquanto meandros protegidos da ação do vento têm muitas espécies e podem estar bloqueados por bancos de macrófitas, que na fase mais avançada formam verdadeiras ilhas flutuantes (floating mats) com solo orgânico submerso de 1 m de espessura, com arbustos como saivero *Ludwigia* sp. e arvoretas como embaúba *Cecropia pachystachya* e pinho-do-brejo *Tabebuia insignis*. Em águas correntes e/ou superfícies amplas, as macrófitas são restritas às margens, enquanto nos corixos protegidos das ondas e em lagoas menores, aumenta a cobertura e a riqueza de plantas aquáticas.

Em geral, a forma biológica das plantas aquáticas varia conforme o ambiente e a fase de sucessão. Assim, da maior para a menor profundidade de água, há submersas livres, submersas fixas, flutuantes livres, flutuantes fixas, emergentes e anfíbias, todas herbáceas.

Há ainda a forma epífita, porque nasce e cresce sobre outras plantas aquáticas, como é o caso do *Oxycaryum cubense*. O batume ou baceiro é um conjunto flutuante que contém espécies de várias formas biológicas, numa fase adiantada de sucessão, em que figuram arbustos e arvoretas.

Nas margens dos rios de toda a região ocorrem muitas espécies de plantas aquáticas, como o aguapé (*Eichornia crassipes*) que serve de abrigo a inúmeros peixes que nelas depositam seus ovos. Na época das cheias, verdadeiras ilhas de aguapé descem flutuando o rio Paraguai, servindo como meio de transporte para muitas outras espécies animais e vegetais. Junto a esta espécie ocorre a *Eichornia azurea*, a qual ocupa maior extensão que a primeira e é chamada também de aguapé. As “ilhas” flutuantes que descem o rio são chamadas de “camalotes”. Ainda nas áreas alagadas há a Vitória Régia (*Victoria cruziana*), a *Pistia stratiotes*, denominada erva de Santa Luzia, as ninféas (*Nymphaea* ssp.), bem como o *Cyperus giganteus* (popularmente conhecida como Piri), *Equinodorus macrophylus*, *Sagittaria guyanensis*, *Pontederia lanceolata*, dentre outras. Estas plantas são importantes para a cadeia alimentar da região, pois disponibilizam habitats para algas perifíticas e uma riquíssima fauna de invertebrados (Pott e Pott, 2000). Existe inclusive a descrição de uma espécie endêmica da região, chamada *Drosophila aguape*, coletada nas flores de *E. azurea* da Ilha de Taiamã (Val e Marques, 1996).

Junto a essa vegetação, em áreas menos encharcadas, ocorrem *Canna* sp., *Thalia geniculata* e *Maranta* sp.

b) Campos: são áreas inundáveis cobertas com gramíneas, outras ervas e arbustos, de composição florística muito variável durante o ciclo anual, e, dependendo da duração do período de seca, podem ser cobertos por arbustos e árvores (campos-sujos).

Os campos inundáveis são a fisionomia mais extensa do Pantanal. No Pantanal há campos inundáveis em todos os tipos de solo existentes em áreas alagáveis. Na região a transição para a vegetação aquática é um gradiente sutil e contínuo.

Algumas porções (muito frequentes) dos campos inundáveis tendem a ser arbustivos, denominados regionalmente de "marmiquezal", pela alta freqüência de malmequer ou girassol-do-pantanal *Aspilia latissima*, com arbustos e trepadeiras não lenhosas, entrelaçados, alguns espinhosos dos gêneros *Byttneria*, *Mimosa* e *Cissus*, formando uma paisagem muito freqüente e inconfundível da Estação.

A composição espacial é heterogênea, em mosaico, de populações de plantas que dominam pela forte propagação vegetativa, como a erva-de-bicho *Polygonum acuminatum*, *Panicum mertensii*, *P. pernambucense*, praieiro *Paspalum fasciculatum* e algodão-bravo *Ipomoea carnea*.

São freqüentes indivíduos jovens de árvores pioneiras de mata ciliar, como ingá *Inga* sp. e falso-ingá *Pterocarpus* sp., o que indica que esta formação é um estágio preparatório para a formação lenhosa de mata ciliar, sucessão que depende de drenagem, como na beira do rio ou com alguns anos sem inundação.

Nos campos inundáveis da área de estudo ocorrem gramíneas cespitosas e estoloníferas, ervas semi-aquáticas emergentes e anfíbias, pequenos arbustos e trepadeiras, ou hemicriptófitas, nanofanerófitas e fanerófitas, além de algumas terófitas. Várias das gramíneas têm plasticidade morfológica, onde a morfologia muda conforme as condições do ambiente, geralmente para acompanhar a subida do nível da água, como por exemplo o que ocorre com o capim-de-capivara *Hymenachne amplexicaulis*, ou pode ter hábito cespitoso em população densa, onde houver espaço a ocupar, como é o caso do praieiro *Paspalum* sp. Também há pequenos agrupamentos de palmeiras e esparsas árvores jovens.

c) Formações arbóreas: são elevações arborizadas distribuídas nos campos sazonalmente inundáveis; com árvores pertencentes aos cerrados ou à Floresta Semidecidual.

Do ponto de vista botânico, as formações vegetacionais ripárias são interessantes pois apresentam características, muitas vezes, diversas da vegetação adjacente. Isto pelo fato de sofrerem influências do rio, que apresenta papel fundamental na distribuição das espécies. Além da influência local determinada principalmente pela dinâmica da água no solo, os rios possibilitam uma distribuição mais ampla de espécies, uma vez que serpenteiam por entre diversos domínios vegetacionais, criando as redes hidrográficas, ao longo das quais muitas espécies encontram condições

favoráveis, tanto para o completo ciclo de vida de seus indivíduos quanto para a dispersão de seus diásporos reprodutivos.

Do ponto de vista ecológico, as interações da vegetação ripária são incontáveis, tanto para o domínio abiótico quanto para o biótico, inclusive nas interações entre as próprias plantas. Dentre as mais conhecidas podem ser citadas as relações com o tipo de margem e de solo; com os períodos de águas baixas e de águas altas, e com a dinâmica do rio, principalmente nos aspectos de geração de refúgio, substrato, matéria orgânica e de determinadas variações de condições ambientais.

A região de estudo compreende vários estágios de sucessão, desde franjas de arbustos até a verdadeira floresta em dique de rio, por isso o termo Sistema Ripário. Em geral, a margem côncava e mais alta tem floresta desenvolvida, enquanto a convexa, mais baixa e mais inundável e em processo de sedimentação, apresenta arbustos pioneiros. Em outros trechos foram observadas faixas paralelas de zonação, começando com malmequer *Aspilia latissima*, passando a sara *Alchornea* sp., e depois sarã-leiteiro *Sapium obovatum*, à medida dos degraus ascendentes para o dique marginal. A floresta mais evoluída, estruturada, contém árvores emergentes como jatobá-mirim *Hymenaea stilbocarpa* e tarumã *Vitex cymosa*.

As formações arbóreas que ocorrem na área de estudo são as matas ripárias, capões de mata, e, principalmente a formação arbórea monotípica conhecida como Abobral. A ocorrência da vegetação arbórea está relacionada com a umidade do solo e a topografia (Ponce & Cunha 1993), sendo a diversidade florística em áreas secas, maior do que em áreas inundáveis (Nunes da Cunha, 1990).

Abobral é a denominação utilizada quando a formação dominante pioneira é composta por indivíduos da espécie *Erythrina fusca* Lour. (Fabaceae). Este povoamento ocorre nas planícies, na sub-região de Cáceres e também ao longo das margens do Rio Aquidauana (POTT et al., 2011). *Erythrina fusca* é uma planta que possui de 20-30 metros de altura, com copa globosa e tronco curto e ramificado, espinhento quando jovem. As inflorescências são em forma de racemos terminais, com flores vistosas de cor amarela-alaranjada. Ocorre frequentemente nas matas ciliares, principalmente na região amazônica e floresce nos meses de maio a setembro, com frutificação a partir de novembro (LORENZI, 2002). Parrini e Raposo (2010) em um estudo realizado em Porto Jofre, região norte do Pantanal do Mato Grosso, observaram que esta espécie apresentou distribuição do tipo agregada, ou seja, uma elevada concentração de árvores da espécie em um dado local. Sabe-se que as espécies que ocorrem em formações monoespecificas são, teoricamente, mais sujeitas a doenças e predação quando comparadas a outras que não exercem monodominância. No entanto algumas dessas comunidades com ocorrência no Pantanal, dentre elas a formação de *Erythrina fusca* sobrevivem sem sofrer grandes injurias que poderiam prejudicar seu desenvolvimento.

Em pequenos capões que podem ficar alagados na cheia, existem extratos arbóreos com a presença de espécies de Leguminosae, Moraceae, Melinaceae, Elaeocarpaceae, Capparidaceae, Anarcadiaceae, entre outras,

geralmente atingindo altura entre 12 e 18 metros (Guarim Neto,1983). Ocorre também um estrato subarbustivo – arbustivo, com representantes das famílias Compositae, Apocynaceae, Malpighiaceae, Melastomataceae e outras, com altura não ultrapassando 3 metros. O estrato herbáceo é pouco encontrado nas áreas mais afastadas das águas. Nas áreas alagáveis, os troncos de árvores e arbustos, às vezes mortos, são cobertos por trepadeiras das famílias Vitaceae, Passifloraceae, Convolculaceae, entre outras.

Dentre as palmeiras existentes na região estão: o Acuri (*Attalea princeps*), que é encontrado nas margens mais elevadas dos rios e corixos; o Tucum, também designado Tucumã, que corresponde a diversas espécies do gênero *Bactris* e *Astrocaryum* (Guarim Neto, 1983).

Outras espécies observadas principalmente nestes pequenos capões ou nas matas ripárias são: Louro Preto (*Nectandra mollis*); Tarumã (*Vitex cymosa*); Jatobá (*Hymenaea stigonocarpa*); Manduvi (*Sterculia apetala*); Aroeiro (*Astronium* sp.); Guatambu (*Apidosperma* sp.); Angico vermelho (*Piptadenia* sp.); Angelim (*Andira* sp.); Ipê (*Tabebuia* sp.); Cambará (*Vochysia divergens*) e Figueira (*Fícus trigona*).

Em estudos esporádicos de levantamento de espécies vegetais realizados na região, foram identificadas 48 espécies de macrófitas aquáticas, 126 espécies de angiospermas e 17 espécies de biofitas e pteridófitas (anexo), mas estas informações ainda são preliminares considerando que o número de espécies vegetais para o bioma Pantanal é bem maior.

8.2.3. Ameaças à vegetação

Dentre as principais ameaças existentes à cobertura vegetal arbórea existente na região, destacam-se os incêndios florestais. A queima e consequente morte de indivíduos florestais de grande porte soma-se à reposição lenta dos mesmos (visto que existe uma dificuldade de crescimento de novas árvores devido ao stress hídrico que ocorre anualmente alagando praticamente toda a área resultando em diminuição de cobertura vegetal arbórea.

A área de estudo está situada na porção do pantanal ainda bem conservada, possivelmente pelo fato de ser uma região em que o uso da terra não é indicado (áreas alagadas). Figura 12É possível observar que as alterações antrópicas na vegetação, bem como o desmatamento estão distantes dos limites das propostas. Com relação À estação Ecológica de Taiamã cabe ressaltar que a UC está protegida ao norte pela RPPN Jubran e ao sul por uma norma de pesca (Resolução CEPESCA 02/2018). Desta forma, somando-se toda a área protegida obtém-se aproximadamente 100.000,00 hectares onde a vegetação está conservada. Esse padrão também é observado na região do parque nacional do pantanal mato-grossense.

Considerando-se ainda que atualmente não há uma tendência regional de desmatamento, e que as áreas de estudo ainda estão em bom estado, conclui-se que a vegetação regional não se encontra em estado de vulnerabilidade.

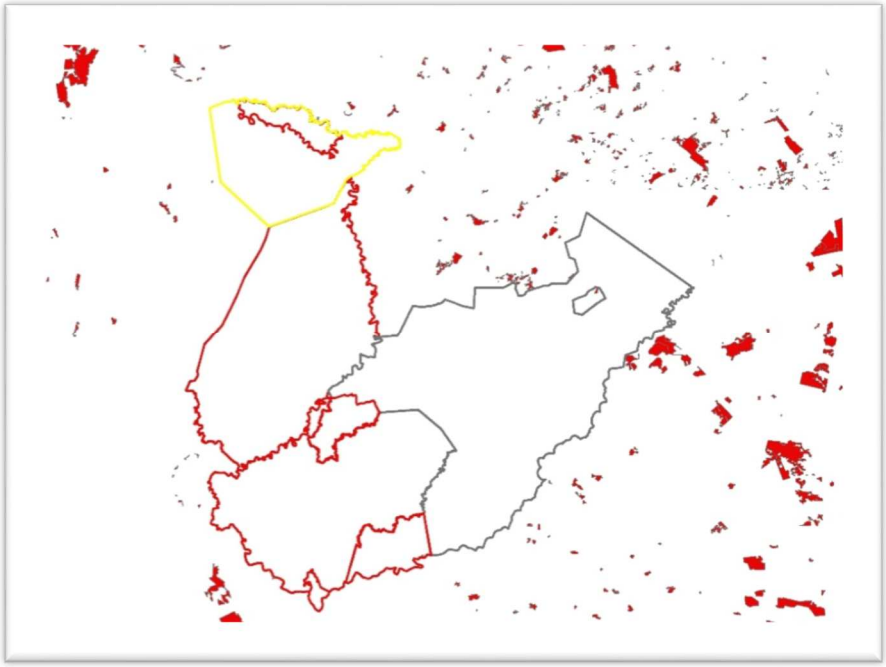


Figura 12 – Áreas desmatadas na região de estudo

Outro fator que pode afetar a vegetação da área de estudo, especificamente as regiões de mata ripária, é a possibilidade de choques de grandes embarcações nos barrancos, visto que os rios Paraguai e Cuiabá possuem muitos meandros. Estas colisões podem causar a queda de grandes árvores, como já foi observado por servidores da Estação Ecológica de Taiamã. As embarcações que causaram os choques são chamadas de “chatas” as quais não conseguiam fazer as curvas da maneira correta e se chocavam com as margens dos rios, muitas vezes arrancando várias árvores do chão. Desde o ano de 2009 as empresas que utilizavam a hidrovia Paraguai-Paraná não estão mais presentes no rio devido a impasses decorrentes do licenciamento ambiental.

8.3. Fauna

Atualmente 127 espécies de répteis estão descritas no bioma Pantanal (Strussman et al., 2007), num total de 179 espécies de répteis para a BAP. Quanto aos anfíbios, além das formas registradas no PCBAP (Brasil, 1997), são conhecidas pelo menos treze espécies adicionais na planície e outras 27 aparentemente exclusivas dos planaltos de entorno. A anurofauna da BAP estaria constituída por pelo menos 80 espécies, das quais mais da metade (45 espécies) parece ocorrer exclusivamente em áreas altas no entorno. Na planície pantaneira são registradas 44 espécies de anfíbios.

Apresentando menor heterogeneidade de habitats e maior disponibilidade de corpos d'água permanentes (menor número de habitats com condições ecológicas contrastantes), a planície inundável abriga espécies de anfíbios em geral abundantes e de ampla distribuição. Assim, mesmo inventários rápidos acusam grande similaridade na composição de anurofaunas em sítios distintos no interior da planície, podendo esta ser considerada melhor amostrada do que o entorno.

A grande diversidade do Pantanal está associada ao regime das inundações que mantém grandes áreas alagadas por períodos que variam entre 6 a 12 meses. Muitos vertebrados invadem a planície na estação seca para explorar a abundância de alimento depositada criada pelas enchentes. Animais migratórios chegam ao Pantanal durante a época de cheias para reprodução e procura de abrigo. O ciclo das inundações determina a disponibilidade de áreas secas e inundadas que, por sua vez, influência a distribuição sazonal das diversas espécies. Com a dinâmica de subida e descida do nível das águas, espécies generalistas são favorecidas em detrimento daquelas muito especializadas. Isso possivelmente é um dos fatores que tentam explicar os baixos números de grupos endêmicos do Pantanal (Lourival et al., 2000)

Devido aos pouquíssimos trabalhos realizados com organismos bênticos invertebrados até o momento, a diversidade destes no Pantanal é ainda pouco conhecida. Alguns grupos abundantes e significativos como, por exemplo, os nematodas, ainda não foram estudados em nenhuma localidade do Pantanal.

Ao longo de rios inundáveis, como o rio Paraguai, a diversidade de habitats transversal é bem maior quando comparada com a longitudinal (Wantzen et al., 2005), sendo que a diversidade de invertebrados segue este padrão (Marchese et al., 2005).

Peixes com 269 espécies (Britsky et al., 2007), aves com 582 (Nunes, 2010) e mamíferos com 152 espécies contaram com listagens de espécies do Pantanal revistas e/ou ampliadas a partir daquelas apresentadas pelo PCBAP.

A região do Bioma Pantanal onde o PARNA Pantanal Matogrossense está localizado, na confluência dos rios Cuiabá e Paraguai, é caracterizada por alto grau de inundação, apresentando uma complexa rede hidrográfica com diversos rios, baías, lagos e corixos, associada ao regime anual de inundação (enchente, cheia, vazante e seca). Essa característica de alta inundação e

diversidade de ambientes aquáticos faz do PARNA Pantanal Matogrossense importante área para conservação dos recursos pesqueiros e aves aquáticas. Na região do Parque Nacional já foram identificadas 180 espécies de peixes, representando aproximadamente 70% das espécies encontradas na bacia pantaneira, demonstrando a importância desta área para a conservação da ictiofauna.

8.3.1. Ictiofauna

Peixes são recursos ecológicos importantes para essa região, como compartimento biótico do sistema. Constituem alimento sazonal em torno do qual há agregação de espécies de vertebrados: aves paludícolas, que se reúnem em vazantes ou baías para se alimentar, ou em ninhais, colônias de reprodução resultantes de comportamento gregário para onde os pais trazem o alimento, geralmente peixes. Nesses locais se congregam grandes quantidades de predadores para se aproveitar da oferta de alimento (filhotes de aves, peixes que caem dos ninhos) como sucuris, jacarés, lobinhos, mão-pelada, coatis e outros oportunistas.

Os peixes representam o grupo mais bem estudado do reino animal no Pantanal. De acordo com Junk e colaboradores (1997), os pulsos de cheia e vazão teriam selecionado ao longo do tempo a ocorrência de uma ictiofauna composta por organismos estrategistas, de grande mobilidade, adaptados para a variação no nível de oxigênio da água e altamente sazonais.

A riqueza ictiológica observada no rio Paraguai se deve à grande quantidade de lagoas e baias existentes na época das cheias do Pantanal. Os peixes necessitam deste tipo de ambiente para a reprodução, e assim utilizam esta região para procriação.

A pesca no Pantanal é concentrada nos organismos carnívoros e frugívoros que podem ser pescados com anzol, como por exemplo: Pintado (*Pseudoplatystoma corruscans*), Pacu (*Piaractus mesopotamicus)*, Pacupeva (*Mylossoma orbignyanum*), Piranha (*Serralmus* sp.), Cachara (*Pseudoplatystoma fasciatum*), Jaú (*Zungaro zungaro*), Dourado (*Salminus maxillosus*), entre outros.

Em função da decomposição da matéria orgânica nas baias e corixos com batume (plantas flutuantes), o cheiro de gás sulfúrico é fortemente acentuado. As concentrações de oxigênio nesse período são baixas, resultando em condições desfavoráveis para os peixes. No Pantanal, o fenômeno da “diquada” ou “dequada”, ocorre nos meses de cheia, ocasionando a mortandade dos peixes, como bagres e pintados. Quando do início da cheia, as águas das bacias com batume saem para os rios, matando boa parte da fauna. Algumas espécies de cascudo dos gêneros *Hypostomus* e *Callychthys* são capazes de sobreviver nestas condições.

Em um levantamento curto realizado por Silva (1983) na EE de Taiamã, foram identificadas 59 espécies de peixes. Além deste estudo, estão tombadas no museu de zoologia da USP, várias espécies adicionais coletadas nos rios que

delineiam a Estação. Além disso, em um estudo recente (Barbosa, 2015; Carvalho-Filho, 2015) foram identificadas várias outras espécies totalizando 131 espécies de peixes para a região da EE, representando 48,33% do total de espécies de peixes registradas para o bioma.

Em um estudo visando obter informações sobre os peixes de valor comercial da Bacia do Alto Paraguai, Arenhart e Muniz (2011) coletaram animais EE e entorno, bem como em regiões do rio Paraguai a montante desta unidade de conservação. Este estudo intitulado MONITORAMENTO REPRODUTIVO DE PEIXES REOFÍLICOS BACIA DO ALTO PARAGUAI 2007/2008, 2008/2009, 2009/2010 e 2010/2011 teve como objetivo acompanhar o desenvolvimento reprodutivo destes peixes ao longo de vários ciclos visando garantir melhor avaliação dos programas de gerenciamento dos recursos pesqueiros e subsidiar a determinação dos períodos de defeso. Consequentemente, estes estudos podem influenciar a conservação da fauna dependente dos recursos pesqueiros (aves aquáticas como tuiuiús, cabeças-secas, biguás, garças, socós, etc., mamíferos como lontras e ariranhas e répteis como jacarés) e o estabelecimento de normas de cunho sócio-ambiental que permitam as populações ribeirinhas e demais atores que se utilizam deste recurso de interagir e contribuir para um uso sustentável.

Dentre os resultados obtidos destaca-se que os espécimes com gônadas em repouso foram obtidos durante todo o período de defeso, compreedendo os meses de outubro a março, com pico nos meses de janeiro e março. Os valores referentes aos espécimes com gônadas maduras estão entre os meses de novembro e fevereiro, tendendo a uma distribuição normal, sendo observados picos nos meses de dezembro e janeiro. Já os espécimes esvaziados, indicando que a desova foi realizada, são observados desde o mês de outubro, embora em menor número, sendo que nos meses de janeiro e fevereiro são observados os maiores valores, refletindo os dados para gônadas maduras.

Em anos anteriores a 2016, o período de defeso foi estipulado entre novembro e fevereiro, atendendo a demanda reprodutiva dos peixes reofílicos quando considerado apenas o pico da desova. É verificado que a atividade reprodutiva nos meses de outubro e também em setembro, são encontrados espécimes com gônadas em maturação antes do início de período de defeso, estabelecido para novembro de cada ano. Diante dos resultados, à partir de 2016, e com base nos dados obtidos na EE e outros pontos de amostragem, o período de defeso da piracema foi reajustado (início em setembro) para incluir também as matrizes com as gônadas já em desenvolvimento, garantindo assim maior proteção ao estoque pesqueiro.

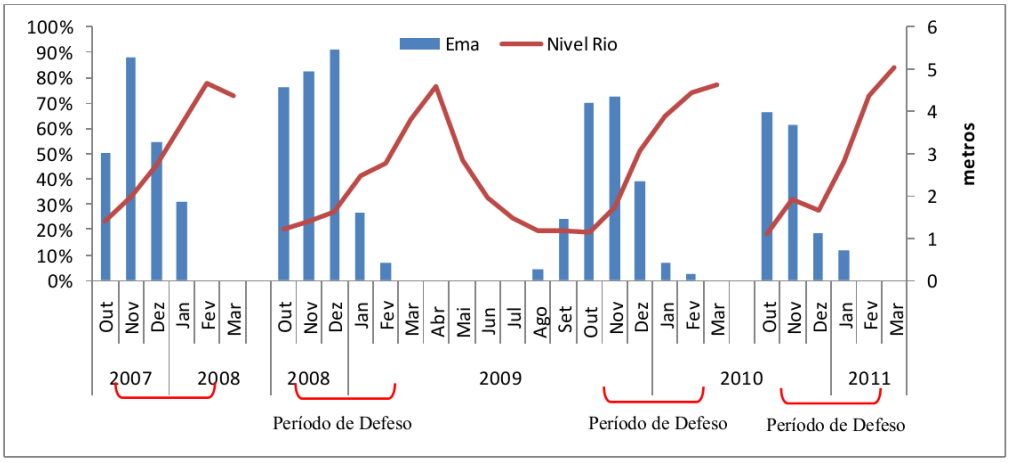


Figura 13 - Espécimes em atividade reprodutiva (Em maturação) durante o monitoramento reprodutivo de peixes reofílicos na BAP e nível do rio Paraguai de outubro de 2007 a março de 2011. Ema = Em Maturação.

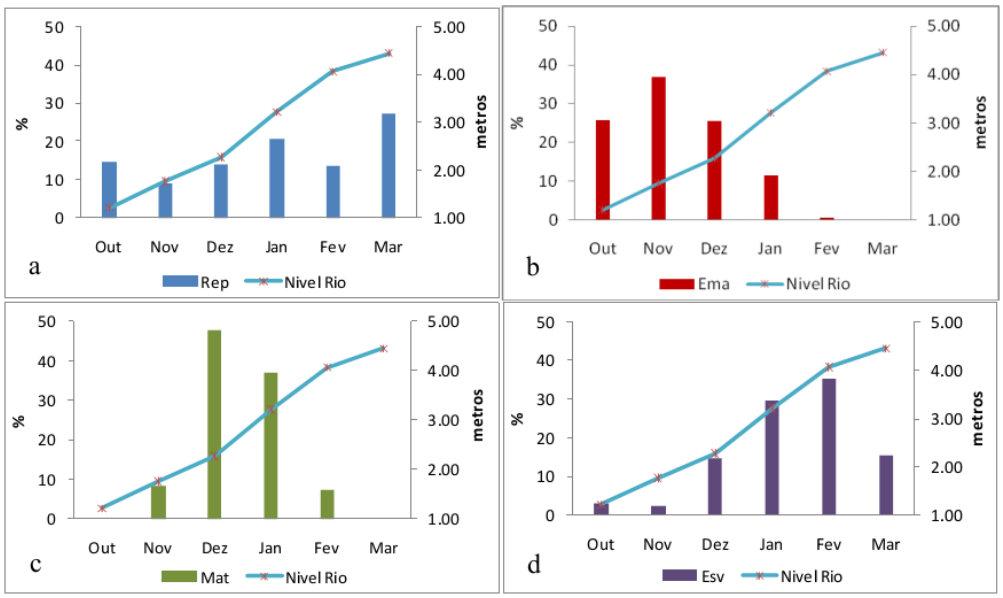


Figura 14 - Estádios gonadais obtidos durante monitoramento reprodutivo de peixes reofílicos na BAP. Valores médios compreendendo os períodos de 2007/2008, 2008/2009, 2009/2010 e 2010/2011 (Rep =repouso; Ema = Em Maturação; Mat = Maduro; Esv = esvaziado).

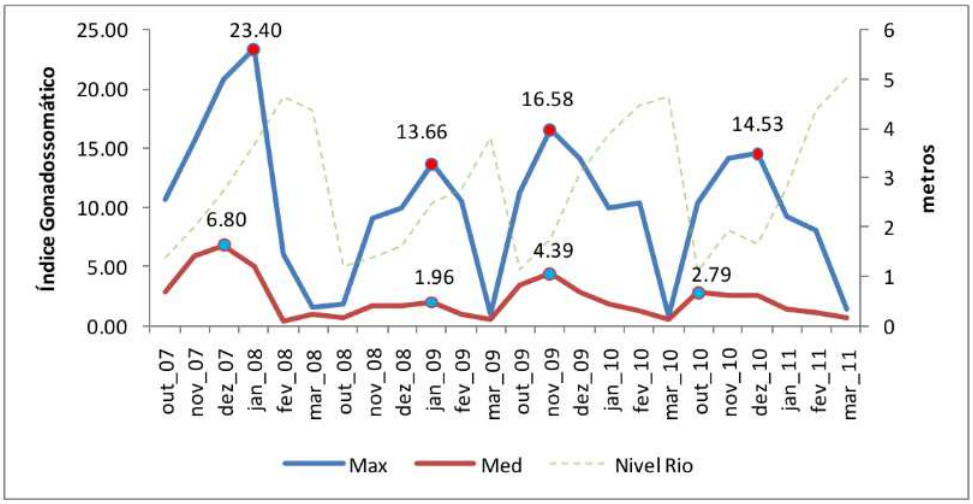


Figura 15 - Estádios gonadais obtidos durante monitoramento reprodutivo de peixes reofílicos na BAP. Valores médios compreendendo os períodos de 2007/2008, 2008/2009, 2009/2010 e 2010/2011 (Rep =repouso; Ema = Em Maturação; Mat = Maduro; Esv = esvaziado).

Vazzoler (1996) aponta que espécimes com índices gonadossomáticos – IGS acima de 10 podem ser considerados maduros. Figura 15Os maiores valores e as médias mensais de IGS obtidas de 2007 a 2011, sendo que os meses de janeiro, no ciclo 2008/2009 e novembro e dezembro no ciclo 2010/2011 foram os maiores índices obtidos.

A variação dos valores do IGS antecede a variação hídrica sazonal, indicado pelo nível do rio Paraguai, mostrando que a atividade reprodutiva está também condicionada ao pulso de inundação nos ambiente de planícies. As maiores médias de IGS foram observadas nos ciclos 2007/2008 e 2009/2010. No ciclo 2008/2009, sobretudo nos meses de novembro/08 a janeiro/09, a quantidade de chuvas foi bem abaixo da média esperada para a região pantaneira, mesmo com um aumento significativo em fevereiro de 2009. Este aspecto influenciou diretamente a variação hídrica do rio Paraguai, condicionando menores valores de IGS para este ciclo (2008/2009).

Na planície pantaneira o pulso de inundação constitui um evento fundamental na perpetuação das populações de peixes, sendo a variação hídrica sazonal um dos fatores preponderantes na regulação da reprodução e viabilidade de larvas e alevinos dos peixes reofílicos.

Este estudo, quando considerado a localização da EE de Taiamã e também o fato de que a UC e entorno próximo foram os principais pontos de coleta, destaca a importância da região da unidade de conservação e da área proposta para a ampliação na manutenção do estoque pesqueiro da Bacia do Alto Paraguai. Destaca-se ainda o fato da importância das estruturas da unidade nas etapas de campo deste estudo.

Em outro estudo em que foram analisados somente os exemplares de pacú da amostra total obtida por Arenhart e Muniz (2001), intitulado ÍNDICES MORFOFISIOLÓGICOS DE *Piaractus mesopotamicus* (OSTEICHTHYES, CHARACIDAE) NA ESTAÇÃO ECOLÓGICA DE TAIAMÃ E FOZ DO RIO SEPOTUBA, CÁCERES, MATO GROSSO, BRASIL (Muniz et al., 2016), foram analisados 637 espécimes de *P. mesopotamicus* nas respectivas áreas, sendo 525 na Estação Ecológica de Taiamã e na área proposta para a ampliação e 112 nas proximidades da foz do rio Sepotuba. Através da análise dos espécimes coletados verificou-se que os exemplares provenientes da região da EET apresentaram maior uniformidade em relação ao índice hepatossomático (índice que analisa a relação do peso do fígado com o peso corporal), enquanto que os exemplares amostrados no rio Sepotuba apresentaram maior oscilação. Este resultado pode ser entendido pela diferença existente entre os dois ambientes. No rio Sepotuba a presença antrópica é muito mais pronuncianda que na região da Estação. Segundo SOUZA (1998) quando o peixe passa por restrição alimentar verifica-se redução no peso do fígado.

Comparando-se o fator de condição corporal de *P. mesopotamicus* da região da Estação Ecológica de Taiamã ($12{,}0x10^5$) com a amostra do rio Sepotuba ($3{,}0x10^5$), verificou-se que nos animais da EET o valor do fator é mais elevado. Este resultado pode ser consequência das diferenças entre os ambientes. A região da EE de Taiamã, por ser uma área protegida (UC + Resolucão CEPESCA 02/2018), possui recursos que favorecem a estabilidade no ciclo de vida do peixe, enquanto que o rio Sepotuba por ser uma área com atividade humana frequente não oferece esses recursos na mesma magnitude. Segundo MOREIRA (2012) os ecossistemas aquáticos têm sido fortemente afetados por atividades antrópicas, desflorestamento e outras ações de impactos aos rios, as quais, ao longo do tempo, causam consequências deletérias para a biota, além das modificações nas características físico-químicas da água que resultam em alterações nas estruturas das comunidades biológicas, o que

acarreta em mudanças no fluxo de energia e nutrientes, interferindo em seu ciclo de vida.

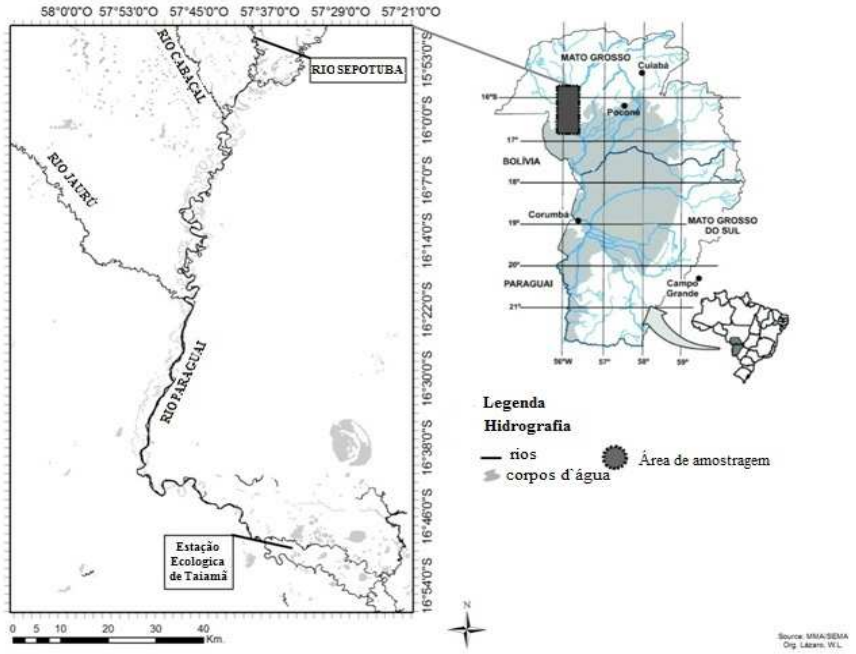


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Figura 16 - Localização das áreas de coleta - Estação Ecológica de Taiamã e rio Sepotuba, Cáceres, Mato Grosso

Em ambientes sazonalmente inundáveis muitas espécies vegetais fornecem abrigo e alimento para a ictiofauna. Em contrapartida diversos peixes podem dispersar as sementes através do mecanismo de ictiocoria, contribuindo com a manutenção das florestas alagáveis. Muniz et al. (2014) realizou um estudo que teve como objetivo testar o potencial de germinação das sementes de *Ficus* cf. *eximia* (figueira) e *Alibertia* sp. (marmelada), após passarem pelo trato digestório (estômago e intestino) do *Piaractus mesopotamicus* (Pacú) coletados na região da Estação Ecológica de Taiamã, no período de cheia. Foi calculado o índice de velocidade de germinação (IVG), e o percentual de sementes germinadas por tratamento (sementes coletadas diretamente das árvores e sementes que passaram pelos tratos digestivos). A análise dos resultados indicou que a passagem das sementes de *Alibertia* sp. e *Ficus* cf. *eximia* pelo trato digestório do *P. mesopotamicus* não inibiu a germinação das mesmas, e o fato deste peixe ser migrador oferece a essas plantas a possibilidade de ampliar sua área de colonização.

Estudos (Barbosa et al., 2014, Freitas et al., 2014, Lara et al., 2014) realizados com algumas espécies de importância econômica, social e ecológica na região da UC, tiveram por objetivo analisar a dieta da sardinha (*T. paranensis*), da pacu-peva (*Myloplus Levis*) e da peraputanga (*Bricon hilarii*) coletados em diferentes ambientes, rio (ambiente lótico) e “campo” (ambiente semi-lótico) e em diferentes períodos (seca, enchente e cheia) na região da EE de Taiamã. Os dois locais de coleta possuem áreas inundáveis bem distintas, sendo os rios Paraguai e Bracinho ambiente lótico e o campo semi-lótico. O “campo” se

localiza a sudoeste da Unidade de Conservação e está inserida no processo de ampliação da UC. Atualmente em parte da região do “campo” a pesca é proibida (Resolução CEPESCA 02/2018) devido à sua importância para a ictiofauna. Um dos objetivos deste trabalho foi verificar se o entorno da UC seria um local adequado para a sobrevivência das espécies em estudo.

A análise realizada indica que as três espécies estudadas possuem grande variedade em sua dieta alimentar (variação temporal) e adaptam-se a diferentes ambientes, rio e campo (variação espacial). Estes estudos apontam que os dois locais de estudo (UC e entorno) estão proporcionando locais adequados para a sobrevivência da espécie.

8.3.2. Herpetofauna

A riqueza de anuros do Pantanal é baixa quando comparada com outros biomas, devido provavelmente à pequena heterogeneidade dos habitats e o alto stress imposto aos organismos devido às diferenças ambientais entre seca e cheia (Uetanabaro et al.,2008). Apesar da pequena diversidade, a abundância é muito alta no Pantanal, possivelmente devido à quantidade de água espalhada pelo bioma. Atualmente são registradas 44 espécies para a região pantaneira.

Existem aproximadamente 113 espécies de répteis reconhecidas para o Pantanal, sendo que destas, perto de 30 são espécies de serpentes. A Sucuri, ou anaconda amarela (*Eunectes notaeus*), é a mais comum e é pequena quando comparada com a anaconda verde (*E. murinus*), a qual vive na borda do Pantanal e pode alcançar até cinco metros. Outra serpente de grande porte é a surucucu (*Hydrodinastes gigas*), com ocorrência preferencial em bordas de galerias. Destacam-se também as pequenas serpentes noturnas como *Thamnodynastes* cf. *strigilis*, *Leptodeira annulata* e *Liophis poecilogyrus*. Vinte espécies de lagartos são conhecidas para a região, todos com preferência por habitats secos, com exceção da víbora-do-pantanal (*Dracaena paraguaiensis*) (Alho, 2008), o qual vive a maior parte do tempo na água.

Dentre os principais répteis encontrados na Estação e região de entorno destaca-se o jacaré (*Caiman crocodilus yacare*).

Outras espécies de répteis encontrados na EE e região são o jabuti (*Geochelone carbonaria*), o cágado (*Platemys macrocephala*), o teiú (*Tupinambis teguixin*), o iguana (*Iguana iguana*), dentre outras. O jabuti é habitante das matas, onde se alimenta de vegetais e frutos caídos, sendo a sua carne apreciada na região. O cágado é uma espécie bastante distribuída nos rios e regiões alagadas. A sucuri é encontrada preferencialmente nas matas que margeiam os grandes rios, encontrando na área de estudo excelentes condições para a sua sobrevivência.

8.3.3. Mastofauna

O Pantanal compartilha boa parte da fauna existente no Cerrado, porém com diversidade um pouco menor, 132 espécies (Alho, 2008). Entretanto, a grande abundância de várias espécies de mamíferos em determinadas estações do ano torna o bioma espetacular. Essa abundância é notável com capivaras *Hydrochaeris hydrochaeris*, coatis *Nasua nasua*, cervo-do-pantanal *Blastocerus dichotomus* (vulnerável - MMA e IUCN), lobinho *Cerdocyon thous*, veado-campeiro *Ozotoceros bezoarticus* e outros mamíferos. Mesmo espécies oficialmente listadas como ameaçadas ainda podem ser vistas com certa frequência como o tamanduá-bandeira *Myrmecophaga tridactyla* (vulnerável - MMA e IUCN), o cervo-do-pantanal, o tatu-canastra *Priodontes maximus* (vulnerável - MMA e IUCN), a onça-pintada *Panthera onca* (vulnerável – MMA) e a ariranha *Pteronura brasiliensis* (vulnerável – MMA, ameaçada IUCN).

O baixo número de espécies de mamíferos para o Pantanal pode ser em decorrência da pouca atenção dada à região. Os primeiros estudos com mamíferos foram realizados na década de 1980 por Schaller (1983), na Fazenda Acurizal, Alho et al. (1987) e Lacher e Alho (1989), na Fazenda Nhumirim, no Pantanal Sul. O Plano de Conservação da Bacia do Alto Paraguai – PCBAP foi a primeira listagem mais completa já publicada dos mamíferos com ocorrência na bacia do alto rio Paraguai, sendo considerado uma referência para a o Pantanal (RODRIGUES et al., 2002).

Dentre os mamíferos da região de estudo destacam-se: a capivara (*Hydrochoerus hydrochaeris*), o maior roedor atualmente vivo, chegando a medir 1,30 metros de comprimento e 0,50 a 0,60 metros de altura; a ariranha (*Pteronura brasiliensis*), o maior carnívoro semi-aquático da América do Sul, vivendo em grupos sociais com estrutura familiar de 5 a 9 membros e distribuição de atividades, é considerada um espécie “em perigo” pela IUCN e “vulnerável” pela classificação do ICMBio, 2016; o bugio (*Alouatta caraya*), animal social que vive em bandos de sete indivíduos em média, sendo o macho o escuro e a fêmea e os jovens mais claros. O grupo é liderado pelo macho mais velho, chamado de capelão. Estes organismos possuem uma vocalização característica, que pode ser ouvida a até 500 metros de distância; o cervo-do-pantanal (*Blastocerus dichotomus*), maior cervídeo da América do Sul, pesa em média 100 quilogramas. Possui membranas entre os dedos das patas, o que o torna adaptado aos terrenos alagáveis típicos do Pantanal, e é classificado como “vulnerável” na lista de espécies ameaçadas de extinção no Brasil (ICMBio, 2016; IUCN, 2015). De acordo com Mauro e colaboradores (1988), as maiores concentrações do cervo-do-pantanal no bioma foram encontradas: (1) próximo à confluência dos rios Paraguai e Bento Gonçalves; (2) na margem alagada da baia Uberaba, (área da Reserva de Fauna proposta) perto do limite com a Bolívia; (3) na Estação Ecológica de Taiamã e seu entorno. Segundo este autor, os animais nesta última localidade constituem a única população viável de cervo-do-pantanal conhecida existente em uma área protegida no Brasil.; e a onça-pintada (*Panthera onca*). Recentemente, em estudos realizados com armadilhas fotográficas, foi detectada a presença constante de vários indivíduos conhecidos popularmente como jaguatirica - *Leopardus pardalis*. Estudos anteriores realizados na região da UC não detectaram a presença desta espécie, de forma que, acredita-se que, possivelmente, esta presença se deve a uma colonização recente.

No estudo realizado por De Lazari (2011), consta a existência de 27 espécies de mamíferos de médio e grande porte na região. Os resultados apontaram que a riqueza de mamíferos foi diretamente influenciada pelo fator inundação (avaliada pela altura do rio) e precipitação. As localidades amostradas nesse estudo apresentam ambientes que são afetados de maneira diferente pelo ciclo hidrológico, refletindo diretamente na riqueza de espécies. A área de estudo tem em sua área a predominância de campos alagáveis compostos por gramíneas e ciperáceas e manchas de mata, tendo praticamente toda sua área alagada no período chuvoso. Na região ocorre extravasamento de água para a planície pelo rompimento de diques marginais (Silva et al., 2007), fazendo com que as inundações sejam generalizadas, e desta forma impedindo que as espécies possam se refugiar e explorar os nichos ecológicos durante o período de cheia.

Ainda segundo De Lazari (2011), de acordo com moradores locais, após uma grande enchente no ano de 1974, muitas espécies que ocorriam na área de EE de Taiamã passaram a não mais serem vistas. Espécies como *Nasua nasua*, *Cerdocyon thous*, *Tayassu pecari*, *Procyon cancrivorus*, *Puma concolor* e *Dasypus novemcinctus* não tiveram mais sua ocorrência registrada para a localidade. Segundo os entrevistados as enchentes no passado não eram tão generalizadas quanto às dos dias atuais, fazendo com que a região da EE pudesse abrigar muitas espécies de mamíferos. Já na área de estudo, a inundação é de altura média e a área de abrangência não é generalizada, com permanência de média a longa duração (ANA 2004). Pelo fato da inundação não ser generalizada, esta área apresenta formações vegetais não afetadas pelo transbordamento das águas, tendo um ambiente com condições de abrigar espécies tanto no período seco quanto na cheia. Os resultados demonstram que a área de estudo abriga rica comunidade de mamíferos de médio e grande porte comparável com outras áreas do Pantanal. A ocorrência de carnívoros na área de estudo é um indicativo do bom estado de conservação dos habitats, uma vez que são predadores de topo de cadeia e necessitam de toda a estrutura de presas e do ambiente conservados. As presenças de espécies ameaçadas de extinção apontam para o importante papel da área na conservação da fauna pantaneira.

Panthera onca

A região das ilhas de Taiamã, Sararé e Porto Jofre são notoriamente reconhecidas pela visualização constante de indivíduos da espécie *Panthera onca* (onça-pintada), realizadas principalmente por turistas, pescadores profissionais, pesquisadores e agentes ambientais. A observação de onças-pintadas é um dos principais atrativos turísticos na região, juntamente com a pesca esportiva.

A onça-pintada, espécie considerada quase ameaçada de extinção (IUCN 2015), é o maior felídeo vivente da América. Sua distribuição estendia-se, antes da destruição da maior parte de seu habitat, do Arizona, passando pela

Califórnia e Novo México nos Estados Unidos, até o Rio Negro na Argentina. Atualmente, esta espécie pode ser considerada praticamente extinta na América do Norte, terras baixas do México, El Salvador, Uruguai e regiões desenvolvidas do Brasil (Morato et al. 1998; Leite 2000), devido principalmente à perda de habitat e caça. De acordo com Sanderson et al. (2002), 50% da área da distribuição de onças-pintadas está no Brasil. O Pantanal, maior área úmida tropical do planeta, com 147.574 km^2, é considerada uma área importante para a conservação de *P. onca* (Sanderson et al. 2002; Soisalo & Cavalcanti 2006; Cavalcanti et al. 2012), principalmente na região central-norte e também no extremo sul do bioma, sendo que estas regiões são consideradas de extrema importância para a conservação em longo prazo deste grande felino (Quigley & Crawshaw 1992) no ecossistema citado.

Considerando que a Estação Ecológica de Taiamã e as propostas de criação estão localizadas no centro de uma das áreas de grande concentração de onças-pintadas no Pantanal Figura 17, Kantek & Onuma (2013) fizeram um estudo que teve como objetivo correlacionar os dados obtidos (fotos) da população de onças-pintadas com a área protegida legalmente na região da EET.

Imagens georrefenciadas foram obtidas entre os anos de 2006 e 2011 nos rios que ficam no entorno e na borda da Estação. Os animais foram observados na EET e na Ilha de Sararé. Em um total de 50 visualizações foi possível identificar, através do padrão de pigmentação, 27 indivíduos de *P. onca*, todos aparentemente saudáveis.

Apesar da não quantificação dos períodos amostrais, o número de visualizações de cada um dos 27 exemplares catalogados é desigual, sugerindo que os indivíduos que foram avistados com mais frequência possuem uma alteração comportamental, possivelmente originada pela presença de atividades antrópicas, como o costume ilegal de alguns agentes de turismo de alimentar onças-pintadas com o objetivo de aumentar o número de visualizações para os turistas. Costume este observado por outros pesquisadores nesta e outras regiões do Pantanal (Neto et al. 2011).

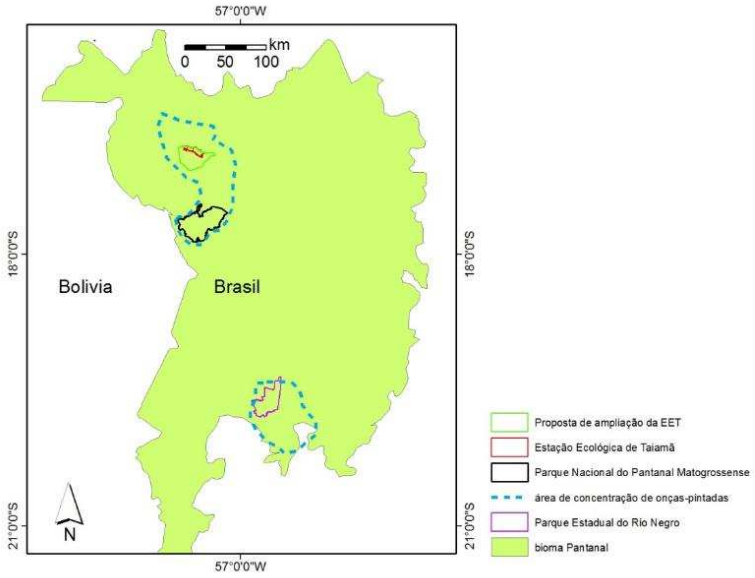


Figura 17 - Mapa do Bioma Pantanal (verde), com localização das regiões de maior concentração de onças–pintadas (Quigley & Crawshaw, 1992) e Unidades de Conservação localizadas nestas áreas.

Dados apresentados por Astete et al. (2008) indicam uma densidade média de 4.53 indivíduos de onça-pintada a cada 100 km² no bioma Pantanal. Ao extrapolar esta informação para a área da Estação Ecológica de Taiamã (115,55 km²), observa-se que a área da Estação estaria protegendo legalmente 5.05 onças-pintadas, ou seja, o tamanho da área atual da UC não seria sufuciente para assegurar a sobrevivência da população existente.

Dentro de toda a área de distribuição da onça-pintada pelo continente americano, o Pantanal é um dos poucos habitats onde a espécie pode ser observada com relativa facilidade (Mittermeier et al. 1990). Dentre as áreas procuradas pelos turistas, a região da EE de Taiamã e a região de Porto Jofre são uma das mais visitadas. A criação das unidades poderá proporcionar maior efetividade na proteção desta espécie, possibilitando que o turismo de observação continue a gerar renda para as populações locais.

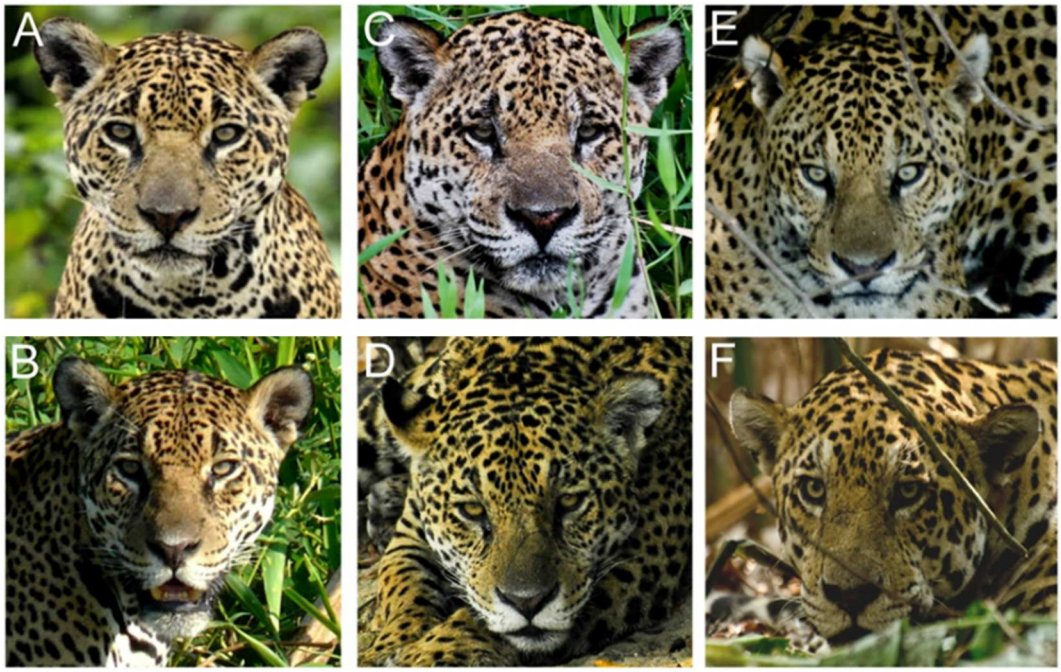


Figura 18 - Registros fotográficos de alguns exemplares de onças-pintadas registradas. A e B são registros de um único indivíduo em anos distintos. C, D, E e F representam quatro indivíduos distintos.

A interconectividade entre populações é extremamente importante para a sobrevivência das espécies a longo prazo (Gilpin, 1987). Recentemente várias terras foram adquiridas no Pantanal Norte com intenções conservacionistas, produzindo um mosaico de áreas legalmente protegidas com fazendas privadas (Cavalcanti et al. 2012). Porém, entre a EET e o PMNP ainda não existe nenhuma área protegida, seja ela privada ou governamental. Desta forma a criação da Reserva de Fauna e o aumento da área da Estação seria o primeiro passo para a criação de um corredor ecológico legalmente protegido entre as duas UCs de proteção integral federais que ocorrem na região de concentração de onças-pintadas. O rio Paraguai, principal rio do bioma Pantanal, interliga estas duas áreas protegidas e tem parte de seus limites dentro da área central de concentração de onças-pintadas. Futuramente, mais áreas protegidas poderiam fazer parte de um mosaico de unidades de conservação a fim de aumentar a efetividade deste corredor que se encontra ainda muito bem conservado.

Desde o final do ano 2011 foram capturadas 19 onças-pintadas através da técnica de *foot snare* (Balme et al., 2009) na área da EE e entorno próximo. A captura destes animais possibilitou, dentre outras coisas, a colocação de rádio-colares nos exemplares, os quais permitiram e ainda permitem a obtenção de dados valiosos sobre a biologia destes felinos e suas relações com a EE de Taiamã. Os colares instalados estão equipados com GPS e armazenam informações como a localização dos animais, temperatura e altitude em

intervalos de tempo pré-programados. Desta forma, foi possível obter informações sobre as localizações de vários animais.

Observou-se que ocorre sobreposição das áreas de uso entre os animais, fato que já que foi registrado para esta espécie em vários outros trabalhos, inclusive para o bioma Pantanal (Astete et al., 2008).

É possível observar o agrupamento das áreas de uso das onças-pintadas monitoradas por colar/GPS. As áreas de uso foram obtidas para cada animal pela metolodia AKDE e agrupamentos foram feltos através de softwares de geoprocessamento. Os dados foram separadados em estação seca e úmida sendo que as áreas utilizadas nos dois períodos foram muito similares. Aparentemente estes animais não fazem incursões para as fazendas próximas da UC (não existem áreas de produção de gado nas áreas adjacentes).

Ainda sobre a área de uso, nota-se que as citadas áreas estão localizadas no interior da Estação Ecológica de Taiamã, na área proposta para ampliação e na RPPN Jubran. Os dados de perfil sanitário apresentados para animais capturados na própria UC também corroboram esta hipótese. Aparentemente os animais não estão saindo das áreas conservadas devido à boa quantidade de recursos alimentares existentes na região.

Novamente sobre as áreas de uso, e considerando as localizações de todos os animais estudados, é possível perceber que parte significativa dos pontos fornecidos pelo GPS está em área não protegida, fora da EE. Como já mencionado anteriormente, para uma proteção mais eficiente destes animais, é desejável que as áreas alagadas que estes animais utilizam no entorno da Estação também estejam amparadas pelas normas de restrição de uma unidade de conservação.

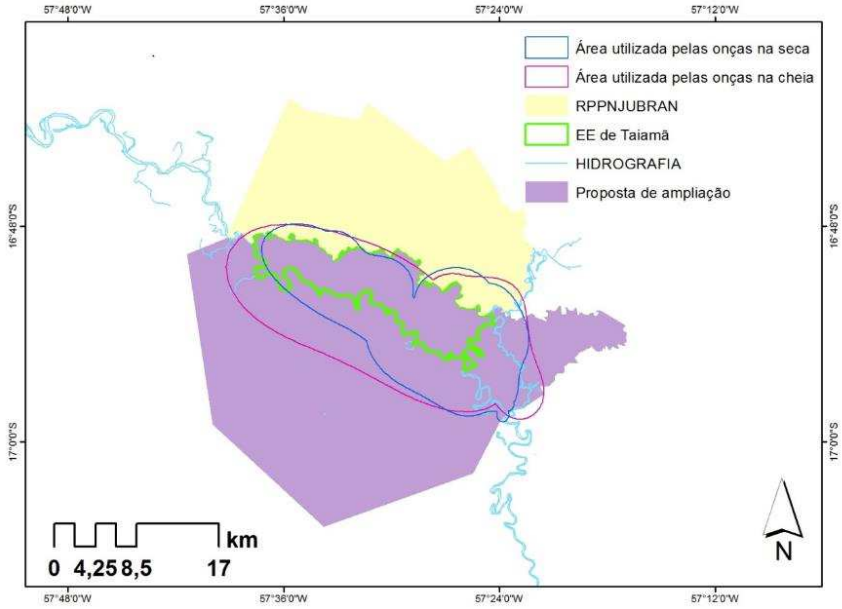


Figura 60 - Área de uso das onças pintadas monitoradas e EE de Taiamã, proposta de ampliação e RPPN Jubran.

Avaliação do perfil sanitário

Nas últimas décadas, o impacto das doenças nas populações de espécies selvagens de vida livre tem chamado a atenção de pesquisadores e conservacionistas (CLEAVELAND et al. 2007). Segundo estudos recentes realizados no Brasil e em outros países, os carnívoros selvagens têm sido expostos a agentes infecciosos que comumente causam morbidade e mortalidade em animais domésticos, como revelam os resultados encontrados por Jorge (2008) em uma reserva particular no Pantanal matogrossense, e já causaram mortalidade em carnívoros selvagens em outros continentes. A transmissão de patógenos entre animais domésticos e selvagens é ainda mais preocupante se estes estão em ambientes fragmentados, com baixa variabilidade genética e/ ou expostos a patógenos emergentes (McCALLUM & DOBSON 2002, PATZ et al. 2004, TRAVIS et al. 2006), sendo que esta situação ocorre principalmente através da incursão e modificação humana em ambientes naturais.

Muitos fatores ecológicos e epidemiológicos podem influenciar a distribuição de infecções em uma população animal susceptível e serem responsáveis por epizootias, com graves consequências em populações ameaçadas (SCOTT 1988; CLEAVELAND et al. 2006). Além disso, os animais selvagens também podem atuar como fontes de infecção para os animais domésticos e seres humanos, representando uma ameaça a programas de controle e erradicação de doenças zonóticas (BENGIS; KOCK; FISHER, 2002).

Por ser um animal topo de cadeia trófica, a onça-pintada, como outros carnívoros, são importantes para a manutenção de condições ecológicas saudáveis (ALHO, 1992), além de ser considerada espécie bioindicadora na avaliação da qualidade de conservação ambiental (CIMARDI, 1996, SILVEIRA, 1999), podendo ser usada como sentinela de diversos patógenos de importância em saúde pública e animal (CLEAVELAND et al. 2006, AGUIRRE, 2009). Diante disso, um programa eficiente de monitoramento de doenças em animais selvagens de vida livre deve promover a detecção da ocorrência de doenças novas e emergentes em estágios iniciais, a fim de subsidiar as ações dos serviços de Saúde Pública através do conhecimento dos focos naturais das zoonoses, e as estratégias para o controle de doenças com implicações econômicas.

Todas as 7 onças-pintadas estudadas foram capturadas através do sistema de captura *foot snare* (BALME et al., 2009), imobilizadas quimicamente e equipadas com rádio-colares providos de Sistema de Posicionamento Global (GPS). Todos os procedimentos anestésicos foram acompanhados por médico veterinário. Após exame clínico, pesagem, coleta de dados biométricos, material biológico, como sangue, urina, pelo e ectoparasitas quando presentes, todos os animais foram soltos no mesmo local da captura.

O estado clínico geral de todos os animais no momento da captura foi considerado muito bom. Somente um animal capturado apresentou infestação

por carrapatos (dois indivíduos adultos da espécie *Amblyomma cajennense*) (ONUMA 2014).

Uma onça-pintada apresentou anticorpos para *Leptospira* spp., sendo o sorovar Canicola o mais provável por causar a infecção, cujo título foi de 3.200. Nenhuma onça amostrada apresentou anticorpos para *Brucella abortus*. Estes dois agentes representam importantes zoonoses de distribuição mundial, e podem determinar barreiras econômicas quanto ao comércio de produtos de origem animal com outros países. A baixa frequência de animais reatores para *Leptospira* spp., além da ausência de animais reatores a sorovares mantidos por animais como Hardjo, Pomona e Grippotyphosa, pode sugerir baixa predação ou menor contato com espécies domésticas, ressaltando a importância dessa área protegida na conservação de espécies ameaçadas, como a onça-pintada (ONUMA et al., 2015). Este resultado difere de outros estudos realizados com onças-pintadas de vida livre, porém capturadas em fazendas e regiões que propiciavam maior interação com animais domésticos e seres humanos, onde a detecção da exposição aos mesmos agentes indicou que este contato pode representar um risco à transmissão de doenças e à biodiversidade local (FURTADO 2010; NAVA 2008).

Esta hipótese pode também fundamentar a negatividade da exposição a *B. abortus* e carrapatos como *Bhoophilus microplus,* comumente relacionados ao contato com áreas de criação de bovinos e a predação destes animais, sugerindo, por conseguinte, a necessidade da elaboração de medidas regulatórias no Plano de Manejo no que se refere à ocupação humana e seus animais domésticos nas áreas de entorno, com o intuito de prevenir os problemas sanitários decorrentes da interação com a vida selvagem local.

8.3.4. Avifauna

Espécies de aves aquáticas são comuns no Pantanal com abundância notável, incluindo garças e socós dos gêneros *Egretta, Ardea, Tigrisoma* e *Butorides*, como também cabeça-seca *Mycteria americana*, tabuiaiá *Ciconia maguari* e tuiuiú *Jabiru mycteria*. Martim-pescador está presente com as cinco espécies brasileiras dos gêneros *Megaceryle e Chloroceryle*. Dentre as outras espécies aquáticas podemos citar o tachã *Chauna torquata*, o pato *Cairina moschata*, a marreca *Dendrocygna bicolor*, bem como outras marrecas: *D. viduata, D. autumnalis e Amazonetta brasiliensis*.

A planície pantaneira recebe grupos de aves com migração transcontinental. São basicamente dois grandes grupos já reconhecidos. Espécies com reprodução no sul do continente durante a primavera/verão austrais que migram para o norte até o Pantanal ou passam por ele indo mais ao norte. O outro grande grupo de migratórias possui reprodução na América do Norte durante a primavera boreal. No final do verão e início do outono do Hemisfério Norte migram para a América do Sul, com várias dessas aves chegando ao Pantanal a partir de agosto/setembro. (Antas *et al*., 1986).

A avifauna mais representativa região é constituída de aves aquáticas, as quais no período da vazante se alimentam dos peixes aprisionados nas baias e lagoas rasas. Algumas espécies reúnem-se em grandes grupos, constituindo os "viveiros". As aves mais representativas na ilha são: o Biguá (*Phalacrocorax brasilienus*); o Biguá-Tinga (*Anhinga anhinga*); o Baguari ou Garça Cinza (*Ardea cocoi*); o Socozinho (*Butorides striata*); a Garça-branca grande (*Ardea albas*); a Garça-branca pequena (*Egretta thula*); o Socó-boi (*Tigrisoma lineatum*); o Tuiuiú (*Jabiru mycteria*); o Cabeça seca (*Mycteria americana*); o Tapicuru (*Phimosus infuscatus*); o Trinta-réis-anão (*Sterna superciliaris*); o Trinta-réis grande (*Phaetusa simplex*); o Coro-Coró (*Mesembrinibis cayennensis*); o Carão (*Aramus guarauna*); o Jaçanã (*Jacana jacana*); a Curicaca cinza (*Harpiprion caerulescens*); a Curicaca (*Theristicus caudatus*); o Periquito (*Myiopsitta monachus*); o Caracará (*Polyborus plancus*); o Gavião Caramujeiro (*Rosthramus sociabilis*); Aranquã (*Ortalis canicollis*) e o Tachan ou Anhuma (*Chauna torquata*). Dentre os anatídeos (grupo formado por patos, gansos, cisnes e marrecos), as principais espécies observadas estão a Marreca-cabocla (*Dendrocygna autunnalis*) e o pato do mato (*Cairina moschata*).

Em uma pesquisa (Bueno, 2013, Almeida, 2013) que teve como objetivo conhecer melhor a avifauna da região, foram amostradas duas fitofisionomias a fim de registrar a riqueza e abundância destas áreas, além de analisar a composição de diferentes ambientes. Para a realização da pesquisa foram utilizados dois métodos para a amostragem das aves, a captura com redes de neblinas e censo por pontos. Foram registradas 157 espécies de aves, correspondente a 33,90% das espécies registradas para a planície Pantaneira. A curva cumulativa demonstra que a continuação do inventário na área poderá aumentar o número de espécies. Considerando a pequena área da UC e também ao fato de que a continuidade de amostragens tende a aumentar o número de espécies amostradas, o valor registrado é considerado significativo. Dentre as 157 espécies registradas uma se encontra ameaçada de extinção no Brasil, a *Penelope ochrogaster*.

As espécies amostradas estão distribuídas em 19 ordens e 38 famílias. Destas, 21 famílias (55,26%) são pertencentes à ordem dos não-Passeriformes, e 17 famílias (44,73%) pertencem à Ordem Passeriformes.

As famílias mais representativas na floresta inundável foram Tyrannidae (16), Thraupidae (9) e Picidae (7), enquanto na floresta não-inundável foram Tyrannidae (23), Thraupidae (11), Emberezidae e Icteridae (8).

Thraupidae e Tyrannidae foram as famílias mais representativas no presente estudo e estão entre as maiores em número de espécies dentre os Passeriformes da América do Sul (SICK, 1997). Representantes da família Picidae (pica-paus) são insetívoros de troncos e galhos e constituem um dos grupos expressivos em estágios avançados da vegetação, sendo sensíveis a alterações ambientais. Sua representatividade nas áreas estudadas indica boa qualidade do hábitat (GIMENES e ANJOS, 2003; LAPS et al., 2003).

Dentre as espécies registradas no presente estudo as guildas alimentares com maior representatividade foi a dos insetívoros (43%), seguida de onívoros

(17%) e frugívoros (16%). Todas as outras guildas alimentares juntas corresponderam a 24% da avifauna amostrada, com destaque para os granívoros com 9%.

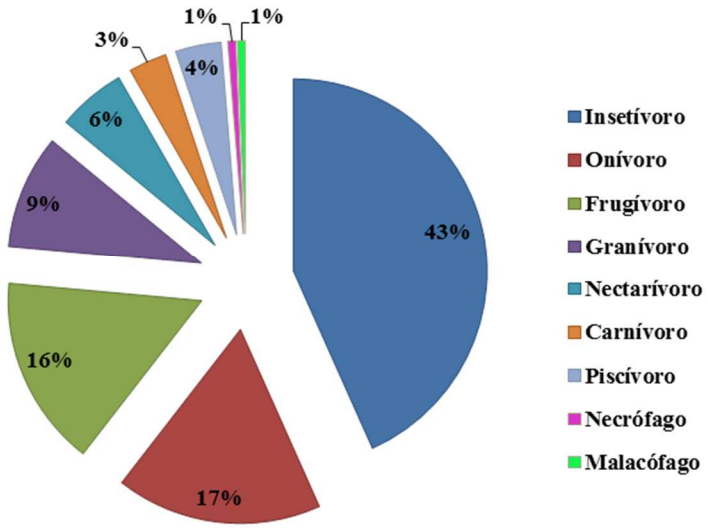


Figura 19 - Número de espécies de aves distribuídas nas guildas alimentares registradas na região, entre os meses de setembro de 2012 e junho de 2013.

Insetívoros e onívoros também foram os agrupamentos tróficos mais representativos em outros estudos (SCHERER et al., 2005; BISPO e SCHERER-NETO, 2010; DARIO, 2010). Espécies destas guildas possuem disponibilidade de alimento o ano todo, pois os insetos não constituem um recurso limitante para os insetívoros, enquanto onívoros utilizam táticas alimentares variadas, possibilitando-lhes a utilização do recurso alimentar de acordo com as condições oferecidas (SCHERER et al., 2005). Por outro lado, um número muito elevado de espécies onívoras representaria alto grau de perturbação da área, uma vez que são espécies generalistas que se adaptam a ambientes alterados (LAPS et al., 2003; GIMENES e ANJOS, 2003).

Grandes frugívoros registrados neste estudo como o jacu-de-barriga-castanha (*Penelope ochrogaster*), a cujubi (*Aburria cujubi*) e o mutum-de-penacho (*Crax fasciolata*) tem papel fundamental na manutenção de áreas florestais, atuando como agentes dispersores de sementes. A presença destas espécies requer a presença de diferentes espécies vegetais frutificando em diferentes estações do ano (GIMENES e ANJOS, 2003).

Por outro lado, granívoros, como as espécies da família Emberizidae (Ex: tiziu, *Volatinia jacarina*) são bastante favorecidos pelo efeito de borda, devido à proliferação de espécies de gramíneas, base de sua alimentação (DARIO, 2010). A presença de várias espécies da família se deve aos grandes campos de gramíneas existentes na região.

Dentre as 157 espécies registradas na região, 26 espécies são migratórias, compreendendo 19,54% da lista de aves migratórias na planície do Pantanal (Nunes & Tómas, 2008). Os dados obtidos neste estudo correspondem a um valor significativo, e que as análises evidenciaram que existem ainda várias espécies a serem identificadas.

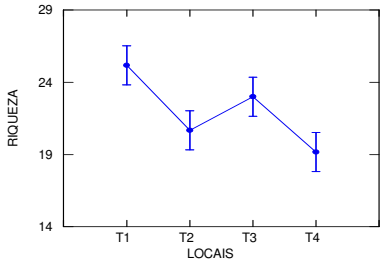
Em um estudo entitulado “COMUNIDADE DE AVES AQUÁTICAS DA ESTAÇÃO ECOLÓGICA DE TAIAMÃ, PANTANAL NORTE, CÁCERES - MATO GROSSO” (Melo, 2014), foram comparadas a riqueza e abundância de aves aquáticas em quatro trechos localizados na EET e entorno.

Das 80 espécies de aves aquáticas predominantes para o Pantanal segundo Cintra e Yamashita, (1990), registrou-se neste estudo 45 espécies para a EE de Taiamã e área de entorno, mostrando a importância dessa área para conservação da biodiversidade. Esse padrão é superior ao encontrado por Nunes (2010) em levantamento da avifauna no Rio Paraguai, Pantanal de Cáceres, onde encontrou 315 espécies, sendo destas 37 aquáticas.

A maior abundância considerando todos os trechos amostrados ocorreu na cheia.

O grande número de indivíduos (6858) observados no trecho I **Erro! Fonte de referência não encontrada.**pode estar relacionado a um fenômeno natural que ocorre nesta área, denominado “dequada”, o qual provoca alterações limnológicas de forma a deteriorar a qualidade da água, desencadeando a mortandade de peixes. Esta abundância de recurso alimentar influencia diretamente na abundância das espécies de aves aquáticas (Calheiros & Ferreira 1996). Outro fator que pode ter contribuído é a presença de uma grande quantidade de corpos d’água nesta região, os quais na estação da seca ficam isolados de outros corpos d’água, maximizando a oferta de alimento para as espécies aquáticas.

A alta riqueza e abundância observadas na região da Estação ecológica devem-se, possivelmente, ao elevado grau de conservação desta área e a grande variedade de habitats. Além disso, a pesca é proibida neste trecho e o tráfego de barcos é bem menor que nas outras áreas, evidenciando que a antropização pode levar a um declínio na abundância e riqueza de espécies, até mesmo em áreas adjacentes a unidades de conservação.



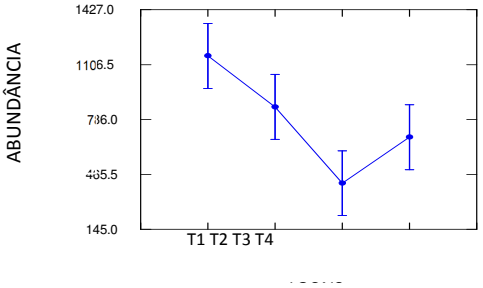


Figura 62 - Análise da riqueza (Fig. 2a) e abundância (Fig. 2b) da avifauna aquática.

O transecto III é uma região fora da UC que sofre com a degradação devido às áreas de criação de gado e com o fluxo maior de embarcações (nesta área a pesca é permitida), porém, porção significativa da área amostrada é formada por vegetação de porte arbóreo de mata ripária. Mesmo com essas atividades antrópicas este trecho apresentou maior riqueza de espécies, em comparação ao transecto II (que corresponde uma região protegida) e IV área alagada. Isto se deve, provavelmente, à variedade de habitats, visto que os trechos II e IV são bastante homogêneos. Do ponto de vista conservacionista, nota-se que mesmo áreas que não estejam protegidas legalmente são extremamente importantes para a conservação das espécies de aves aquáticas do pantanal.

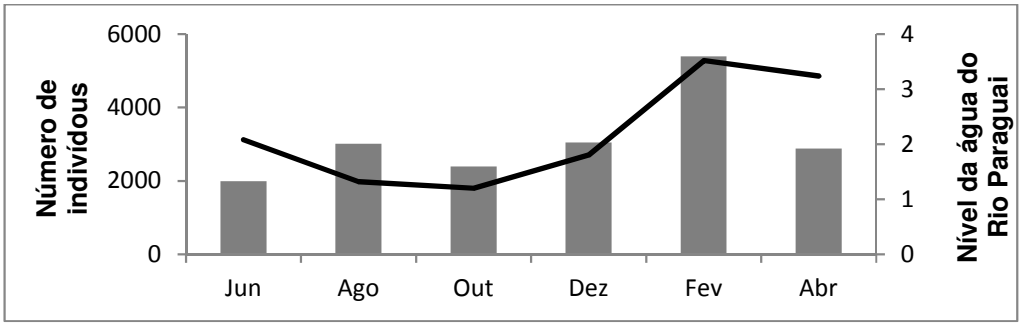


Figura 63 - Variação da abundância de espécies de aves aquáticas da EE de Taiamã e área de entorno, com relação a o nível da água do Rio Paraguai. (Fonte: Marinha de Cáceres, 2013).

A maior abundância de espécies no transecto IV (4101)(área proposta para a ampliação) em relação ao transecto III (2491) pode estar ligada a disponibilidade de alimento, visto que este último é uma área alagada de grande importância ictiológica.

A comunidade de aves aquáticas da EE de Taiamã esteve numericamente dominada pelas espécies piscívoras *Phalacrocorax brasilianus*, *Butorides striata*, *Anhinga anhinga, Ardea alba* e *Ardea cocoi,* fato que corrobora as informações sobre a importância ictiológica da UC da área proposta para a ampliação.

Ao fazer a junção de todos os registros de espécies de aves com ocorrência na EE de Taiamã e entorno, através da comparação de dados de alguns poucos estudos realizados na UC, foi obtido o quantitativo de 237 espécies, ou 51,18% do total de aves já descritas para o bioma Pantanal.

Outra informação relevante sobre a avifauna da Estação Ecológica de Taiamã é o registro de 14 espécies de migrantes neárticos (FROTA, 2017), as quais cruzam hemisférios, são oriundas do ártico, e deslocam-se por mais de 20 mil quilômetros para encontrar os sítios de invernada. A abundância de alimentos em locais como o Pantanal proporciona a estas aves a garantia de engorda e

a aquisição de energia suficiente para realizar a troca de penas e retornar ao seu sítio de reprodução (SICK, 1983).

9. Ocupação da planície do pantanal

Pesquisas arqueológicas confirmam a presença indígena no Pantanal desde, pelo menos, 8.200 anos atrás. Além disso, na primeira metade do século XVI, momento do início da Conquista Ibérica da região platina, o Pantanal apresentava-se como um extraordinário mosaico cultural, provável área de confluência para onde grupos de agricultores e ceramistas deslocaram-se desde o período pré-histórico. Isto significa dizer que a região foi habitada por diferentes grupos étnicos, cujo modo de vida também esteve intimamente relacionado aos recursos naturais ali existentes. Esta constatação por estudos antropológicos e arqueológicos comprova que etnias ameríndias também desenvolveram complexas estratégias de utilização dos recursos naturais existentes nos ecossistemas pantaneiros, explorando-os através da pesca, caça, coleta e formas de manejo ambiental.

Os índios Bororos, Paiaguás e Guaicurus foram os primeiros habitantes do corredor fluvial, o que dificultou a ocupação da área pelos brancos. No final do século XVIII, ocorreu a efetiva ocupação da área, o que levou à diminuição e extinção dos índios. A ilha de Taiamã foi o último reduto da tribo Bororo na região.

Por outro lado, os índios Guató formam o grupo étnico remanescente que vive na região, mas ainda pouco conhecido na literatura etnológica, é importante esclarecer que eles constituem um grupo étnico diretamente filiado ao tronco lingüístico Macro-Jê e se encontram estabelecidos no Pantanal há mais de 500 anos, sendo que a primeira referência textual sobre eles consta nos relatos do conquistador espanhol Alvar Nuñez Cabeza de Vaca, importante figura que compôs a história da região e que ali esteve em 1543

A natureza, nesta região, sempre foi um personagem a contracenar vigorosamente com os demais, condicionante que determinou a incorporação desse território à história ocidental do século XVI, mais precisamente, desde 1513. Para se chegar ao destino traçado (alcançar as riquezas andinas), tinha-se que percorrer suas poderosas águas entre rios, lagoas, plantas e animais. Além dos habitantes originais, se observava a presença dos índios Payaguá e Guaykurú.

Desta forma, toda a região inundável do Alto-Paraguai foi narrada e descrita entre os séculos XVI e XVIII, por conquistadores, jesuítas, monçoeiros e demarcadores, que cruzaram seus caminhos fluviais motivados por razões diversas, atribuindo valores também diversos a este lugar, quais sejam: os espanhóis o descreveram como um lugar maravilhoso e paradisíaco e o denominaram como *Mar ou Laguna de los Xarayes2*; enquanto os portugueses o denominaram como *Pantanais*, referência a pântanos, campos alagados, território de índios guerreiros.

Os primeiros registros de exploração datam de 1543, conforme já mencionado, com a passagem pelo solo pantaneiro dos espanhóis vindos da Bolívia. Nesse momento, os espanhóis penetraram pela baía da Gaíva até identificar o

caminho por terra para o Peru e fundaram um posto a oeste, denominado de Puerto de los Reyes.Posteriormente, em 1557, os espanhóis se adiantaram até a baía Uberaba, navegando pelo braço fluvial que une as duas baías. O povoamento dessa área de planície inundável, com a ocorrência e ocupação efetiva, somente teve início a partir da segunda metade do século XVIII. A condição tardia desse processo se deve, principalmente, a resistência indígena (Guaicurus, Paiagás e Cadiwues), associada às condições ambientais adversas, conforme comentado. De acordo com citações em Palhano *et al*., a conquista do Pantanal começou a acontecer apenas em 1775. Outros fatores limitantes ao povoamento dos pantanais foram as condições ambientais adversas. Na realidade, a compreensão do processo de ocupação da área em estudo passa necessariamente pela sua observação nos espaços do oeste brasileiro, ocorridos em fins do século XVII e início do século XVIII.

O mercantilismo português teve repercussões espaciais significativas pela expansão do bandeirismo paulista. Nesse período, com a mineração do ouro, foram surgindo povoamentos que mais tarde dariam feição às cidades. Além disso, o expansionismo português associado à fase mercantilista propiciou também a criação de fortificações militares, dando forma ao poderio da metrópole portuguesa no interior e se justapondo, espacialmente, às áreas de mineração. É na esteira desse processo que surgem nas margens de alguns rios, entre eles o Paraguai, núcleos urbanomilitares, consolidando a ocupação da fronteira, como Cáceres e Corumbá, em 1778, e Poconé, em 1781. Cidades como Corumbá e Cáceres cumpriram um papel central nesse processo, se consolidando como centros receptores e difusores de relações comerciais diversas.

A ocupação do corredor fluvial entre a cidade de Cáceres e a EET foi iniciada no século XVIII, começou com a abertura de fazendas e o surgimento do núcleo urbano da cidade de Cáceres à margem esquerda do rio Paraguai. Em meados do século XIX até início do século XX ocorreu, nas margens do rio Paraguai, o desenvolvimento da pecuária extensiva com as grandes fazendas de charqueadas (Descalvado e Barranco Vermelho), para exportação de carne e couro para a Europa.

A cidade de Cáceres iniciou-se próxima ao rio, sendo que as primeiras residências e casas comerciais foram construídas às margens do rio Paraguai e em sua planície de inundação, devido à necessidade de abastecimento de água, bem como pelo fato de todo o comércio estar localizado em torno do porto de Cáceres.

Na margem direita do rio Paraguai, localiza-se a fazenda Descalvado Figura que até a segunda metade do século XIX possuía cerca de 600 mil cabeças de gado e uma área em torno de 350 mil léguas quadradas. A localização privilegiada da fazenda facilitava a compra de rebanho bovino de outras propriedades rurais, cujo transporte dos produtos era feito por via fluvial, assim como sua exportação para a Europa e comercialização com outros estados brasileiros. No auge da produção, o abate atingia 30 mil cabeças de boi ao ano. Suas atividades compreendiam a produção de charque, extrato e caldo de carne, além de vários subprodutos (IBGE, 1958). A fazenda Descalvado era regionalmente muito importante, devido à sua arrecadação de impostos, sendo considerada, na época, a maior fonte de concentração da receita no estado de

Mato Grosso (IBGE, 1958), principalmente em função da exportação de seus produtos para o mercado europeu.

O aumento da produção de carne em alguns estados brasileiros e o desenvolvimento das indústrias frigoríficas em São Paulo e países platinos, na forma de monopólios, assim como a construção da estrada de ferro Noroeste do Brasil, facilitou o transporte de gado do estado de Mato Grosso para São Paulo, provocando o declínio da charqueada produzida na fazenda Descalvado.

Figura 64 - Localização da Fazenda Descalvados, próximo à EET.

Figura 65 - Fotografia da fachada da Fazenda Descalvados.

Outra fazenda de destaque produtivo, localizada no corredor fluvial, denominava-se Barranco Vermelho, situada na margem esquerda do rio Paraguai, a 75 km de Cáceres. Na fazenda, em meados do século XIX e início do século XX, desenvolviam-se as atividades da indústria de charqueada e a usina de açúcar e aguardente, ambas de importância regional.

Na década de 90, políticas voltadas para o desenvolvimento regional de Cáceres foram implantadas, visando à integração latino-americana. Nessa fase, vários projetos foram voltados para o desenvolvimento regional, tais como o projeto da hidrovia Paraguai-Paraná, através da implementação do sistema fluvial, abrangendo cinco países da Bacia do Prata (porto em Cáceres) para escoamento da soja; implantação da Zona de Livre Comércio (zona de processamento para exportação), visando à integração latino americana e ligação com o Oceano Pacífico por via terrestre.

Nas regiões propostas para a ampliação da EET e da criação da reserva de fauna não existem populações ribeirinhas, vilarejos ou cidades. Somente alguns pescadores profissionais de Cáceres e Corumbá, que utilizam em determinadas épocas do ano, para a pesca de iscas e peixes de interesse comercial, sendo que durante este período ficam acampados nas margens do rio Paraguai.

A equipe de servidores da Estação Ecológica de Taiamã faz frequentemente incursões fluviais, em vários trechos do limite proposto para a ampliação da UC. Não foi detectado nenhum tipo de construção ou mesmo acampamento de pessoas na área.

9.1 Patrimônio arquelológico

Como prova da presença indígena foram registrados sítios arqueológicos em literatura (Palhano *et al.*, 2002, p. 10). Os levantamentos realizados para a elaboração do Plano de manejo do Parque Nacional do Pantanal Matogrossense também registraram a ocorrência na encosta norte do morro do Caracará, local onde a interferência de culturas indígenas pretéritas foi significativa, de um grande sítio a céu aberto, com desenhos entalhados nas pedras.
Este sítio é composto por gravuras e pinturas de grande beleza, sendo considerado pelo Instituto do Patrimônio Histórico e Artístico Nacional (IPHAN) um sítio de alta relevância.
Existem sítios que datam de 2.000 a 4.000 anos e têm sido documentados no Pantanal do Mato Grosso do Sul, em alguns casos chegando a 8.000 anos (Palhano *et al.,* p. 10)

Segundo o documento Pólos de Desenvolvimento de Ecoturismo nas Regiões Sul e Centro-Oeste, foram identificados 153 sítios na planície de inundação, localizados em capões e cordilheiras, áreas não atingidas pelas águas. Estes se caracterizam, principalmente, por aterros elevados, trabalhados por ocupantes indígenas tanto para habitação quanto para cemitérios

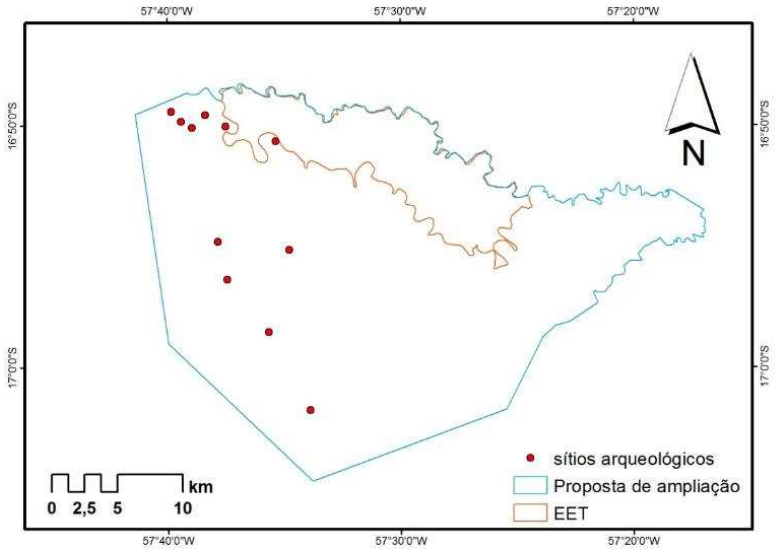
Figura 66. Pinturas rupestres da região do morro do Caracará.

Nas proximidades da Estação Ecológica de Taiamã o patrimônio arqueológico abrange vários sítios arqueológicos cadastrados pelo Instituto do Patrimônio Histórico e Artístico Nacional (IPHAN), Figura 20com se segue:

Sigla do Sítio	***Nome do Aterro***	**Eixo Maior (m)**	**Altura Máx. (m)**	**Área (m^2)**	**Coordenadas Geográficas**	**Localização**
MT-PO-38	Jatobá (I e II)	46,80	0,70	1.154	57º42'13"W e 16º44'46"S	No terreno das edificações do retiro Jatobá, margem esq. do rio Paraguai
MT-PO-39	Marimbondo	18,00	0,70	215	57º39'25"W e 16º49'51"S	Baía do Uvar, a W da Ilha de Taiamã
MT-PO-40	Tuiuiu	32,40	1,10	580	57º38'22"W e 16º49'35"S	Coricho do Uvar
MT-PO-41	Carajás	51,40	1,20	1.453	57º37'27"W e 16º56'23"S	Baía do Caicai
MT-PO-42	Jacarezinho	52,20	1,30	1.910	57º35'40"W e 16º58'34"S	Baía do Caicai
MT-PO-44	Cemitério Índio Grande	Peq. faixa			57º40'16"W e 16º45'12"S	5' de barco abaixo do Porto Jatobá, margem esquerda do rio Paraguai
MT-PO-53	Camisa	37,60	0,90	885	57º33'53"W e 17º01'48"S	Baía abaixo da ESEC Taiamã
MT-PO-67	Capado Gordo	50,40	1,40	1.329	57º37'50"W e 16º54'50"S	Baía do Caicai
MT-PO-68	Bananalzinho Bororo	44,00	0,30	836	57º37'30"W e 16º50'04"S	Margem direita do rio Paraguai
MT-PO-79	Mata Escura	45,00	2,20	982	57º39'50"W e 16º49'27"S	Baía do Uvar, a W da Ilha de Taiamã
MT-PO-80	Pedro Flores	54,00	1,50	1.975	57º38'56"W e 16º50'07"S	Baía do Uvar, a W da Ilha de Taiamã
MT-PO-82	Palácio	76,00	3,40	4.415	57º34'46"W e 16º55'10"S	Baía do Caicai
MT-PO-117	Japuíra	27,40	0,51	482	57º35'205"W e 16º50'40"S	Em frente ao porto da ESEC Taiamã, margem direita do rio Paraguai
MT-PO-142	Bananal do Acuri	75,00	1,10	2.850	21K0419726 e UTM 8153082	Baía do Miguel, acessada pela margem esquerda do rio Paraguai, em frente à sede da fazenda Descalvados

Tabela 04 - Localização e Dimensões de aterros estudados no Pantanal de Cáceres Adaptado de Migliacio 2000, 2006.

A



B

Figura 20 - (A) Mapa com localização dos sítios arqueológicos cadastrados pelo IPHAN na área proposta para ampliação e (B) foto aérea do sítio Palácio – conjunto arbóreo no centro da imagem.

Conforme a denominação arqueológica, os sítios encontrados na planície do rio Paraguai são identificados como aterros (Oliveira, 1995). São sítios localizados a céu aberto, sendo que, nos pontos elevados da planície, são encontrados materiais arqueológicos (utensílios e fragmentos de cerâmica). As partes mais baixas das planícies de inundação eram usadas para sepultamento, sendo encontradas urnas funerárias contendo esqueletos. A visita aberta pode contribuir para a degradação dos sítios, o que torna necessária a implementação de uma política de turismo para o município de Cáceres, contemplando necessidades de conservação deste patrimônio.

Vários (10) destes sítios arqueológicos (tabela 07) estão dentro da área proposta para a ampliação da ESEC de Taiamã.

9.2 Propriedades rurais das propostas.

Dentro da área proposta para ampliação estão registradas no Cadastro Ambiental Rural (CAR), consultado em 06/08/2018, seis propriedades.

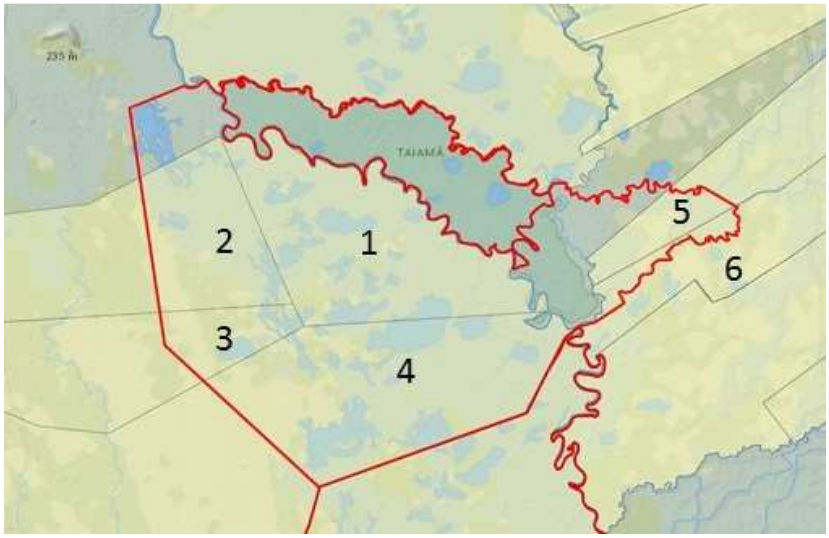


Figura 21 – Mapa dos imóveis rurais abrangidos pela ampliação da Estação Ecológica de Taiamã. Fonte: CAR

Dentre as áreas observadas, somente uma delas (imóvel 1 citado na figura acima) está totalmente inserida na área proposta para ampliação. Na margem direita do rio Paraguai existem quatro propriedades, e na margem esquerda duas. As porções das propriedades 3, 4, 5, 6 inseridas na proposta de ampliação são também áreas de reserva legal. Somente nos imóveis 1 e 2 existem áreas, no interior da proposta de ampliação, que não são área de reserva legal.

Além disso, é possível perceber a grande quantidade de corpos d`água no polígono da proposta, de forma que praticamente toda a área pode ser considerada área de preservação permanente.

Cabe ressaltar que tanto a Estação Ecológica de Taiamã quanto o Parque Nacional do Pantanal Mato-Grossense apresentam toda a sua situação fundiária regularizada.

Com relação à reserva de Fauna foram registrados apenas três imóveis rurais, sendo que um deles também está abrangido pela proposta de ampliação da Estação ecológica de Taiamã, mesmo número de imóveis abrangidos pela proposta de ampliação do Parque Nacional do Pantanal Mato-Grossense, sendo que dois dos imóveis também são abrangidos pelo Refúgio de Vida

Silvestre. Na proposta de Refugio foram registrados em torno de 10 imóveis rurais sendo que neste caso a proposta permite a presença dos imóveis sem a necessidade tácita de aquisição dos mesmos, ficando condicionada ao de acordo dos proprietários ao objetivo de criação da unidade de conservação.

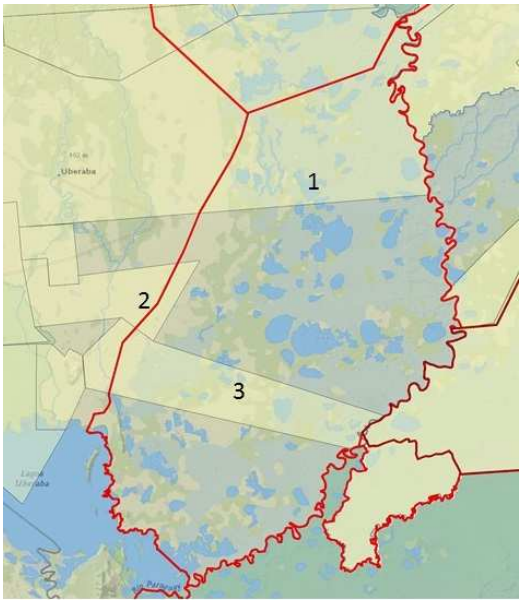


Figura 69 – Mapa dos imóveis rurais abrangidos pela Reserva de Fauna. Fonte: CAR

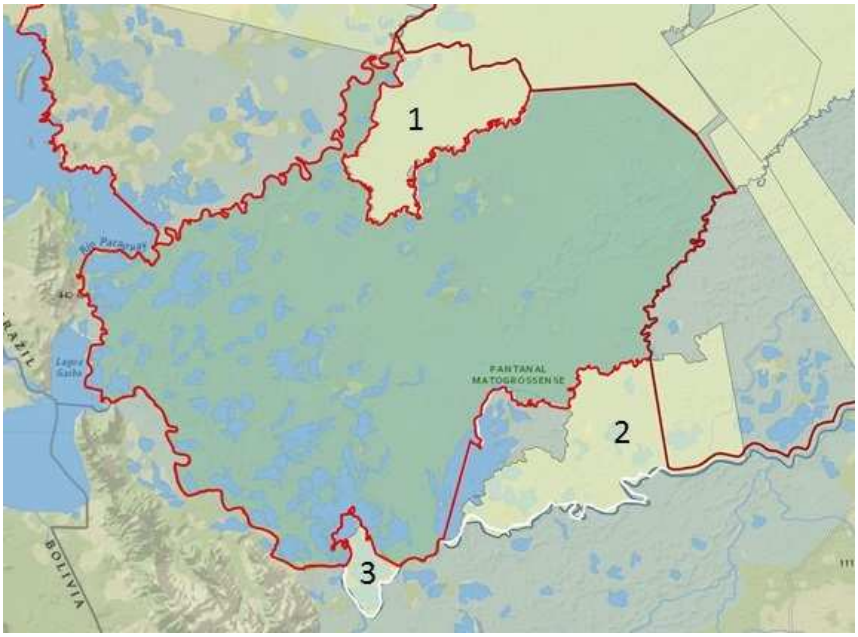


Figura 70 – Mapa dos imóveis rurais abrangidos pela ampliação do Parque Nacional do Pantanal Matogrossense. Fonte: CAR

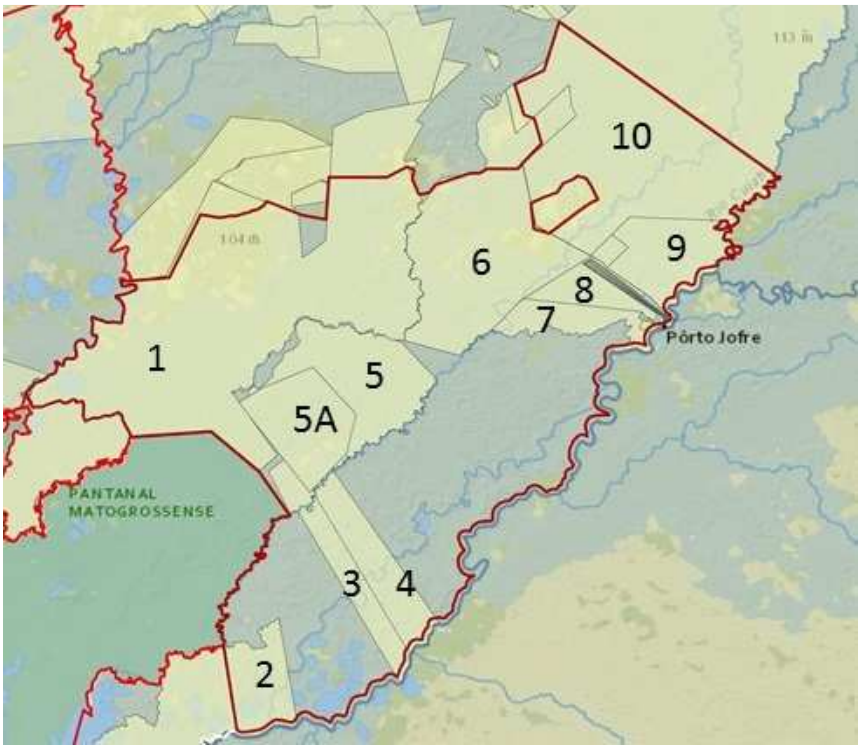


Figura 71 – Mapa dos imóveis rurais abrangidos pelo Refúgio de Vida Silvestre. Fonte: CAR

10. Considerações e justificativas para a criação/ampliação das unidades de conservação

10.1 Necessidade de proteção da região devido à sua importância biológica e considerando a alta produtividade ictiológica da região.

- A pesca no Pantanal, na região da EE de Taiamã, é concentrada nos organismos carnívoros e frugívoros que podem ser pescados com anzol, como por exemplo: pintado (*Pseudoplatystoma corruscans*), pacu (*Piaractus mesopotamicus)*, pacupeva (*Mylossoma orbignyanum*), piranha (*Pigocentrus nattereri*), cachara (*Pseudoplatystoma fasciatum*), jaú (*Zungaro zungaro*), dourado (*Salminus maxillosus*), entre outras espécies de alto valor comercial e cultural.

- A região do Bioma Pantanal onde o PARNA Pantanal Matogrossense está localizado, na confluência dos rios Cuiabá e Paraguai, é caracterizada por alto grau de inundação, apresentando uma complexa rede hidrográfica com diversos rios, baías, lagos e corixos, associada ao regime anual de inundação (enchente, cheia, vazante e seca). Essa característica de alta inundação e diversidade de ambientes aquáticos faz do PARNA Pantanal Matogrossense importante área para conservação dos recursos pesqueiros e aves aquáticas. Na região do Parque Nacional já foram identificadas 180 espécies de peixes, representando aproximadamente 70% das espécies encontradas na bacia pantaneira, demonstrando a importância desta área para a conservação da ictiofauna.

- Estudos citados anteriormente relatam que os peixes provenientes de áreas protegidas, como a ESEC Taiamã, são mais nutridos, pois essas áreas possuem recursos que favorecem a estabilidade no ciclo de vida do peixe.

- Em ambientes sazonalmente inundáveis muitas espécies vegetais fornecem abrigo e alimento para a ictiofauna. Em contrapartida diversos peixes podem dispersar as sementes através do mecanismo de ictiocoria, contribuindo com a manutenção das florestas alagáveis.

- A análise da dieta de peixes indicou que a passagem das sementes de *Alibertia* sp. e *Ficus* cf. *eximia* pelo trato digestório do *P. mesopotamicus* não inibiu a germinação das mesmas, e o fato deste peixe ser migrador oferece a essas plantas a possibilidade de ampliar sua área de colonização. Neste caso, esta espécie estaria realizando dispersão de sementes à montante do rio Paraguai.

- A área de ampliação da Estação Ecológica onde a pesca é proibida (RESOLUÇÃO CEPESCA 002/2018) devido à sua importância para a ictiofauna e essa proteção favorece a manutenção e repovoamento das popoulações de de peixes nas áreas vizinhas e conríguas, como a reserva de fauna proposta.

- A região da EE de Taiamã (UC e adjacências) é um local considerado ótimo para algumas espécies de peixe, visto que há alimento (FURLAN et al., 2017) e condições ambientais favoráveis (MUNIZ et al., 2016).

- Verificação da entrada de larvas na região de entorno da UC (campo), carreadas pelo rio Paraguai, da família Characidae e da ordem Siluriformes, grupos em que estão inseridas as espécies de valor comercial. Muitas espécies de piracema como o dourado, pintado, cachara e pacu se reproduzem também na região da EE de Taiamã, visto que são coletados na UC e entorno (área de proibição de pesca) espécimes com gônadas maduras durante os seus respectivos períodos reprodutivos (ARENHART, MUNIZ, 2011).

- A área da EE de Taiamã e da região de criação da reserva de fauna e a ampliação das UC está localizada em planície fluvial não confinada. À montante desta região o rio Paraguai encontra-se confinado à calha do rio. É possível perceber a grande presença de lagos na região da UC e a ausência dos mesmos a montante no rio Paraguai. A existência desta região alagada possui larga relação com os dados ictiológicos apontados anteriormente.

10.2. **Necessidade de uma maior área de proteção para espécies em risco de extinção, como onças-pintadas, ariranhas e cervo-do-pantanal, visto que a atual área da UC não é suficiente para manter populações saudáveis destas espécies em longo prazo.**

- A onça-pintada, espécie considerada quase ameaçada de extinção (IUCN 2015), é o maior felídeo vivente da América. De acordo com Sanderson et al. (2002), 50% da área da distribuição de onças-pintadas está no Brasil. O Pantanal, maior área úmida tropical do planeta, com 147.574 km^2, é considerada uma área importante para a conservação de *P. onca* (Sanderson et al. 2002; Soisalo & Cavalcanti 2006; Cavalcanti et al. 2012), principalmente na região central-norte e também no extremo sul do bioma, sendo que estas regiões são consideradas de extrema importância para a conservação em longo prazo deste grande felino (Quigley & Crawshaw 1992) no ecossistema citado.

- A região é notoriamente reconhecida pela visualização constante de indivíduos da espécie *Panthera onca* (onça-pintada), realizadas principalmente por turistas, pescadores profissionais, pesquisadores e agentes ambientais. A observação de onças-pintadas é um dos principais atrativos turísticos na região, juntamente com a pesca esportiva

- Considerando que as propostas estão localizadas no centro de uma das áreas de grande concentração de onças-pintadas no Pantanal, Kantek & Onuma (2013) fizeram um estudo que teve como objetivo correlacionar os dados obtidos (fotos) da população de onças-pintadas com a área protegida legalmente na região da EET. Imagens georrefenciadas foram obtidas entre os anos de 2006 e 2011 nos rios

que ficam no entorno e na borda da Estação. Estes autores argumentam que a área legalmente protegida pela EET não é capaz de assegurar a sobrevivência da população observada no estudo.

- Desde o final do ano 2011 foram capturadas 19 onças-pintadas através da técnica de *foot snare* (Balme et al. ,2009) na área da EE e entorno próximo. A captura destes animais possibilitou, dentre outras coisas, a colocação de rádio-colares nos exemplares, os quais permitiram a obtenção de dados valiosos sobre a biologia destes felinos. Um dos aspectos mais importantes percebidos através das informações obtidas com estes estudos é que as principais concentrações dos pontos estão localizadas próximas a corpos d'água. Ainda sobre a área de uso, nota-se que as citadas áreas estão localizadas em sua maioria no interior da Estação Ecológica de Taiamã e no entorno alagado. Aparentemente estes animais não fazem incursões para as fazendas próximas da UC (não existem áreas de produção de gado nas áreas adjacentes às UC). Os dados de perfil sanitário apresentados para animais capturados na própria UC também corroboram esta hipótese. Aparentemente os animais não estão saindo das áreas conservadas devido à boa quantidade de recursos alimentares existentes na região. Novamente sobre as áreas de uso, e considerando as localizações de todos os animais estudados, é possível perceber que parte significativa dos pontos fornecidos pelo GPS está em área não protegida, fora da EE. Como já mencionado anteriormente, para uma proteção mais eficiente destes animais, é desejável que as áreas alagadas que estes animais utilizam no entorno da Estação também estejam amparadas pelas normas de restrição de uma unidade de conservação.

- Por ser um animal topo de cadeia trófica, a onça-pintada, como outros carnívoros, são importantes para a manutenção de condições ecológicas saudáveis (ALHO, 1992), além de ser considerada espécie bioindicadora na avaliação da qualidade de conservação ambiental (CIMARDI, 1996, SILVEIRA, 1999), podendo ser usada como sentinela de diversos patógenos de importância em saúde pública e animal (CLEAVELAND et al. 2006, AGUIRRE, 2009). Diante disso, em parte das onças-pintadas capturadas na EET ocorreu análise de perfil sanitário. O estado clínico geral de todos os animais no momento da captura foi considerado muito bom. A negatividade de exposição às várias doenças testadas para a maior parte dos indivíduos analisados sugere ausência de contato com as áreas de criação de bovinos e a predação destes animais.

- O cervo-do-pantanal (*Blastocerus dichotomus*), maior cervídeo da América do Sul, adaptado aos terrenos alagáveis típicos do Pantanal é classificado como "vulnerável" na lista de espécies ameaçadas de extinção no Brasil (ICMBio, 2016; IUCN, 2015). Tem as maiores populações no bioma (1) próximo à confluência dos rios Paraguai e Bento Gonçalves; (2) na margem alagada da baia Uberaba, perto do limite com a Bolívia; (3) na Estação Ecológica de Taiamã e seu entorno.

10.3. Áreas prioritárias para a conservação

- A região abrange áreas classificada como PRIORIDADE DE CONSERVAÇÃO MUITO ALTA, segundo o "Mapa das Áreas Prioritárias para conservação, uso sustentável e repartição de benefícios da biodiversidade dos biomas Cerrado e Pantanal – 2ª atualização", publicado em 2016 pelo Ministério do Meio Ambiente.

10.4. Ilha de Sararé faz parte do patrimônio da União

- A Estação Ecológica de Taiamã foi criada em junho de 1981 e segundo este ato, a área da Estação corresponde à ilha de Taiamã, com 11.555 Ha. Posteriormente, em 1983, a área da ilha de Sararé (com aproximadamente 3125 ha) foi incorporada ao patrimônio da União. Entretanto esta última ainda não faz parte da UC. Cabe informar que os mapas gerados pelo IBAMA/ICMBio da EET estiveram durante décadas considerando a ilha de Sararé como parte da EET. A intenção no momento da incorporação desta ilha ao patrimônio público era ampliar a Estação Ecológica de Taiamã, e desta forma a inclusão desta área no limite proposto para a ampliação da UC dará continuidade, ainda que tardiamente, à intenção inicial. Em 2013 foi assinado um termo de entrega do imóvel entre a Secretaria do Patrimônio da União e o MMA e, posterior a este, do MMA ao ICMBio.

10.5. Áreas de restrição de pesca no entorno da UC

- Desde abril de 2009 o entorno da UC foi protegido por uma norma elaborada pelo Conselho Consultivo da Estação Ecológica de Taiamã e publicada pelo IBAMA (IN 09/2009), a qual proibia a pesca em uma grande região contígua à Estação. A região é notadamente reconhecida como uma área de criação e reprodução de organismos aquáticos. Durante o processo de construção desta normativa estiveram presentes todos os segmentos da sociedade que utilizam o entorno da Estação, sendo que a citada normatização representa um grande ganho na proteção ambiental desta região. Os gestores da UC, em parceria com o citado conselho consultivo da unidade, apresentaram a proposta em dezembro de 2017 ao Conselho Estadual de Pesca do Estado de Mato Grosso, o qual aprovou por unanimidade a restrição de pesca no entorno da Estação Ecológica de Taiamã. A normatização foi publicada através da Resolução CEPESCA 02/2018 no dia 05/01/2018, e representa uma demanda das instituições e usuários do entorno da UC (setor de turismo de pesca e pescadores profissionais).
- Ampliação da EET ou o estabelecimento de uma nova unidade conservação na área onde hoje a pesca é proibida no entorno da UC não representará nenhuma alteração nos locais onde a pesca é permitida atualmente.

10.6 Proposta de ampliação desde 2004

- A proposta de ampliação está indicada no plano de manejo do parque elaborado em 2005 e ainda são de grande relevância para a consolidação da gestão do PARNA Pantanal Matogrossense em áreas estratégicas para Uso Público da UC, em especial nas áreas da Fazenda Boa Esperança e da Fazenda Belica.

10.7 Áreas de uso público.

- Na Fazenda Boa Esperança está localizada parte do Morro do Caracará, no limite com o PARNA Pantanal Matogrossense, sendo este um dos principais atrativos de visitação da UC. O acesso à trilha do Morro do Caracará é feito pela sede da Fazenda Boa Esperança . O acréscimo desta área garante ao Parque Nacional o acesso e controle da trilha, a proteção do Morro do Caracará, que é considerado um complexo arqueológico com ocorrência de diversos sítios de arte rupestre e é ameaçado pela exploração clandestina de pedras semipreciosas (ametista). A área também abrange a Baía do Morro, que além de estar incluída na Zona de Uso Extensivo, possui conectividade direta com o interior da UC, representando área estratégica para a proteção e controle dos acessos.

10.8 Aumento da proteção e fiscalização.

- A área inundada ao norte do parque nacional do pantanal matogrossense, entre os rios Alegre e Caracará Grande, parte da Fazenda Santa Isabel, representa ambientes conectados ao PARNA Pantanal Matogrossense. A região está na Zona de Amortecimento da UC, com normas que proíbem a pesca comercial e esportiva nos rios Alegre e Caracará Grande. A área é importante para simplificação dos limites e aprimoramento a proteção da UC.

10.9 Criação do Corredor ecológico.

- A criação das unidades de conservação irá conectar as unidades de conservação permitindo um maior fluxo das espécies e proporcionando uma maior intercâmbio gênico principalmente das espécies de grnade porte.

10.10 Conciliar a conservação com as atividades pecuárias.

- A principal atividade econômica do pantanal é a atividade pecuária e a criação do refúgio de vida silvestre permite a conciliação da conservação da biodiversidade com a manutenção da pecuária extensiva

10.11. Zoneamento estadual

O estado de Mato Grosso aprovou através da lei 9.523/2011, o Zoneamento Socioeconômico Ecológico de Mato Grosso (ZSEE). Neste zoneamento na área proposta da ampliação da Estação Ecológica de Taiamã, da criação da Reserva de Fauna e parte da área de ampliação do parque nacional do pantanal mato-grossense e da criação do refúgio de vida silvestre é categorizada como: "área protegida proposta com elevado potencial biótico".

Entretanto, em 16/02/2012, o juiz titular da Vara Especializada do Meio Ambiente, José Zuquim Nogueira, determinou a suspensão dos efeitos dos dispositivos da Lei Estadual nº 9.523/2011, que instituiu o Zoneamento Socioeconômico Ecológico de Mato Grosso (ZSEE-MT). Segundo Zuquim, a conversão dos ambientes naturais e o uso inadequado do território na forma proposta na lei, afetarão, consideravelmente, a disponibilidade de água e biodiversidade, além de gerar conseqüências graves para a sustentabilidade da produção agrícola e dos próprios processos ecológicos e serviços ambientais mantidos pelos diversos ecossistemas de Mato Grosso.

Desta forma, esta suspensão projeta uma mudança no ZSEE de MT, no sentido de ampliar as áreas protegidas. E portanto, se ocorrer alguma mudança na zona 3.2.6., será para ampliar as áreas propostas para criação de unidades de conservação.

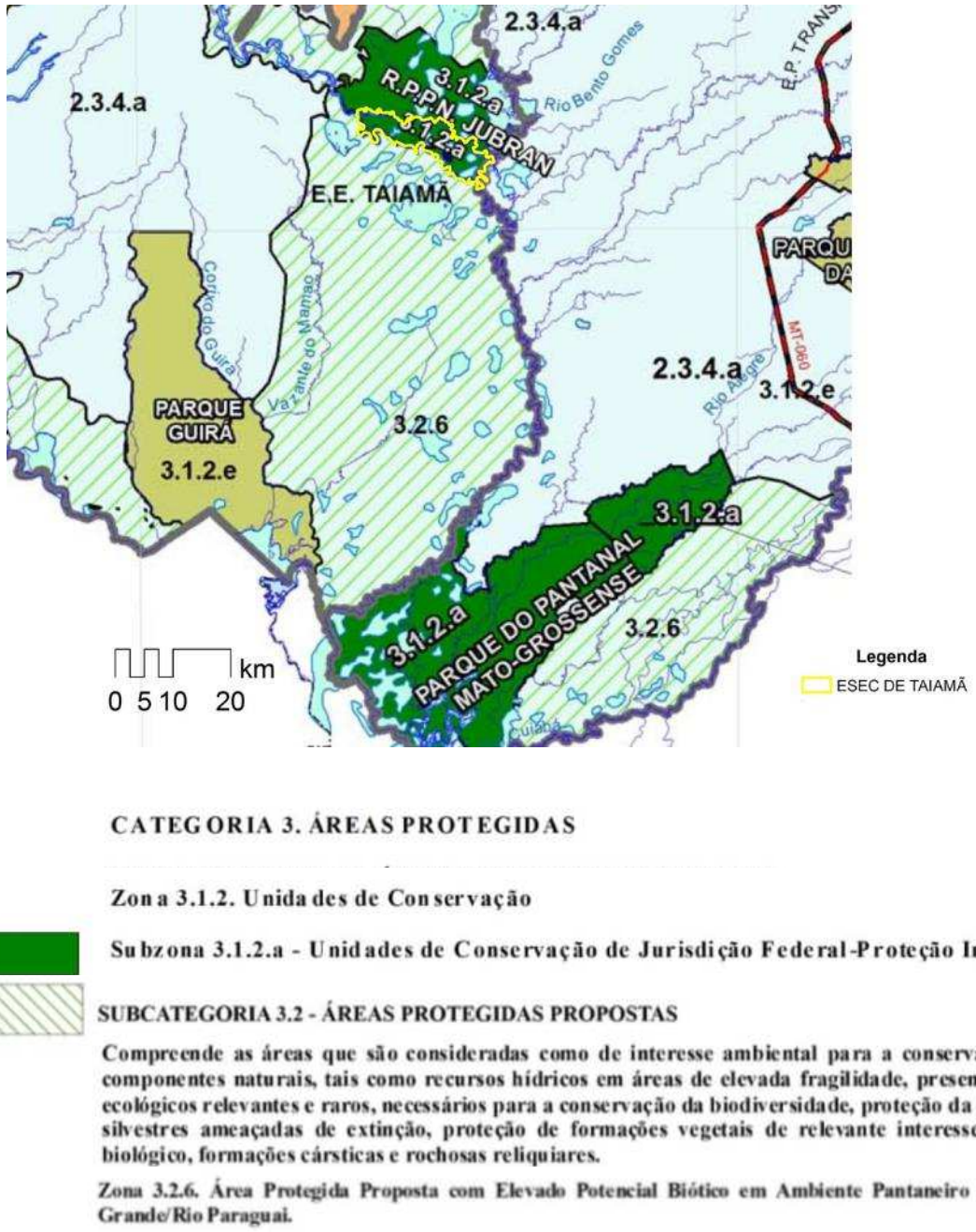


Figura 72 - Porção do Zoneamento Socio Cconômico Ecológico do estado de Mato Grosso, referente à região da ESEC de Taiamã.

10.12. UCs federais no Bioma Patanal

O Pantanal foi reconhecido como Patrimônio Nacional pela constituição de 1988 e como área Úmida de Importância Internacional pela Convenção Ramsar. Em 2000, foi designado como Reserva da Biosfera e Patrimônio Natural da Humanidade pela Unesco. Referindo-se ao seu valor biológico e ao

seu estado e prioridade de conservação, Olson e colaboradores (1998) concluíram que o Pantanal é uma região de “grande significância global, vulnerável e com altíssima prioridade para a conservação”.

Entretanto, este bioma conta com apenas duas unidades de Conservação sob gestão do ICMBio. Diante da baixíssima porcentagem do bioma Pantanal em relação às áreas protegidas e considerando que a Convenção da Diversidade Biológica das Nações Unidas definiu uma meta aos governantes de proteger 10% de todas as regiões ecológicas até 2010, torna-se urgente e necessário a ampliação do território protegido do citado bioma.

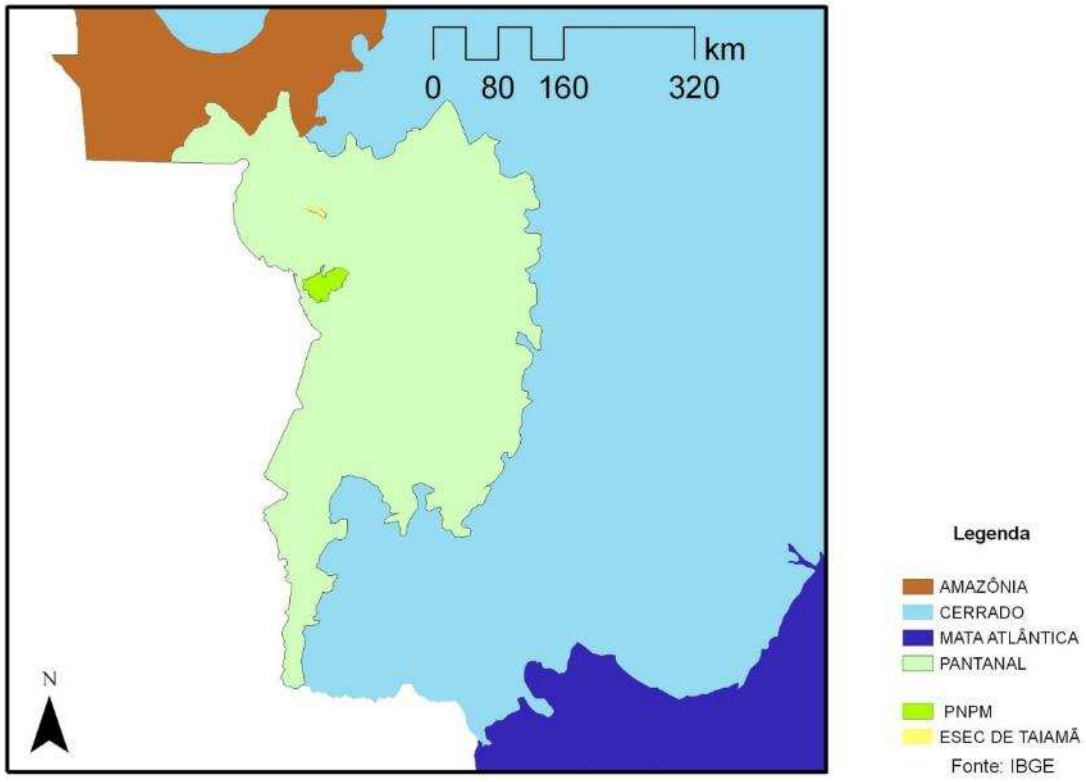


Figura 22 - Duas únicas UCs geridas pelo ICMBio no Bioma Pantanal.

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ANEXOS

ANEXO I

Sexta-Feira, 5 de Janeiro de 2018 **Diário Oficial** Nº 27174 Página 15

RESOLUÇÃO CEPESCA N° 002, DE JANEIRO DE 2018.

Estabelece restrições à pesca amadora e comercial no entorno da Estação Ecológica de Taiamã, na bacia do rio Paraguai.

O CONSELHO ESTADUAL DE PESCA DO ESTADO DE MATO GROSSO - CEPESCA, no uso das competências que lhe são conferidas por lei pelo art. 6°, inciso III da Lei nº 9.096, de 16 de janeiro de 2009 e,

Considerando o inciso XX, art. 8° da Lei Complementar da União nº 140, de 08 de dezembro de 2011;

Considerando a crescente preocupação com a exploração dos recursos pesqueiros na área de entorno da Estação Ecológica de Taiamã, no estado do Mato Grosso, pondo em risco o equilíbrio de lagoas e riachos que servem de refúgio reprodutivo e de desenvolvimento para a fauna aquática;

Considerando os conflitos sociais decorrentes da prática das diversas modalidades de pesca num mesmo espaço;

Considerando que a fauna e a flora aquática são bens de domínio da União e que compete ao Poder Público a sua proteção, administração e fiscalização, dispondo de poder para restringir seu uso e gozo; e

Considerando, ainda, as deliberações do Conselho Consultivo da Estação Ecológica de Taiamã, instituído pela Portaria n° 19, de 3 de abril de 2008; e o que consta do Processo n° 02001.000871/2009-95.

RESOLVE:

Art. 1º Estabelecer restrições à pesca amadora e comercial no entorno da Estação Ecológica de Taiamã, na bacia do rio Paraguai.

Art. 2° Proibir a atividade de pesca amadora e comercial na área contida no polígono formado pelas seguintes coordenadas geográficas, na ordem em que são apresentadas: 1. S16°48'28.7" W057°38'19.1"; 2. S16°48'27.4" W057°38'15.6"; 3. S16°48'51.08" W057°38'43.89"; 4. S16°48'39.6" W057°39'09.9"; 5. S16°48'40.5" W057°39'08.8"; 6. S16°49'33.02" W057°41'22.97"; 7. S16°59'03.40" W057°39'58.48"; 8. S17°04'44.19" W057°33'47.05"; 9. S17°01'46.23" W057°25'27.65"; 10. S16°58'41.78" W057°23'55.64"; 11. S16°58'19.40" W057°23'18.01"; 12. S16°57'33.83" W057°21'07.89"; 13. S16°50'34.83" W057°24'45.23"; 14. S16°48'28.31" W057°33'36.76"; 15. S16°48'28.7" W057°38'19.1", de acordo com o mapa anexo.

Art. 3° Permitir a pesca amadora e comercial acima do local denominado Poção, a montante da Estação Ecológica de Taiamã, conforme a reta formada pelas coordenadas S16°48'27.4" W057°38'15.6" e S16°48'28.7" W057°38'19.1".

Art. 4° Proibir a pesca amadora e artesanal na localidade denominada Campo, cujas coordenadas S16°48'39.6" W057°39'09.9" e S16°48'40.5" W057°39'08.8" formam a reta que delimita a entrada da citada área.

Art. 5º Exclui-se das proibições previstas nesta Resolução a pesca de caráter científico, devidamente autorizada pelos órgãos competentes.

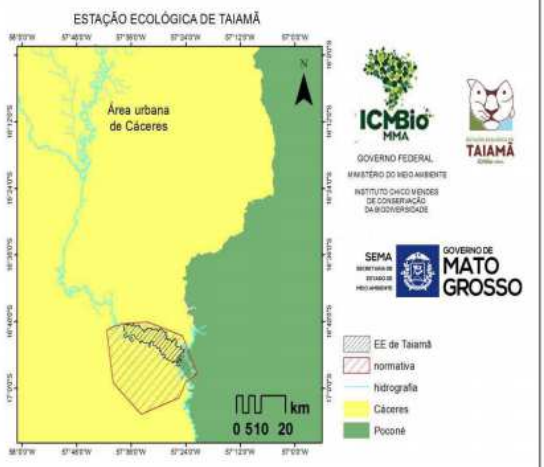
Art. 6º Aos infratores da presente Resolução serão aplicadas as penalidades previstas na Lei Federal nº 9.605 de 12 de fevereiro de 1998, Decreto Federal nº 6.514 de 22 de julho de 2008, Lei Estadual n° 9.096 de 16 de novembro de 2009 e demais normas complementares e legislações pertinentes.

Art. 7º Esta Resolução entra em vigor na data de sua publicação.

REGISTRE-SE, PUBLIQUE-SE e CUMPRA-SE.

Cuiabá, 03 de Janeiro de 2018.

André Luís Torres Baby
Secretário de Estado de Meio Ambiente e
Presidente do CEPESCA



Link do mapa: http://www.sema.mt.gov.br/attachments/article/3085/Mapa_Entorno%20Estacao%20Ecologica%20Taiama.jpg

RESOLUÇÃO CEPESCA n° 003/2018, DE JANEIRO DE 2018

Aprova calendário anual de reuniões ordinárias do Conselho Pleno do CEPESCA em 2018.

O CONSELHO ESTADUAL DE PESCA DO ESTADO DE MATO GROSSO - CEPESCA, no uso das competências que lhe são conferidas pelo art. 6°, inciso I da Lei nº 9.096, de 16 de janeiro de 2009, e

Considerando o princípio da publicidade disposto no caput do art. 37 da Constituição da República Federativa do Brasil;

Considerando o § 2° do art. 3° do Regimento Interno do Conselho Estadual de Pesca.

RESOLVE:

Art. 1º - Aprovar o Calendário Anual, do ano de 2018, das Reuniões Ordinárias do Conselho Pleno do CEPESCA a se realizarem no Auditório da Escola Superior de Advocacia de MT - ESA/OAB/MT, localizado no Centro Político Administrativo, município de Cuiabá/MT, às 08h00min, conforme cronograma a seguir:

I- 1ª Reunião Ordinária - **08/02/2018**

II- 2ª Reunião Ordinária - **05/04/2018**

III- 3ª Reunião Ordinária - **07/06/2018**

IV- 4ª Reunião Ordinária - **09/08/2018**

V- 5ª Reunião Ordinária - **11/10/2018**

VI- 6ª Reunião Ordinária - **06/12/2018**

Art. 2º Esta resolução entra em vigor na data de sua publicação.

REGISTRE-SE, PUBLIQUE-SE e CUMPRA-SE.

Cuiabá, 03 de Janeiro de 2018.
André Luís Torres Baby
Secretário de Estado de Meio Ambiente
Presidente do CEPESCA

GOVERNO DO ESTADO DE MATO GROSSO Secretaria de Estado de Gestão - Imprensa Oficial

ANEXO II

Lista preliminar de espécies da Região

Macrófitas aquáticas

Modificado de Da Silva (1983).

Táxon	Forma de Vida	Nome comum
ALISMATACEAE		
Echinodorus sp.	fixa emergente	chapéu-de-couro
Echinodorus macrophyllus	fixa emergente	chapéu-de-couro
Echinodorus grandiflorus	fixa emergente	chapéu-de-couro
Sagittaria guyanensis	fixa	chapéu-de-couro
AZOLLACEAE		
Azolla sp.	flutuante livre	--
BUTOMACEAE		
Hydrocleis nymphoides	flutuante livre	lagartixa
COMPOSITAE		
Aspilia latíssima	higrofita herbácea	fumeiro
CONVOLVULACEAE		
Ipomoea carnea	higrofita herbácea	algodão bravo
CYPERACEAE		
Eleocharis nodulosa	fixa emergente	
Eleocharis sp.	fixa emergente	
Cyperus sp.	fixa emergente	
Cyperus sp.	fixa emergente	
Cyperus giganteus	higrofita herbácea	papiro-brasileiro
ERIOCAULACEAE		
Tonina fluviatilis	fixa submersa	Tonina
GRAMINAE		
Hymenachne amplexicaulis	fixa submersa	capim de capivara
Hymenachne donacifolia	fixa submersa	
Laercia hexandra	fixa submersa	arrozinho
Panicum mertensii	fixa submersa	felpudo

Paspalum repens	fixa submersa	capim fofo
HYDROCHARITACEAE		
Limnobium stoloniferum	flutuante livre	
LEGUMINOSAE		
Aeschynomene fluminensis	fixa emergente	cortiça
Aeschynomene sensitiva	fixa emergente	cortiça
Discolobium pulchellum	fixa emergente	
Neptunia oleracea	flutuante livre	
MARANTHACEAE		
Maranta sp.	higrofita herbácea	caetezinho
Thalia geniculata	higrofita herbácea	caeté
MELASTOMATACEAE		
Tibouchina sp.	higrofita herbácea	
NYMPHAEACEAE		
Nymphaea sp.	fixa de folhas flutuantes	lagartixa
Victoria cruziana	fixa de folhas flutuantes	vitória régia
ONAGRACEAE		
Ludwigia sp.	higrófita flutuante	
Ludwigia natans	flutuante livre	
Ludwigia sp.	higrófita flutuante	
PARKERIACEAE - Pteridophyta		
Ceratopteris pteridoides	flutuante livre	pé de sapo
POLYGONACEAE		
Polygonum acuminatum	fixa emergente	erva de bicho
Polygonum acre	fixa emergente	erva de bicho
PONTEDERICEAE		
Eichornia crassipes	flutuante livre	camalote
Eichornia azurea	fixa emergente	camalote
Reussia rotundifolia	fixa emergente	camalote
Pontederia lanceolata	fixa emergente	aguapé; guapé
RICCIACEAE - Marchantiophyta (Bryophyta)		

Ricciocarpus natans	flutuante livre	
SALVINIACEAE - Pteridophyta *Salvinia auriculata*	flutuante livre	orelha de onça
LENTIBULARIACEAE *Utricularia* sp.	flutuante submersa	lodo

Flora – Dicotiledôneas

Modificado de Guarim Neto (1983).

Táxon	Forma de Vida	Nome comum
ANARCADIACEAE		
Spondias dulcis	árvore	cajá
Astronium sp.	árvore	aroeiro
APOCYNACEAE		
Apidosperma sp	subarbusto	guatambú
Bonafousia juruana	trepadeira	
Rhabdadenia acrostoma	subarbusto	chapéu de napoleão
Thevetia peruviana		
ARECACEAE		
Attalea princeps	árvore	acuri
Bactris sp.	árvore	tucumã
Astrocaryum sp.	árvore	tucumã
ASCLEPIADACEAE		
Oxypetalum sp.	trepadeira	
BALANOPHORACEAE		
Helosis brasiliensis	parasita	
BIGNONIACEAE		
Arrabidaea sp.	trepadeira	
Tabebuia sp.	árvore	paratudo do pantanal
CAPPARIDACEAE		
Crataeva tapia	árvore	cabaceira
CHRYSOBALANACEAE		
Licania cf. parvifolia	árvore	pimenteira
COMBRETACEAE		
Combretum laxum	trepadeira	
Combretum lanceolatum	trepadeira	remela de macaco; pombeiro
COMPOSITAE		
Eupatorium sp.	subarbusto	
Mikania sp.	trepadeira	
Aspilia latíssima	subarbusto	fumeiro

Wulffia baccata	herbácea	
ELAEOCARPACEAE		
Sloanea porphyrocarpa	árvore	
Sloanea terniflora	árvore	
EUPHORBIACEAE		
Alchornea schomburgkiana	árvore	
Caperonia castaneifolia	subarbustivo	
Sapim sp.	subarbustivo	eiteiro
FLACOURTIACEAE		
Banara guianensis	subarbustivo	
Casearia sp.	árvore	
GUTTIFERAE		
Rheedia aff. Brasiliensis	subarbustivo	amapari; bacopari
LAURACEAE		
Nectandra mollis	árvore	ouro preto
LAMIACEAE		
Citex cymosa	árvore	arumã
LEGUMINOSAE		
Andira sp.	árvore	angelim
Aschynomene sp.	herbácea	
Calopogenium sp.	trepadeira	
Canavalia sp.	trepadeira	
Cássia grandis	árvore	canafístula
Erythrina fusca	árvore	abobreiro
Hymeneae stignocarpa	árvore	atobá
Inga sp.	árvore	ngá
Piptadenia sp.	árvore	angico vermelho
Pterocarpus rohrii	árvore	pau-sangue
Vigna sp.	trepadeira	
LORANTHACEAEA		
Phoradendron piperoides	hemiparasita	
MALPIGHIOACEAE		
Byrsonima sp.	arbusto	canjiquinha
MALVACEAE		

Hibiscus sp.	subarbusto	algodoal
MELASTOMATACEAE		
Tibouchina sp.	subarbusto	quaresmeira
MELIACEAE		
Trichilia guianensis	árvore	
MORACEAE		
Cecropia pachystachya	árvore	embaúba
Fícus trigona	árvore	figueira
MYRTACEAE		
Psidium sp.	arbusto	araçá
NYCTAGINACEAE		
Neea mollis	arbusto	
ONAGRACEAE		
Ludwigia sp.	subarbusto	
PASSIFLORACEAE		
Passiflora foetida	trepadeira	maracujá-de-cheiro
Passiflora vespertilio	trepadeira	
POLYGONACEAE		
Polygonum sp.	herbácea	erva-de-bicho
Triplaris americana	árvore	novateiro; pau-de-novato
RUBIACEAE		
Genipa americana	árvore	genipapo
Psychotria carthagenensis	subarbusto	
Rudgea cornifolia	subarbusto	
Sphinctanthus microphyllus	arbusto	rebenta-laço
SAPINDACEAE		
Paullina seminuda	trepadeira	
STERCULIACEAE		
Sterculia apetala	árvore	manduvi
Bytteneria filipes	arbusto	
VERBENACEAE		
Stachytarpheta sp.	herbáceae	
VOCHYSIACEAE		
Vochysia divergens	árvore	cambará

VITACEAE		
Cissus gongylodes	trepadeira	cupá; rabo-de-arraia
Cissus sicyoides	trepadeira	

Peixes

Modificado de Silva (1983), Barbosa (2015), Cavalho Filho (2015) e MZUSP.

Táxon

Characiformes

Anostomidae

Abramites hypselonotus
Schizodon sp.
Leporinus macrocephalus
Leporinus friderici
Leporinus striatus

Characidae

Acestrorhynchus pantaneiro
Acestrorhynchus falcatus
Aphyocarax dentatus
Astyanax abramis
Astyanax assuncionensis
Astyanax sp.
Astyanax asuncionensis
Bryconamericus exodon
Characidium sp.
Charax leticiae
Cheirodon sp. A.
Cheirodon sp. B.
Ctenobrycon sp.
Cyphocharax dillii
Brycon hilarii
Bryconamericus sp.
Hemigrammus sp.
Hemigrammus ulreyi
Hemiodus orthonops
Hyphessobrycon eques
Hyphessobrycon elachys
Hyphessobrycon herbertaxelrodi
Metynnis sp.
Moenkhausia dichroura
Moenkhausia sanctaefilomenae
Moenkhausia sanctaefilomenae
Mylossoma duriventre
Myleus levis
Odontostilbe Pequira
Phenacogaster tegatus
Poptella paraguayensis
Piaractus mesopotamicus
Piabucus melanostoma
Pygocentrus nattereri
Roeboides descalvadensis
Roeboides prognathus
Salminus brasiliensis
Serrapinnus sp.
Stethaprion sp.
Tetragonopterus argenteus
Triportheus nematurus
Triportheus pantanensis
Triportheus paranensis
Aphyocharax anisitsi
Jupiaba acanthogaster
Moenkhausia dichroura
Serrapinnus calliurus
Serrapinnus kriegi
Serrasalmus maculatus
Serrasalmus marginatus
Serrasalmus sp.

Crenuchidae

Characidium aff. *zebra*

Curimatidae

Curimatella dorsalis
Potamorhina squamoralevis
Psectrogaster curviventris
Steindachnerina brevipinna
Steindachnerina conspersa
Curimatopsis myersi

Gasteropelecidae

Gasteropelecus sternicla
Thoracocharax stellatus

Hemiodontidae

Hemiodus semitaeniatus
Hemiodus orthonops

Herythrinidae

Erythrinus erythrinus
Hoplias malabaricus

Lebiasinidae

Pyrrhulina sp.
Pyrrhulina australis

Parodontidae

Apareiodon affinis
Parodon sp.

Prochilodontidae

Prochilodus lineatus

Gymnotiformes

Apteronotidae

Apteronotus albifrons

Gymnotidae

Gymnotus sp.

Hypopomidae

Hypopomus sp. A

Hypopomus sp. C

Rhamphichthydae

Gymnorhamphichthys hypostomus

Sternopygidae

Eigenmannia virescens

Eigenmannia trilineata

Sternopygus macrurus

Sternopygus macrurus

Siluriformes

Auchenipteridae

Ageneiosus inermis

Parauchenipterus sp.

Beloniformes

Belonidae

Potamorhaphis eigenmanni

Siluriformes

Callichthydae

Hypoptopoma inexspectatum

Corydoras sp.

Loricariidae

Sturisoma robustum

Pterygoplichthys anisitsi

Loricaria sp.

Loricariichthys platymetopon

Rineloricaria parva

Hypostomus sp.

Pimelodidae

Iheringichthys labrosus

Pimelodella gracilis

Pimelodella mucosa

Pimelodus maculatus

Rhamdia sp.

Sorubim sp.

Hemisorubim platyrhynchos

Megalonema platanum

Zungaro zungaro

Pinirampus pirinampu

Pseudoplatystoma fasciatum

Pseudoplatystoma corruscans

Sorubim lima

Doradidae

Oxydoras kneri

Trachydoras paraguayensis

Ossancora eigenmanni

Scoloplacidae

Scoloplax empousa

Scoloplax distolothrix

Trichomycteridae

Ituglanis herberti

Perciformes

Cichlidae

Apistogramma borellii

Apistogramma commbrae

Crenicichla vittata

Aequidens plagiozonatus

Bujurquina vittata

Cichlasoma dimerus

Crenicichla lepidota

Laetacara dorsigera

Mesonauta festivum

Aequidens sp.

Astronous ocellatus

Satanoperca pappaterra

Sciaenidae

Pachyurus bonariensis

Rajiformes

Potamotrygonidae

Potamotrygon falkneri

Potamotrygon motoro

Cyprinodontiformes

Poeciliidae

Pamphorichthys hasemani

Rivulidae

Melanorivulus punctatus

Synbranchiformes

Synbranchidae

Synbranchus marmoratus

Aves.

Modificado de Oliveira (1983), Melo (2014), Bueno (2013) e Almeida (2013).

Táxon

Accipitriformes

Accipitridae

Busarellus nigricollis
Geranoaetus albicaudatus
Heterospizias meridionalis
Ictinia plumbea
Rosthramus sociabilis
Rupornis magnirostris
Urubitinga urubitinga

Cathartidae

Coragyps atratus
Cathartes aura
Cathartes burrovianus

Anseriformes

Anatidae

Dendrocygna viduata
Amazonetta brasiliensis
Cairina moschata
Dendrocygna autumnalis

Anhimidae

Chauna torquata

Apodiformes

Trochilidae

Amazilia fimbriata
Amazilia versicolor
Chlorostilbon lucidus
Glaucis hirsutus
Hylocharis chrysura
Phaethornis pretrei
Phaethornis ruber
Phaethornis subochraceus
Polytmus guainumbi
Thalurania furcata

Caprimulgiformes

Caprimulgidae

Chordeiles nacunda
Hydropsalis parvula
Hydropsalis albicollis

Charadriiformes

Charadriidae

Vanellus cayanus
Vanellus chilensis

Jacanidae

Jacana jacana

Recurvirostridae

Himantopus melanurus

Rynchopidae

Rynchops niger

Scolopacidae

Tringa solitaria

Sternidae

Sterna hirundo
Phaetusa simplex
Sternula superciliaris

Ciconiiformes

Anhingidae

Anhinga anhinga

Ardeidae

Ixobrychus exilis
Ardea alba
Ardea cocoi
Butorides striata
Cochlearius cochlearius
Egretta thula
Nycticorax nycticorax
Pilherodius pileatus
Tigrisoma lineatum

Ciconiidae

Mycteria americana
Ciconia maguari
Jabiru mycteria

Columbiformes

Columbidae

Patagioenas cayennensis
Patagioenas picazuro
Columbina picui
Claravis pretiosa
Leptotila rufaxilla
Columbina squammata
Columbina talpacoti

Leptotila verreauxi

Coraciiformes

Alcedinidae

Megaceryle torquata
Chloroceryle inda
Chloroceryle americana
Chloroceryle amazona

Cuculiformes

Cuculidae

Piaya cayana
Crotophaga ani
Guira guira
Crotophaga major
Coccycua minuta
Tapera naevia

Falconiformes

Falconidae

Herpetotheres cachinnans
Milvago chimachima
Caracara plancus
Falco sparverius

Galbuliformes

Galbulidae

Galbula ruficauda

Galliformes

Cracidae

Ortalis canicollis
Aburria cujubi
Crax fasciolata
Penelope ochrogaster

Gruiformes

Aramidae

Aramus guarauna

Heliornithidae

Heliornis fulica

Rallidae

Porzana albicollis
Gallinula angulata
Aramides cajaneus
Porphyrio flavirostris
Porphyrio martinicus
Pardirallus nigricans
Aramides saracura

Nyctibiiformes

Nyctibiidae

Nyctibius griseus

Passeriformes

Conopophagidae

Conopophaga lineata

Dendrocolaptidae

Dendroplex picus
Sittasomus griseicapillus
Lepidocolaptes angustirostris

Donacobiidae

Donacobius atricapilla

Fringilidae

Euphonia chlorotica

Furnariidae

Furnarius leucopus
Pseudoseisura unirufa
Synallaxis albilora
Furnarius rufus
Certhiaxis cinnamomeus
Phacellodomus ruber
Phacellodomus rufifrons

Hirundinidae

Progne tapera
Progne chalybea
Stelgidopteryx ruficollis
Tachycineta albiventer
Tachycineta leucorrhoa

Icteridae

Cacicus cela
Procacicus solitarius
Icterus croconotus
Molothrus oryzivorus
Molothrus bonariensis
Agelaioides badius
Gnorimopsar chopi
Agelasticus cyanopus
Amblyramphus holosericeus

Mimidae

Mimus saturninus

Parulidae

Geothlypis aequinoctialis
Myiothlypis flaveola
Setophaga pitiayumi

Passerellidae

Zonotrichia capensis

Passeridae

Passer domesticus

Polioptilidae

Polioptila dumicola

Rhynchocyclidae

Todirostrum cinereum
Poecilotriccus latirostris
Hemitriccus margaritaceiventer

Thamnophilidae

Thamnophilus caerulescens
Thamnophilus doliatus
Pyriglena leuconota
Herpsilochmus longirostris
Hypocnemoides maculicauda
Taraba major
Cercomacra melanaria
Thamnophilus palliatus

Thraupidae

Sporophila angolensis
Paroaria capitata
Paroaria coronata
Ramphocelus carbo
Dacnis cayana
Saltator coerulescens
Lanio cucullatus
Sicalis flaveola
Sporophila hypoxantha
Volatinia jacarina
Sporophila leucoptera
Sporophila lineola
Sporophila nigricollis
Sporophila nigrorufa
Sporophila collaris
Sporophila bouvreuil
Sporophila caerulescens
Tangara palmarum
Lanio penicillatus
Nemosia pileata
Tachyphonus rufus
Tangara sayaca
Saltator similis
Thlypopsis sórdida
Conirostrum speciosum

Tityridae

Xenopsaris albinucha
Pachyramphus polychopterus

Troglodytidae

Trogon curucui
Pheugopedius genibarbis
Cantorchilus leucotis
Troglodytes musculus

Turdidae

Turdus amaurochalinus
Turdus leucomelas
Turdus rufiventris

Tyrannidae

Xolmis irupero
Tyrannus albogularis
Griseotyrannus aurantioatrocristatus
Myiopagis caniceps
Myiozetetes cayanensis
Elaenia chiriquensis
Colonia colonus
Elaenia cristata
Myiophobus fasciatus
Myiarchus ferox
Elaenia flavogaster
Cnemotriccus fuscatus
Myiopagis gaimardii
Knipolegus hudsoni
Satrapa icterophrys
Inezia inornata
Arundinicola leucocephala
Legatus leucophaius
Philohydor lictor
Tyrannus melancholicus
Euscarthmus meloryphus
Sublegatus modestus
Camptostoma obsoletum
Megarynchus pitangua
Machetornis rixosa
Pyrocephalus rubinus
Serpophaga subcristata
Pitangus sulphuratus
Myiarchu tyrannulus
Tyrannus tyrannus
Empidonomus varius
Gubernetes yetapa

Vireonidae

Cyclarhis gujanensis
Hylophilus pectoralis
Vireo olivaceus

Pelecaniformes

Threskiornithidae

Platalea ajaja

Theristicus caerulescens
Theristicus caudatus
Mesembrinibis cayennensis
Phimosus infuscatus

Piciformes

Bucconidae

Monasa nigrifrons

Ramphastidae

Ramphastos toco

Picidae

Picumnus albosquamatus
Piculus chrysochloros
Melanerpes cruentatus
Celeus flavescens
Celeus flavus
Celeus lugubris
Colaptes melanochloros
Campephilus melanoleucos
Veniliornis passerinus

Podicediformes

Podicipedidae

Podilymbus podiceps

Psittaciformes

Psittacidae

Amazona aestiva
Amazona amazonica
Eupsittula aurea
Primolius auricollis
Brotogeris chiriri
Psittacara leucophthalmus
Pionus maximiliani
Myiopsitta monachus
Myiopsitta monachus
Aratinga nenday
Diopsittaca nobilis
Brotogeris versicolurus
Forpus xanthopterygius

Suliformes

Phalacrocoracidae

Phalacrocorax brasilianus

Strigiformes

Strigidae

Glaucidium brasilianum
Megascops choliba
Bubo virginianus

Tinamiformes

Tinamidae

Crypturellus noctivagus

Trogoniformes

Trogonidae

Campylorhynchus turdinus

ANEXO III

MINISTÉRIO DO PLANEJAMENTO, ORÇAMENTO E GESTÃO
SECRETARIA DO PATRIMÔNIO DA UNIÃO
Superintendência do Patrimônio da União em Mato Grosso

Livro nº 20 **Fls. 136/138**

TERMO DE ENTREGA, firmado entre a SUPERINTENDÊNCIA DO PATRIMÔNIO DA UNIÃO DO ESTADO DE MATO GROSSO, do Ministério do Planejamento, Orçamento e Gestão e o MINISTÉRIO DO MEIO AMBIENTE, do imóvel descrito em sua Cláusula Primeira, conforme Processo nº.04997.000095/2013-70, na forma abaixo:

Aos onze dias do mês de Dezembro do ano de dois e treze (11/12/2013), na Superintendência do Patrimônio da União do Estado de Mato Grosso, situada na Avenida Vereador Juliano da Costa Marques, 99, Bairro Jardim Aclimação, Cuiabá/MT, compareceram partes entre si justas e acordadas, a saber: de um lado, como OUTORGANTE do presente instrumento, o MINISTÉRIO DO PLANEJAMENTO, ORÇAMENTO E GESTÃO, por intermédio da SUPERINTENDÊNCIA DO PATRIMÔNIO DA UNIÃO DO ESTADO DO MATO GROSSO, representada neste ato pelo Superintendente WILMAR SCHRADER, brasileiro, casado, portador da carteira de identidade nº 124.1879-0 SSP/MT e CPF/MF nº 312.549.939-91, nomeado pela Portaria nº 1050, de 09/12/2011 da Secretaria Executiva do Ministério do Planejamento, publicada no DOU de 12/12/2011, com delegação de competência outorgada pelo artigo 1º, da Portaria SPU nº 40, datada de 18 de março de 2.009, publicada no D.O.U. de 20/03/2009, Seção 2, fls. 43, da Secretaria do Patrimônio da União e do outro lado, como OUTORGADO, o MINISTÉRIO DO MEIO AMBIENTE - MMA, nº 37.115.375/0001-07, neste ato representado pela Ministra de Estado IZABELLA MÔNICA VIEIRA TEIXEIRA, brasileira, solteira, portadora da Carteira de Identidade RG nº 457.256 SSP/DF e do CPF/MF nº 279.754.601-68, nomeada pelo Decreto Presidencial, publicado no Diário Oficial da União de 1º de janeiro de 2011, residente e domiciliada em Brasília, Distrito Federal, e as testemunhas qualificadas e assinadas ao final do presente Termo, lavrado em conformidade com o disposto nos artigos 18, § 1º e §4º c/c e 40, I, da Lei nº 9.636, de 15 de maio de 1998, no art. 64 e 79, § 3º do Decreto-Lei nº 9.760, de 5 de setembro de 1946, art. 1º da Portaria SPU nº 40, de 18 de março de 2009, Portaria SPU nº 100, de 03 de junho de 2009, Portaria SPU nº 173, de 31 de agosto de 2009 (revogada pela Portaria nº 200, de 29/06/2010), no art. 19 do Decreto nº 3.725, de 10 de janeiro de 2001 e art. 13 do Decreto 4.340/2002, e a autorização do Sr. Superintendente do Patrimônio da União do Estado do Mato Grosso, datada de 09/04/2013, exarada às fls. 14 do processo em referência. E, perante as mesmas testemunhas foi dito que: **CLÁUSULA PRIMEIRA** - que a UNIÃO é senhora e legítima proprietária do imóvel denominado Ilha Sararé, com área de 3.125,00 hectares no município de Cáceres/MT; **CLÁUSULA SEGUNDA** - que o aludido imóvel assim se descreve e caracteriza: inicia-se o perímetro da área, junto ao P1 de coordenadas

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geográficas aproximadas Longitude 57°24'16"WGR e Latitude 16°53'21" Sul, situado no encontro do Rio Formoso com o Rio Bracinho; segue-se pelo Rio Formoso abaixo, margem direita, com distância aproximada de 12.300,00 m (doze mil e trezentos metros), até o P2, de coordenadas geográficas aproximadas Longitude 57°22'20"WGR e Latitude 16°57'06" Sul, situado no encontro do Rio Formoso com o Rio Sararé; segue-se por este último, margem direita, com a distância aproximada de 3.300,00 m (três mil e trezentos metros), até o P3, de coordenadas geográficas aproximadas longitude 57°23'19"WGR e Latitude16°58'14" Sul, situado na Barra do Rio Sararé com o Rio Paraguai; segue pelo Rio Paraguai acima, margem esquerda com a distância aproximada de 14.600,00 m (quatorze mil e seiscentos metros), até o P4, de coordenadas geográficas aproximadas Longitude 57°25'56"WGR e Latitude 16°56'02" Sul, situado na foz do Rio Bracinho com o Rio Paraguai; segue-se pelo Rio Bracinho acima, margem esquerda, com a distância de 11.400,00m (onze mil e quatrocentos metros), chega-se ao P1, ponto inicial da descrição do perímetro. **A** área contida nos limites acima descritos é de aproximadamente 3.125,00 ha (três mil, cento e vinte e cinco hectares), tomando-se como referência planta na escala de 1:100.000 ano 1.975, elaborada pela SE-21-V-B-VI-DSG; **CLÁUSULA TERCEIRA** - neste ato, a OUTORGANTE formaliza a entrega ao **OUTORGADO** da administração, uso, conservação e demais responsabilidades sobre as despesas oriundas da Ilha de Sararé; **CLÁUSULA QUARTA** - na forma prevista no citado Decreto-lei n° 9.760, de 1946, e Portaria MP-MMA n. 436/2009, a presente entrega é feita nas seguintes condições: a) cessada a aplicação, reverterá o imóvel à administração da **OUTORGANTE**, independentemente de ato especial; b) a entrega fica sujeita à confirmação 2 (dois) anos após a lavratura deste instrumento, cabendo à **OUTORGANTE** ratificá-la, através de apostilamento em livro próprio na SPU/MT, desde que, nesse período, tenha o imóvel sido utilizado para os fins a que foi entregue (Art.79, §1°); c) não será permitida a utilização do imóvel para fim diverso do que justificou a entrega (Art.79, §2°); d) qualquer ampliação ou alteração do imóvel entregue deve, obrigatoriamente, ser comunicada prévia e formalmente à SPU/MT, incumbindo ao OUTORGADO, quando for o caso, e após a autorização, encaminhar à SPU/MT a documentação necessária à averbação no **C**artório de Registro de Imóveis competente, bem como a certidão comprobatória de sua ocorrência; e) a autorização para o uso do imóvel da União de que trata este Termo fazendo-se cumprir sua função socioambiental é da exclusiva responsabilidade do Ministro do Meio Ambiente ou do Presidente do Instituto **C**hico Mendes de **C**onservação da Biodiversidade República, observadas as condições definidas neste Termo, devendo o **OUTORGADO** zelar pelo uso do imóvel na forma definida neste instrumento e no processo administrativo correspondente; **CLÁUSULA QUINTA** - que verificado o descumprimento de quaisquer das condições mencionadas nas letras "a", "b", "c", "d" e "e" da **C**láusula Quarta, serão fixadas as responsabilidades decorrentes dos fatos apurados, resguardados os imperativos legais e os preceitos da hierarquia funcional; **CLÁUSULA SEXTA** - fica o OUTORGADO autorizado a promover a **C**essão de uso Gratuito do imóvel da União objeto desta entrega para o Instituto **C**hico Mendes de **C**onservação da Biodiversidade para fins de desenvolvimento de sua atividade finalística na Unidade da Ilha de Sararé, nos termos da Lei n° 9.985/2000; **CLÁUSULA SÉTIMA** - fica o

MINISTÉRIO DO PLANEJAMENTO, ORÇAMENTO E GESTÃO
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Superintendência do Patrimônio da União em Mato Grosso

OUTORGADO autorizado a: outorgar a Cessão de uso gratuito do imóvel da União objeto desta entrega ao Instituto Chico Mendes de Conservação da Biodiversidade - ICMBio com o encargo deste, mediante licitação, promover a cessão onerosa de frações do terreno cedido, cujos recursos obtidos deverão ser aplicados exclusivamente para os fins definidos no art. 3, §4°, da Portaria MP-MMA n° 436/2009 , *ou seja de acordo com os seguintes critérios: I- em se tratando de unidade de conservação do Grupo de Proteção Integral : **a)** até cinquenta por cento , e não menos que vinte e cinco por cento, na implementação , manutenção e gestão da própria unidade: **b)** até cinquenta por cento, e não menos que vinte e cinco por cento , na regularização fundiária das unidades de conservação do Grupo ; e **c)** até cinquenta por cento, e não menos que quinze por cento, na implementação , manutenção e gestão de outras unidades de conservação do Grupo de Proteção Integral , **II** – em se tratando de Reserva de Desenvolvimento Sustentável ou de Reserva Extrativista: **a)** cinquenta por cento, na implementação , manutenção e gestão da própria unidade , e **b)** cinquenta por cento na regularização fundiária da própria unidade ou de outra unidade da mesma categoria* . Pelo representante do OUTORGADO, foi dito que RECEBE o imóvel identificado no presente instrumento na forma nele prescrita. E, por assim se declararem ajustados, assinam OUTORGANTE e OUTORGADO, por seus representantes legais juntamente com as testemunhas, presentes a todo ato. E, eu ....., Jocélia Cardoso de Albus, agente administrativo, lotada na DIDEP/SPU/MT, lavrei o presente **TERMO DE ENTREGA**, que vai assinado e conferido pelo Superintendente do Patrimônio da União em Mato Grosso, Wilmar Schrader.

Wilmar Schrader
Superintendente da SPU/MT
OUTORGANTE

Izabella Mônica Vieira Teixeira
Ministra do Meio Ambiente-MMA/DF
OUTORGADO

Testemunhas:

João Bosco Moreira
Datilógrafo/SPU/MT

Márcia Oliveira Spadoni Pinto
Agente Adm./SPU/MT

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Apoio:

Ministério do Meio Ambiente – MMA

Instituto Chico Mendes de Conservação da Biodiversidade – ICMBio

Diretoria de Criação e Manejo de Unidades de Conservação

RELATÓRIO SOCIOECONÔMICO E AMBIENTAL DA PROPOSTA DE CRIAÇÃO DO MOSAICO DE UNIDADES DE CONSERVAÇÃO DO PANTANAL NORTE

O presente documento tem por objetivo apresentar os principais elementos técnicos acerca do uso socioeconômico e relevância ambiental que nortearam a proposta de criação do Mosaico de unidades de conservação do Pantanal Norte.

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INTRODUÇÃO

Todo processo de criação de unidades de conservação envolve uma avaliação socioeconômica e ambiental da área de interesse. Este estudo tem como objetivo caracterizar os diferentes usos econômicos da região e dimensionar como a criação destas unidades de conservação pode contribuir ou afetar estas atividades econômicas além de apresentar e discutir a importância biológica da área proposta. O Brasil é signatário da Conferência das Partes (COP) 10 da Convenção sobre Diversidade Biológica (CDB), realizada em Nagoya, Japão, em 2010. Nesta conferencia foram estabelecidas 20 Metas do Plano Estratégico 2011-2020, conhecidas como Metas de Aichi (https://www.cbd. int/sp/targets/). Em particular a Meta 11 estabelece que:

Até 2020, pelo menos 17% de áreas terrestres e de águas continentais e 10% de áreas marinhas e costeiras, especialmente áreas de especial importância para biodiversidade e serviços ecossistêmicos, terão sido conservados por meio de sistemas de áreas protegidas, geridas de maneira efetiva e equitativa, ecologicamente representativas e satisfatoriamente interligadas e por outras medidas espaciais de conservação, e integradas em paisagens terrestres e marinhas mais amplas.

Acerca da Meta 11, no documento do Ministério do Meio Ambiente intitulado "Estratégia e Plano de Ação Nacionais para a Biodiversidade" está estabelecida a ação 63 "*Apoio à expansão do Sistema Nacional de Unidades de Conservação na Caatinga, Cerrado, Pantanal e Mata Atlântica.* " (MMA 2017). Diante deste cenário, a criação de novas unidades de conservação (UC) e ampliação das UCs já existentes, e a melhoria na representatividade dos habitats locais constitui um compromisso assumido do governo Brasileiro para garantir a conservação da sua biodiversidade.

O Pantanal, considerado a maior área úmida tropical continental contígua do mundo, tem apenas 4,6% de seu território, em unidades de conservação formal (sejam públicas ou privadas), muito aquém do compromisso que assumimos frente às Nações Unidas, como primeiro signatário da CDB. Localizado na porção central da América do Sul, constitui-se como uma depressão geológica da bacia do Alto Paraguai com cerca de 180.000 km² de planície e 365,000 km^2 de área total em território brasileiro, assim o Brasil representa 80% desta área úmida, restando 15% na Bolívia e 5% no Paraguai. (Swarts 2000). O Pantanal é reconhecido mundialmente por sua produtividade, biodiversidade e pela abundância de sua fauna (Mittermeier *et al*. 1990; Harris *et al*.

2005). Assim sendo tem sido reconhecido como importante elemento na política de desenvolvimento sustentável do Brasil, e destino de classe mundial para o desenvolvimento de atividades de ecoturismo (Chardonnet *et al*. 2002). Por tais características, e por sua relevância para conservação da biodiversidade Neotropical, o Pantanal foi declarado Patrimônio Nacional pela Constituição Federal de 1988, Reserva da Biosfera Mundial e Patrimônio Natural da Humanidade pela UNESCO. Algumas áreas situadas dentro do Pantanal, incluindo o Parque Nacional do Pantanal Mato-grossense, foram declaradas como "sítios do patrimônio mundial" (UNESCO) e áreas úmidas de importância global no âmbito da Convenção Ramsar de sobre Zonas Úmidas. De acordo com o Zoneamento Socioeconômico Ecológico de Mato Grosso, o Pantanal é uma área de grande potencial biótico, com grande complexidade ecológica e paisagística, devido ao seu relevo, solo e regime fluvial (http://www.seplan.mt.gov.br/-/3704951-zsee?ciclo=cv_gestao_inf).

A principal atividade econômica do Pantanal é a pecuária extensiva que coexiste com a paisagem natural há aproximadamente 200 anos (Wilcox 1992). Sob práticas de gestão tradicionais, esta atividade é considerada de baixo impacto sobre a biodiversidade, quando comparada a outras formas de uso da terra nos trópicos (Seidl *et al*. 2001). Apesar deste uso sustentável nos últimos dois séculos, o desmatamento para a introdução de pastagens exóticas nas áreas mais altas e o subseqüente aumento na intensidade de uso do solo constitui-se como ameaças recentes ao Pantanal (Seidl *et al*. 2001; Harris *et al*. 2005; Junk *et al*. 2006). O desmatamento já comprometeu grande parte dos planaltos de entorno do Pantanal (Roque *et al*. 2016) e vem causando enorme pressão por assoreamento na planície, assim, caso medidas de precaução para controlar a conversão de ambientes naturais não forem adotadas, a vegetação nativa da planície do Pantanal estará ameaçada (Silva *et al*. 2011), visto que em menos de 50 anos, já foram convertidos na planície 17% e nos planaltos 65% de sua vegetação nativa, para a agricultura e pecuária. Aproximadamente 95% do Pantanal são constituídos de propriedades privadas e apenas 4,6% encontram-se protegidos por unidades de conservação (UC), dos quais 2,9% correspondem a unidades de conservação de proteção integral e 1,7% a UCs de uso sustentável, como Reservas Particulares do Patrimônio Natural (Harris *et al*. 2005; BRASIL, 2018).

Este documento apresenta dados socioeconômicos e ambientais compilados, das áreas propostas para a criação de duas novas unidades de conservação, além das

ampliações da Estação Ecológica do Taiamã e Parque Nacional do Pantanal Mato-grossense. Serão apresentados os mapas de uso do solo, mapa de vegetação, um diagnóstico das principais atividades econômicas da área e os locais onde ocorrem e dados bióticos relevantes para área de interesse. Para fins deste documento, será utilizado o termo "Mosaico de Unidades de Conservação do Pantanal Norte" (MUCPN), pois as áreas propostas neste estudo são limítrofes, formando um grande corredor ecológico entre as unidades de conservação localizadas no norte do Pantanal.

MOSAICO DE UNIDADES DE CONSERVAÇÃO DO PANTANAL NORTE

As áreas propostas para criação e ampliação de unidades de conservação no Pantanal abrangem os municípios de Cáceres e Poconé, no sudoeste do estado de Mato Grosso. Estes dois municípios possuem unidades de conservação federais (Estação Ecológica do Taiamã e Parque Nacional do Pantanal Mato-grossense) e estaduais (Parque Estadual Guirá e Parque Estadual Encontro das Águas). A proposta de criação do MUCPN (Fig. 1) conecta as áreas já existentes, formando assim um corredor biológico.

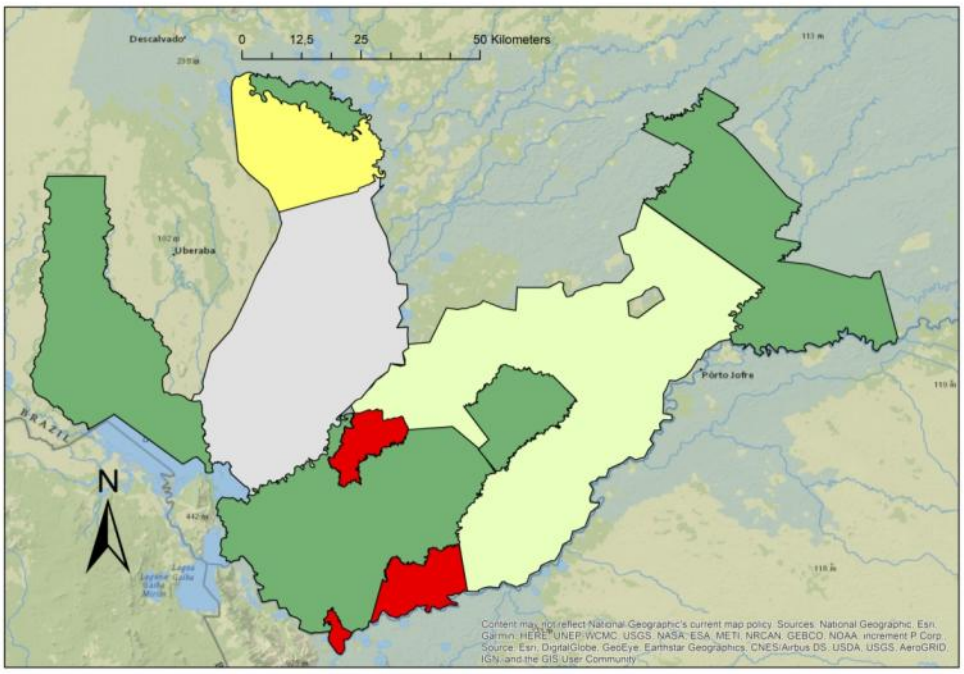

Figura 1. Mapa com os polígonos propostos pelo ICMBio para Ampliação da Estação Ecológica de Taiamã em amarelo; Reserva de Fauna do Pantanal em cinza; Refúgio de Vida Silvestre da Onça-pintada em verde-claro; Ampliação do Parque Nacional do Pantanal Mato-grossense em vermelho. Em verde escuro são as unidades de conservação já existentes na região.

A área onde o MUCPN está situado é considerada prioritária para conservação da biodiversidade (Eg., MMA 2007, MMA 2016, Develey & Goerck 2009, WWF 2015). No mapa do Zoneamento Socioeconômico Ecológico de Mato Grosso (Fig. 2), elaborado com a participação de equipe técnica qualificada define a região do MUCP como:

Zona 4.2.15. Área Protegida Proposta com Elevado Potencial Biótico em Ambientes Pantaneiros no Corixo Grande/Rio Paraguai;

Zona 3.2.4. Manejos Específicos com Elevado Potencial Biótico em Ambientes Pantaneiros, onde Predominam Formações Savânicas, na Área de Influência do Pólo Regional de Cuiabá (Subzona 3.2.4.a e 3.2.4.b).

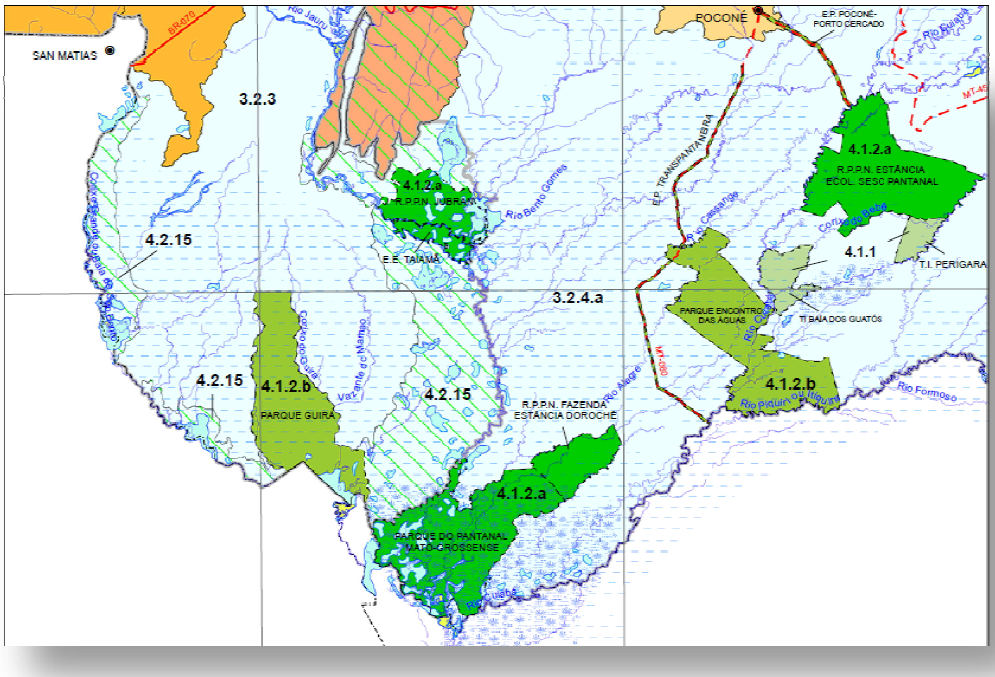

Figura 2. Recorte da região do Mosaico de Unidades de Conservação do Pantanal Norte no mapa do Zoneamento Socioeconômico Ecológico de Mato Grosso. Informações disponíveis no website da Secretaria de Estado e Meio Ambiente de Mato Grosso (http://www.sema.mt.gov.br/attachments/article/109/Mapa%20do%20ZSEE%202008.pdf). É importante informar que Justiça determinou a suspensão da lei 9.523/11 que institui o Zoneamento Socioeconômico

Ecológico de Mato Grosso (http://g1.globo.com/mato-grosso/noticia/2012/02/justica-suspende-lei-do-zoneamento-ambiental-de-mato-grosso.html), pois a mesma poderia causar eventuais prejuízos ambientais se entrasse em vigor.

Abaixo são descritos de acordo com o Sistema Nacional de Unidades de Conservação (MMA 2011) as quatro classes de unidades de conservação propostas para compor o Mosaico de Unidades de Conservação do Pantanal Norte:

RESERVA DE FAUNA DO PANTANAL

De acordo com o artigo 19 do Sistema Nacional de Unidades de Conservação (SNUC) a Reserva de Fauna "... *é uma área natural com populações animais de espécies nativas, terrestres ou aquáticas, residentes ou migratórias, adequadas para estudos técnico-científicos sobre o manejo econômico sustentável de recursos faunísticos."* Os incisos abaixo caracterizam este tipo de unidade de conservação:

§ 1o A Reserva de Fauna é de posse e domínio públicos, sendo que as áreas particulares incluídas em seus limites devem ser desapropriadas de acordo com o que dispõe a lei.

§ 2o A visitação pública pode ser permitida, desde que compatível com o manejo da unidade e de acordo com as normas estabelecidas pelo órgão responsável por sua administração.

§ 3o É proibido o exercício da caça amadorística ou profissional.

§ 4o A comercialização dos produtos e subprodutos resultantes das pesquisas obedecerá ao disposto nas leis sobre fauna e regulamentos.

A proposta de Reserva de Fauna do Pantanal abrange 165.000 hectares entre a Estação Ecológica Taiamã e o Parque Nacional do Pantanal Mato-grossense, incluindo terras devolutas e propriedades privadas localizadas ao longo da margem direita do rio Paraguai (Fig. 3).

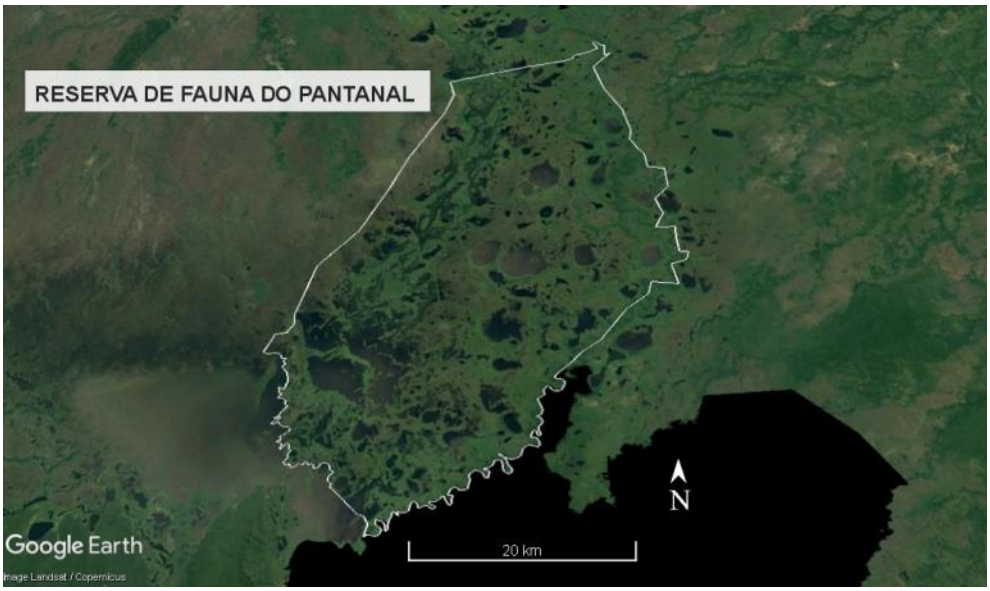

Figura 3. Imagem de satélite do polígono proposto para Reserva de Fauna do Pantanal. Polígono preto ao sul da imagem é o Parque Nacional do Pantanal Mato-grossense.

REFÚGIO DE VIDA SILVESTRE DA ONÇA-PINTADA

De acordo com o artigo 13 do Sistema Nacional de Unidades de Conservação o Refúgio de Vida Silvestre "... *tem como objetivo proteger ambientes naturais onde se asseguram condições para a existência ou reprodução de espécies ou comunidades da flora local e da fauna residente ou migratória."* Os incisos abaixo caracterizam este tipo de unidade de conservação:

§ 1o O Refúgio de Vida Silvestre pode ser constituído por áreas particulares, desde que seja possível compatibilizar os objetivos da unidade com a utilização da terra e dos recursos naturais do local pelos proprietários.

§ 2o Havendo incompatibilidade entre os objetivos da área e as atividades privadas ou não havendo aquiescência do proprietário às condições propostas pelo órgão responsável pela administração da unidade para a coexistência do Refúgio de Vida Silvestre com o uso da propriedade, a área deve ser desapropriada, de acordo com o que dispõe a lei.

§ 3o A visitação pública está sujeita às normas e restrições estabelecidas no Plano de Manejo da unidade, às normas estabelecidas pelo órgão responsável por sua administração, e àquelas previstas em regulamento.

§ 4o A pesquisa científica depende de autorização prévia do órgão responsável pela administração da unidade e está sujeita às condições e restrições por este estabelecidas, bem como àquelas previstas em regulamento.

A proposta de Refúgio de Vida Silvestre da Onça-pintada abrange 270.000 hectares entre o Parque Nacional do Pantanal Mato-grossense e Parque Estadual Encontro das Águas, incluindo a Reserva Particular do Patrimônio Natural Dorochê e propriedades privadas (Fig. 4).

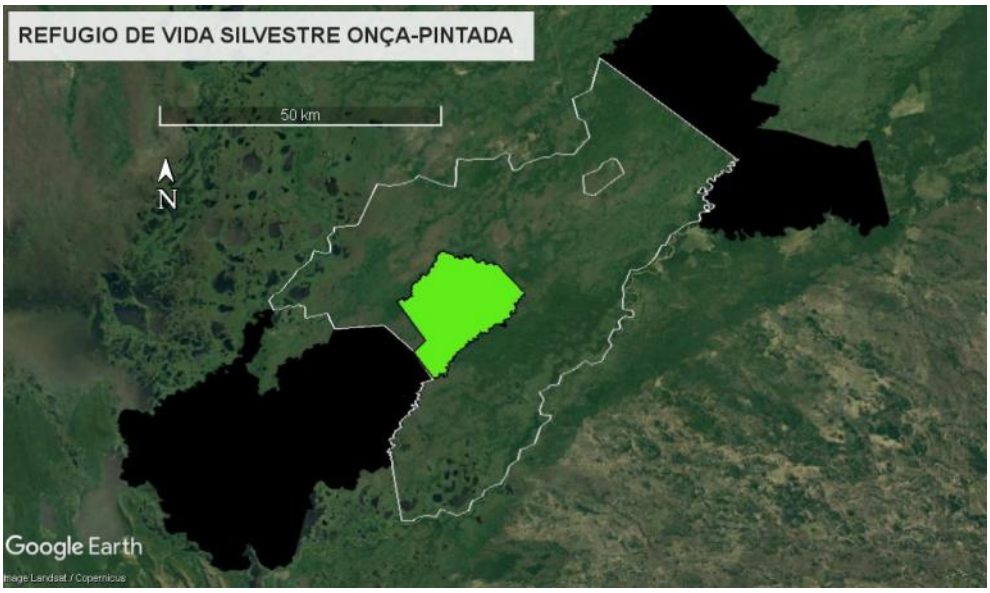

Figura 4. Polígono com perímetro branco ilustra a proposta de criação do Refúgio de Vida Silvestre da Onça-pintada. A sudoeste da imagem o polígono preto representa o Parque Nacional do Pantanal Mato-grossense e a nordeste da imagem o polígono preto representa o Parque Estadual Encontro das Águas. O polígono verde ao centro da imagem representa a RPPN Dorochê que estará integrada na proposta do Refúgio de Vida Silvestre da Onça-pintada, na sua qualidade de RPPN.

A AMPLIAÇÃO DO PARQUE NACIONAL DO PANTANAL MATO-GROSSENSE

De acordo com o artigo 11 do Sistema Nacional de Unidades de Conservação o Parque Nacional "*...tem como objetivo básico a preservação de ecossistemas naturais de grande relevância ecológica e beleza cênica, possibilitando a realização de pesquisas científicas e o desenvolvimento de atividades de educação e interpretação*

ambiental, de recreação em contato com a natureza e de turismo ecológico". Os incisos abaixo caracterizam este tipo de unidade de conservação:

§ 1o O Parque Nacional é de posse e domínio públicos, sendo que as áreas particulares incluídas em seus limites serão desapropriadas, de acordo com o que dispõe a lei.

§ 2o A visitação pública está sujeita às normas e restrições estabelecidas no Plano de Manejo da unidade, às normas estabelecidas pelo órgão responsável por sua administração, e àquelas previstas em regulamento.

§ 3o A pesquisa científica depende de autorização prévia do órgão responsável pela administração da unidade e está sujeita às condições e restrições por este estabelecidas, bem como àquelas previstas em regulamento.

§ 4o As unidades dessa categoria, quando criadas pelo Estado ou Município, serão denominadas, respectivamente, Parque Estadual e Parque Natural Municipal.

A proposta de ampliação do Parque Nacional do Pantanal Mato-grossense abrange 33.000 hectares envolvendo três áreas distintas que englobam propriedades privadas limítrofes a esta unidade de conservação (Fig. 5). Que completariam junto com as RPPNs presentes na Serra do Amolar (Penha, Acurizal e Elieser Baptista) o plano original de proteção de áreas contíguas e de relevo variado na região, mas que como a maioria das Áreas Protegidas brasileiras, carece de uma abordagem mais focada nos recursos hídricos e na biodiversidade e produtividade das áreas úmidas e do chamado "Pulso de Inundação" (Junk *et al*. 1989, Lourival *et al*. 2009).

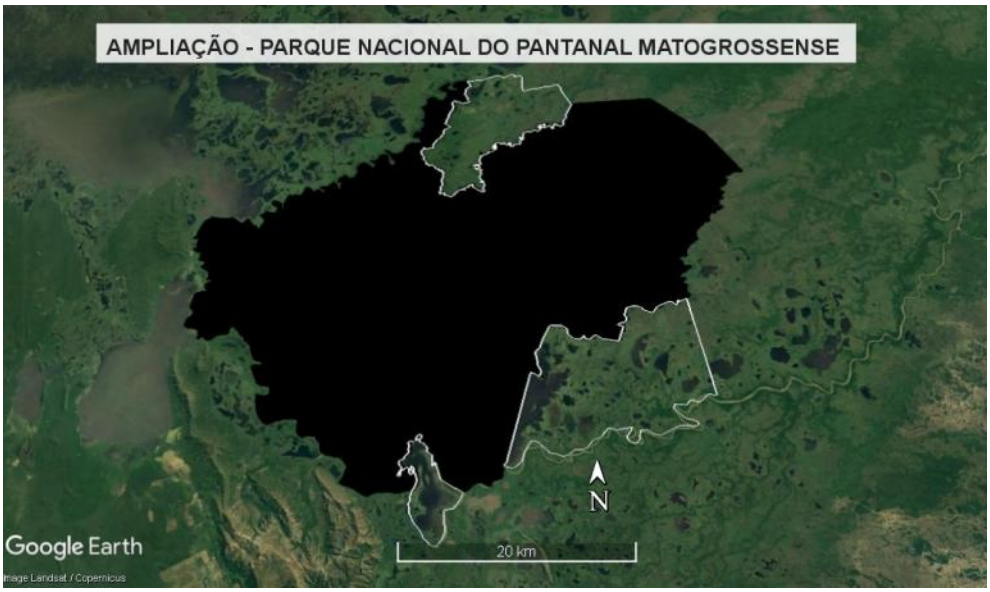

Figura 5. Polígono preto ao centro indicando o Parque Nacional do Pantanal Mato-grossense. Ao sul da imagem dois polígonos e ao norte mais outro polígono com perímetro em branco indicam as áreas propostas para ampliação do Parque Nacional do Pantanal Mato-grossense.

AMPLIAÇÃO DA ESTAÇÃO ECOLÓGICA DE TAIAMÃ

De acordo com o artigo 11 do Sistema Nacional de Unidades de Conservação a Estação Ecológica "*... tem como objetivo a preservação da natureza e a realização de pesquisas científicas*". Os incisos abaixo caracterizam este tipo de unidade de conservação:

§ 1o A Estação Ecológica é de posse e domínio públicos, sendo que as áreas particulares incluídas em seus limites serão desapropriadas, de acordo com o que dispõe a lei.

§ 2o É proibida a visitação pública, exceto quando com objetivo educacional, de acordo com o que dispuser o Plano de Manejo da unidade ou regulamento específico.

§ 3o A pesquisa científica depende de autorização prévia do órgão responsável pela administração da unidade e está sujeita às condições e restrições por este estabelecidas, bem como àquelas previstas em regulamento.

§ 4o Na Estação Ecológica só podem ser permitidas alterações dos ecossistemas no caso de:

I - medidas que visem a restauração de ecossistemas modificados;

II - manejo de espécies com o fim de preservar a diversidade biológica;

III - coleta de componentes dos ecossistemas com finalidades científicas;

IV - pesquisas científicas cujo impacto sobre o ambiente seja maior do que aquele causado pela simples observação ou pela coleta controlada de componentes dos ecossistemas, em uma área correspondente a no máximo três por cento da extensão total da unidade e até o limite de um mil e quinhentos hectares.

A proposta de ampliação da Estação Ecológica de Taiamã abrange 51.000 hectares englobando propriedades privadas limítrofes a esta unidade de conservação na porção sul (Fig. 6).

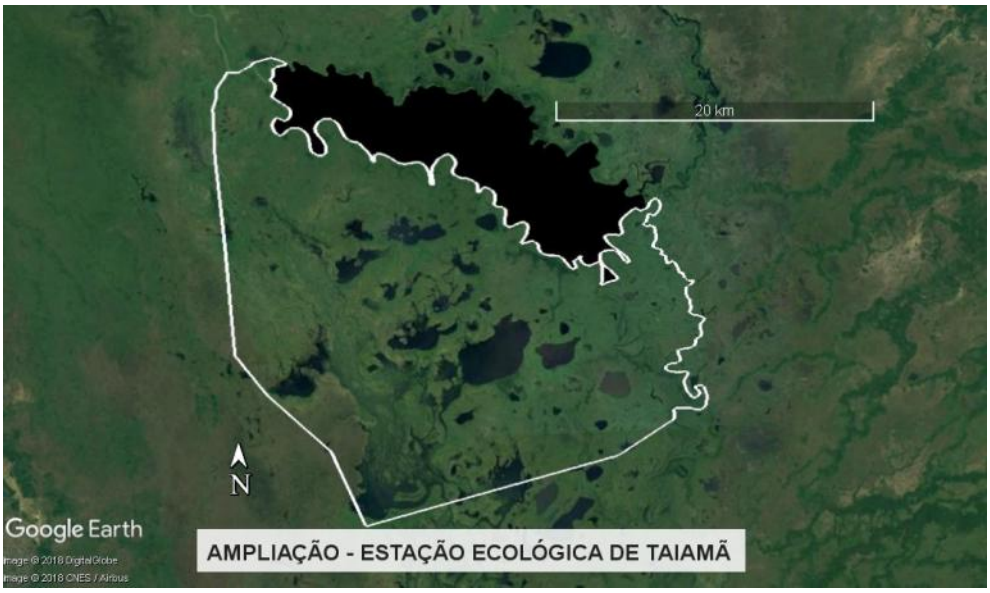

Figura 6. Polígono com perímetro em branco ilustrando a área proposta para ampliação da Estação Ecológica de Taiamã. Polígono preto ilustrando a Estação Ecológica de Taiamã.

FATORES SOCIOECONÔMICOS

SITUAÇÃO FUNDIÁRIA

O município de Cáceres possui 3524 propriedades rurais e Poconé com 2713 propriedades rurais (http://www.cadastrorural.gov.br/estatisticas/cafir-cadastro-de-imoveis-rurais/copy2_of_total-de-imoveis-ativos-no-cadastro-de-imoveis-rurais-cafir-da-rfb-sao-7-442.515). Na área proposta para o MUCP há aproximadamente 25 propriedades rurais considerando a base de dados do INCRA (Fig. 7) (http://acervofundiario.incra.gov.br/geodownload/geodados.php). Mesmo considerando as lacunas no cadastro no INCRA, as propriedades rurais na área do MUCP representam menos de 1% do total de propriedades rurais de Cáceres e Poconé (6237). É importante considerar que muitas destas propriedades têm somente parte de sua área inserida dentro do MUCPN, se destacando na proposta da Reserva de Fauna do Pantanal, que somente abrange o chamado "fundo de fazendas", hoje em áreas remotas e alagadas (Fig. 8). A maior unidade de conservação proposta, o Refúgio de Vida Silvestre da Onça-pintada (270.000ha) foi selecionada por permitir propriedades particulares e a criação de animais e plantas domésticas em seu interior (SNUC, Artigo 13, Inciso 1), desde que desenvolvidas de formas sustentáveis, tais quais as que já vêm sendo desenvolvidas a séculos nesta região do Pantanal. A exceção de dá somente em caso onde não houver aquiescência do proprietário, sendo realizados em casos extremos, processos de desapropriação. Se somarmos a área de ampliação da Estação Ecológica do Taiamã, ampliação do Parque Nacional do Pantanal Mato-grossense, criação da Reserva de Fauna do Pantanal e criação do Refúgio de Vida Silvestre da Onça-pintada, estas abrangem 12,5% do território de Cáceres e Poconé, um incremento de 519.000 hectares em relação às áreas existentes, e fundamentais na manutenção a produtividade pesqueira e seu manejo, bem como a viabilidade das populações silvestres de espécies ameaçadas, e ambas fundamentais ao turismo de base local.

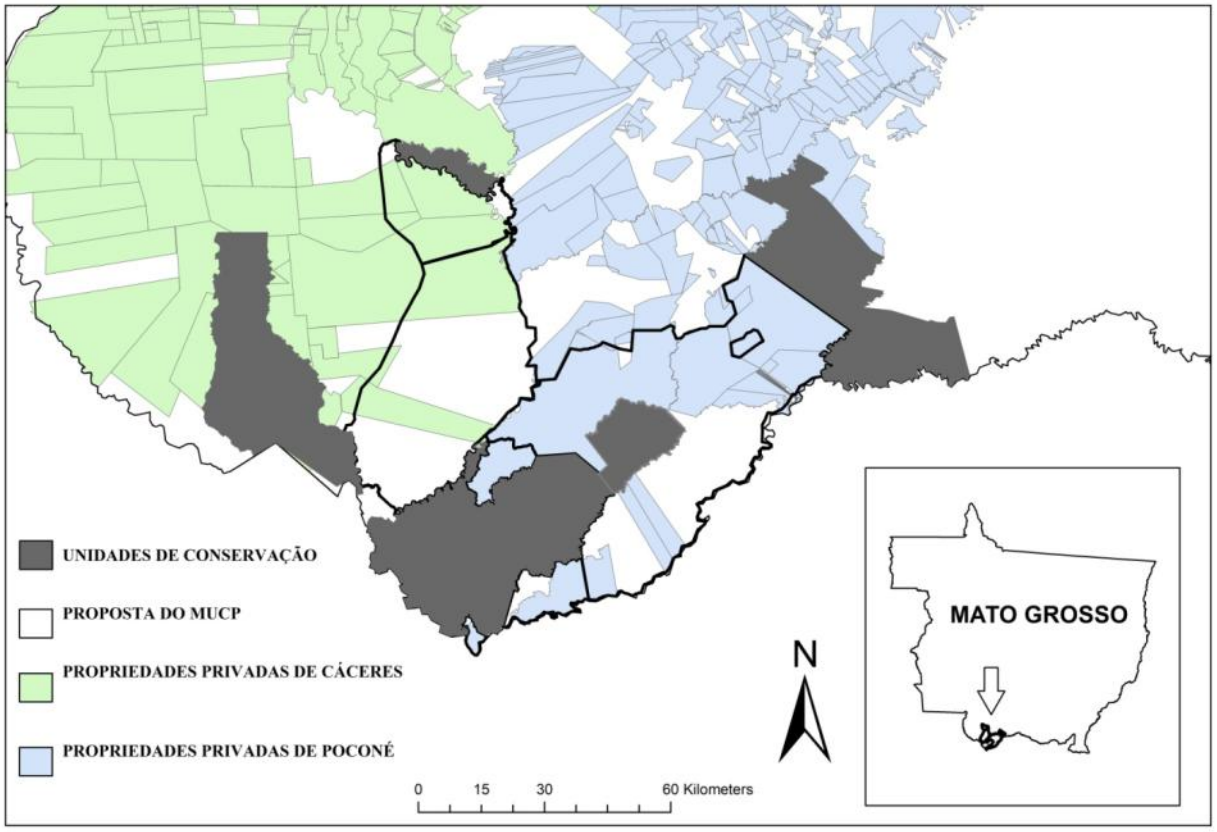

Figura 7. Propriedades privadas inseridas na área proposta do Mosaico de Unidades de Conservação do Pantanal Norte. Em verde as propriedades do município de Cáceres, em azul propriedades no município de Poconé. Em cinza escuro as Unidades de Conservação já existentes. Linhas pretas demarcam o limite das áreas propostas para ampliação e criação de unidades de conservação que compõe o Mosaico de Unidades de Conservação do Pantanal Norte (MUCPN). Base de dados disponível em http://acervofundiario.incra.gov.br/.

Figura 8. Imagens aéreas da área da proposta de Mosaico de Unidades de Conservação do Pantanal Norte demonstrando sua heterogeneidade de habitats e baixo potencial econômico.

ICMS ECOLÓGICO

O ICMS Ecológico é uma ferramenta legal que possibilita aos municípios acessarem recursos financeiros do Imposto sobre Circulação de Mercadorias e Serviços (ICMS). Constitui um instrumento para compensação e incentivo econômico de municípios que possuem unidades de conservação em seu território. A área ocupada por unidades de conservação e as terras indígenas dentro do território de um município são um dos principais critérios ambientais para calcular o valor de repasse deste mecanismo de compensação. Em avaliação realizada no ano de 2014, os municípios de Cáceres e Poconé receberam respectivamente R$287.746 e R$652.689 de ICMS Ecológico (Dados disponíveis em http://www.sema.mt.gov.br/). No Mato Grosso do Sul, municípios como Bonito, Bodoquena, Costa Rica e Ivinhema, recebem anualmente, pela presença de áreas protegidas de proteção integral, em seu interior, mais de quatro (de 4 a 7) milhões de reais anuais, uma contribuição substancial a economia e a infraestrutura municipal, e em nada comprometendo as atividades agropecuárias, muito pelo contrário, garantem a produção da qualidade e quantidade de água destes.

PECUÁRIA

A porção norte do Pantanal teve como principal atividade econômica por aproximadamente 200 anos a pecuária extensiva (Wilcox 1992). A pecuária constitui uma das principais atividades econômicas dos municípios de Cáceres e Poconé. Cáceres possui o quarto maior rebanho bovino do Brasil, com 1.113.134 cabeças de gado (https://cidades.ibge.gov.br/brasil/mt/caceres/pesquisa/18/16459) e Poconé possui 505.084 cabeças de gado (https://cidades.ibge.gov.br/brasil/mt/pocone/pesquisa/24/27745). A pecuária no Pantanal ocorre em sua maioria como atividade extensiva e de baixo impacto, com relevante cultural, e que bem se agrega ao turismo que ali se desenvolve. Autores como Girardi e Rosseto (2011) abordam essa questão:

"O regime hidrológico e a baixa fertilidade natural dos solos foram os principais responsáveis pelo estabelecimento de uma pecuária extensiva relativamente pouco impactante no meio natural do Pantanal, porém não os únicos. Para a manutenção deste quadro também contribuíram outros elementos da questão agrária brasileira, como a forma de apropriação privada da terra, que remonta ao período colonial; a expansão da agropecuária brasileira para o Cerrado e a Amazônia; o baixo preço da terra e os laços tradicionais das famílias pecuaristas centenárias na região. "

A expansão e retração da pecuária no Pantanal são regidas pela água em regimes anuais e plurianuais. Na década de 1970, devido a grandes cheias, o Pantanal apresentou uma queda drástica no rebanho, reduzindo de 4,89 milhões de cabeças em 1970 para 3,53 milhões de cabeças em 1980 (Cadavid-Garcia, 1981). Estas grandes cheias transformaram vastas áreas outrora de pastagem em campos permanentemente inundados e formações arbustivo-arbóreas com dominância monoespecífica (Ex: Pomberais- *Combretum* sp. e Cambarazais- *Vochysia divergens*) inviabilizando a atividade de pecuária (Nunes da Cunha & Junk 2004) e provocando a sua desaceleração econômica nesta região do Pantanal (McManus *et al*. 2016). Lacerda & Lima (2015) em estudo realizado no município de Poconé constaram que 78,5% dos pecuaristas entrevistados não vivem exclusivamente da pecuária e 23,8% tem a pecuária como atividade econômica principal.

Atualmente a maioria das fazendas de pecuária da região que abrange o MUCPN é utilizada somente no período de seca e início do período chuvoso do Pantanal, entre julho e dezembro. A taxa de lotação destas propriedades, mesmo no período de seca,

raramente ultrapassa 0.3 cabeças por hectare (Tortato *et al*. Dados não publicados). Na área proposta para a Reserva de Fauna e área proposta para ampliação da EET à atividade de pecuária possui limitações logísticas e o terreno permanece boa parte do ano inundado sendo, portanto inadequado a atividade. Na área proposta para ampliação do PNPM há também as mesmas limitações logísticas e ecológicas, com maior parte da área com uso limitado devido às intensas inundações e o uso para fins de pecuária pode ser considerado ocasional. Na área proposta para criação do Refúgio de Vida Silvestre há fazendas de pecuária, contudo estão subutilizadas em relação ao seu potencial agropecuário, estando com rebanhos pequenos, inclusive com algumas propriedades a venda (e.g. Fazenda Jofre, Fazenda Campina Grande).

Para o propósito deste relatório foi realizado uma avaliação minuciosa de indícios de pecuária na área proposta para criação do Refúgio de Vida Silvestre da Onça-pintada (RVSOP). Através de imagens de satélite com alta resolução (Google Earth Pro) foram identificados 15 locais de descanso do rebanho, reconhecidos popularmente como malhador. Com estes pontos georreferenciados, foi elaborado um mapa de densidade, servindo de referência para intensidade de uso da pecuária na área proposta para o RVSOP (Fig. 9). Estas mesmas propriedades, em suas porções mais próximas ao curso do rio, em seu dique marginal, tem sido palco do desenvolvimento do turismo de visualização de fauna, com particular interesse na onça-pintada. Esta atividade tem o potencial de solucionar o conflito comum entre a pecuária e os grandes felinos, tendo em vista que as onças têm gerado recursos substanciais para a economia regional em Poconé. A integração do turismo com pecuária possibilita um incremento na renda dos pecuaristas em áreas muito alagadas.

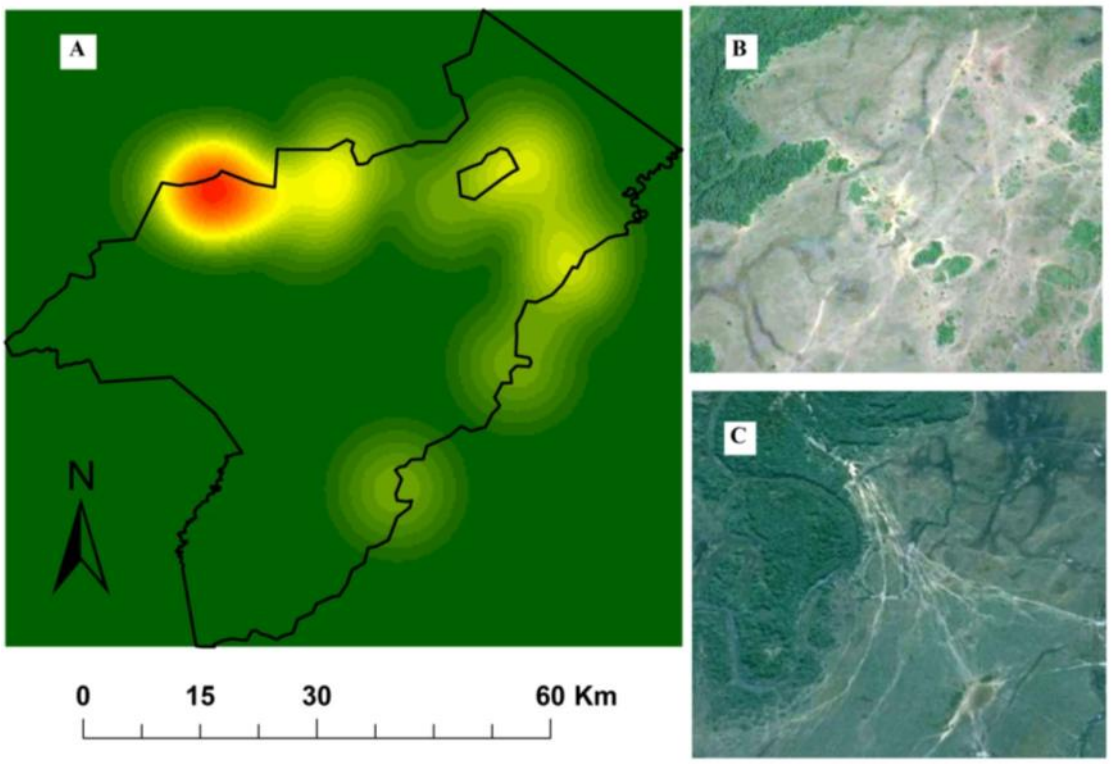

Figura 9. A. Mapa apresentando a densidade de uso pela pecuária na área proposta para o Refúgio de Vida Silvestre da Onça-pintada. Áreas vermelhas indicam um maior uso e área verde menor uso. B e C são imagens de satélite que representam os indícios de uso pela pecuária na área proposta para o Refúgio de Vida Silvestre da Onça-pintada.

Considerando o uso pela pecuária descrito na figura 8 e criando um cenário otimista, temos aproximadamente 50.000 hectares da área proposta para o Refúgio de Vida Silvestre da Onça-pintada com uso econômico da pecuária. Baseado na capacidade de carga da região de 0.3 animais por hectare, a área do RVSOP terá um rebanho de 15.000 animais. Isto representa menos de 3% do rebanho do município de Poconé. Reforçamos que esta categoria de unidade de conservação permite propriedades privadas e criação de animais domésticos.

A PESCA

A região do Mosaico de Unidades proposto é uma área de concentração da atividade de pesca, que representa uma importante atividade econômica no Pantanal Norte. Não por acaso, a importância desta região ocorre em função desta área apresentar condições extremamente favoráveis aos peixes de interesse comercial e amador. No mundo as unidades de conservação têm sido criadas, em colaboração com pescadores

locais por sua importância em produzir peixes que por efeito de dispersão, deixam seus territórios de cria e recria, repovoando as demais áreas circunvizinhas (Arias *et al*. 2015; Campos-Silva & Peres 2016). Esta região é reconhecida por pescadores profissionais e desportivos, que a partir dos municípios de Cáceres, Poconé e Barão de Melgaço no estado de Mato Grosso e também Corumbá no Mato Grosso do Sul exploram os rios Paraguai, Cuiabá, Piquiri e São Lourenço, buscam os cardumes oriundos do PARNA do Pantanal Mato-grossense e da ESEC Taiamã. Um exemplo que dimensiona a pesca profissional é a Colônia Z11 do município de Poconé que conta com aproximadamente 600 pescadores profissionais cadastrados (http://www.mt.gov.br/-/9198883 representantes-do-setor-de-pesca-participam-de-dialogo-na-sema). Diversas pousadas, pesqueiros e barcos-hotel exploram a pesca amadora nesta região do Pantanal. Há carência de dados acerca da quantidade de turistas de pesca que visitam o Pantanal de Mato Grosso, mas a título de comparação, no ano de 2009, mais de 15.000 turistas de pesca visitaram o Pantanal de Mato Grosso do Sul (Albuquerque *et al*. 2011). Esta atividade econômica fornece emprego e renda para comunidade ribeirinha, que atua tanto como empregados de hotéis, como na coleta de iscas vivas para venda aos pescadores. A área utilizada para pesca profissional e amadora só é restringida em unidades de conservação como o Parque Estadual Encontro das Águas, Parque Nacional do Pantanal Mato-grossense e Estação Ecológica de Taiamã. A intensidade de uso destas atividades é limitada por questões logísticas, sendo mais concentrada nos arredores do Porto Jofre, próximo ao PEEA para pescadores oriundos de Poconé e Barão de Melgaço, na área permitida próxima a confluência entre os rios São Lourenço e Paraguai próxima ao PNPM para pescadores oriundos de Poconé e Corumbá, no rio Paraguai a montante dos limites do PNPM por pescadores oriundos de Corumbá e na porção do rio Paraguai entre a EET e o município de Cáceres para pescadores oriundos deste mesmo município.

As propostas de ampliação da Estação Ecológica de Taiamã e o Parque Nacional do Pantanal Mato-grossense incorporam somente regiões remotas, com baixo uso humano e grande valor biológico. Os resultados destas ampliações podem ser considerados positivos, principalmente para pesca amadora e profissional, por proteger sítios reprodutivos de peixes de interesse econômico do Pantanal, como pacus (*Piaractus mesopotamicus*) e pintados (*Pseudoplatystoma corruscan*), garantindo assim a viabilidade do estoque pesqueiro da região, pelo fenômeno conhecido como efeito de

spillover ou extravasamento. O ecoturismo também pode ser diretamente beneficiado, principalmente com a ampliação do Parque Nacional do Pantanal Mato-grossense, aumentando as potenciais áreas de visitação desta unidade de conservação. A proposta de criação da Reserva de Fauna entre a Estação Ecológica Taiamã e o Parque Nacional do Pantanal Mato-grossense não restringe o uso sustentável da pesca, fortalecendo a proteção do estoque pesqueiro do Pantanal Norte.

Apesar dos dados de captura de pescado no pantanal ser objeto de anos de coleta, através do SCPESCA, e ser utilizado nos processos de definição de cotas e período de defeso, há poucos estudos sobre os processos reprodutivos e seus gargalos. Os diversos setores interessados usualmente têm conflitos e, portanto, a informação sobre quais seriam os sítios de maior produtividade e o porquê destes níveis terem uma distribuição pouco homogênea na planície pantaneira é tópico interessante para o desenvolvimento de modelos de Fonte e Sumidouro (Eg. Johnson 2004), que venham nos ajudar a melhor manejar os recursos pesqueiros do Pantanal, para todos os seus usuários, incluindo-se ai a cadeia alimentar local. Neste contexto o Mosaico de Unidades propostas para esta região, busca proteger os recursos aquáticos do Pantanal de modo a privilegiar a produtividade pesqueira e a biodiversidade local, simultaneamente. Esta perspectiva vem em grande parte pelo acompanhamento de anos das atividades na região. É neste encontro das águas que vem da porção norte da BAP, que ocorre boa parte das atividades na região. A fundamentação biológica desta observação parece similar ao fenômeno da "ressurgência no mar", quando águas com nutrientes afloram e criam uma bolha de produtividade.

No Pantanal, todavia, é a confluência de diversos rios que carreiam nutrientes de diversas bacias sedimentares diferentes, que aliada e sincronizada ao pulso de inundação, extravasam matéria orgânica e minerais que servem de base a produção primária e secundária, elevando esta produtividade, cadeia trófica acima, seja para os herbívoros seja para seus consumidores, tanto na água quanto em terra. Deste modo o Mosaico proposto amplia a salvaguarda da base de produção pesqueira do Pantanal Norte, e um de seus elementos funcionais mais importantes da planície, e seu complexo de áreas úmidas lóticas e lênticas conectadas e com potencial de restaurar seus estoques. É assim, do nosso entendimento, que no melhor interesse dos usuários dos recursos pesqueiros do Pantanal, que este mosaico seja implantado, e que das diversas categorias

disponíveis no SNUC, que as categorias de UCs escolhidas são as que mais apropriadamente protegem estes recursos.

O MUCPN deverá restringir à atividade de pesca em áreas já vedadas a pesca na área de ampliação da Estação Ecológica de Taiamã no rio Paraguai, enquanto em área de ampliação do Parque Nacional do Pantanal Mato-grossense no rio São Lourenço/Cuiabá, pequenas parcelas terão restrição, mas passarão a contribuir ao processo de proteção/reprodução dos peixes. Contudo é importante considerar que a área de ampliação da Estação Ecológica de Taiamã já se encontra com limitações de uso a aproximadamente 10 anos, em acordo firmado pelo ICMBio com comunidade de pescadores da região (Instrução Normativa IBAMA 09/2009 - anexo III). A proteção destas áreas auxilia na manutenção do estoque pesqueiro e colabora com a sustentabilidade da atividade de pesca no Pantanal.

ECOTURISMO

O ecoturismo é uma atividade mais recente, e crescente, se comparada ao turismo de pesca, mas que vem crescendo significativamente em algumas regiões do Pantanal, incluindo a região do Mosaico de Unidades de Conservação do Pantanal Norte. No município de Poconé, a construção da Rodovia Transpantaneira no fim da década de 1970 impulsionou o desenvolvimento do ecoturismo pantaneiro. Os primeiros guias de ecoturismo iniciaram suas atividades na década de 1980 trazendo pequenos grupos em busca, principalmente, de aves e contemplação da paisagem. Esses guias utilizavam a infraestrutura já existente para o turismo de pesca amadora para acomodação dos visitantes. As primeiras pousadas nesta rodovia foram construídas em meados da década de 1980. Atualmente, a Transpantaneira possui aproximadamente 20 opções de hospedagem voltadas ao turismo de observação de fauna e contemplação da natureza. Esta região é considerada um *hotspot* de visitação mundial em áreas selvagens (Levin *et al.* 2015, Tortato & Izzo 2016) recebendo milhares de turistas todos os anos (Tortato & Izzo 2017). A oferta hoteleira de ecoturismo desenvolvida na rodovia Transpantaneira duplicou nos últimos 20 anos e pode gerar um valor anual de até 83,4 milhões de dólares anuais (Carlos, 2018). Se considerarmos a distribuição de 54 pousadas de ecoturismo em todo Pantanal, a região do MUCPN está localizada em local com grande potencial para esta atividade econômica (Fig. 10).

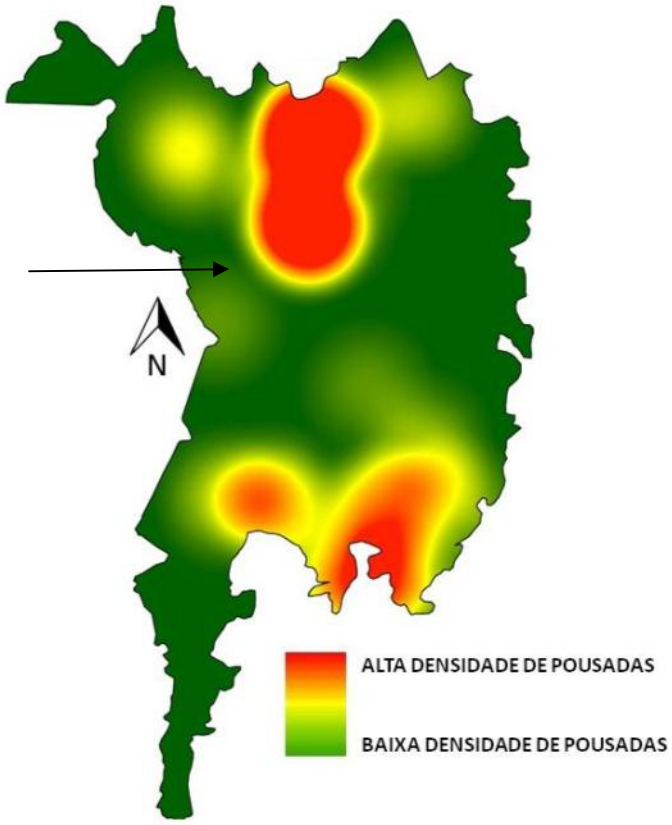

Figura 10. Mapa de "calor" do bioma Pantanal com áreas em vermelho com alta concentração de pousadas de ecoturismo e áreas em verde escuro com baixa concentração de pousadas de ecoturismo. Seta indica a área do Mosaico de Unidades de Conservação do Pantanal Norte (Tortato, F.R. Dados não publicados).

Nas margens do rio Cuiabá, porção final da Transpantaneira, na localidade de Porto Jofre, até início dos anos 2000 havia principalmente hotéis voltados ao turismo de pesca amadora. Contudo, nos últimos 15 anos iniciou-se um turismo para a observação de onças-pintadas. Essa atividade é sazonal, ocorrendo somente nos meses de seca do Pantanal, entre junho e novembro. Os turistas se deslocam em barcos de alumínio com motor de popa pelos rios e corixos da região observando a fauna nas barrancas e praias (Tortato e Izzo 2017). Uma informação que quantifica a intensidade desta atividade é que durante os meses de agosto e setembro de 2012 houve um fluxo de 10 turistas por hora durante o dia (06:00AM-06:00PM) na foz do rio Piquiri com o rio Cuiabá (Fernando Tortato, Dados não publicados). Durante o período de seca, os turistas estrangeiros representam mais de 80% dos hóspedes das principais pousadas e hotéis desta localidade. No Hotel Pantanal Norte, que oferece o maior número de leitos no Porto Jofre, há uma mudança no perfil dos turistas de acordo com o período do ano: de

março a junho predominantemente turistas de pesca, e de julho a novembro, turistas que buscam observar a fauna, principalmente à onça-pintada (Tortato e Hoogesteijn 2014, Hoogesteijn *et al*. 2016, Tortato e Izzo 2017). A atividade de observação de onças-pintadas na região do Porto Jofre representou uma receita de 6.8 milhões de dólares em sete pousadas de ecoturismo no ano de 2015, sendo uma atividade considerada em expansão na região (Tortato *et al*. 2017, Tortato & Izzo, 2017).

A área proposta para o Refúgio de Vida Silvestre inclui em seus limites a atividade de pecuária extensiva, que é permitida por esta categoria de UC. Considerando a intensidade de uso humano na região, o polígono proposto para esta unidade de conservação provocará pouca ou nenhuma limitação econômica para pecuária extensiva e pesca amadora e profissional. Para o ecoturismo, a sua criação é positiva, pois aumentará a divulgação da região a nível nacional e internacional. Por estar sob jurisdição federal, o governo poderá destinar recursos para o controle do fogo, mantendo permanentemente brigadistas de incêndio nesta unidade de conservação nos períodos mais críticos da estação seca. A criação deste Refúgio de Vida Silvestre garante também a conservação em longo prazo de espécies carismáticas, como por exemplo, a onça-pintada, arara-azul e ariranha, reforçando o potencial do ecoturismo para região norte do Pantanal. A porção final da rodovia Transpantaneira irá cortar esta unidade de conservação e servirá de entrada para milhares de turistas todos os anos desfrutarem desta área protegida.

FATORES AMBIENTAIS

A criação de unidades de conservação constitui atualmente uma das ações mais efetivas para a conservação de habitats e espécies ameaçadas de extinção (Margules e Pressey, 2000, Carranza *et al*. 2014). A proposta de criação do MUCPN Norte abrange totalmente ou parcialmente áreas reconhecidas como prioritárias para a conservação da biodiversidade em diversas avaliações técnicas, como os documentos "Cerrado e Pantanal - Áreas e Ações Prioritárias para Conservação da Biodiversidade" (MMA 2007), "Áreas prioritárias para conservação da biodiversidade no Cerrado e Pantanal" (WWF 2015), incluindo também avaliações específicas para grupos taxonômicos como as aves no documento "Áreas importantes para Conservação das aves - América - Brasil" (Develey & Goerck 2009). O Pantanal possui 36 espécies da fauna ameaçadas de extinção a nível nacional (Disponível em: http://www.icmbio.gov.br/portal/images/stories/comunicacao/publicacoes/publicacoesdiversas/dcom_sumario_executivo_livro_vermelho_ed_2016.pdf), sendo que 17 delas ocorrem na região proposta para o MUCPN.

VEGETAÇÃO

O número total de espécies da flora do Pantanal é de 1.903, com 247 espécies consideradas macrófitas aquáticas ou hidrófitas e 1.656 espécies terrestres. Destas espécies terrestres, 900 espécies são gramíneas, ervas, epífitas e parasitas e 756 espécies são plantas lenhosas como arbustos, árvores (Pott & Pott, 2000). A vegetação do Pantanal é moldada principalmente pelas suas inundações sazonais que produzem variabilidade espacial marcante em abundância e diversidade de espécies (Hamilton 1999). Influenciado por rios que drenam a bacia do Alto Paraguai, o Pantanal sofre a influência direta dos biomas da Amazônia, Cerrado e Mata Atlântica, além do Chaco. Devido a esta dinâmica natural de seca e cheia do Pantanal, a vegetação do Pantanal está em constante sucessão ecológica. Com isso, propostas de unidades de conservação para o Pantanal devem considerar cenários futuros, onde as fitofisionomias podem ser diferentes do contexto atual (Lourival *et al.* 2011). A região proposta para o MUCPN leva em consideração o gradiente altimétrico do Pantanal, abrangendo diferentes fitofisionomias que permitem a manutenção da heterogeneidade de habitats característica do Pantanal. A Estação Ecológica do Taiamã e Parque Nacional do Pantanal Mato-grossense e suas áreas de ampliação propostas, alem da Reserva de

Fauna do Pantanal se encontram em uma região baixa do Pantanal, com rica rede hídrica. A área proposta para o Refúgio de Vida Silvestre da Onça-pintada já possui um gradiente que abrange áreas altas e áreas baixas. Esta diferença altimétrica resulta em diferentes tipos de vegetações existentes no MUCPN. De acordo com os dados do documento "Bacia do Alto Paraguai Cobertura Vegetal" (Disponível em: https://www.wwf.org.br/?48922/Bacia-do-Alto-Paraguai-Cobertura-Vegetal) são 11 classes de vegetação existentes na região do MUCPN mais a classe referente a corpos d'água, totalizando 12 classificações para região (Fig. 11).

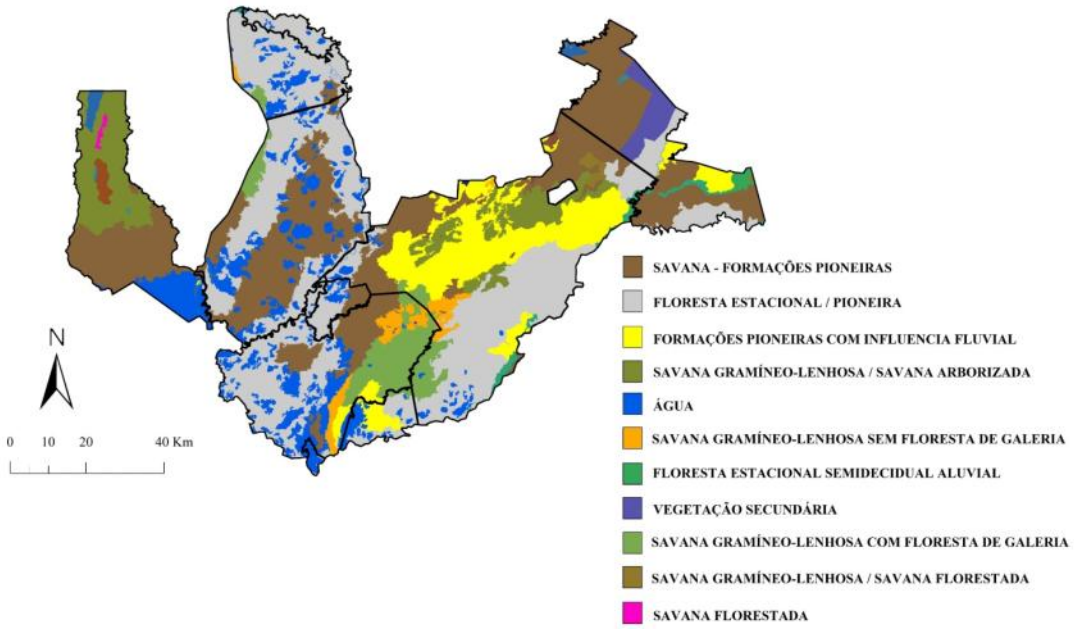

Figura 11. Mapa com as 11 classes (+ água) de vegetações inseridas no Mosaico de Unidades de Conservação do Pantanal Norte.

Das classes de vegetação existentes na área do MUCPN se destacam:

- Savana: É caracterizado por árvores de pequeno porte inseridas em uma matriz de campo. O adensamento das árvores e seu tamanho distinguem as diferentes classes de savana que ocorrem na região do MUCPN.
- Floresta Estacional: Formação florestada caracterizada por sua sazonalidade. Durante a seca maioria de suas espécies arbóreas perdem as folhas. Possui um sub-bosque e ocorre normalmente em áreas altas e mais secas do Pantanal. Representa uma área de refúgio para fauna durante o período de cheia do Pantanal.

- Formações Pioneiras com influência fluvial: Ambientes dinâmicos caracterizado pela transição entre ambientes abertos (savanas) e ambientes mais florestados. Área com predominância de Cambarazais (*Vochysia divergens*).

As áreas proposta para ampliação da EET e PNPM, além das propostas de Reserva de Fauna do Pantanal e Refúgio de Vida Silvestre onça-pintada englobam importantes formações de vegetação, colaborando para conservação da flora do Pantanal e toda sua fauna associada. A área do RVSOP abrange importantes manchas de vegetação florestada, de essencial importância para fauna terrestre do Pantanal.

ICTIOFAUNA

A complexa rede de rios, corixos e baías inseridas dentro do MUCPN constituem um verdadeiro berçário para fauna de peixes do Pantanal (Lima 1987, Polaz 2013). O Parque Nacional do Pantanal, por exemplo, possui 182 espécies de peixes (Polaz *et al.* 2014) (Apêndice 1), representando 70% de toda ictiofauna existente no Pantanal (Britski *et al.* 2007). Para a Estação Ecológica de Taiamã são listadas 143 espécies de peixes (ICMBio, 2017). Baginski *et al.* (2007) avaliou a dimensão espacial e temporal da diversidade de peixes em lagoas marginais ao rio Cuiabá. Estes autores concluem que a criação de unidades de conservação que abrangem um grande número de lagoas com diferentes formas e tamanhos conservaria um maior contingente da diversidade regional de peixes, pois a maioria das espécies de pequeno porte apresenta distribuição restrita a poucas lagoas (Baginski *et al.* 2007).

A região do MUCPN pode ser considerada um berçário para ictiofauna do Pantanal, exercendo um papel importante no recrutamento dos recursos pesqueiros (Polaz 2013) explorados pela pesca amadora e profissional de pescadores provenientes das cidades de Corumbá no estado de Mato Grosso do Sul além de Cáceres, Poconé e Barão de Melgaço no estado de Mato Grosso. De acordo com os dados disponibilizados pelo SCPesca, no ano de 2014 o rio Paraguai teve 141 toneladas de peixes capturados por pescadores amadores e profissionais (Catella *et al.* 2014). As espécies mais capturadas por pescadores foram: cachara *Pseudoplatystoma reticulatum,* pintado *Pseudoplatystoma corruscans* e pacu *Piaractus mesopotamicus* (Catella *et al.* 2014). Polaz (2013) recomenda a criação de um programa de monitoramento ambiental que

tenha a ictiofauna como indicadora dos processos ecológicos para o Pantanal. A proposta de ampliações da EET, PNPM e criação da Reserva de Fauna do Pantanal e o Refúgio de Vida Silvestre da Onça-pintada englobam dois dos principais rios da planície do Pantanal alem de centenas de lagoas e corixos, representando uma medida efetiva para conservação da ictiofauna do Pantanal.

HERPETOFAUNA

Apesar da abundante paisagem de ambientes aquáticos e terrestres, o Pantanal não possui uma riqueza significativa de anfíbios (44 espécies) e répteis (127 espécies) (Apendice 2), com pouco endêmismo (Strussman *et al.* 2007), porem com as espécies amplamente distribuídas (Junk *et al.* 2006, Strussman *et al.* 2007). A dinâmica de seca e cheia natural do Pantanal restringe a colonização de anfíbios e répteis dos biomas vizinhos, como Cerrado e Amazônia (Junk *et al.* 2006).

Em relação ao uso do habitat dos répteis no Pantanal, 52% das espécies possuem hábitos terrestres, 22% são arborícolas ou semi-arborícolas, 13% são aquáticos ou semiaquáticos e 13% são fossoriais, semi-fossoriais ou criptozoicos. Se considerarmos as espécies de anfíbios do Pantanal, 52% possuem hábitos terrestres, 26% arbóreos, 12% fossorial e 10% aquático ou semiaquático (Junk *et al.* 2006). Strussman *et al.* (2007) propõem como medida de conservação a criação de unidades e conservação que considerem a representatividade de habitats do Pantanal. As áreas propostas para ampliação no Parque Nacional do Pantanal e principalmente o Refúgio de Vida Silvestre da Onça-pintada incluem esta representatividade de habitats que garante a diversidade de répteis e anfíbios do Pantanal.

AVIFAUNA

O Pantanal é reconhecido por ser a área úmida com maior riqueza de aves do mundo. Em relação à avifauna, a Estação Ecológica de Taiamã possui 237 espécies registradas (ICMBio, 2017) e o Parque Nacional do Pantanal Matogrossense / áreas de entorno possui 251 espécies registradas (Ibama, 2003). Somente estas duas áreas protegidas protegem assim aproximadamente metade das espécies de aves já registradas para o Pantanal (Nunes 2011). Estas unidades de conservação possuem maioria de seu território em áreas baixas, susceptíveis a inundações, com isso, estas UCs garantem a conservação da avifauna migratórias associadas à ambientes aquáticos (Nunes &

Tomas, 2004). O Pantanal possui 133 espécies de aves migratórias (Nunes & Tomas 2004) e a região do MUCPN representa um importante refúgio para estas espécies. Espécies associadas à ambientes secos do Pantanal são menos freqüentes no PNPM e EET. A ampliação da EET e PNPM além da criação da Reserva de Fauna do Pantanal e o Refúgio de Vida Silvestre da Onça-pintada inserem novas fitofisionomias do Pantanal, aumentando a heterogeneidade de habitats, e por conseqüência agregando novas espécies ao MUCPN. Se considerarmos os planos de manejo do PNPM e EET, além de dados de literatura e listas de aves utilizadas por guias de ecoturismo, pode se estimar o número de 400 espécies de aves com provável ocorrência na área proposta para o MUCPN (Apêndice 3), representando assim aproximadamente 65% de toda avifauna do Pantanal. Considerando a avifauna da área proposta para o Refúgio de Vida Silvestre da onça-pintada, em geral as aves utilizam diferentes fitofisionomias disponíveis na paisagem, sendo que ambientes florestados apresentam maior riqueza e maior estabilidade de habitat, seguidos por ambientes mais abertos de Cerrado e apresentando menor riqueza e menor estabilidade os campos inundáveis e ambientes aquáticos (Figueira *et al.* 2006). Com isso, a inserção de ambientes florestados é uma ação necessária para manutenção da riqueza de aves do MUCPN.

Na área proposta para criação do MUCPN há possibilidade de se encontrar quatro espécies de aves ameaçadas de extinção: Jacu-de-barriga-castanha (*Penelope ochrogaster*), Harpia (*Harpia harpyja*), Caboclinho-de-barriga-vermelha (*Sporophila hypoxantha*) e Caboclinho-de-papo-escuro (*Sporophila ruficollis*) (http://www.mma.gov.br/biodiversidade/especies-ameacadas-de-extincao/faunaameacada). Não foram encontrados registros de Harpia especificamente para região do MUCPN, contudo há registros recentes para região da RPPN SESC Pantanal, inclusive com registro de ninho. Esta RPPN fica aproximadamente 60 km em linha reta da área proposta para o MUCPN, distancia esta possível de ser percorrida por um indivíduo em dispersão. Há também registros recentes para rodovia Transpantaneira, a 50 km da área proposta para o MUCPN. As duas espécies de caboclinho são associadas a áreas abertas do Pantanal, como as áreas de formação pioneira e savanas-gramíneo lenhosas existentes na área proposta para o MUCPN. De acordo com a Matriz de planejamento do Plano de Ação Nacional para conservação das aves do Cerrado e Pantanal (disponível em: http://www.icmbio.gov.br/portal/images/stories/docs-plano-

deacao/pan-aves-cerrado-pantanal/sumario_aves_cerrado_pantanal.pdf), dois objetivos são atingidos com a criação do MUCPN. São eles:

- Identificar e mapear áreas relevantes para implantação de corredores ecológicos nas áreas de ocorrência da espécie *Penelope ochrogaster*.
- Identificar regiões para propor a criação de Mosaico de áreas protegidas que beneficiem a conservação das espécies do Plano de Ação Nacional.

O jacu-de-barriga-castanha (*Penelope ochrogaster*) é a espécie ameaçada de extinção mais abundante na região do MUCPN. Em estudos realizados no final da década de 80, esta espécie foi considerada rara para esta região (Cintra & Yamashita, 1990). Estudos mais recentes demonstram que a região norte do Pantanal, incluindo a área proposta para o Refúgio de Vida Silvestre da onça-pintada, possui uma população vigorosa desta espécie (Olmos 1998, Antas, 2002, Kaestner 2003, Nunes *et al.* 2006). Estudos realizados durante o Plano de Manejo do Parque Nacional do Pantanal Matogrossense relataram a ausência de *P.ochrogaster* para região (Ibama 2003). Entre o Porto Jofre e a sede do PNPM foi avaliado a ocorrência de cracídeos nos quintais das casas de ribeirinhos. Constatou-se que a presença de *P.ochorgaster* fica menos freqüente a jusante do rio, sendo considerado raro nas proximidades do PNPM (Bonanomi *et al.* Dados não publicados). Entre os anos de 2009 e 2016 foram percorridas diferentes trilhas na região proposta para o Refúgio de Vida Silvestre, onde a taxa de encontro do Jacu-de-barriga-castanha era de um indivíduo a cada 8,7 km percorrido. Se considerarmos somente as trilhas em ambientes abertos, não houve nenhum registro desta espécie (Fernando Tortato, Dados não publicados). O Plano de Ação Nacional para a Conservação dos Galliformes Ameaçados de Extinção considera como medida importante para população de *P. ochrogaster* do Pantanal a proteção de áreas altas de floresta decidual, pois são estas áreas que vem sendo desmatadas para substituição por pastagens (Silveira *et al.* 2008). Considerando as informações discutidas, a ampliação do PNPM e criação do Refúgio de Vida Silvestre podem ser consideradas ações efetivas para manutenção e conservação de *P. ochrogaster* e demais espécies de aves ameaçadas na porção norte do Pantanal.

MASTOFAUNA

O Pantanal é considerado um importante refúgio para espécies ameaçadas de extinção a nível nacional como a onça-pintada (*Panthera onca*), cachorro-vinagre (*Speothos venaticus*) ariranha (*Pteronura brasiliensis*), cervo-do-pantanal (*Blastocerus dichotomus*), veado-campeiro (*Ozotoceros bezoarticus*) e o tatu-canastra (*Priodontes maximus*). Se comparado com outros biomas do Brasil, estas espécies possuem populações mais vigorosas no Pantanal. De acordo com Rodrigues *et al.* (2002) ocorrem 89 espécies de mamíferos na planície do Pantanal (Apêndice 4). O Parque Nacional do Pantanal Mato-grossense em seu plano de manejo (Ibama 2003) registrou 56 espécies ou 63% das espécies de mamíferos ocorrentes no Pantanal. Se considerarmos as espécies com ocorrência confirmada para o MUCPN, temos 13 espécies de mamíferos na lista nacional de espécies ameaçadas de extinção: tamanduá-bandeira (*Myrmecophaga tridactyla*), tatu-canastra (*Priodontes maximus*), lobo-guará (*Chrysocyon brachyurus*), cachorro-vinagre (*Speothos venaticus*), ariranha (*Pteronura brasiliensis*), gato-palheiro (*Leopardus colocolo*), gato-do-mato-pequeno (*Leopardus tigrinus*), gato-mourisco (*Puma yagouaroundi*), onça-parda (*Puma concolor*), onça-pintada (*Panthera onca*), anta (*Tapirus terrestris*), queixada (*Tayassu pecari*) e cervo-do-pantanal (*Blastocerus dichotomus*). Em relação ao uso de habitats por estas espécies ameaçadas, maioria delas (N=09 - *Myrmecophaga tridactyla, Priodontes maximus, Speothos venaticus, Puma concolor, Panthera onca, Leopardus tigrinus, Puma yagouaroundi, Tapirus terrestris* e *Tayassu pecari*) é associada a ambientes mais altos e florestados do MUCPN, como as áreas de floresta estacional e savana arborizada. O Lobo-guará e gato-palheiro são associados a áreas de savana e campos e há registros esporádicos na rodovia Transpantaneira. Lobo-guará tem registros de rastros e visualizações na região do Porto Jofre e fazendas próximas. As ariranhas ocorrem principalmente nos principais rios do MUCPN (Rio Paraguai e Rio São Lourenço/Cuiabá), porém são freqüentes as observações desta espécie em corixos e baías. O cervo-do-pantanal ocorre em ambientes abertos e sempre associados à água.

Figura 12. Macho adulto de cervo-do-pantanal (*Blastocerus dichotomus*) registrado por armadilha fotográfica na região proposta para criação do Mosaico de Unidades de Conservação do Pantanal Norte

Dentre as espécies ameaçadas de extinção da lista nacional que ocorre no MUCPN, se destaca a onça-pintada. Por ser uma espécie de topo de cadeia trófica, necessita grandes áreas para sua sobrevivência. Estratégias focadas na conservação da onça-pintada, como a criação de unidades de conservação e corredores ecológicos fazem com que esta espécie desempenhe um papel guarda-chuva, mantendo uma população viável de diversas outras espécies em escala regional (Thornton *et al.* 2016). Maioria das unidades de conservação existente no Brasil não mantém uma população viável de onças-pintadas para sua sobrevivência em longo prazo. É necessário o planejamento e criação de corredores ecológicos, conectando estas populações, para que se garanta a viabilidade populacional desta espécie (Rabinowitz & Zeller 2010, Silveira *et al.* 2014). O Pantanal possui um grande potencial para o estabelecimento destes corredores, garantindo a conservação da onça-pintada (Silveira *et al.* 2014). A onça-pintada é considerada vulnerável de extinção no Pantanal (Morato *et al.* 2013). A principal ameaça é a caça retaliatória provocada por eventuais ataques de onças no rebanho doméstico (Crawshaw 2002, Quigley & Crawshaw 1992). A presença da onça-pintada na propriedade é vista por maioria dos pecuaristas como uma ameaça ao rebanho (Zimmermann *et al.* 2005, Boulhosa & Azevedo 2014). A região do Parque Nacional do Pantanal Mato-grossense, Estação Ecológica de Taiamã e áreas inseridas na proposta de criação do Refúgio de Vida Silvestre da Onça-pintada contam com uma alta

densidade populacional de onças-pintadas (Kantek & Onuma 2013; Devlin *et al.* Dados não publicados). Estimativas para região do PNPM estimam oito indivíduos a cada 100km² (Devlin *et al.* Dados não publicados). Kantek & Onuma (2013) concluem que apesar da alta densidade populacional encontrada na EET, a área desta unidade de conservação é insuficiente para garantir a manutenção de populações viáveis de onças-pintadas. Amostras de DNA de indivíduos capturados para fins científicos na Estação Ecológica de Taiamã, Parque Nacional do Pantanal Matogrossense e propriedades privadas próximas ao Porto Jofre concluíram que as onças-pintadas destas três áreas distintas podem ser consideradas uma mesma população genética (Kantek *et al.* 2016).

Se avaliarmos o modelo de distribuição potencial da onça-pintada para o Pantanal, constatamos que a área do MUCPN possui alta probabilidade de ocorrência desta espécie (Tortato *et al*. Dados não publicados) (Fig 12). A criação do Mosaico de Unidades de Conservação no Pantanal Norte cria um cenário muito favorável à manutenção desta população de onça-pintada em longo prazo no Pantanal e atinge as metas estabelecidas em planos de conservação desta espécie já propostos em estudos anteriores (Quigley & Crawshaw 1992; Cavalcanti *et al*. 2012; Paula *et al*. 2013).

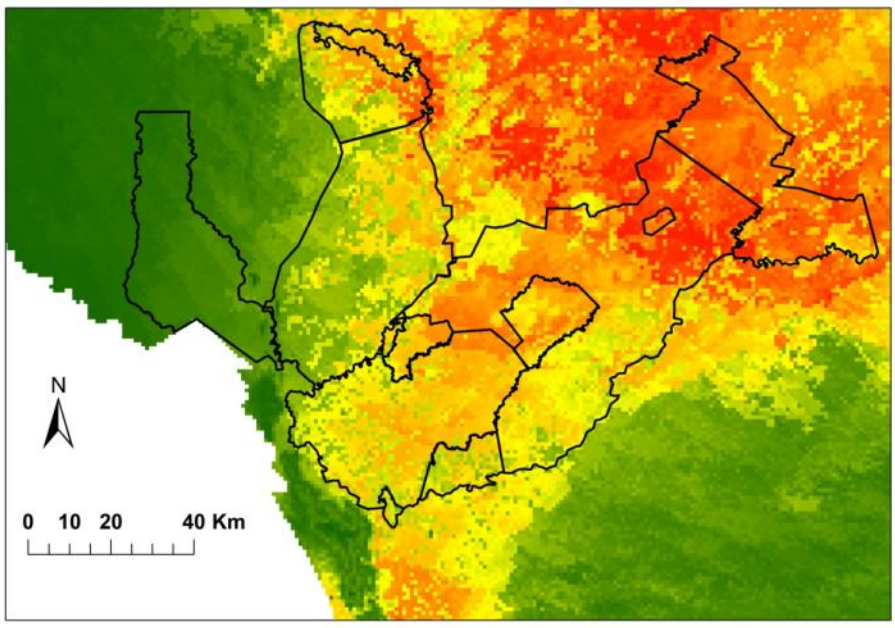

Figura 13. Modelo de distribuição potencial da onça-pintada na região do MUCPN. Em vermelho as áreas com maior probabilidade de ocorrência da onça-pintada. Em verde escuro as áreas com menor probabilidade de ocorrência da onça-pintada.

CONCLUSÃO

A região do Mosaico de Unidades de Conservação do Pantanal Norte faz parte de uma proposta antiga de conservação deste que é um dos pontos chave para a dinâmica hídrica regional. Sendo um ponto de confluência de águas que carreiam nutrientes de diversas regiões que circundam o a planície pantaneira. Este "HUB" hidrológico parece funcionar como um centro de elevada produtividade pesqueira, onde estes nutrientes são depositados na planície inundável pelo extravasamento destes rios (Jaurú e Paraguai e Paraguaizinho a noroeste, Cuiabá, São Lourenço e Piquirí a nordeste) no período de enchente. Esta produtividade que se inicia como material em suspensão se transforma em organismos que dão suporte as populações de peixes, de aves aquáticas e, por conseguinte ao restante da cadeia alimentar. Em relação à biodiversidade terrestre, o mosaico proposto permite a conectividade entre as unidades de conservação estaduais e federais existentes, além de Reservas Particulares do Patrimônio Natural existentes na região da Serra do Amolar, criando assim um grande corredor biológico abrangendo tanto áreas altas como áreas úmidas do Pantanal.

Este documento busca trazer informações técnicas que justificam a criação do Mosaico de Unidades de Conservação do Pantanal Norte. Através de categorias de manejo que mais se adequam as atividades em andamento no território. Assim as ampliações de unidades de conservação existentes bem como da criação de novas unidades de conservação propostas no MUCPN levam em consideração o uso do território, tornando assim compatível a conservação da biodiversidade e manutenção das atividades econômicas sustentáveis desenvolvidas na região. Os dados aqui compilados comprovam tanto o baixo impacto desfavorável as atividades socioeconômicas que estas unidades de conservação podem trazer aos municípios de Cáceres e Poconé e corroboram com o mapa do Zoneamento Socioeconômico e Ambiental do estado de Mato Grosso (http://www.seplan.mt.gov.br/-/3704951-zsee?ciclo=cv_gestao_inf). As áreas propostas abrangem menos de 1% das propriedades rurais destes dois municípios. A maior área proposta, o Refúgio de Vida Silvestre da Onça-pintada permite propriedades privadas e uso econômico pela pecuária sustentável. A criação do MUCPN amplia o potencial do turismo de natureza desenvolvido na região e dá garantias para sua viabilidade em longo prazo, pois garante a integridade dos habitats e manutenção de populações de espécies carismáticas como a arara-azul e onça-pintada. O ICMS ecológico também representa um ganho econômico oriundo da criação destas novas

unidades de conservação e pode auxiliar os municípios na gestão de outros problemas ambientais, como a falta de saneamento básico.

Através do mapa de vegetação fica evidente a representatividade de habitats incorporados na proposta do MUCPN. Esta diversidade na vegetação reflete diretamente na diversidade de espécies terrestres, com 65% das espécies de aves e 63% das espécies de mamíferos do Pantanal ocorrendo na área do MUCPN. Em relação às espécies aquáticas, os poucos estudos acerca da ictiofauna já demonstram que a área do MUCPN possui 70% das espécies de peixes existentes no Pantanal. A criação do MUCPN viabiliza a manutenção e proteção de uma das maiores populações de onças-pintadas, em toda sua distribuição desde o México até a Argentina. Alem da onça-pintada, outras 12 espécies de mamíferos e quatro espécies de aves ameaçadas de extinção a nível nacional vão ser beneficiadas diretamente com a criação do MUCPN. Os dados bióticos aqui apresentados confirmam que a proposta de criação destas novas unidades de conservação e ampliação das existentes representa uma ação efetiva para conservação da biodiversidade do Pantanal.

Há várias razões para se proteger o Pantanal. É considerado um dos principais destinos turísticos do Brasil. É também um bioma considerado fundamental como refúgio para diversas espécies ameaçadas da fauna brasileira. Sua complexidade hídrica bem preservada é essencial para manutenção de estoques pesqueiros. A criação de unidades de conservação, como discutido neste documento, constitui uma das ferramentas mais importantes para garantir que gerações futuras possam usufruir deste patrimônio brasileiro.

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APENDICES

Apendice 1. Lista das espécies de peixes coletadas no Parque Nacional do Pantanal Matogrossense publicada por Polaz *et al.* (2014).

CLASSE/ORDEM/FAMILIA/ESPÉCIE

CLASSE CHONDRICHTHYES (1)

MYLIOBATIFORMES (1)

Potamotrygonidae (1)

***Potamotrygon motoro* (Müller & Henle, 1841)**

CLASSE ACTINOPTERYGII (191 species)

CLUPEIFORMES (2)

Engraulidae (1)

***Anchoviella* sp.**

Pristigasteridae (1)

***Pellona flavipinnis* (Valenciennes, 1837)**

CHARACIFORMES (82)

Parodontidae (1)

***Apareiodon affinis* (Steindachner, 1879)**

Curimatidae (8)

***Curimatella dorsalis* (Eigenmann & Eigenmann, 1889)**

***Curimatopsis myersi* Vari, 1982**

***Cyphocharax gillii* (Eigenmann & Kennedy, 1903)**

***Potamorhina squamoralevis* (Braga & Azpelicueta, 1983)**

***Psectrogaster curviventris* Eigenmann & Kennedy, 1889**

***Steindachnerina brevipinna* (Eigenmann & Eigenmann, 1889)**

***Steindachnerina conspersa* (Holmberg, 1891)**

***Steindachnerina "nigrotaenia"* Boulenger, 1902**

Prochilodontidae (1)

***Prochilodus lineatus* (Valenciennes, 1837)**

Anostomidae (8)

***Abramites hypselonotus* (Günther, 1868)**

***Leporinus* cf. *friderici* Bloch, 1794**

***Leporinus lacustris* Amaral Campos, 1945**

***Leporinus macrocephalus* Garavello & Britski, 1988**

***Leporinus obtusidens* (Valenciennes, 1836)**

***Leporinus striatus* Kner, 1858**

***Schizodon borellii* (Boulenger, 1900)**

***Schizodon isognathus* Kner, 1858**

Crenuchidae (2)

***Characidium laterale* (Bouleger, 1895)**

***Characidium* aff. *zebra* Eigenmann, 1909**

***Characidium* sp.**

Hemiodontidae (1)

***Hemiodus orthonops* Eigenmann & Kennedy, 1903**

Bryconidae (2)

***Brycon hilarii* (Valenciennes, 1850)**

***Salminus brasiliensis* (Cuvier, 1816)**

Triportheidae (3)

***Clupeacharax anchoveoides* Pearson, 1924**

***Triportheus nematurus* (Kner, 1858)**

***Triportheus pantanensis* Malabarba, 2004**

Gasteropelecidae (2)

***Gasteropelecus sternicla* (Linnaeus, 1758)**

***Thoracocharax stellatus* (Kner, 1858)**

Characidae (38)

***Aphyocharax anisitsi* Eigenmann & Kennedy, 1903**

***Aphyocharax dentatus* Eigenmann & Kennedy, 1903**

***Aphyocharax nattereri* Steindachner, 1882**

***Aphyocharax rathbuni* Eigenmann, 1907**

***Astyanax abramis* (Jenyns, 1842)**

***Astyanax asuncionensis* Géry, 1972**

***Astyanax* sp.**

***Bryconamericus exodon* Eigenmann, 1907**

***Bryconamericus stramineus* Eigenmann, 1908**

***Bryconamericus* sp.**

***Charax leticiae* Lucena, 1987**

***Ctenobrycon alleni* (Eigenmann & Kennedy, 1907)**

***Cynopotamus kincaidi* (Schultz, 1950)**

***Gymnocorymbus ternetzi* (Boulenger, 1895)**

Galeocharax humeralis **(Valenciennes, 1834)**

Hemigrammus lunatus **Durbin, 1918**

Hemigrammus marginatus **Ellis, 1911**

Hemigrammus **sp.**

Hemigrammus ulreyi **(Boulenger, 1895)**

Hyphessobrycon eques **(Steindachner, 1882)**

Hyphessobrycon megalopterus **(Eigenmann, 1915)**

Hyphessobrycon **sp.**

Jupiaba acanthogaster **(Eigenmann, 1911)**

Knodus chapadae **(Fowler, 1906)**

Moenkhausia bonita **Benine, Castro & Sabino, 2004**

Moenkhausia dichroura **Kner, 1858**

Moenkhausia forestii **Benine, Mariguela & Oliveira, 2009**

Moenkhausia **cf.** ***oligolepis*** **(Günther, 1864)**

Odontostilbe paraguayensis **Eigenmann & Kennedy, 1903**

Odontostilbe pequira **(Steindachner, 1882)**

Odontostilbe **sp.**

Phenacogaster tegatus **(Eigenmann, 1911)**

Piabarchus analis **(Eigenmann, 1914)**

Poptella paraguayensis **(Eigenmann, 1907)**

Prionobrama paraguayensis **(Eigenmann, 1914)**

Psellogrammus kennedyi **(Eigenmann, 1903)**

***Roeboides affinis* (Günther, 1868)**

***Roeboides descalvadensis* Fowler, 1932**

***Roeboides microlepis* (Reinhardt, 1851)**

***Serrapinnus calliurus* (Boulenger, 1900)**

***Serrapinnus kriegi* (Schindler, 1937)**

***Serrapinnus microdon* (Eigenmann, 1915)**

***Serrapinnus* sp.**

***Tetragonopterus argenteus* Cuvier, 1816**

Serrassalmidae (8)

***Metynnis maculatus* (Kner, 1858)**

***Metynnis mola* Eigenmann & Kennedy, 1903**

***Myleus levis* Eigenmann & McAtee, 1907**

***Mylossoma duriventre* (Cuvier, 1818)**

***Piaractus mesopotamicus* Holmberg, 1887**

***Pygocentrus nattereri* Kner, 1858**

***Serrasalmus maculatus* Kner, 1858**

***Serrasalmus marginatus* Valenciennes, 1837**

Acestrorhynchidae (1)

***Acestrorhynchus pantaneiro* Menezes, 1992**

Cynodontidae (1)

***Rhaphiodon vulpinus* Spix & Agassiz, 1829**

Erythrinidae (3)

***Erythrinus erythrinus* (Bloch & Schneider, 1801)**

***Hoplerythrinus unitaeniatus* (Spix & Agassiz, 1829)**

***Hoplias* aff. *malabaricus* (Bloch, 1794)**

Lebiasinidae (1)

***Pyrrhulina australis* Eigenmann & Kennedy, 1903**

Iguanodectidae (2)

***Bryconops melanurus* (Bloch 1794)**

***Piabucus melanostoma* Holmberg, 1891**

Aspredinidae (3)

***Amaralia hypsiura* (Kner, 1855)**

***Bunocephalus doriae* Boulenger, 1902**

***Pseudobunocephalus rugosus* (Eigenmann & Kennedy, 1903)**

Trichomycteridae (4)

***Ituglanis eichorniarum* (Miranda Ribeiro, 1912)**

***Ituglanis herberti* (Miranda Ribeiro, 1940)**

***Ochmacanthus batrachostomus* (Miranda Ribeiro, 1912)**

***Trichomycterus johnsoni* (Fowler, 1932)**

Callichthyidae (4)

***Callichthys callichthys* (Linnaeus, 1758)**

***Corydoras hastatus* Eigenmann & Eigenmann, 1888**

***Hoplosternum littorale* (Hancock, 1828)**

***Lepthoplosternum pectorale* (Boulenger, 1895)**

Scoloplacidae (2)

***Scoloplax distolothrix* Schaefer, Weitzman & Britski, 1989**

***Scoloplax empousa* Schaefer, Weitzman & Britski, 1989**

Loricariidae (17)

***Ancistrus* sp.**

***Farlowella paraguayensis* Retzer & Page, 1997**

***Hemiodontichthys acipenserinus* (Kner, 1853)**

***Hypoptopoma inexspectatum* (Holmberg, 1893)**

***Hypostomus* aff. *ancistroides* (Ihering, 1911)**

***Hypostomus boulengeri* (Eigenmann & Kennedy, 1903)**

***Hypostomus cochliodon* Kner, 1854**

***Hypostomus latifrons* Weber, 1986**

***Hypostomus* sp.**

***Loricaria* sp.**

***Loricariichthys labialis* (Boulenger, 1895)**

***Loricariichthys platymetopon* Isbrücker & Nijssen, 1979**

***Megalancistrus parananus* (Peters, 1881)**

***Otocinclus vittatus* Regan, 1904**

***Proloricaria prolixa* (Isbrücker & Nijssen 1978)**

***Pterygoplichthys ambrosettii* (Holmberg, 1893)**

***Rineloricaria parva* (Boulenger, 1895)**

***Sturisoma barbatum* (Kner, 1853)**

Pseudopimelodidae (1)

Microglanis cottoides **(Boulenger 1891)**

Heptapteridae (6)

Imparfinis **sp.**

Phenacorhamdia hoehnei **(Miranda Ribeiro, 1914)**

Pimelodella **cf.** ***gracilis*** **(Valenciennes, 1835)**

Pimelodella mucosa **Eigenmann & Ward, 1907**

Pimelodella notomelas **Eigenmann, 1917**

Pimelodella **sp.**

Rhamdia **aff.** ***quelen*** **(Quoy & Gaimard, 1824)**

Pimelodidae (11)

Pseudoplatystoma corruscans **(Spix & Agassiz, 1829)**

Pseudoplatystoma reticulatum **Eigenmann & Eigenmann, 1889**

Hemisorubim platyrhynchos **(Valenciennes, 1840)**

Hypophthalmus edentatus **Spix & Agassiz, 1829**

Megalonema platanum **(Günther, 1880)**

Pimelodus argenteus **Perugia, 1891**

Pimelodus ornatus **Kner, 1858**

Pimelodus pantaneiro **Souza-Filho & Shibatta, 2007**

Pimelodus **sp.**

Pinirampus pirinampu **(Spix & Agassiz, 1829)**

Sorubim lima **(Bloch & Schneider, 1801)**

Zungaro jahu **(Ihering, 1898)**

Doradidae (6)

***Anadoras weddellii* (Castelnau, 1855)**

***Ossancora eigenmanni* (Boulenger, 1895)**

***Oxydoras kneri* Bleeker, 1862**

***Platydoras armatulus* (Valenciennes, 1840)**

***Pterodoras granulosus* (Valenciennes, 1821)**

***Rhinodoras dorbignyi* (Kner, 1855)**

Auchenipteridae (9)

***Ageneiosus inermis* (Linnaeus, 1766)**

***Ageneiosus ucayalensis* Castelnau, 1855**

***Auchenipterus nigripinnis* (Boulenger, 1895)**

***Auchenipterus osteomystax* (Miranda Ribeiro, 1918)**

***Entomocorus radiosus* Reis & Borges, 2006**

***Tatia neivai* (Ihering, 1930)**

***Trachelyopterus coriaceus* Valenciennes, 1840**

***Trachelyopterus galeatus* (Linnaeus, 1766)**

***Trachelyopterus striatulus* (Steindachner, 1877)**

GYMNOTIFORMES (10)

Gymnotidae (3)

***Gymnotus* cf. *carapo* Linnaeus 1758**

***Gymnotus inaequilabiatus* (Valenciennes, 1839)**

***Gymnotus paraguensis* Albert & Crampton, 2003**

Sternopygidae (3)

***Eigenmannia trilineata* López & Castello, 1966**

***Eigenmannia virescens* (Valenciennes ,1842)**

***Eigenmannia* sp.**

***Sternopygus macrurus* (Bloch & Schneider, 1801)**

Ramphichthyidae (2)

***Gymnorhamphichthys britskii* Carvalho, Ramos & Albert, 2011**

***Rhamphichthys hahni* (Meiken, 1937)**

Hypopomidae (2)

***Brachyhypopomus* sp.**

***Brachyhypopomus* sp. B**

Apteronotidae (2)

***Apteronotus albifrons* (Linnaeus, 1766)**

***Apteronotus caudimaculosus* de Santana, 2003**

CYPRINODONTIFORMES (3)

Rivulidae (2)

***Melanorivulus punctatus* (Boulenger, 1895)**

***Neofundulus paraguayensis* (Eigenmann & Kennedy, 1903)**

Poeciliidae (1)

***Pamphorichthys hasemani* (Henn, 1916)**

BELONIFORMES (1)

Belonidae (1)

***Potamorhaphis eigenmanni* Miranda Ribeiro, 1915**

SYNBRANCHIFORMES (1)

Synbranchidae (1)

***Synbranchus marmoratus* Bloch, 1795**

PERCIFORMES (16)

Sciaenidae (1)

***Plagioscion ternetzi* Boulenger, 1895**

Cichlidae (15)

***Aequidens plagiozonatus* Kullander, 1984**

***Apistogramma borellii* (Regan, 1906)**

***Apistogramma commbrae* (Regan, 1906)**

***Apistogramma trifasciata* (Eigenmann & Kennedy, 1903)**

***Astronotus crassipinis* (Heckel, 1840)**

***Astronotus ocellatus* (Agassiz, 1831)**

***Bujurquina vittata* (Heckel, 1840)**

***Cichlasoma dimerus* (Heckel, 1840)**

***Crenicichla lepidota* Heckel, 1840**

***Crenicichla vittata* Heckel, 1840**

***Crenicichla semifasciata* (Heckel, 1840)**

***Gymnogeophagus balzanii* (Perugia, 1891)**

***Laetacara dorsigera* (Heckel, 1840)**

***Mesonauta festivus* (Heckel, 1840)**

***Satanoperca pappaterra* (Heckel, 1840)**

CLASSE SARCOPTERYGII (1)

LEPIDOSIRENIFORMES (1)

Lepidosirenidae (1)

***Lepidosiren paradoxa* Fitzinger, 1837**

Apendice 2: Número de táxons superiores, de famílias, de gêneros e de espécies de anfíbios e de répteis registrados para o Pantanal. Adaptado de Strussmann et al 2007.

Táxons superiores	Famílias	Gêneros	Espécies
AMPHIBIA			
Anura	Bufonidae	1	3
	Hylidae	6	18
	Leptodactylidae	6	17
	Microhylidae	3	5
Gymnophiona	Caecilidae	1	1
REPTILIA			
Amphisbaenia	Amphisbaenidae	4	8
Chelonia	Chelidae	2	2
	Testudinidae	1	2
Crocodylia	Alligatoridae	2	2
Sauria	Anguidae	1	1
	Gekkonidae	5	5
	Gymnophthalmidae	5	5
	Iguanidae	1	1
	Polychrotidae	2	3
	Scincidae	1	3
	Teiidae	6	7
	Tropiduridae	2	5

Serpentes	Boidae	3	4
	Typhlopidae	1	1
	Colubridae	36	72
	Elapidae	1	3
	Viperidae	2	3
Total		92	171

Apendice 3. Lista com 394 espécies de aves com ocorrência para o município de Poconé e área do Mosaico de Unidades de Conservação do Pantanal Norte.

NOME DO TÁXON	NOME COMUM	ICMBIO 2016
Rheiformes		
Rheidae		
Rhea americana	Ema	
Tinamiformes		
Tinamidae		
Crypturellus undulatus	Jaó	
Crypturellus parvirostris	Inambu-chororó	
Rhynchotus rufescens	Perdiz	

Anseriformes

Anhimidae

Chauna torquata	Tachã	

Anatidae

Dendrocygna viduata	Irerê	
Dendrocygna autumnalis	Marreca-cabocla	
Cairina moschata	Pato-do-mato	
Callonetta leucophrys	Marreca-de-coleira	
Amazonetta brasiliensis	Ananaí	
Nomonyx dominicus	Marreca-caucau	

Galliformes

Cracidae

Penelope superciliaris	Jacupemba	
Penelope ochrogaster	Jacu-de-barriga-castanha	VU
Aburria cumanensis	Jacutinga-de-garganta-azul	
Aburria cujubi	Cujubi	
Ortalis canicollis	Aracuã-do-pantanal	
Crax fasciolata	Mutum-de-penacho	

Podicipediformes

Podicipedidae

Tachybaptus dominicus	Mergulhão-pequeno	

Ciconiiformes

Ciconiidae

Ciconia maguari	Maguari	
Jabiru mycteria	Tuiuiú	
Mycteria americana	Cabeça-seca	

Suliformes

Phalacrocoracidae

Nannopterum brasilianus	Biguá

Anhingidae

Anhinga anhinga	Biguatinga

Pelecaniformes

Ardeidae

Tigrisoma lineatum	Socó-boi
Agamia agami	Garça-da-mata
Cochlearius cochlearius	Arapapá
Zebrilus undulatus	Socoí-zigue-zague
Botaurus pinnatus	Socó-boi-baio
Ixobrychus exilis	Socoí-vermelho
Ixobrychus involucris	Socoí-amarelo
Nycticorax nycticorax	Socó-dorminhoco
Butorides striata	Socozinho
Bubulcus ibis	Garça-vaqueira
Ardea cocoi	Garça-moura
Ardea alba	Garça-branca
Syrigma sibilatrix	Maria-faceira
Pilherodius pileatus	Garça-real
Egretta thula	Garça-branca-pequena
Egretta caerulea	Garça-azul

Threskiornithidae

Plegadis chihi	Caraúna
Mesembrinibis cayennensis	Coró-coró
Phimosus infuscatus	Tapicuru
Theristicus caerulescens	Curicaca-real

Theristicus caudatus	Curicaca
Platalea ajaja	Colhereiro

Cathartiformes

Cathartidae

Cathartes aura	Urubu-de-cabeça-vermelha
Cathartes burrovianus	Urubu-de-cabeça-amarela
Coragyps atratus	Urubu
Sarcoramphus papa	Urubu-rei

Accipitriformes

Pandionidae

Pandion haliaetus	Águia-pescadora

Accipitridae

Leptodon cayanensis	Gavião-gato
Chondrohierax uncinatus	Caracoleiro
Elanoides forficatus	Gavião-tesoura
Gampsonyx swainsonii	Gaviãozinho
Circus buffoni	Gavião-do-banhado
Accipiter superciliosus	Tauató-passarinho
Accipiter striatus	Tauató-miúdo
Accipiter bicolor	Gavião-bombachinha-grande
Ictinia mississippiensis	Sovi-do-norte
Ictinia plumbea	Sovi
Busarellus nigricollis	Gavião-belo
Rostrhamus sociabilis	Gavião-caramujeiro
Geranospiza caerulescens	Gavião-pernilongo
Heterospizias meridionalis	Gavião-caboclo
Urubitinga urubitinga	Gavião-preto

Rupornis magnirostris	Gavião-carijó	
Parabuteo unicinctus	Gavião-asa-de-telha	
Geranoaetus albicaudatus	Gavião-de-rabo-branco	
Pseudastur albicollis	Gavião-branco	
Buteo nitidus	Gavião-pedrês	
Buteo albonotatus	Gavião-urubu	
Harpia harpyja	Gavião-real	VU
Spizaetus tyrannus	Gavião-pega-macaco	
Spizaetus melanoleucus	Gavião-pato	
Eurypygiformes		
Eurypygidae		
Eurypyga helias	Pavãozinho-do-pará	
Gruiformes		
Aramidae		
Aramus guarauna	Carão	
Rallidae		
Aramides cajaneus	Saracura-três-potes	
Laterallus viridis	Sanã-castanha	
Laterallus melanophaius	Sanã-parda	
Porzana flaviventer	Sanã-amarela	
Mustelirallus albicollis	Sanã-carijó	
Pardirallus maculatus	Saracura-carijó	
Gallinula galeata	Galinha-d'água	
Porphyrio martinicus	Frango-d'água-azul	
Porphyrio flavirostris	Frango-d'água-pequeno	
Heliornithidae		
Heliornis fulica	Picaparra	

Charadriiformes

Charadriidae

Vanellus cayanus	Mexeriqueira
Vanellus chilensis	Quero-quero
Pluvialis dominica	Batuiruçu
Charadrius collaris	Batuíra-de-coleira

Recurvirostridae

Himantopus mexicanus	Pernilongo-de-costas-negras
Himantopus melanurus	Pernilongo-de-costas-brancas

Scolopacidae

Gallinago paraguaiae	Narceja
Limosa haemastica	Maçarico-de-bico-virado
Bartramia longicauda	Maçarico-do-campo
Actitis macularius	Maçarico-pintado
Tringa solitaria	Maçarico-solitário
Tringa melanoleuca	Maçarico-grande-de-perna-amarela
Tringa flavipes	Maçarico-de-perna-amarela
Calidris fuscicollis	Maçarico-de-sobre-branco
Calidris melanotos	Maçarico-de-colete
Calidris himantopus	Maçarico-pernilongo

Jacanidae

Jacana jacana	Jaçanã

Sternidae

Sternula superciliaris	Trinta-réis-pequeno
Phaetusa simplex	Trinta-réis-grande

Rynchopidae

Rynchops niger	Talha-mar

Columbiformes

Columbidae

Columbina minuta	Rolinha-de-asa-canela
Columbina talpacoti	Rolinha
Columbina squammata	Fogo-apagou
Columbina picui	Rolinha-picuí
Claravis pretiosa	Pararu-azul
Uropelia campestris	Rolinha-vaqueira
Columba livia	Pombo-doméstico
Patagioenas picazuro	Asa-branca
Patagioenas cayennensis	Pomba-galega
Patagioenas plumbea	Pomba-amargosa
Zenaida auriculata	Avoante
Leptotila verreauxi	Juriti-pupu
Leptotila rufaxilla	Juriti-de-testa-branca

Cuculiformes

Cuculidae

Coccycua minuta	Chincoã-pequeno
Micrococcyx cinereus	Papa-lagarta-cinzento
Piaya cayana	Alma-de-gato
Coccyzus melacoryphus	Papa-lagarta
Coccyzus euleri	Papa-lagarta-de-euler
Crotophaga major	Anu-coroca
Crotophaga ani	Anu-preto
Guira guira	Anu-branco
Tapera naevia	Saci

Dromococcyx pavoninus	Peixe-frito-pavonino

Strigiformes

Tytonidae

Tyto furcata	Suindara

Strigidae

Megascops choliba	Corujinha-do-mato
Bubo virginianus	Jacurutu
Strix virgata	Coruja-do-mato
Strix huhula	Coruja-preta
Glaucidium brasilianum	Caburé
Athene cunicularia	Coruja-buraqueira

Nyctibiiformes

Nyctibiidae

Nyctibius grandis	Urutau-grande
Nyctibius griseus	Urutau

Caprimulgiformes

Caprimulgidae

Antrostomus rufus	João-corta-pau
Nyctiprogne leucopyga	Bacurau-de-cauda-barrada
Nyctidromus albicollis	Bacurau
Hydropsalis parvula	Bacurau-chintã
Hydropsalis longirostris	Bacurau-da-telha
Hydropsalis maculicaudus	Bacurau-de-rabo-maculado
Hydropsalis torquata	Bacurau-tesoura
Podager nacunda	Corucão

Apodiformes

Trochilidae

Glaucis hirsutus	Balança-rabo-de-bico-torto
Phaethornis nattereri	Besourão-de-sobre-amarelo
Phaethornis subochraceus	Rabo-branco-de-barriga-fulva
Phaethornis pretrei	Rabo-branco-acanelado
Anthracothorax nigricollis	Beija-flor-de-veste-preta
Chrysolampis mosquitus	Beija-flor-vermelho
Lophornis magnificus	Topetinho-vermelho
Chlorostilbon lucidus	Besourinho-de-bico-vermelho
Thalurania furcata	Beija-flor-tesoura-verde
Hylocharis chrysura	Beija-flor-dourado
Polytmus guainumbi	Beija-flor-de-bico-curvo
Amazilia versicolor	Beija-flor-de-banda-branca
Amazilia fimbriata	Beija-flor-de-garganta-verde
Heliomaster longirostris	Bico-reto-cinzento
Heliomaster furcifer	Bico-reto-azul
Calliphlox amethystina	Estrelinha-ametista

Trogoniformes

Trogonidae

Trogon melanurus	Surucuá-de-cauda-preta
Trogon curucui	Surucuá-de-barriga-vermelha

Coraciiformes

Alcedinidae

Megaceryle torquata	Martim-pescador-grande
Chloroceryle amazona	Martim-pescador-verde
Chloroceryle aenea	Martim-pescador-miúdo
Chloroceryle americana	Martim-pescador-pequeno
Chloroceryle inda	Martim-pescador-da-mata

Momotidae

Momotus momota	Udu

Galbuliformes

Galbulidae

Galbula ruficauda	Ariramba

Bucconidae

Nystalus chacuru	João-bobo
Monasa nigrifrons	Chora-chuva-preto

Piciformes

Ramphastidae

Ramphastos toco	Tucanuçu
Pteroglossus castanotis	Araçari-castanho

Picidae

Picumnus albosquamatus	Picapauzinho-escamoso
Melanerpes candidus	Pica-pau-branco
Melanerpes cruentatus	Benedito-de-testa-vermelha
Melanerpes cactorum	Pica-pau-de-testa-branca
Veniliornis passerinus	Pica-pau-pequeno
Piculus chrysochloros	Pica-pau-dourado-escuro
Colaptes melanochloros	Pica-pau-verde-barrado
Colaptes campestris	Pica-pau-do-campo
Celeus lugubris	Pica-pau-louro
Celeus flavus	Pica-pau-amarelo
Dryocopus lineatus	Pica-pau-de-banda-branca
Campephilus melanoleucos	Pica-pau-de-topete-vermelho

Cariamiformes

Cariamidae

Cariama cristata	Seriema

Falconiformes

Falconidae

Caracara plancus	Carcará
Milvago chimachima	Carrapateiro
Herpetotheres cachinnans	Acauã
Micrastur semitorquatus	Falcão-relógio
Falco sparverius	Quiriquiri
Falco rufigularis	Cauré
Falco femoralis	Falcão-de-coleira

Psittaciformes

Psittacidae

Anodorhynchus hyacinthinus	Arara-azul
Ara ararauna	Arara-canindé
Ara chloropterus	Arara-vermelha
Orthopsittaca manilatus	Maracanã-do-buriti
Primolius auricollis	Maracanã-de-colar
Diopsittaca nobilis	Maracanã-pequena
Thectocercus acuticaudatus	Aratinga-de-testa-azul
Psittacara leucophthalmus	Periquitão
Aratinga nenday	Periquito-de-cabeça-preta
Aratinga weddellii	Periquito-de-cabeça-suja
Eupsittula aurea	Periquito-rei
Pyrrhura molinae	Tiriba-de-cauda-vermelha
Myiopsitta monachus	Caturrita
Forpus xanthopterygius	Tuim

Brotogeris tirica	Periquito-verde
Brotogeris chiriri	Periquito-de-encontro-amarelo
Pionus menstruus	Maitaca-de-cabeça-azul
Pionus maximiliani	Maitaca
Amazona amazonica	Curica
Amazona aestiva	Papagaio

Passeriformes

Thamnophilidae

Formicivora melanogaster	Formigueiro-de-barriga-preta
Formicivora rufa	Papa-formiga-vermelho
Dysithamnus mentalis	Choquinha-lisa
Herpsilochmus longirostris	Chorozinho-de-bico-comprido
Thamnophilus doliatus	Choca-barrada
Thamnophilus pelzelni	Choca-do-planalto
Taraba major	Choró-boi
Hypocnemoides maculicauda	Solta-asa
Cercomacra melanaria	Chororó-do-pantanal

Dendrocolaptidae

Sittasomus griseicapillus	Arapaçu-verde
Xiphorhynchus guttatus	Arapaçu-de-garganta-amarela
Campylorhamphus trochilirostris	Arapaçu-beija-flor
Dendroplex picus	Arapaçu-de-bico-branco
Lepidocolaptes angustirostris	Arapaçu-de-cerrado
Dendrocolaptes platyrostris	Arapaçu-grande
Xiphocolaptes major	Arapaçu-do-campo

Xenopidae

Xenops rutilans	Bico-virado-carijó

Furnariidae

Furnarius leucopus	Casaca-de-couro-amarelo
Furnarius rufus	João-de-barro
Pseudoseisura cristata	Casaca-de-couro
Pseudoseisura unirufa	Casaca-de-couro-de-crista-cinza
Phacellodomus rufifrons	João-de-pau
Phacellodomus ruber	Graveteiro
Schoeniophylax phryganophilus	Bichoita
Certhiaxis cinnamomeus	Curutié
Synallaxis frontalis	Petrim
Synallaxis hypospodia	João-grilo
Synallaxis albilora	João-do-pantanal
Cranioleuca vulpina	Arredio-do-rio

Pipridae

Pipra fasciicauda	Uirapuru-laranja
Antilophia galeata	Soldadinho

Tityridae

Tityra inquisitor	Anambé-branco-de-bochecha-parda
Tityra cayana	Anambé-branco-de-rabo-preto
Tityra semifasciata	Anambé-branco-de-máscara-negra
Pachyramphus viridis	Caneleiro-verde
Pachyramphus polychopterus	Caneleiro-preto

Pachyramphus validus	Caneleiro-de-chapéu-preto
Xenopsaris albinucha	Tijerila
Rhynchocyclidae	
Tolmomyias sulphurescens	Bico-chato-de-orelha-preta
Todirostrum poliocephalum	Teque-teque
Todirostrum cinereum	Ferreirinho-relógio
Poecilotriccus latirostris	Ferreirinho-de-cara-parda
Hemitriccus striaticollis	Sebinho-rajado-amarelo
Hemitriccus margaritaceiventer	Sebinho-de-olho-de-ouro
Tyrannidae	
Hirundinea ferruginea	Gibão-de-couro
Inezia inornata	Alegrinho-do-chaco
Euscarthmus meloryphus	Barulhento
Camptostoma obsoletum	Risadinha
Elaenia flavogaster	Guaracava-de-barriga-amarela
Elaenia spectabilis	Guaracava-grande
Suiriri suiriri	Suiriri-cinzento
Myiopagis gaimardii	Maria-pechim
Myiopagis viridicata	Guaracava-de-crista-alaranjada
Capsiempis flaveola	Marianinha-amarela
Phaeomyias murina	Bagageiro
Polystictus pectoralis	Papa-moscas-canela
Pseudocolopteryx acutipennis	Tricolino-oliváceo
Serpophaga subcristata	Alegrinho
Attila bolivianus	Bate-pára

Legatus leucophaius	Bem-te-vi-pirata
Myiarchus tuberculifer	Maria-cavaleira-pequena
Myiarchus swainsoni	Irré
Myiarchus ferox	Maria-cavaleira
Myiarchus tyrannulus	Maria-cavaleira-de-rabo-enferrujado
Casiornis rufus	Maria-ferrugem
Pitangus sulphuratus	Bem-te-vi
Philohydor lictor	Bentevizinho-do-brejo
Machetornis rixosa	Suiriri-cavaleiro
Myiodynastes maculatus	Bem-te-vi-rajado
Tyrannopsis sulphurea	Suiriri-de-garganta-rajada
Megarynchus pitangua	Neinei
Myiozetetes cayanensis	Bentevizinho-de-asa-ferrugínea
Myiozetetes similis	Bentevizinho-de-penacho-vermelho
Tyrannus albogularis	Suiriri-de-garganta-branca
Tyrannus melancholicus	Suiriri
Tyrannus savana	Tesourinha
Tyrannus tyrannus	Suiriri-valente
Griseotyrannus aurantioatrocristatus	Peitica-de-chapéu-preto
Empidonomus varius	Peitica
Colonia colonus	Viuvinha
Myiophobus fasciatus	Filipe
Sublegatus modestus	Guaracava-modesta
Pyrocephalus rubinus	Príncipe
Fluvicola albiventer	Lavadeira-de-cara-branca

Fluvicola nengeta	Lavadeira-mascarada
Arundinicola leucocephala	Freirinha
Cnemotriccus fuscatus	Guaracavuçu
Lathrotriccus euleri	Enferrujado
Hymenops perspicillatus	Viuvinha-de-óculos
Satrapa icterophrys	Suiriri-pequeno
Xolmis cinereus	Primavera
Xolmis velatus	Noivinha-branca
Vireonidae	
Cyclarhis gujanensis	Pitiguari
Hylophilus pectoralis	Vite-vite-de-cabeça-cinza
Vireo chivi	Juruviara
Corvidae	
Cyanocorax cyanomelas	Gralha-do-pantanal
Cyanocorax chrysops	Gralha-picaça
Hirundinidae	
Pygochelidon cyanoleuca	Andorinha-pequena-de-casa
Stelgidopteryx ruficollis	Andorinha-serradora
Progne tapera	Andorinha-do-campo
Progne subis	Andorinha-azul
Progne chalybea	Andorinha-grande
Tachycineta albiventer	Andorinha-do-rio
Petrochelidon pyrrhonota	Andorinha-de-dorso-acanelado
Troglodytidae	
Troglodytes musculus	Corruíra
Campylorhynchus turdinus	Catatau
Pheugopedius genibarbis	Garrinchão-pai-avô

Cantorchilus leucotis	Garrinchão-de-barriga-vermelha
Cantorchilus guarayanus	Garrincha-do-oeste
Donacobiidae	
Donacobius atricapilla	Japacanim
Polioptilidae	
Polioptila dumicola	Balança-rabo-de-máscara
Turdidae	
Turdus leucomelas	Sabiá-branco
Turdus rufiventris	Sabiá-laranjeira
Turdus amaurochalinus	Sabiá-poca
Mimidae	
Mimus saturninus	Sabiá-do-campo
Mimus triurus	Calhandra-de-três-rabos
Motacillidae	
Anthus lutescens	Caminheiro-zumbidor
Passerellidae	
Ammodramus humeralis	Tico-tico-do-campo
Arremon flavirostris	Tico-tico-de-bico-amarelo
Parulidae	
Setophaga pitiayumi	Mariquita
Basileuterus culicivorus	Pula-pula
Myiothlypis flaveola	Canário-do-mato
Icteridae	
Psarocolius decumanus	Japu
Procacicus solitarius	Iraúna-de-bico-branco
Cacicus cela	Xexéu

Icterus cayanensis	Inhapim
Icterus pyrrhopterus	Encontro
Icterus croconotus	João-pinto
Gnorimopsar chopi	Pássaro-preto
Amblyramphus holosericeus	Cardeal-do-banhado
Agelasticus cyanopus	Carretão
Agelaioides badius	Asa-de-telha
Molothrus rufoaxillaris	Chupim-azeviche
Molothrus oryzivorus	Iraúna-grande
Molothrus bonariensis	Chupim
Sturnella superciliaris	Polícia-inglesa-do-sul

Thraupidae

Cissopis leverianus	Tietinga
Schistochlamys melanopis	Sanhaço-de-coleira
Paroaria coronata	Cardeal
Paroaria capitata	Cavalaria
Tangara sayaca	Sanhaço-cinzento
Tangara palmarum	Sanhaço-do-coqueiro
Nemosia pileata	Saíra-de-chapéu-preto
Conirostrum speciosum	Figuinha-de-rabo-castanho
Sicalis citrina	Canário-rasteiro
Sicalis flaveola	Canário-da-terra
Sicalis luteola	Tipio
Hemithraupis guira	Saíra-de-papo-preto
Volatinia jacarina	Tiziu
Eucometis penicillata	Pipira-da-taoca
Coryphospingus cucullatus	Tico-tico-rei

Lanio luctuosus	Tem-tem-de-dragona-branca	
Tachyphonus rufus	Pipira-preta	
Ramphocelus carbo	Pipira-vermelha	
Charitospiza eucosma	Mineirinho	
Tersina viridis	Saí-andorinha	
Coereba flaveola	Cambacica	
Tiaris fuliginosus	Cigarra-preta	
Sporophila lineola	Bigodinho	
Sporophila collaris	Coleiro-do-brejo	
Sporophila nigricollis	Baiano	
Sporophila caerulescens	Coleirinho	
Sporophila leucoptera	Chorão	
Sporophila bouvreuil	Caboclinho	
Sporophila hypoxantha	Caboclinho-de-barriga-vermelha	VU
Sporophila ruficollis	Caboclinho-de-papo-escuro	VU
Sporophila hypochroma	Caboclinho-de-sobre-ferrugem	
Sporophila angolensis	Curió	
Emberizoides herbicola	Canário-do-campo	
Saltatricula atricollis	Batuqueiro	
Saltator maximus	Tempera-viola	
Saltator coerulescens	Sabiá-gongá	
Thlypopsis sordida	Saí-canário	
Cypsnagra hirundinacea	Bandoleta	
Cardinalidae		
Pheucticus aureoventris	Rei-do-bosque	
Fringillidae		

Euphonia chlorotica	Fim-fim
Euphonia laniirostris	Gaturamo-de-bico-grosso
Estrildidae	
Estrilda astrild	Bico-de-lacre
Passeridae	
Passer domesticus	Pardal

Apendice 4. Lista de especies de mamiferos do Pantanal e área proposta para o Mosaico de Unidades de Conservação do Pantanal Norte (MUCPN), além das espécies listadas como ameaçadas de extinção pelo Ministério do Meio Ambiente.

LISTA DE ESPÉCIES POR FAMÍLIA	Rodrigues *et al.* 2002	MUCPN	MMA 2014
Didelphidae			
Caluromys lanatus	x		
Didelphis albiventris	x	x	
Gracilinanus agilis	x	x	
Micoureus cinereus	x		
Marmosa murina	x		
Monodelphis domestica	x	x	
Philander opossum	x	x	
Myrmecophagidae			
Myrmecophaga tridactyla	x	x	x
Tamandua tetradactyla	x	x	
Dasypodidae			
Cabassous unicinctus	x	x	

Dasypus novencinctus	x	x	
Euphractus sexcinctus	x	x	
Priodontes maximus	x	x	x
Tolypeutes matacus	x		
Emballuronidae			
Centronycteris maximiliani	x		
Peropteryx macrotis	x		
Rhynchonycteris naso	x	x	
Saccopteryx bilineata	x		
Noctilionidae			
Noctiolio albiventris	x	x	
Noctilio leporinus	x	x	
Phyllostomidae			
Artibeus jamaicensis	x	x	
Carollia perspicillata	x	x	
Desmodus rotundus	x	x	
Diphila ecaudata	x		
Micronycteris minuta	x	x	
Mimon benneti	x		
Platyrrhinus lineatus	x	x	
Phyllostomus hastatus	x		
Sturnira lilium	x		
Tonatia bidens	x		
Tonatia silvicola	x	x	
Uroderma bilobatum	x		
Vampyrum spectrum	x		
Vespertilionidae			

Eptesicus furinalis	x		
Myotis nigricans	x	x	
Myotis albescens	x		
Molossidae			
Eumops perotis	x		
Eumops auripendulus	x		
Molossops planirostris	x	x	
Molossops temminckii	x	x	
Molossus ater	x		
Molossus molossus	x		
Nyctinomops cf. laticaudatus	x		
Promops cf. nasutus	x		
Callithricidae			
Callithrix argentata	x	x	
Alouatta caraya	x	x	
Aotus azarae	x	x	
Cebus apella	x	x	
Canidae			
Chrysocyon brachyurus	x	x	x
Cerdocyon thous	x	x	
Pseudalopex vetulus	x		
Speothos venaticus	x	x	x
Procyonidae			
Nasua nasua	x	x	
Procyon cancrivorus	x	x	
Mustelidae			
Conepatus sp.	x		

Eira barbara	x	x	
Galictis vittata	x		
Lontra longicaudis	x	x	
Pteronura brasiliensis	x	x	x
Felidae			
Leopardus colocolo	x	x	x
Puma concolor	x	x	x
Leopardus pardalis	x	x	
Leopardus tigrinus	x	x	x
Puma yagouaroundi	x	x	x
Panthera onca	x	x	x
Tapiridae			
Tapirus terrestris	x	x	x
Tayassuidae			
Tayassu pecari	x	x	x
Pecari tajacu	x	x	
Cervidae			
Blastocerus dichotomus	x	x	x
Mazama americana	x	x	
Mazama goazoubira	x	x	
Ozotoceros bezoarticus	x	x	x
Sciuridae			
Sciurus spadiceus	x		
Muridae			
Akodon cursor			
Akodon varius	x		
Bolomys lasiurus	x	x	

Calomys callosus	x	
Holochilus brasiliensis	x	x
Oecomys concolor	x	
Oligoryzomys fornesi	x	x
Oryzomys delicatus	x	
Erethizontidae		
Coendou prehensilis	x	x
Caviidae		
Galea musteloides	x	x
Hydrochaeridae		
Hydrochaeris hydrochaeris	x	x
Agoutidae		
Agouti paca	x	x
Dasyproctidae		
Dasyprocta punctata	x	x
Echimyidae		
Clyomys laticeps	x	
Trichomys apereoides	x	x
Leporidae		
Sylvilagus brasiliensis	x	x

RELATÓRIO TÉCNICO

ESTUDO DA PROPOSTA DE AMPLIAÇÃO

DAS UNIDADES DE CONSERVAÇÃO DO PANTANAL NORTE

MATO GROSSO | CÁCERES e POCONÉ

REALIZAÇÃO

AgroTools

Setembro, 2018

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CONTEXTO

O presente estudo tem como principal finalidade realizar uma análise territorial sobre as terras ocupadas pelas Unidades de Conservação Parque Estadual Encontro das Águas, Estação Ecológica Taiamã, Parque Nacional do Pantanal Mato-grossense, Parque Estadual do Guirá; o espaço geográfico não protegido existente entre elas.

No processo investigativo e analítico buscou-se quantificar e qualificar minuciosamente a composição territorial, a vocação agro/ambiental, a limitação produtiva e a relevância ecossistêmica deste mosaico de terras.

O ambiente geográfico deste estudo, está composto por um conjunto de 13 áreas (blocos de terras) que perfazem uma superfície total de 887.855 mil hectares.

Deste total, temos 41% que estão protegidos na forma de Unidades de Conservação, e 59% não protegidos, identificados por AOIs (Áreas Objeto de Interesse) e que têm papel fundamental na conexão entre as áreas protegidas.

A estratégia de ampliar as UCs existentes e consolidar uma área maior, permite alcançar um porte significativo de um 'bloco único de terras' com natureza abundante e sem a intervenção antrópica com o potencial de salvaguardar uma fração importante da biodiversidade do Bioma Pantanal.

Este mosaico completo, representa 6% de todo o Bioma do Pantanal, e 13% do Pantanal Norte, no estado de Mato Grosso.

Como conclusão do estudo, gerou-se um conjunto de números e indicadores para evidenciar:

i. A representatividade de cada 'bloco de terra' que compõe este território de preenchimento entre as UCs existentes.
ii. A relevância de cada 'bloco de terra' na conexão das UCs existentes.
iii. A relação entre o baixo potencial econômico e a significativa vocação ambiental destes 'blocos de terras'
iv. Fatores de classificação e qualificação territorial

A análise se concentrou em determinar a importância das áreas selecionadas para conservação, baseando-se em ciência de dados e geoprocessamento aplicado, para determinar as áreas de baixa aptidão produtiva e alta biodiversidade.

Para a referida análise, foram utilizadas competências das ciências agrárias, fundiária, meio ambiente, terrestres, computacionais e econômicas.

Os "blocos de terras" estão presentes em dois municípios principais, Cáceres e Poconé, ambos no Mato Grosso. Para a referida análise, foram compilados alguns dados das suas características, como solos, relevo, clima, bacia hidrográfica, inundação, população entre outras informações relevantes para compreensão geográfica local.

O conteúdo e o racional das análises, foram organizados de forma concisa neste documento, e demonstrado por uma série de mapas temáticos que visam aproximar o leitor da realidade desta paisagem tão exuberante quanto vulnerável.

Figura ilustrativa | Contextualização geográfica das UCs existentes e AOIs

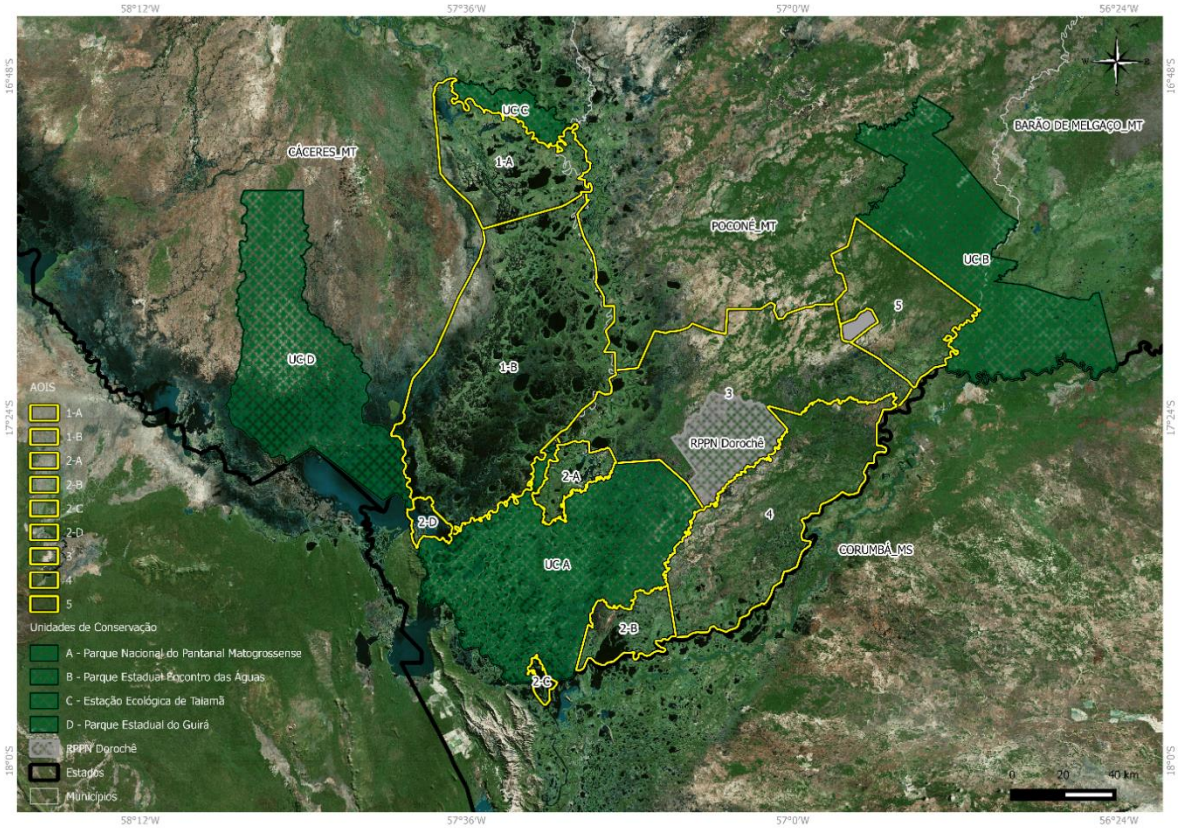
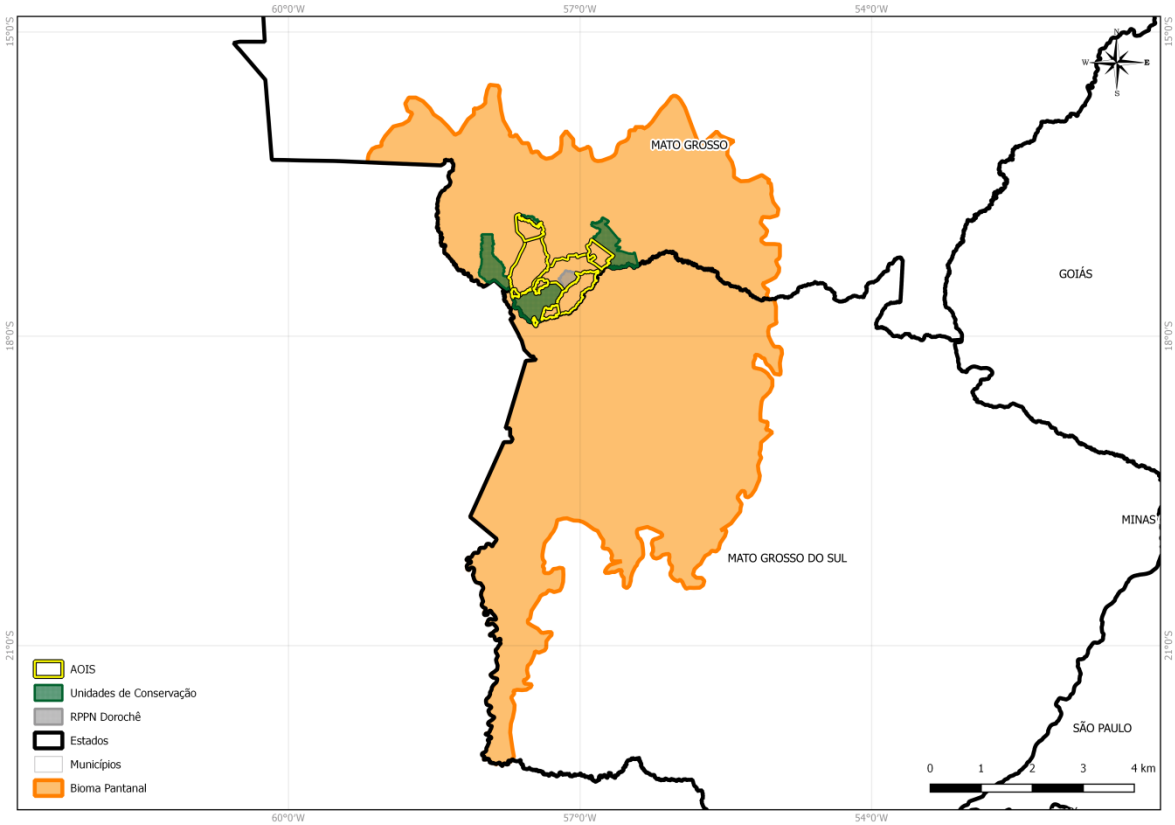


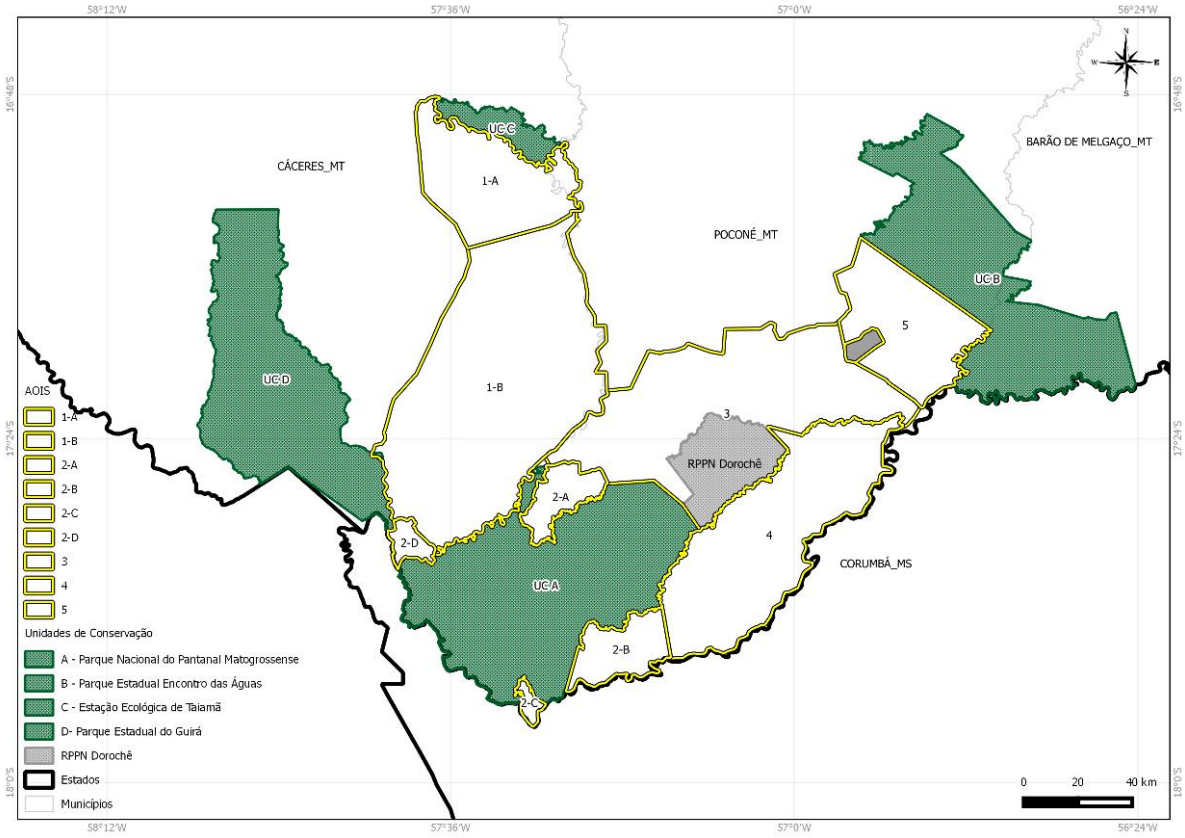
Figura ilustrativa | Contextualização geográfica das UCs e AOIs no Bioma Pantanal



UNIDADES DE CONSERVAÇÃO EXISTENTES

As unidades de conservação são territórios nacionais destinados a assegurar a biodiversidade e funções ecológicas locais, garantindo a proteção de recursos naturais, serviços ecossistêmicos, ecossistemas e populações nativas. Como a paisagem pantaneira em questão apresenta uma importância ímpar para a dinâmica socioambiental local, o estudo concentrou-se na relação geográfica entre 4 unidades de conservação regionais, possibilitando a organização de 5 áreas objeto de interesse (AOIs) para melhor direcionamento e precisão analítica.

Figura ilustrativa | UNIDADES DE CONSERVAÇÃO EXISTENTES E ÁREAS DE EXPANSÃO



Na figura acima, é possível identificar como a proposta de ampliação (limites amarelos) das áreas atualmente protegidas (hachura verde) podem conectar este relevante conjunto de UCs já existentes, e que vêm cumprindo importante papel de preservação da vegetação nativa, biodiversidade e a rede hidrográfica desta região no Pantanal Norte.

Chama-se a atenção para a localização e dimensão da RPPN Doroché, a qual foi incorporada pelo SNUC há poucos meses, e demonstra uma sinalização na continuidade do papel de proteção da natureza que as UCs estabelecidas vêm promovendo.

A seguir um breve descritivo das dimensões das UCs existentes, que foram apresentadas no mapa acima.

UC1 | PARQUE NACIONAL DO PANTANAL MATOGROSSENSE

Unidade de Conservação de proteção integral criada em 1981, com área de 135.922,84 Ha e perímetro de 301,53 Km.

UC2 | ESTAÇÃO ECOLÓGICA DE TAIAMÃ

Unidade de Conservação de proteção integral criada em 1981, com área de 11.555 Ha e perímetro de 97,12 Km.

UC3 | PARQUE ESTADUAL DO GUIRÁ

Unidade de Conservação de proteção integral criada em 2002, com área de 104.663,04 Ha e apresenta perímetro de 206,86 Km.

UC4 | PARQUE ESTADUAL ENCONTRO DAS ÁGUAS

Unidade de Conservação de proteção integral criada em 2004, com área de 108.130,92 Ha e perímetro de 299,76 Km.

A tabela abaixo traz a proporção das referidas UCs nos respectivos municípios que ocupam.

UF	Municípios	Área total do município	% do município com UC
MT	Cáceres	2.456.325,05	4,74%
MT	Poconé	1.712.811,05	11,46%
MT	Barão de melgaço	1.116.879,20	4,18%

Tabelas demonstrativas | Distribuição territorial das UCs no contexto regional

Territórios	Perímetro total (km)	Área Total (Ha)	Mesorregiões	Microrregiões	Municípios	UF	Sobrepoisção Municípios (ha)	%
UC: Parque Estadual Encontro das Águas	**300**	**108.131**	Centro-Sul Mato-Grossense	Alto Pantanal	Barão de Melgaço	MT	46.738,17	4%
					Poconé	MT	61.264,56	4%
UC: Parque Nacional do Pantanal Matogrossense	**302**	**135.923**	Centro-Sul Mato-Grossense	Alto Pantanal	Poconé	MT	134.944,06	8%
UC: Estação Ecológica de Taiamã	**97**	**11.555**	Centro-Sul Mato-Grossense	Alto Pantanal	Cáceres	MT	11.541,70	1%
UC: Parque Estadual do Guirá	**207**	**104.663**	Centro-Sul Mato-Grossense	Alto Pantanal	Cáceres	MT	104.608,03	4%

A tabela acima traz um resumo quanto às dimensões de cada uma das UCs existentes, a localização das mesmas desde a Meso e Macro regiões, até os municípios onde se encontram, incluindo a representatividade destas em relação à superfície total dos referidos municípios.

O município de Barão de Melgaço, apesar de possuir uma parte do Parque Estadual Encontro das Águas, não é explorado neste estudo, uma vez que a proposta de ampliação das UCs existentes não contempla novas áreas neste município.

Neste sentido, os municípios de Cáceres e Poconé, ambos no Mato Grosso, encontram-se completamente dentro de Bioma Pantanal, e resumem as municipalidades que são objetos deste estudo.

A soma das quatro UCs representa um território total de aproximadamente 360.000 hectares, compreendidos por quase 1.000 quilômetros de perímetro.

PROPOSTA DE AMPLIAÇÃO DAS ÁREAS PROTEGIDAS

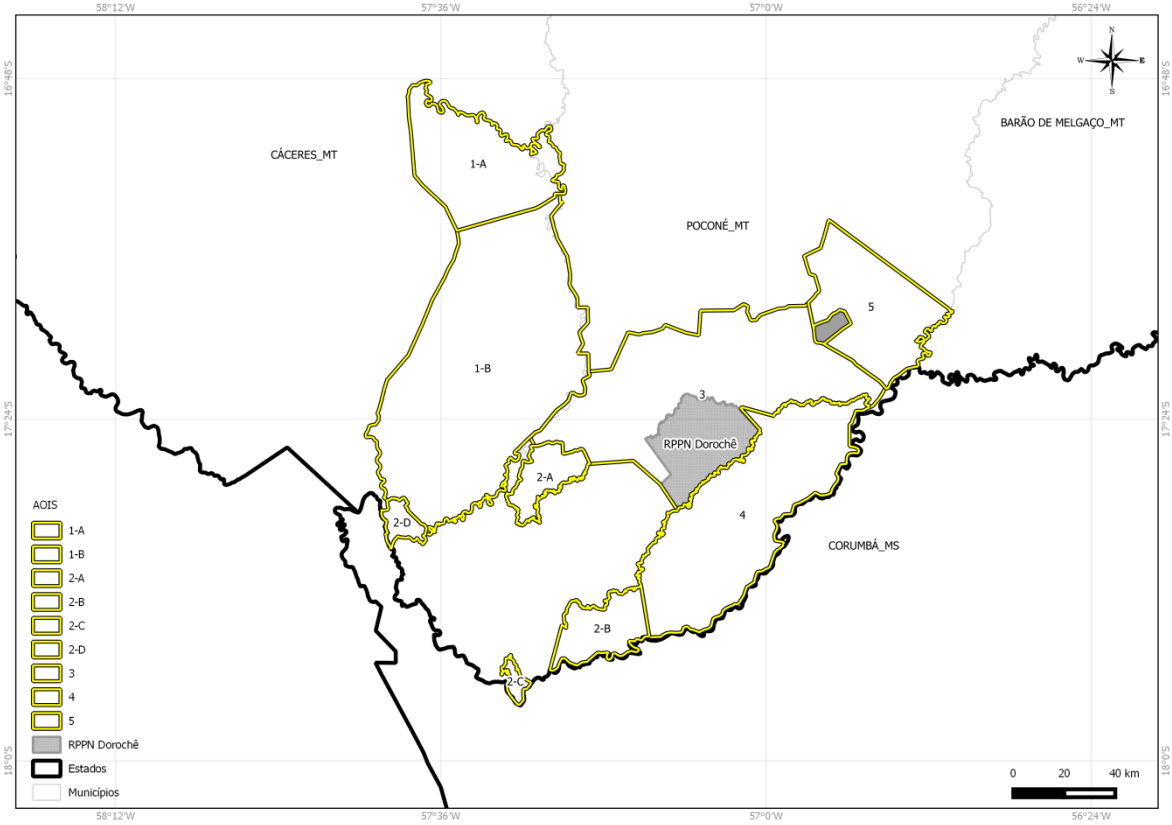
As unidades de conservação contempladas apresentam ampla distribuição entre os diferentes ecótonos pantaneiros mato-grossenses, apresentando alta diversidade ecológica.

Para melhor enriquecimento biológico e maior resiliência do ecossistema da região, o espaço territorial entre as UCs existentes, foram delimitadas em cinco partes, denominadas de AOIs (Áreas Objeto de Interesse).

Duas destas AOIs foram subdivididas em territórios menores, para melhor qualificação analítica, os quais foram designados por letras.

Estas cinco áreas foram analisadas de acordo com suas características morfológicas e geográficas para conceber um conjunto de informações qualificadas para subsidiar a avaliação e discussões quanto à destinação destas áreas para fins compor novas Unidades de Conservação que permita, a conexão das UCs existentes na região de estudo.

Figura ilustrativa | ÁREAS OBJETO DE INTERESSE (AOIs) – CONTEXTO E NOMENCLATURA



Na figura acima, temos uma pequena área cinza, à noroeste e que está encravada na AOI 5, a qual trata-se de uma fazenda aparentemente bem estruturada, não foi incluída neste estudo e não faz parte de nenhuma das AOIs que compõem a proposta de ampliação do Mosaico de UCs existentes.

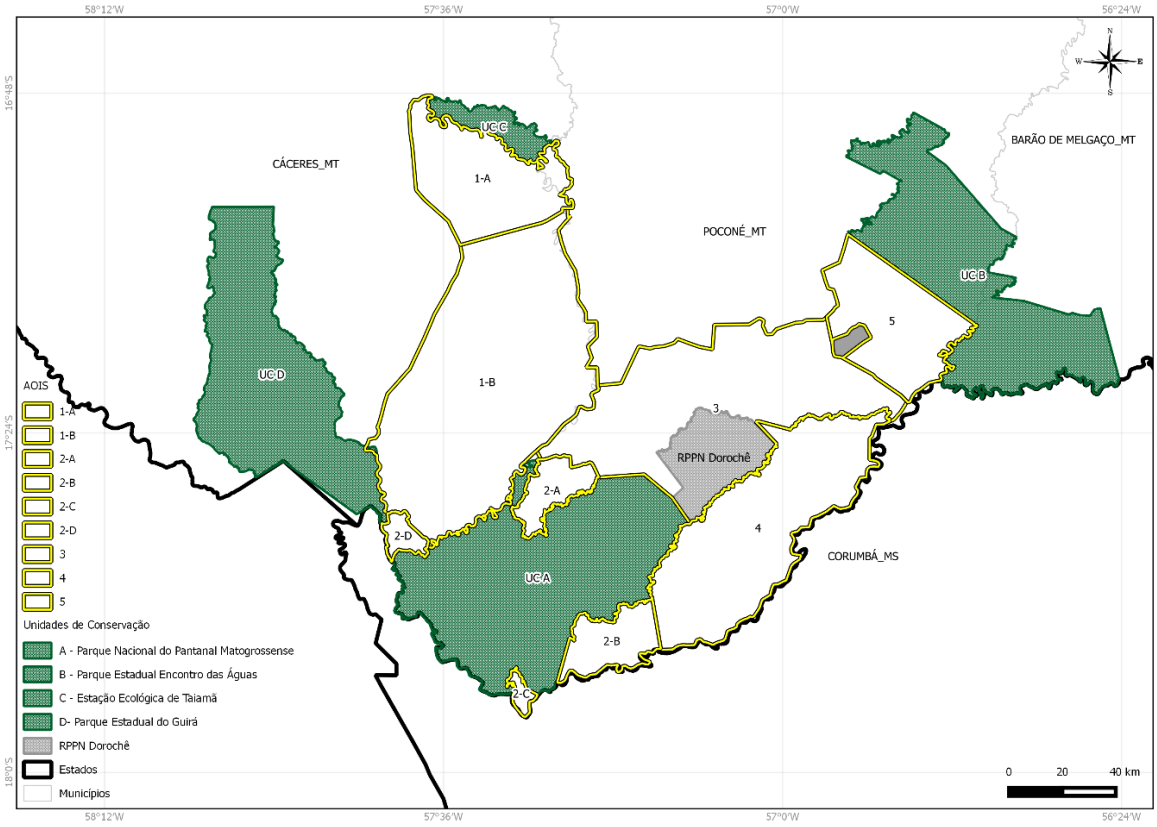
CARACTERIZAÇÃO DA PAISAGEM

A região de estudo, está inserida no âmbito de ocupação de 4 (quatro) UCs já existentes, sendo todas estas enquadradas na categoria de Proteção Integral, e está composta por 5 (cinco) AOIs que representam a proposta de ampliação e conexão das referidas UCs.

O mosaico completo, composto pela conjunção das 4 UCs e as 5 AOIs, compreendem um território total de aproximadamente 887.855 hectares.

As UCs somam uma área total de 360.272 hectares, e representam respectivamente 41% do Mosaico total, e as AOIs, que ao todo somam uma área de 527.583 hectares, representam 59% do mosaico completo.

Figura ilustrativa | MOSAICO DE UCs e AOIs NA REGIÃO DO PANTANAL NORTE



Conforme dados apurados na construção do processo de ampliação das UCs, temos que a proposta apresentada, considera que serão enquadradas na categoria Proteção Integral, apenas a expansão da UC Taiamã, com a AOI1-A, e a expansão do Parque Nacional do Pantanal Matogrossense, com as AOIs 2-A, 2-B e 2-C, que somam um total de 89.108 há, e representam menos de 17% da área total das AOIs. Logo, todas as demais áreas, que somam mais de 80%, estão sendo enquadradas como UC de Uso Sustentável, nas subcategorias Reserva de Fauna, Reserva de Desenvolvimento Sustentável e Área de Proteção Ambiental (APA), ou seja, mantendo tanto a ocupação humana atual como também seus costumes pantaneiros.

Tabela demonstrativa | Territórios de composição do mosaico - AOIs

Territórios	Perímetro total (km)	Área Total (Ha)	% do Mosaico	% das AOIs
AOI 1 - A: Ampliação da Estação Ecológica Taiamã	**138**	**50.710**	6%	10%
AOI 1 - B: Reserva de Fauna do Pantanal	**215**	**165.343**	19%	31%
AOI 02 - A: Ampliação do Parque Nacional Pantanal Mato-grossense	**80**	**12.678**	1%	2%
AOI 02 - B: Ampliação do Parque Nacional Pantanal Mato-grossense	**81**	**18.452**	2%	3%
AOI 02 - C: Ampliação do Parque Nacional Pantanal Mato-grossense	**30**	**2.394**	0%	0%
AOI 02 - D: Ampliação do Parque Nacional Pantanal Mato-grossense	**37**	**4.873**	1%	1%
AOI 03: Refúgio da Vida Silvestre da Onça Pintada	**235**	**131.184**	15%	25%
AOI 04: Refúgio da Vida Silvestre da Onça Pintada	**208**	**94.421**	11%	18%
AOI 05: Refúgio da Vida Silvestre da Onça Pintada	**124**	**47.527**	5%	9%

Tabela demonstrativa | Territórios de composição do mosaico - UCs

Territórios	Perímetro total (km)	Área Total (Ha)	% do Mosaico	% das UCs
UC: Parque Estadual Encontro das Águas	**300**	**108.131**	12%	30%
UC: Parque Nacional do Pantanal Matogrossense	**302**	**135.923**	15%	38%
UC: Estação Ecológica de Taiamã	**97**	**11.555**	1%	3%
UC: Parque Estadual do Guirá	**207**	**104.663**	12%	29%

AOIs | ÁREAS OBJETO DE INTERESSE

Cada AOI apresenta condições e propriedades territoriais distintas, o que influencia em sua dinâmica natural e condições físicas por terem sobreposições diferentes entre as terras que compõem sua superfície territorial.

Neste sentido, segue breve resumo a respeito de cada uma destas AOIs, e também um conjunto de figuras visando simplificar a visualização e percepção quanto às dimensões e correlações entre as áreas de interesse analisadas.

AOI 1: Ampliação da Estação Ecológica Taiamã e Reserva de Fauna do Pantanal

A AOI 1 corresponde à ampliação da Estação Ecológica Taiamã e criação da Reserva de Fauna do Pantanal, caracterizando um corredor ecológico de interligação entre 2 unidades de conservação existentes a Estação Ecológica Taiamã e o Parque Nacional do Pantanal. Para efeitos de análise seu território foi dividido em dois subterritórios, a Ampliação da Estação Ecológica Taiamã (AOI 1-A) e a Reserva de Fauna do Pantanal (AOI 1-B).

AOI 02: Ampliação do Parque Nacional Pantanal Mato-grossense

A área de interesse 2 corresponde à ampliação do Parque Nacional Pantanal Mato-grossense, caracterizando pela consolidação da proteção de áreas de planícies alagáveis, consequentemente, sua biodiversidade e recursos naturais, fundamentais para conservação da dinâmica hidrológica regional. Para efeitos de análise seu território foi dividido em quatro subterritórios, todos denominados como Ampliação do Parque Nacional Pantanal Mato-grossense, separados em AOI 2-A, AOI 2-B, AOI 2-C e AOI 2-D.

AOI 03: Refúgio da Vida Silvestre da Onça Pintada (parte1)

A área de interesse 3 corresponde à criação de parte do Refúgio de Vida Silvestre da Onça pintada, caracterizando um corredor ecológico antropizado entre duas unidades de conservação pré-existentes na região, o Parque Nacional do Pantanal Mato-grossense e o Parque Estadual Encontro das Águas. A criação teria o papel de complementação da preservação local, servindo de área território de interligação entre as espécies da planície alagável pantaneira e espécies de fauna e flora presentes em áreas de terra-firme.

AOI 04: Refúgio da Vida Silvestre da Onça Pintada (parte2)

A área de interesse 4 corresponde à criação de parte do Refúgio de Vida Silvestre da Onça pintada, caracterizando uma complementação do corredor ecológico entre duas unidades de conservação pré-existentes na região, o Parque Nacional do Pantanal Mato-grossense e o Parque Estadual Encontro das Águas.

AOI 05: Refúgio da Vida Silvestre da Onça Pintada (Parte3)

A área de interesse 5 corresponde à criação de parte do Refúgio de Vida Silvestre da Onça pintada, caracterizando uma zona de amortecimento da unidade de conservação Parque Estadual Encontro das Águas.

Tabela demonstrativa | Distribuição territorial das AOIs no contexto regional

Territórios	Perímetro total (km)	Área Total (Ha)	Municípios	UF	Sobrepoisção Municípios (ha)	%
AOI 1 - A: Ampliação da Estação Ecológica Taiamã	**138**	**50.710**	Cáceres	MT	47.204	2%
AOI 1 - B: Reserva de Fauna do Pantanal	**215**	**165.343**	Cáceres	MT	163.357	7%
AOI 02 - A: Ampliação do Parque Nacional Pantanal Mato-grossense	**80**	**12.678**	Poconé	MT	12.678	1%
AOI 02 - B: Ampliação do Parque Nacional Pantanal Mato-grossense	**81**	**18.452**	Poconé	MT	18.296	1%
AOI 02 - C: Ampliação do Parque Nacional Pantanal Mato-grossense	**30**	**2.394**	Poconé	MT	2.380	0%
AOI 02 - D: Ampliação do Parque Nacional Pantanal Mato-grossense	**37**	**4.873**	Poconé	MT	29	0%
AOI 03: Refúgio da Vida Silvestre da Onça Pintada	**235**	**131.184**	Poconé	MT	130.775	8%
AOI 04: Refúgio da Vida Silvestre da Onça Pintada	**208**	**94.421**	Poconé	MT	94.420	6%
AOI 05: Refúgio da Vida Silvestre da Onça Pintada	**124**	**47.527**	Poconé	MT	47.428	3%

DISTRIBUIÇÃO REGIONAL

Para compreender a importância da criação dessas diferentes áreas de proteção, a relação com as comunidades de populações locais é um fator significativo da análise espacial, tanto por essas áreas proporcionarem diferentes recursos e serviços naturais essenciais para a manutenção do modo de vida local, quanto para entender a dimensão da influência que áreas antrópicas poderiam interferir na dinâmica natural do território proposto para proteção.

As comunidades presentes no local correspondem uma influência positiva para a dinâmica socio-ecológica do mosaico, pois visto que devido a presença sutil de atividades antrópicas, a região manteve suas características naturais, tanto em termo geomorfológicos e hídricos quanto em termos biológicos.

Isso demonstra também, que a presença de pequenos rebanhos, não geraram mudanças significativas na paisagem, graças a ampla cobertura de pastagens naturais nativas nesta região, o que sugere a não necessidade de expansão e conversão de áreas com vegetação de maior porte.

Portanto, a capacidade de suporte do ecossistema pantaneiro do mosaico demonstrou resiliência e manutenção de sua dinâmica ecológica com a presença de comunidades ribeirinhas.

Essas comunidades estão distribuídas em 3 municípios distintos, Barão de Melgaço (população estimada em 8.563 pessoas – IBGE 2018), Cáceres (população estimada em 93.882 pessoas/IBGE 2018) e Poconé (população estimada em 32.768 pessoas/IBGE 2018).

No mosaico completo identificou-se um total 51 comunidades, listadas pelo IBGE, convivendo em seu interior. É importante ressaltar que a partir de consultas mais aprofundadas, tais comunidades listadas, na maioria dos casos não trata-se de um vila ou comunidade de pessoas, mas sim por um espaço pré-determinado para que ribeirinhos registrados no MMA possam exercer, sazonalmente, a coleta de iscas para comercialização com o turismo de pesca da região.

Para melhor compreensão segue abaixo a relação de nomes referentes às referidas comunidades identificadas dentro das referidas AOIs, as quais cabe ressaltar que não são moradias fixas e ou comunidades propriamente ditas, mas sim acampamentos sazonais de ribeirinhos.

AOI 1 | Ampliação da Estação Ecológica Taiamã e Reserva de Fauna do Pantanal

Dentro dos limites definidos pela AOI 1, foram identificadas 22 comunidades, são elas:
Cancha do Jatobeirão; Cancha do Roncador; Estirão Inferior da Boca do Cará-Cará; Estirão da Prainha; Estirão da Reserva; Estirão do Cervo; Estirão do Paraguai; Jatobeirão; Machadinho; Passo Capitão Fernandes; Porto Macaco; Tapera do Papagaio; Volta da Figueira Preta; Volta da Prainha Superior; Volta da Reserva; Volta do Boi; Volta do Estaleiro ou Japuira; Volta do

Formoso; Volta do Romeu; Volta do Saco; Volta do Sapiquá; Volta do Sinimbu. Todas as comunidades dessa AOI são consideradas ribeirinhas.

AOI 2 | Ampliação do Parque Nacional Pantanal Mato-grossense

Dentro dos limites definidos pela AOI 2, foram identificadas 3 comunidades, são elas: Boca da Anta; Estirão Dom Pedro II; Ilha Boca da Anta Grande. Todas as comunidades dessa AOI são consideradas ribeirinhas.

AOI 3 | Refúgio da Vida Silvestre da Onça Pintada

Dentro dos limites definidos pela AOI 3, foram identificadas 4 comunidades, são elas: Doroché; Estirão Capitão Fernandes; Estirão Superior da Boca do Cará-Cará.

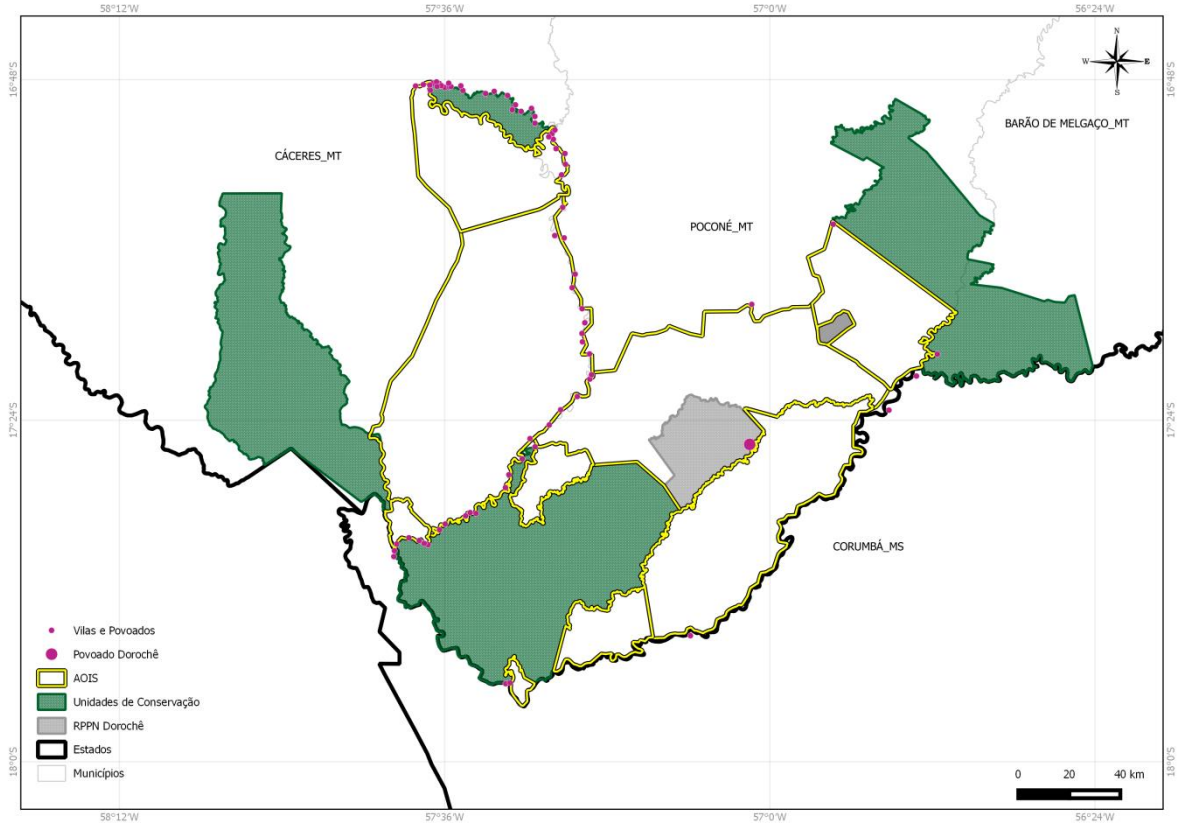
AOI 4 | Refúgio da Vida Silvestre da Onça Pintada

Dentro dos limites definidos pela AOI 4, não foram identificadas comunidades.

AOI 5 | Refúgio da Vida Silvestre da Onça Pintada

Dentro dos limites definidos pela AOI 5, foi identificada 1 comunidade, a Barracão de Santa Helena.

Figura ilustrativa | LOCALIZAÇÃO DE COMUNIDADES EM RELAÇÃO ÀS AOIs



OCUPAÇÃO DO TERRITÓRIO

No processo de caracterização das AOIs, em relação ao grau e antropização, foram utilizadas bases de dados geradas pelo LAPIG (Laboratório de Processamento de Imagens e Geoprocessamento).

Essa análise é fundamental para compreender a abrangência de áreas efetivamente conservadas com vegetação nativa presente em sua superfície, ou áreas com atividades socioeconômicas já consolidadas.

Na figura a seguir, chama a atenção pela quase inexistência de áreas com pastagem formada dentro das AOIs, e para as áreas agrícolas não há nenhuma detecção por meio desta fonte de dados.

Figura ilustrativa | PASTAGEM NAS AOIs (LAPIG)

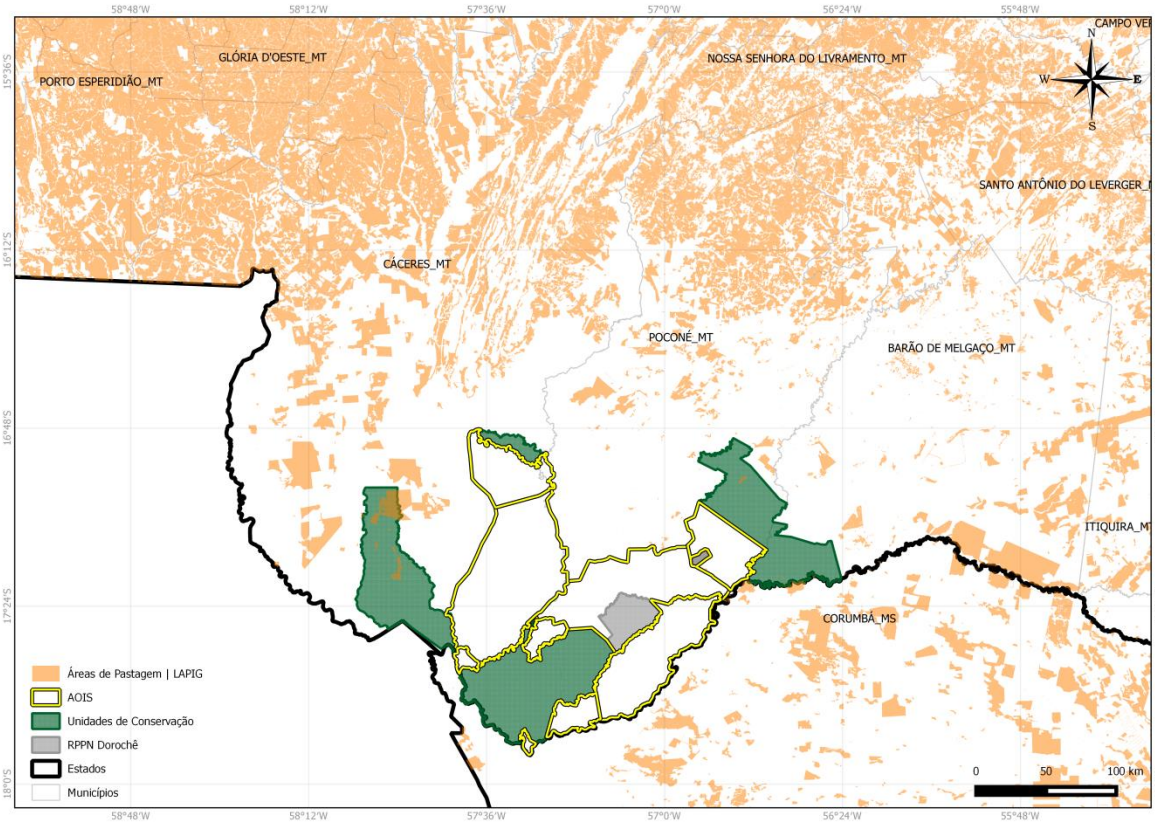
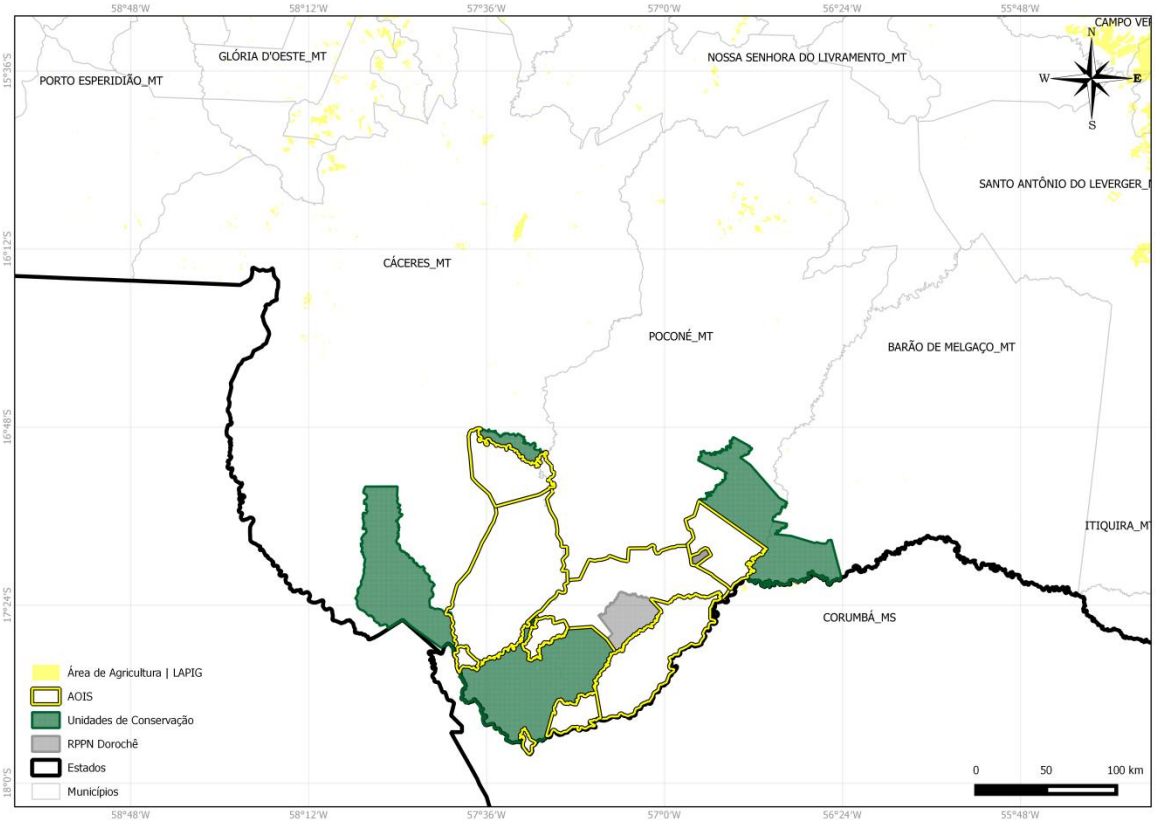


Figura ilustrativa | AGRICULTURA NAS AOIs (LAPIG)



Por meio da visualização dos mapas apresentados, percebe-se que as áreas de pastagem formadas e áreas agrícolas não estão próximas aos limites da área de estudo.

Esta visão indica que as atividades econômico-produtivas mais relevantes estão mais distantes das AOIs.

Tal constatação é decorrente de uma série de fatores que caracterização a aptidão agrícola de uma região, sendo os fatores mais relevantes, o relevo, o tipo de solo e o regime de chuvas.

No caso destas AOIs, o tipo de solos não favorece as atividades agrícolas, e o regime de chuvas associado ao tipo de relevo local gera um ciclo de cheias e secas, onde a maior parte das terras permanece inundado na maior parte do tempo.

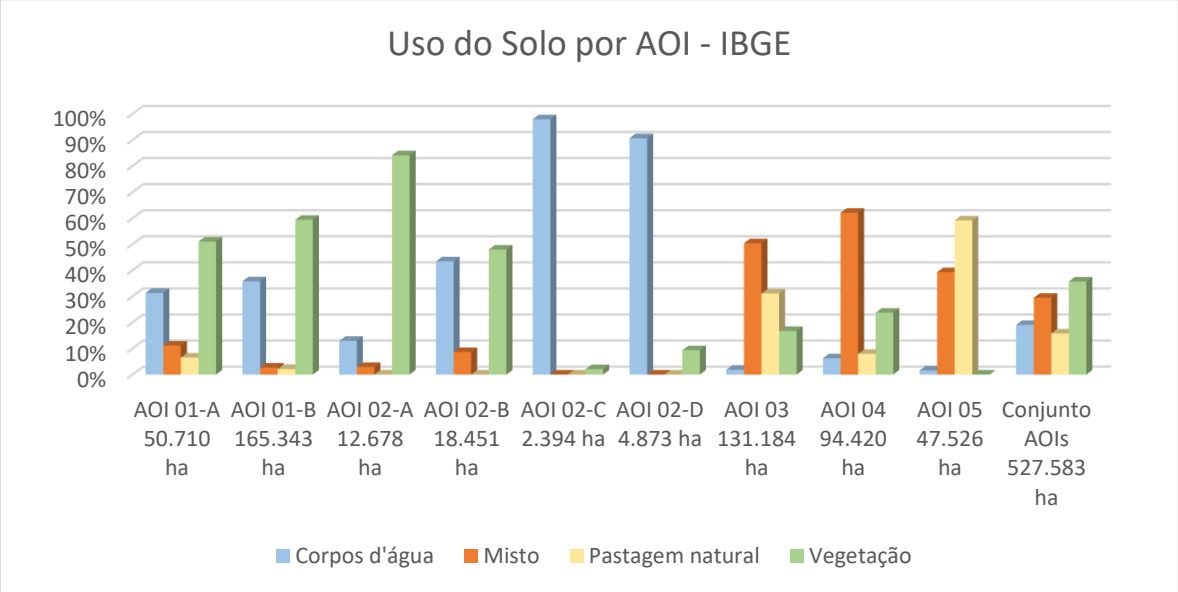
Estes aspectos serão melhor explorados e evidenciados ao longo deste documento.

Além desta análise, também foram utilizados dados disponibilizados pelo IBGE quanto ao uso do solo para esta região. E visando simplificar a compreensão das classes de uso descritas na base de dados do IBGE, utilizou-se classes menos específicas para a análise, as classes da fonte oficial foram ajustadas conforme a tabela referencial abaixo.

Tabela de simplificação das classes de uso do IBGE adaptada pela AgroTools

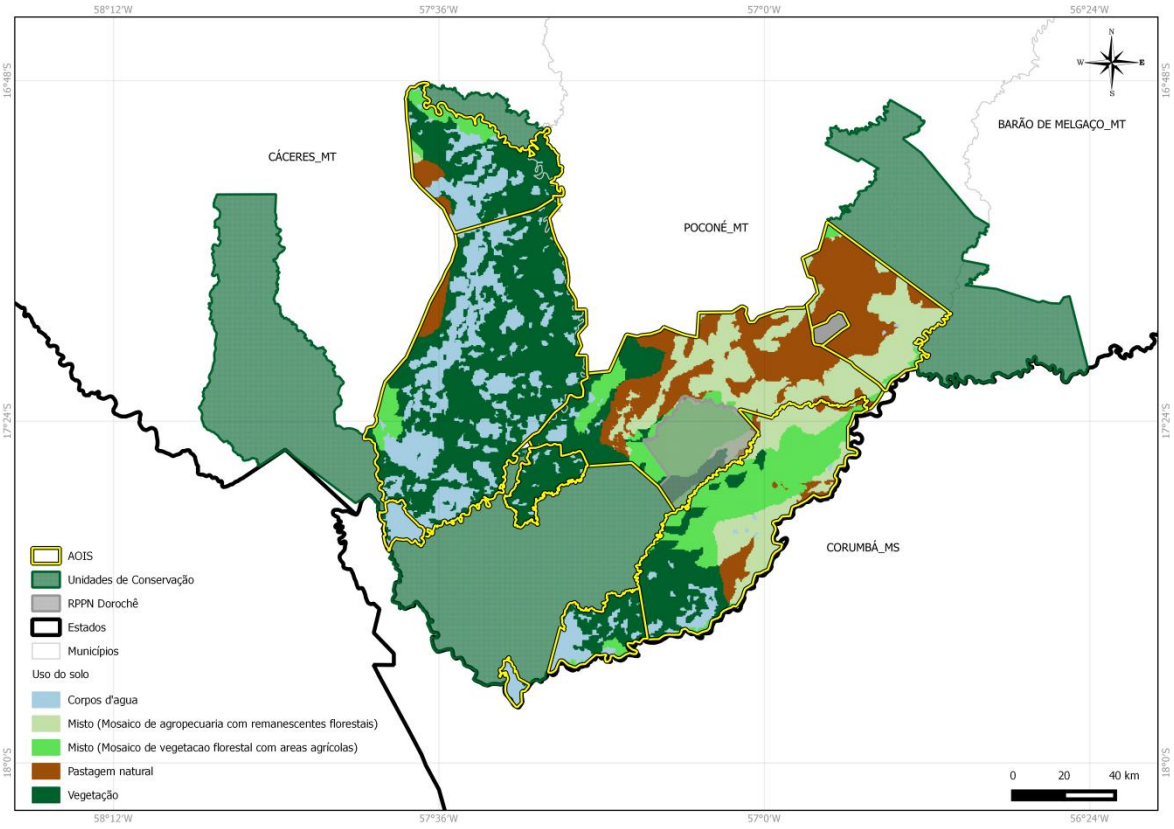
Classe Original IBGE	Classe Resumida AgroTools
Corpo d'água continental	Corpos d'água
Misto (Mosaico de agropecuária com remanescentes florestais)	Misto
Misto (Mosaico de vegetação florestal com áreas agrícolas)	Misto
Pastagem natural	Pastagem natural
Vegetação campestre	Vegetação
Vegetação campestre alagada	Vegetação

A partir dessa lógica, foi possível estabelecer uma proporção simplificada para cada AOI, e uma visão comparativa de uso do solo entre as áreas de interesse. Os gráficos visam ilustrar melhor este cenário.



De modo a ampliar a percepção sobre este item analisado, foram produzidos uma série de mapas temáticos para apresentar a localização e dimensão espacial de cada classe de uso do solo por AOI.

Figura ilustrativa | USO DO SOLO DO TERRITÓRIO DAS AOIs



O uso do solo do mosaico é caracterizado pela mescla de corpos d'água oriundos das inundações naturais pantaneiras com a vegetação nativa, principalmente nos blocos AOI 1 e AOI 2, que apresentam influência das áreas preservadas das unidades de conservação próximas.

Quanto aos blocos AOI 3, AOI 4 e AOI 5 apresentam um caráter mais heterogêneo, com o misto de áreas destinadas à agropecuária com remanescentes florestais e áreas destinadas à agricultura com vegetação florestal, além de apresentar maior presença de pastagens naturais.

Portanto, em termos de uso do solo, duas áreas distintas podem ser compreendidas, uma com áreas muito bem preservadas com vegetação nativa e corpos d'água e outra com predominância de pastagens naturais e uso potencial agropecuário misturado com remanescentes florestais.

ANÁLISE

VOCAÇÃO AMBIENTAL

O bioma pantaneiro apresenta-se em uma depressão geológica da Bacia do Alto Paraguai, caracterizado por ser a maior área úmida tropical continental do mundo, localizando-se entre 3 biomas sul-americanos, a Amazônia, o Cerrado e o Chaco.

A região pantaneira em questão tem como principais fitofisionomias a Savana gramíneo-lenhosa estépica, Savana florestal estacional e uma Savana estrito-senso.

Esse mosaico de vegetação caracteriza-se pela influência biológica dos diferentes biomas adjacentes, que permitem um fluxo genético da flora e fauna nativas, proporcionando a identificação de mais de 2.000 espécies de plantas e 582 espécies de animais.

Além da característica vegetacional da região, também foi contemplada na análise a hidrografia pantaneira, já que o regime hidrológico regional é fundamental para a dinâmica e estrutura ecológica do bioma.

Por tratar-se de uma região com ampla distribuição da planície alagável, todas as espécies dos ecossistemas do bioma são adaptadas para esse regime hídrico peculiar.

Como resultado da análise dos dados hidrológicos, foi possível determinar a extensão de ambientes aquáticos lóticos (rios e riachos) e sobreposição de cada área de interesse com corpos d'água continentais. Estes dados podem ser melhor visualizados na tabela abaixo.

Tabela demonstrativa | Contexto hidrológico das AOIs

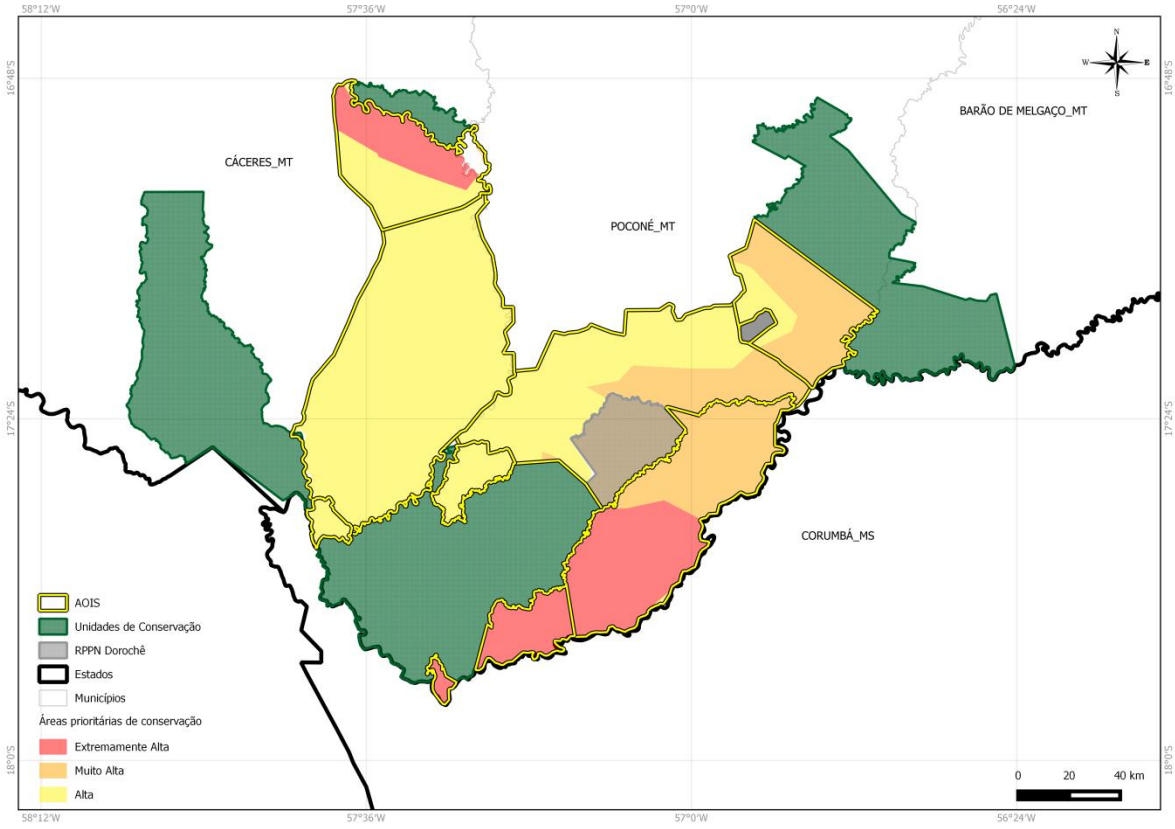
Territórios	Perímetro total (km)	Área Total (Ha)	Municípios	UF	Hidrografia IBGE (km)	Área seca (ha)	Área Inundável (ha)	% Área inundável	Área de massa d'água (ha)	Corpo d'água continental
AOI 1 - A: Ampliação da Estação Ecológica Taiamã	138	50,710	Cáceres	MT	190	446.76	39,523.93	78%	10,924.97	15,783.04
AOI 1 - B: Reserva de Fauna do Pantanal	215	165,343	Cáceres	MT	510	7,104.32	129,317.58	78%	21,162.66	59,209.76
AOI 02 - A: Ampliação do Parque Nacional Pantanal Mato-grossense	80	12,678	Poconé	MT	48.50	1,093.43	8,432.85	67%	440.62	1,689.36
AOI 02 - B: Ampliação do Parque Nacional Pantanal Mato-grossense	81	18,452	Poconé	MT	80.87	2,313.32	-	-	3,539.22	8,015.95
AOI 02 - C: Ampliação do Parque Nacional Pantanal Mato-grossense	30	2,394	Poconé	MT	14.01	12.45	-	-	1,887.07	2,344.91
AOI 02 - D: Ampliação do Parque Nacional Pantanal Mato-grossense	37	4,873	Poconé	MT	19.34	16.88	-	-	3,540.75	4,418.41
AOI 03: Refúgio da Vida Silvestre da Onça Pintada	235	131,184	Poconé	MT	309.22	22,011.48	120,399.00	92%	2,206.10	2,408.00
AOI 04: Refúgio da Vida Silvestre da Onça Pintada	208	94,421	Poconé	MT	215.65	10,361.49	41,199.18	44%	1,877.66	5,912.24
AOI 05: Refúgio da Vida Silvestre da Onça Pintada	124	47,527	Poconé	MT	70.15	798.32	46,905.25	99%	4.75,31	762.10

Outro elemento importante para compreender a vocação ambiental local trata-se da classificação das áreas prioritárias para conservação, pela análise realizada pelo Ministério do Meio Ambiente – MMA, em um estudo que identificou e qualificou o território nacional baseado em características naturais quanto a relevância e prioridade de conservação, como forma de proteção da biodiversidade nacional através de 3 classes de priorização:

I - Prioridade extremamente alta;
II - Prioridade muito alta; e
III - Prioridade alta.

Como forma de incorporação deste indicador geográfico, as áreas do mosaico foram cruzadas com as áreas prioritárias presentes na região, gerando a figura ilustrativa abaixo.

Figura ilustrativa | ÁREAS PRIORITÁRIAS PARA CONSERVAÇÃO NO MOSAICO



APTIDÃO AGRÍCOLA

Para efeitos de determinação das melhores regiões para a expansão de áreas de proteção, é necessário compreender as condições agrícolas da região, não somente para analisar os efeitos que as diferentes distâncias entre áreas agrícolas já existentes podem influenciar na biodiversidade local, mas também para determinar os locais mais eficazes para expansão da conversão agrícola e os locais com menor aptidão, ideais para conservação, por naturalmente ter menor probabilidade de expansão.

Diferentes fatores foram considerados para a análise de aptidão agrícola das áreas propostas, entre eles estão: topografia, uso do solo, área inundável, tipo de solos, fertilidade e clima.

A análise se concentrou em determinar a característica predominante de cada fator em cada área. A primeira tabela abaixo visa ilustrar os fatores naturais das áreas, e a segunda demonstra com maior detalhe o uso do solo.

Tabela demonstrativa | APTIDÃO AGRÍCOLA POTENCIAL

Territórios	Perímetro total (km)	Área Total (Ha)	Municípios	UF	Fertilidade Muito Baixa - IBGE	Topografia Montanhosa a Escarpada	%	Gleissolos háplicos tb distrófico	%	Plintossolos háplicos indiscriminados
AOI 1 - A: Ampliação da Estação Ecológica Taiamã	138	50,710	Cáceres	MT	50,710	50,710	100%	31,488	62%	19,222
AOI 1 - B: Reserva de Fauna do Pantanal	215	165,343	Cáceres	MT	165,343	165,343	100%	119,859	72%	42,921
AOI 02 - A: Ampliação do Parque Nacional Pantanal Mato-grossense	80	12,678	Poconé	MT	12,678	12,678	100%	9,807	77%	2,871
AOI 02 - B: Ampliação do Parque Nacional Pantanal Mato-grossense	81	18,452	Poconé	MT	18,452	18,452	100%	18,416	100%	35
AOI 02 - C: Ampliação do Parque Nacional Pantanal Mato-grossense	30	2,394	Poconé	MT	2,394	2,394	100%	2,223	93%	-
AOI 02 - D: Ampliação do Parque Nacional Pantanal Mato-grossense	37	4,873	Poconé	MT	4,873	4,873	100%	4,408	90%	-
AOI 03: Refúgio da Vida Silvestre da Onça Pintada	235	131,184	Poconé	MT	131,184	131,184	100%	8,768	7%	122,417
AOI 04: Refúgio da Vida Silvestre da Onça Pintada	208	94,421	Poconé	MT	94,421	94,421	100%	16,918	18%	77,503
AOI 05: Refúgio da Vida Silvestre da Onça Pintada	124	47,527	Poconé	MT	47,527	47,527	100%	-	-	47,534

Um dos fatores mais importantes para determinação da aptidão agrícola é a composição pedológica, ou seja, os tipos e naturezas do solo. Na região em questão, os solos apresentam um material de origem de baixa fertilidade, proveniente de sedimentos geológicos da Serra do Amolar e outros relevos serranos da região. Contudo, a dinâmica hídrica local possibilita o aporte de sedimentos orgânicos aluviais provenientes de inundações, que permite aumentar a fertilidade do solo em questão. Os diferentes tipos de solos estão presentes na figura abaixo.

Figura ilustrativa | TIPOS DE SOLOS NAS AOIs

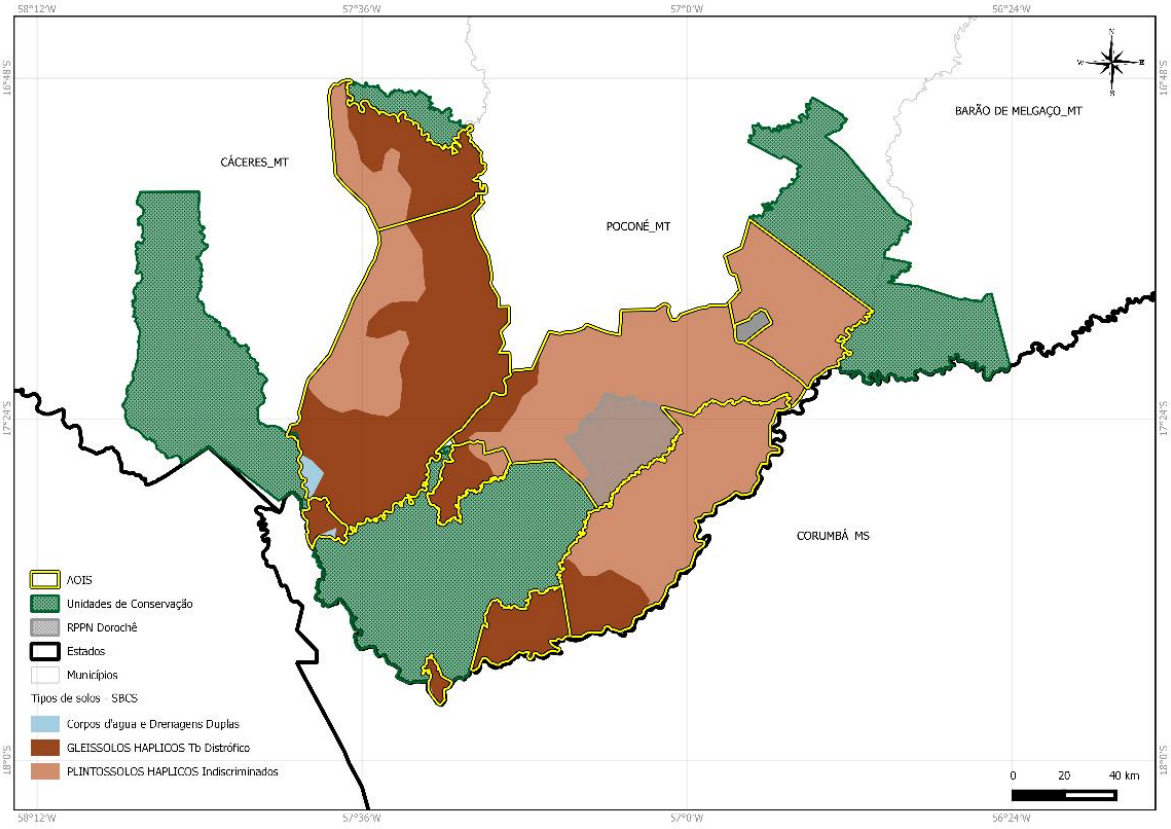


Tabela demonstrativa | USO DO SOLO

Territórios	Perímetro total (km)	Área Total (Ha)	Municípios	UF	Mosaico de agropecuária com remanescentes florestais	%	Mosaico de vegetação florestal com áreas agrícolas	%	Pastagem natural	%	Vegetação campestre	%	Vegetação campestre alagada	%
AOI 1 - B: Reserva de Fauna do Pantanal	215	165,343	Cáceres	MT	-	-	4,447	3%	3,537	2%	100.00	0%	98,050	59%
AOI 02 - A: Ampliação do Parque Nacional Pantanal Mato-grossense	80	12,678	Poconé	MT	382	3%	-	-	-	-	-	-	10,989	87%
AOI 02 - B: Ampliação do Parque Nacional Pantanal Mato-grossense	81	18,452	Poconé	MT	-	-	1,592	9%	-	-	-	-	8,844	48%
AOI 02 - C: Ampliação do Parque Nacional Pantanal Mato-grossense	30	2,394	Poconé	MT	-	-	-	-	-	-	-	-	49	2%
AOI 02 - D: Ampliação do Parque Nacional Pantanal Mato-grossense	37	4,873	Poconé	MT	-	-	-	-	-	-	-	-	455	9%
AOI 03: Refúgio da Vida Silvestre da Onça Pintada	235	131,184	Poconé	MT	37,334	28%	28,751	22%	40,791	31%	-	-	21,900	17%
AOI 04: Refúgio da Vida Silvestre da Onça Pintada	208	94,421	Poconé	MT	23,629	25%	34,973	37%	7,498	8%	-	-	22,409	24%
AOI 05: Refúgio da Vida Silvestre da Onça Pintada	124	47,527	Poconé	MT	17,186	36%	1,482	3%	28,108	59%	-	-	-	-

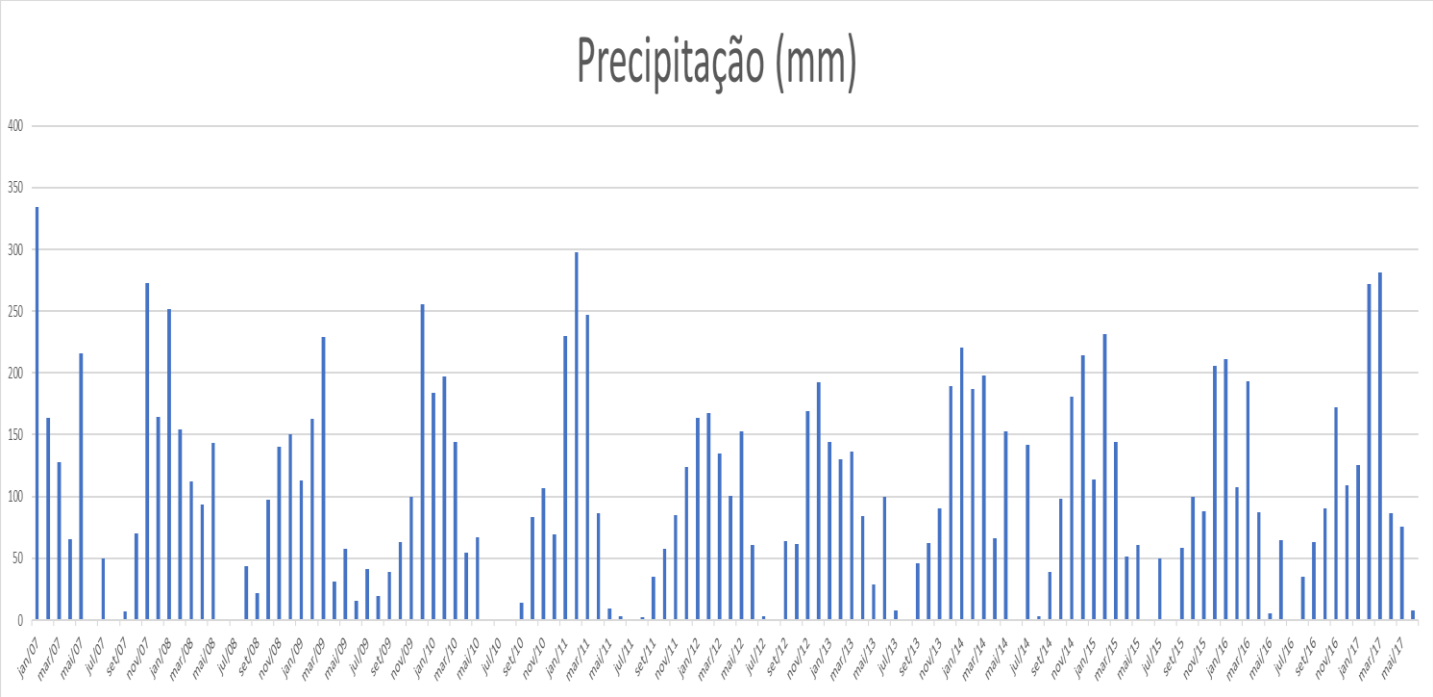
Complementarmente, para efeitos de análise hídrica foram levantadas informação do ciclo hidrológico da microrregião onde apresenta-se o mosaico de unidades de conservação e áreas objeto de interesse.

A partir de um histórico de 10 anos de dados de pluviometria da microrregião do Alto Pantanal pela fonte LAF-INPE, o início do período de seca, em geral, ocorre no início do mês de abril e estende-se até o mês de setembro.

No entanto, a considerar as condições logísticas e de manejo dos animais de produção nesta área, e levando em consideração os riscos no retorno do período de chuvas, e consequente inundação das áreas, o período útil de uso das pastagens naturais é ainda mais reduzido.

O período de menor pluviosidade média é entre junho e agosto.

Os ciclos hidrológicos nos últimos 10 anos (2007-2017) podem ser observados melhor no gráfico abaixo.

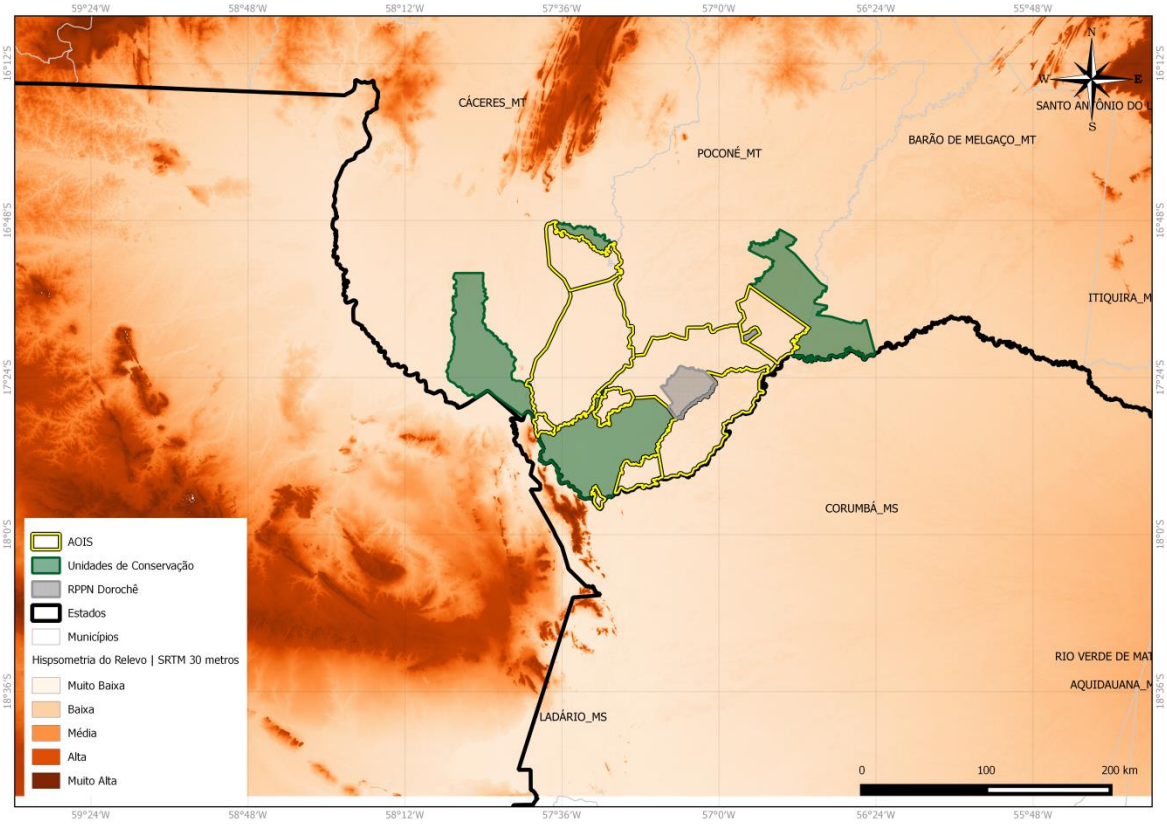


Outra forma de determinar os limitantes quanto à aptidão agrícola da região, foi o estudo das áreas passíveis de inundação.

Parte dessa análise decorre da hipsometria, que determina os diferentes níveis de elevação do terreno por cores.

Essa avaliação proporciona a visualização das diferentes altitudes, e consequentemente, as áreas mais baixas onde apresentam maior concentração de corpos d'água e locais passíveis de inundação.

Figura ilustrativa | HIPSOMETRIA NA REGIÃO DAS AOIs



Como o regime hidrológico da região apresenta características peculiares por se tratar de uma depressão geológica com a maior planície continental alagável do mundo através de períodos de secas e cheias bem definidos, o fator principal para análise de aptidão agrícola é a sujeição à seca.

Logo, no aprofundamento da análise hídrica regional, o fator principal para análise de aptidão agrícola é a sujeição à inundação.

Por meio do processamento de imagens de satélites e uso do modelo de elevação do terreno (SRTM), foi gerada uma série multi-temporal de análise da dinâmica de inundação das AOIs, caracterizando o regime hidrológico na região.

Figura ilustrativa | ÁREAS INUNDADAS POR AOIs (07.JAN.2017)

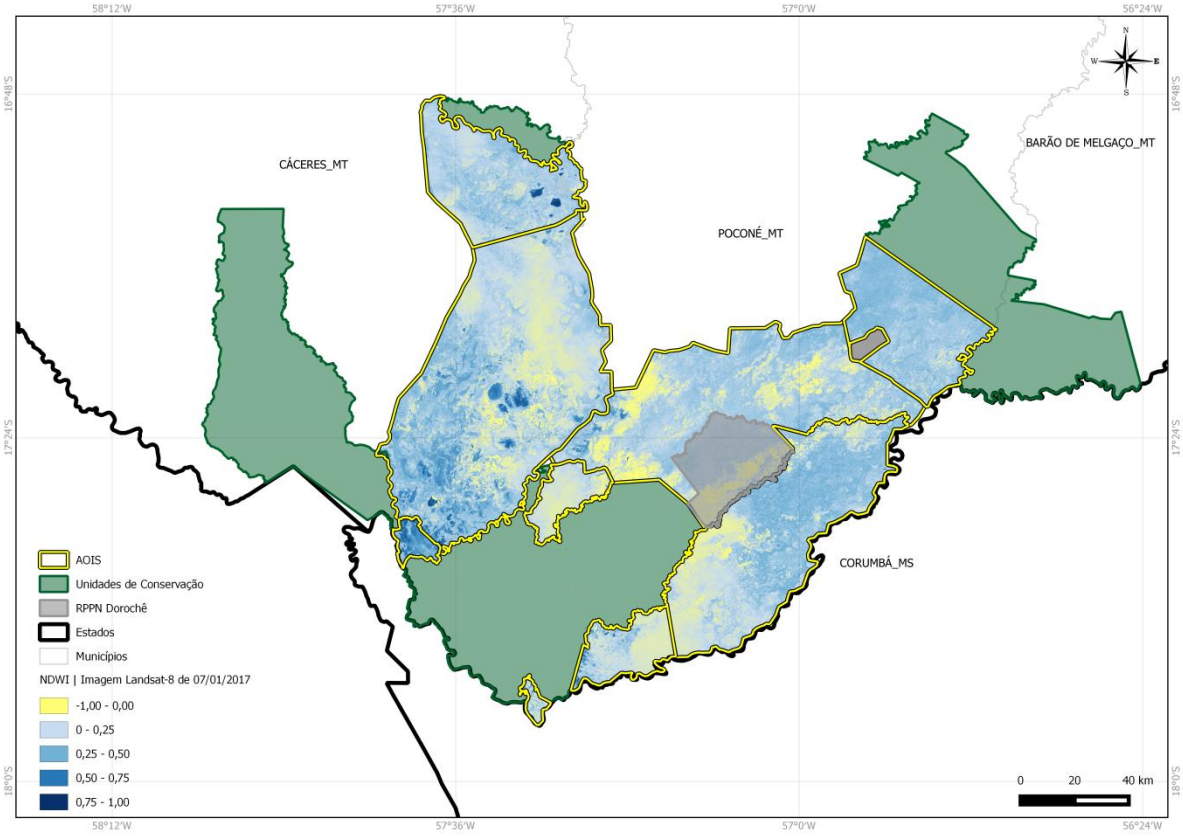


Figura ilustrativa | ÁREAS INUNDADAS POR AOIs (17.MAR.2017)

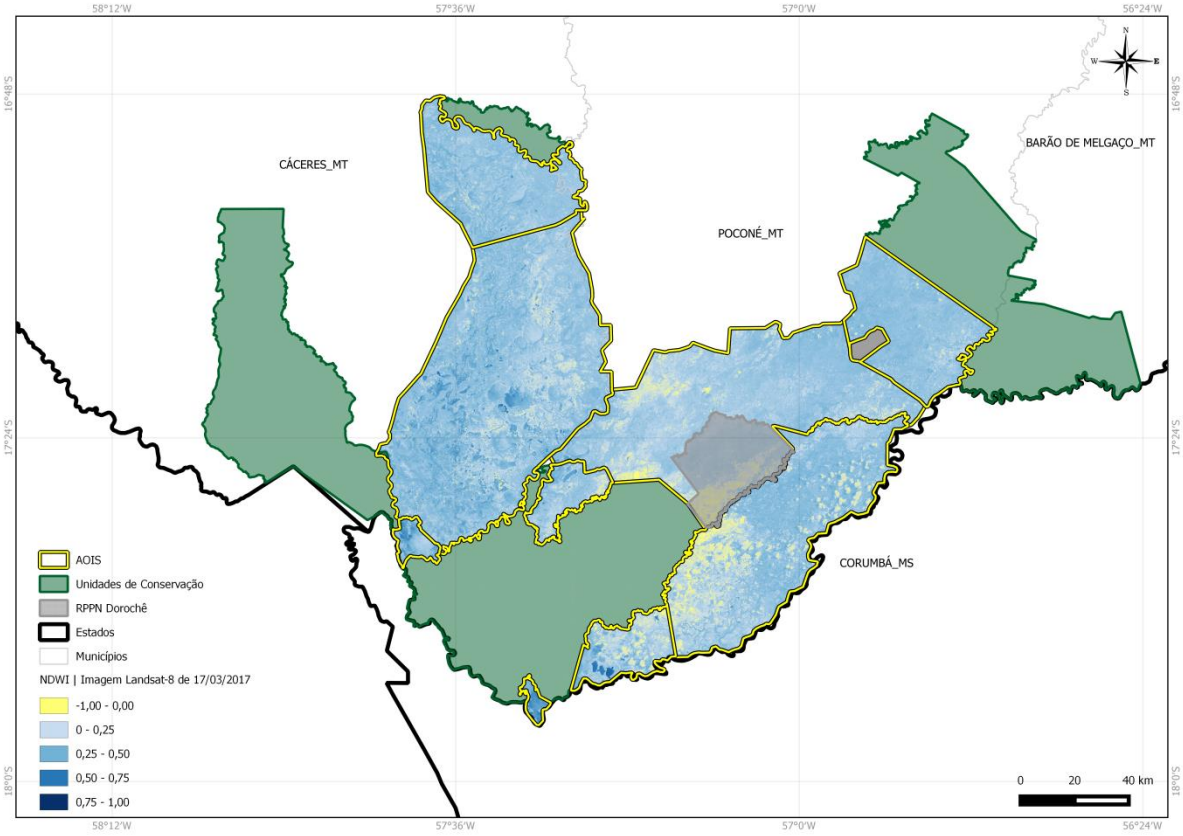


Figura ilustrativa | ÁREAS INUNDADAS POR AOIs (01.MAI.2017)

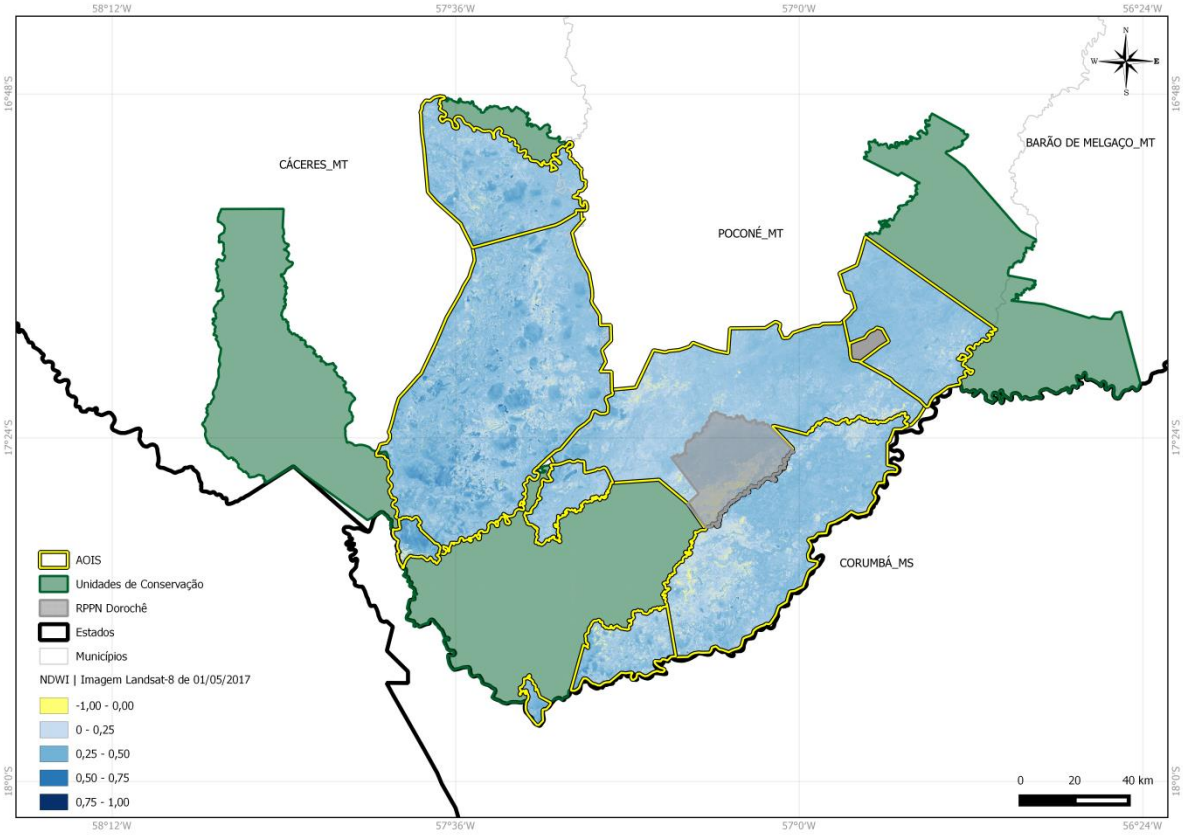


Figura ilustrativa | ÁREAS INUNDADAS POR AOIs (02.JUL.2017)

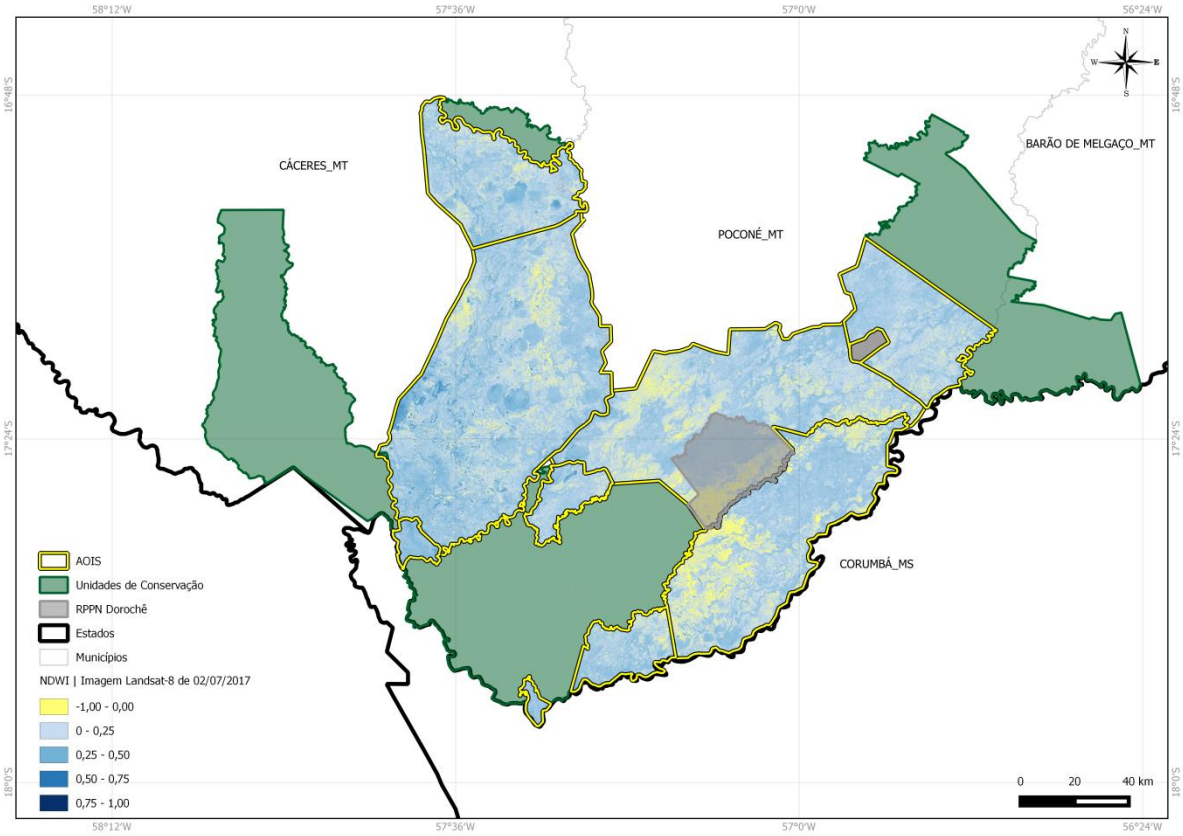


Figura ilustrativa | ÁREAS INUNDADAS POR AOIs (04.SET.2017)

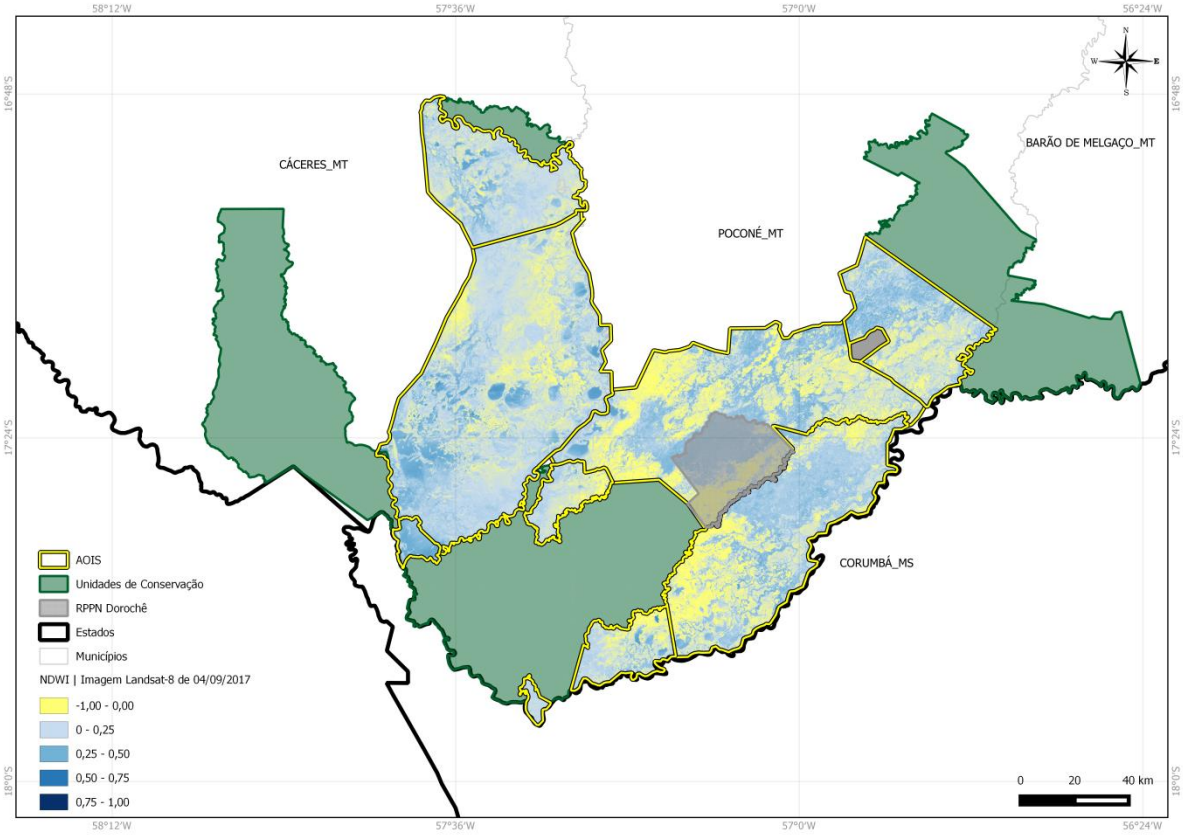


Figura ilustrativa | ÁREAS INUNDADAS POR AOIs (06.OUT.2017)

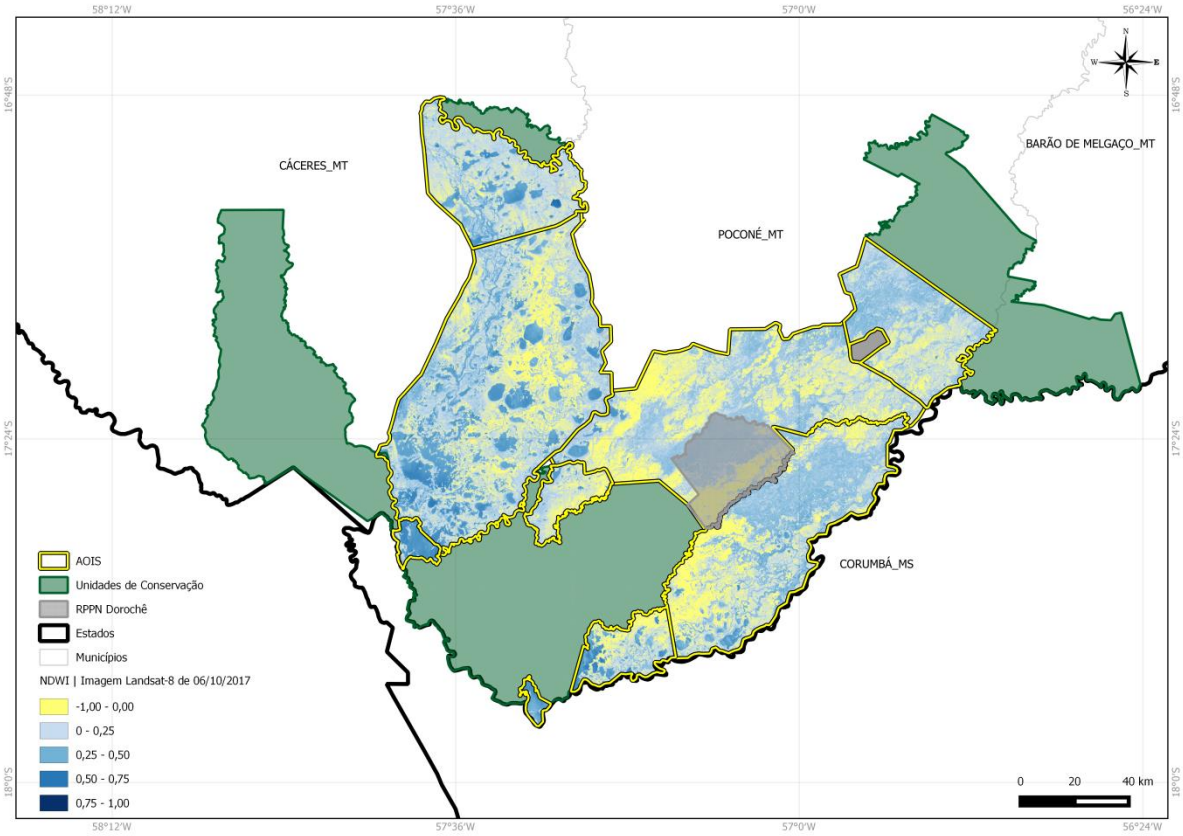


Figura ilustrativa | ÁREAS INUNDADAS POR AOIs (02.MAI.2018)

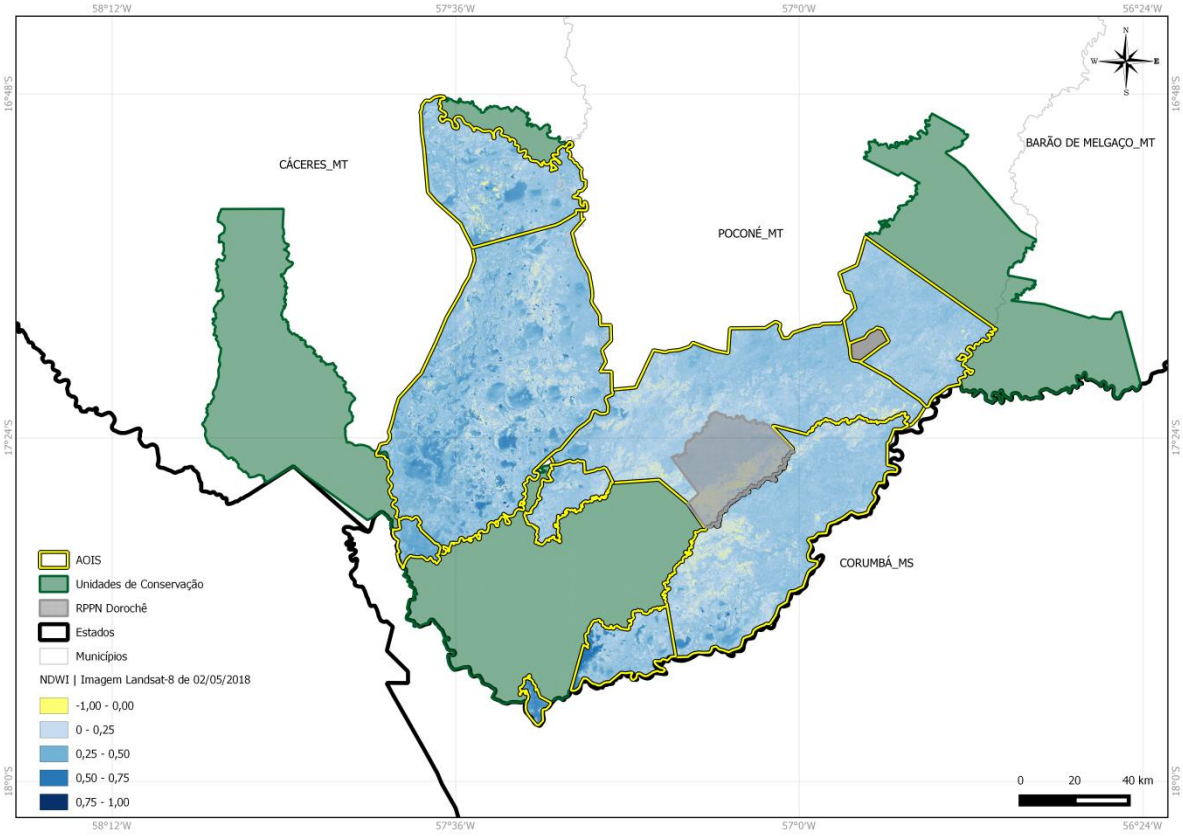


Figura ilustrativa | ÁREAS INUNDADAS POR AOIs (05.JUL.2018)

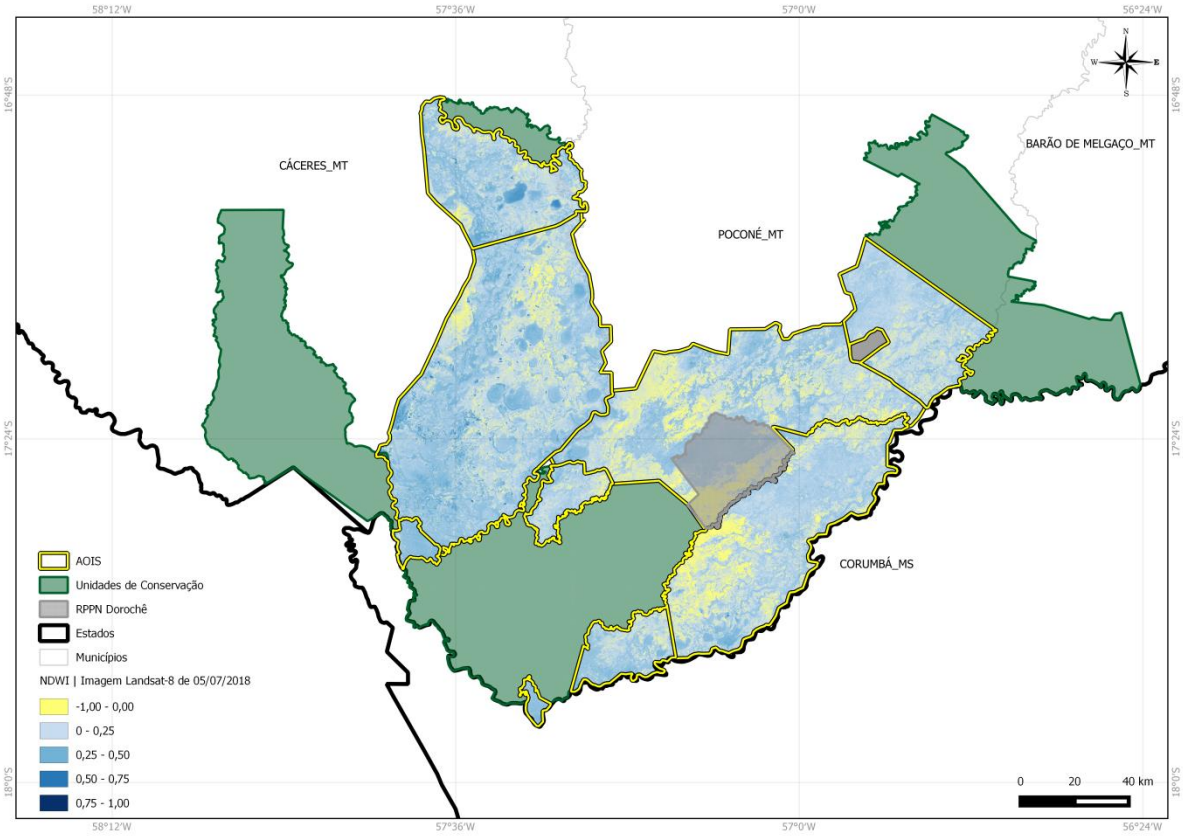


Figura ilustrativa | ÁREAS INUNDADAS POR AOIs (07.SET.2018)

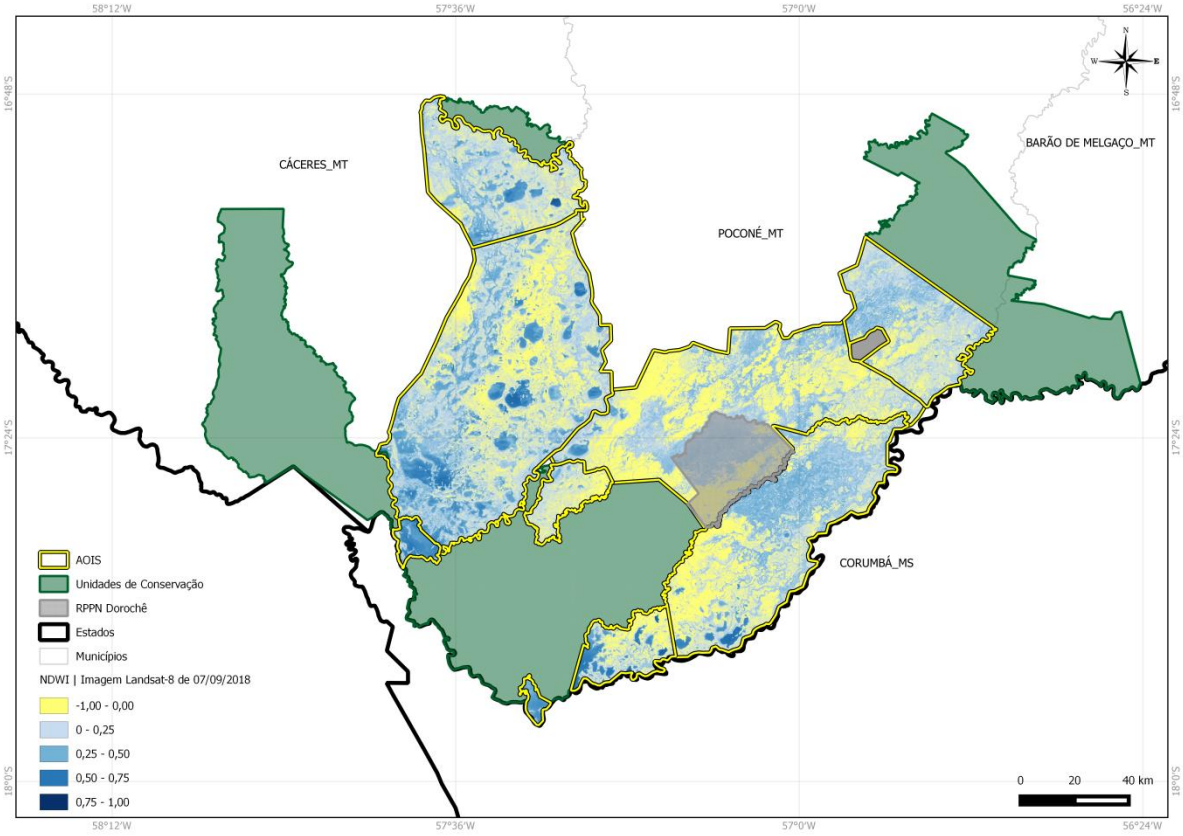
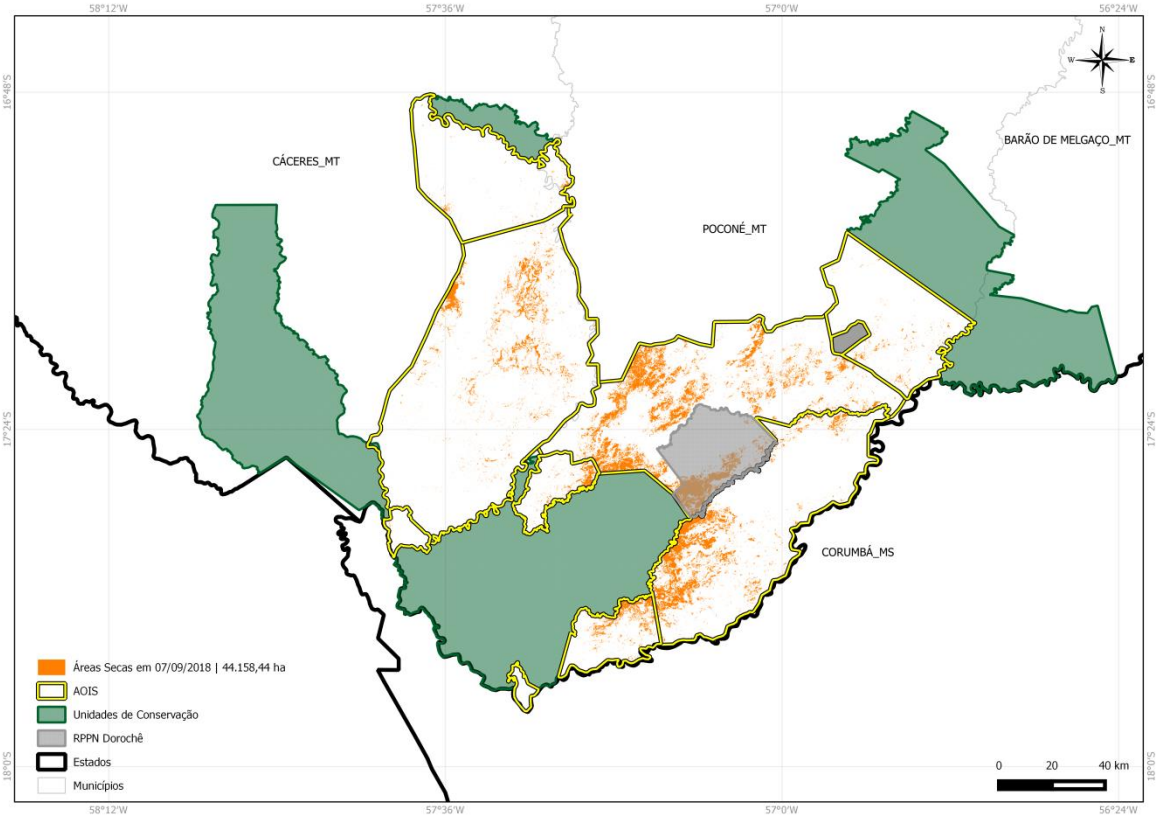


Figura ilustrativa | ÁREAS SECAS NO INTERIOR DAS AOIs (07.SET.2018)



A figura acima evidencia as áreas secas, no mês corrente de elaboração deste estudo, ampliando a percepção quanto a baixa representatividade das referidas áreas secas, e também onde estão mais concentradas, sendo principalmente nas AOIs 3 e 5.

ÁREA CADASTRÁVEL X ÁREA CADASTRADA

Na análise das bases públicas dos limites de propriedades rurais, foram verificados dados do INCRA e do CAR os quais foram cruzados entre si e com suas localizações com as áreas objeto de interesse, gerando informações sobre as sobreposições, quantidade de propriedades encontradas e nível de ocupação atual das AOIs.

Em resumo foram 70 detecções, sendo que 44 destas foram sobreposições ínfimas (menor que 1% e ou 100ha do polígono em questão), as quais foram descartadas nas análises.

Logo, considerando as detecções válidas, temos um total de 26 imóveis rurais, que compreendem uma taxa de ocupação das AOIs de 61%, ou seja, 323.834 hectares.

Sendo a AOI 5, com maior taxa de sobreposição com CAR, ou seja 99 %, e a AOI 4 com a menor taxa, apresentando apenas 9% do seu território com sobreposição por polígonos registrados na base CAR.

Figura ilustrativa | IDENTIFICAÇÃO DOS IMÓVEIS RURAIS CAR SOBREPOSTOS COM AS AOIs

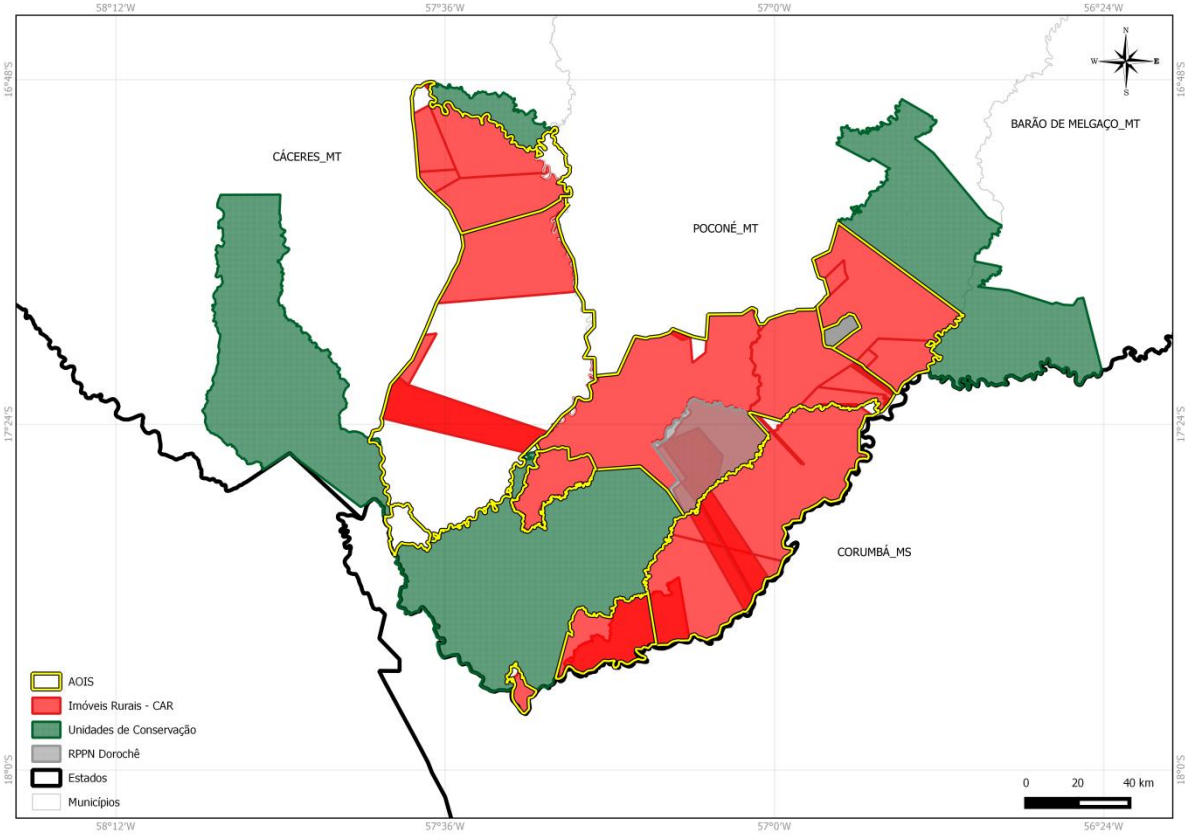


Figura ilustrativa | IDENTIFICAÇÃO DOS IMÓVEIS RURAIS INCRA SOBREPOSTOS COM AS AOIs

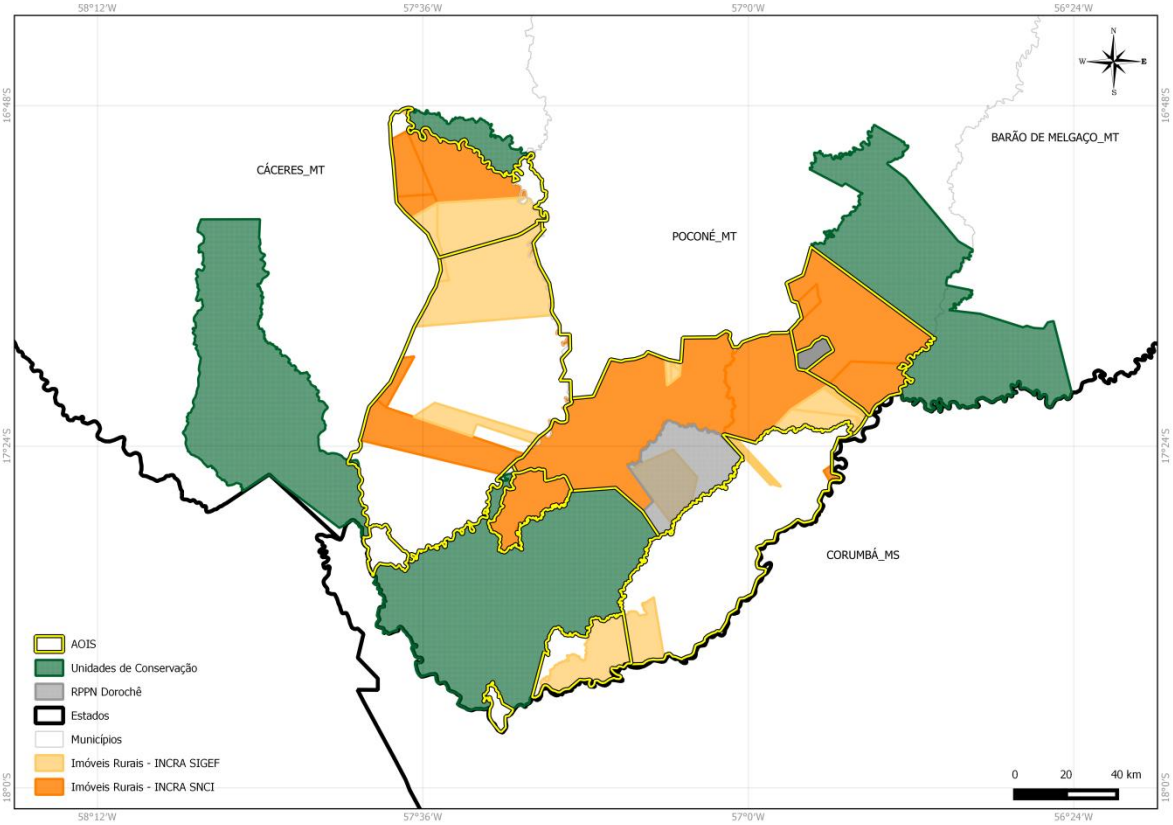
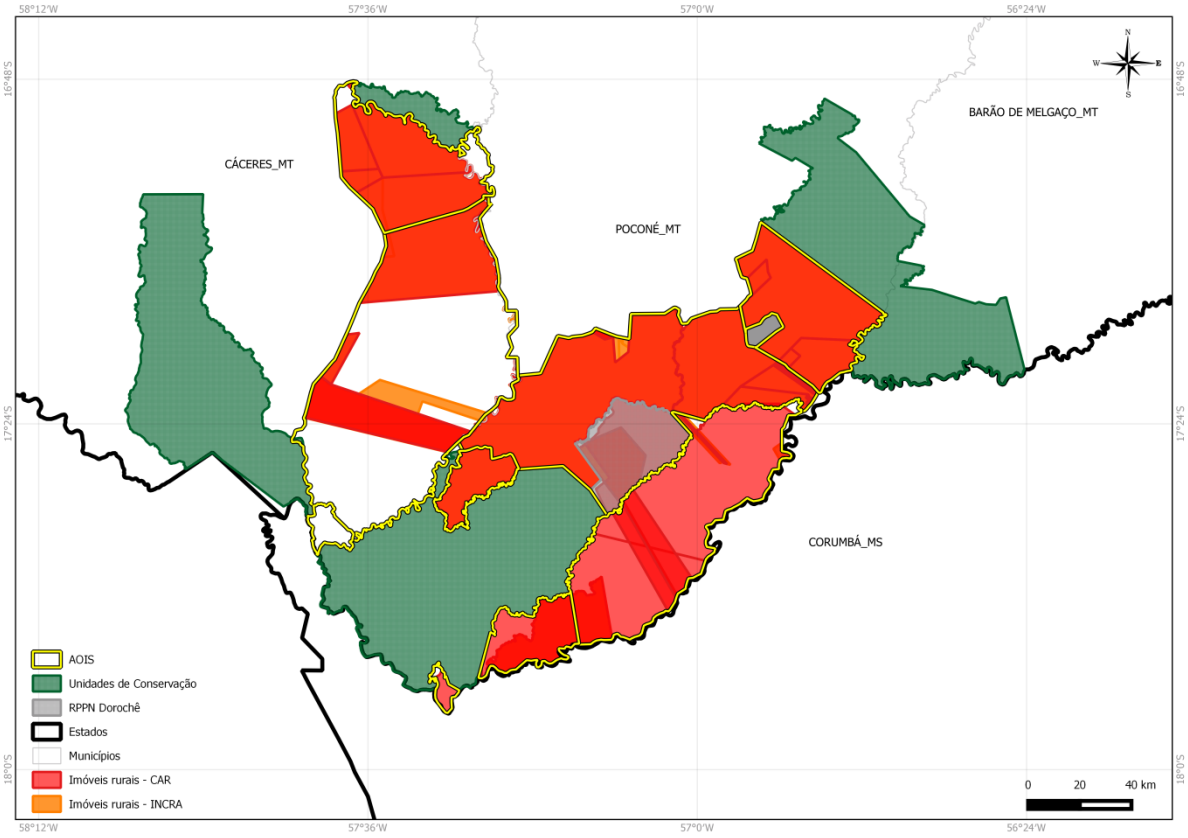


Figura ilustrativa | IDENTIFICAÇÃO DOS IMÓVEIS RURAIS CAR E INCRA SOBREPOSTOS COM AS AOIs



ESTRUTURA FUNDIÁRIA

Por meio da classificação da dimensão e finalidade das propriedades detectadas com sobreposição com as AOIs, permite-se compreender melhor o cenário e perfil das respectivas fazendas e suas influências nas AOIs.

As faixas de classificação

(A) Menor que 4 módulos fiscais (referência do município em questão)
(B) Maior que 4 módulos fiscais até 1.000 hectares
(C) Maior que 1.000 hectares até 3.000 hectares
(D) Maior que 3.000 hectares até 10.000 hectares
(E) Maior que 10.000 hectares

Neste sentido foram preparadas duas tabelas, sendo uma com o objetivo de demonstrar a situação das áreas conhecidas e cadastradas e o grau de desconhecimento de cada AOI, e outra tabela que busca representar a estrutura fundiária desta ocupação conhecida por imóveis rurais.

Tabela demonstrativa | CLASSIFICAÇÃO DOS IMÓVEIS RURAIS SOBREPOSTOS COM AS AOIs

					Area Cadastrada (ha) [CAR+INCRA]		Area com CAR		Area consolidada		Area com INCRA		Sobreposição entre CAR e INCRA		Área desconhecida	
Territórios	Perímetro total (km)	Área Total (Ha)	Municípios	UF	hectares	%	hectares	%	hectares	%	hectares	%	hectares	%	hectares	%
AOI 1 - A: Ampliação da Estação Ecológica Taiamã	138	50,710	Cáceres	MT	45,182	89%	45,146	89%	2,269	4%	45,007	89%	44,984	89%	5,529	11%
AOI 1 - B: Reserva de Fauna do Pantanal	215	165,343	Cáceres	MT	61,148	37%	54,769	33%	-	-	61,076	37%	33,258	20%	104,195	63%
AOI 02 - A: Ampliação do Parque Nacional Pantanal Mato-grossense	80	12,678	Poconé	MT	12,015	95%	11,863	94%	-	-	11,973	94%	11,820	93%	663	5%
AOI 02 - B: Ampliação do Parque Nacional Pantanal Mato-grossense	81	18,452	Poconé	MT	17,997	98%	17,998	98%	-	-	12,708	69%	12,708	69%	455	2%
AOI 02 - C: Ampliação do Parque Nacional Pantanal Mato-grossense	30	2,394	Poconé	MT	1,931	81%	1,931	81%	-	-	-	-	-	-	463	19%
AOI 02 - D: Ampliação do Parque Nacional Pantanal Mato-grossense	37	4,873	Poconé	MT	-	-	-	-	-	-	-	-	-	-	4,873	100%
AOI 03: Refúgio da Vida Silvestre da Onça Pintada	235	131,184	Poconé	MT	129,540	99%	126,696	97%	7,738	6%	112,337	86%	110,463	84%	1,644	1%
AOI 04: Refúgio da Vida Silvestre da Onça Pintada	208	94,421	Poconé	MT	94,183	100%	92,412	98%	878	1%	8,550	9%	8,550	9%	238	0%
AOI 05: Refúgio da Vida Silvestre da Onça Pintada	124	47,527	Poconé	MT	47,207	99%	47,119	99%	0	0%	47,169	99%	47,111	99%	320	1%

Tabela demonstrativa | CLASSIFICAÇÃO DOS IMÓVEIS RURAIS 'CAR' SOBREPOSTOS COM AS AOIs

					CLASSE A			CLASSE B			CLASSE C			CLASSE D			CLASSE E		
Territórios	Perímetro total (km)	Área Total (Ha)	Municípios	UF	Nº total	Área total (ha)	%	Nº total	Área total (ha)	%	Nº total	Área total (ha)	%	Nº total	Área total (ha)	%	Nº total	Área total (ha)	%
AOI 1 - A: Ampliação da Estação Ecológica Taiamã	138	50,710	Cáceres	MT	2	55	0%	2	240	1%	1	2,328	5%	1	6,530	14%	2	36,005	80%
AOI 1 - B: Reserva de Fauna do Pantanal	215	165,343	Cáceres	MT	-	-	-	3	815	1%	1	2,115	3%	-	-	-	3	71,023	96%
AOI 02 - A: Ampliação do Parque Nacional Pantanal Mato-grossense	80	12,678	Poconé	MT	-	-	-	-	-	-	1	1,931	14%	-	-	-	1	11,863	86%
AOI 02 - B: Ampliação do Parque Nacional Pantanal Mato-grossense	81	18,452	Poconé	MT	-	-	-	-	-	-	-	-	-	-	-	-	2	30,656	100%
AOI 02 - C: Ampliação do Parque Nacional Pantanal Mato-grossense	30	2,394	Poconé	MT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AOI 02 - D: Ampliação do Parque Nacional Pantanal Mato-grossense	37	4,873	Poconé	MT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AOI 03: Refúgio da Vida Silvestre da Onça Pintada	235	131,184	Poconé	MT	7	228	0%	7	1,392	1%	-	-	-	3	8,532	6%	4	126,402	93%
AOI 04: Refúgio da Vida Silvestre da Onça Pintada	208	94,421	Poconé	MT	2	16	0%	1	499	0%	-	-	-	3	21,129	19%	2	92,217	81%
AOI 05: Refúgio da Vida Silvestre da Onça Pintada	124	47,527	Poconé	MT	1	0	0%	1	736	2%	1	1,591	3%	1	8,831	19%	1	35,961	76%

Tabela demonstrativa | CLASSIFICAÇÃO DOS IMÓVEIS RURAIS 'INCRA' SOBREPOSTOS COM AS AOIs

					INCRA														
					CLASSE A			CLASSE B			CLASSE C			CLASSE D			CLASSE E		
Territórios	Perímetro total (km)	Área Total (Ha)	Municípios	UF	Nº total	Área total (ha)	%	Nº total	Área total (ha)	%	Nº total	Área total (ha)	%	Nº total	Área total (ha)	%	Nº total	Área total (ha)	%
AOI 1 - A: Ampliação da Estação Ecológica Taiamã	138	50,710	Cáceres	MT	3	171	0%	-	-		2	4,787	11%	1	6,531	15%	2	33,518	74%
AOI 1 - B: Reserva de Fauna do Pantanal	215	165,343	Cáceres	MT	1	2	0%	4	1,488	2%	1	2,115	3%	1	6,266	10%	2	51,204	84%
AOI 02 - A: Ampliação do Parque Nacional Pantanal Mato-grossense	80	12,678	Poconé	MT	-	-	-	-	-	-	-	-	-	-	-	-	1	11,973	100%
AOI 02 - B: Ampliação do Parque Nacional Pantanal Mato-grossense	81	18,452	Poconé	MT	-	-	-	-	-	-	-	-	-	-	-	-	1	12,708	100%
AOI 02 - C: Ampliação do Parque Nacional Pantanal Mato-grossense	30	2,394	Poconé	MT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AOI 02 - D: Ampliação do Parque Nacional Pantanal Mato-grossense	37	4,873	Poconé	MT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AOI 03: Refúgio da Vida Silvestre da Onça Pintada	235	131,184	Poconé	MT	5	269	0%	8	1,577	1%	-	-	-	2	8,532	8%	3	101,959	91%
AOI 04: Refúgio da Vida Silvestre da Onça Pintada	208	94,421	Poconé	MT	3	7	0%	4	1,888	22%	-	-	-	1	6,655	78%	-	-	-
AOI 05: Refúgio da Vida Silvestre da Onça Pintada	124	47,527	Poconé	MT	3	51	0%	-	-	-	-	-	-	-	-	-	2	47,118	100%

ANÁLISE SOBRE O USO DAS ÁREAS COM REBANHO BOVINO

O último elemento de análise relevante para avaliar a dinâmica socio-econômica e natural da região é a distribuição do rebanho.

A pecuária representa grande parte da economia local, justamente por ser uma região com geografia propícia para essa atividade e por ter amplas áreas de pastagem natural. Esta foi uma atividade pioneira da região, permitindo a ocupação populacional adaptada ao ciclo das águas.

Os rebanhos presentes estão presentes em pastagens nativas apresentando convivência harmônica com a biodiversidade local, viabilizando a exploração turística e evitando a degradação pela ocupação temporária para outras atividades econômicas.

A classes pastagem natural, derivada do uso do solo do IBGE, foi considerada como a área de pastagem dos municípios (Poconé e Cáceres) e o dado de rebanho é oriundo do IBGE, para o ano de 2016 (mais atual no SIDRA).

As áreas de pastagem do município foram consideradas como se estivesse 100% do rebanho e a área sobreposta com a AOI teve cabeças de gado distribuídas proporcionalmente.

O resultado dessa análise está tanto na tabela abaixo quanto nos mapas de sobreposição.

Tabela demonstrativa | ESTIMATIVA DO POTENCIAL DE BOVINOS NAS AOIs

Estimativa de Lotação	CÁCERES	POCONÉ
Área de Pastagem (há)	1,319,036	1,145,984
Rebanho Total (cab)	1,113,134	505,084
Lotação (cab/há)	0.84	0.44

Estimativa de Lotação	Área de Pastagem Natural (há)	Rebanho Potencial estimado (cab)
AOI1-A	3,284	2,771
AOI1-B	3,537	2,985
AOI2-A	-	0
AOI2-B	-	0
AOI2-C	-	0
AOI2-D	-	0
AOI3	40,791	17,978
AOI4	7,498	3,305
AOI5	28,108	12,388
Totais	83,218	39,428

Outra análise complementar realizada, foi a identificação geográfica de áreas com alguma presença de benfeitoria pecuária, tais como currais, estabelecimentos, portos fluviais entre outras estruturas construídas com a finalidade de assessorar a atividade pecuária local. Na figura abaixo pode-se visualizar a concentração destas estruturas ao longo de algumas AOIs.

Figura ilustrativa | CONCENTRAÇÃO DE BENFEITORIA PECUÁRIA NAS AOIs

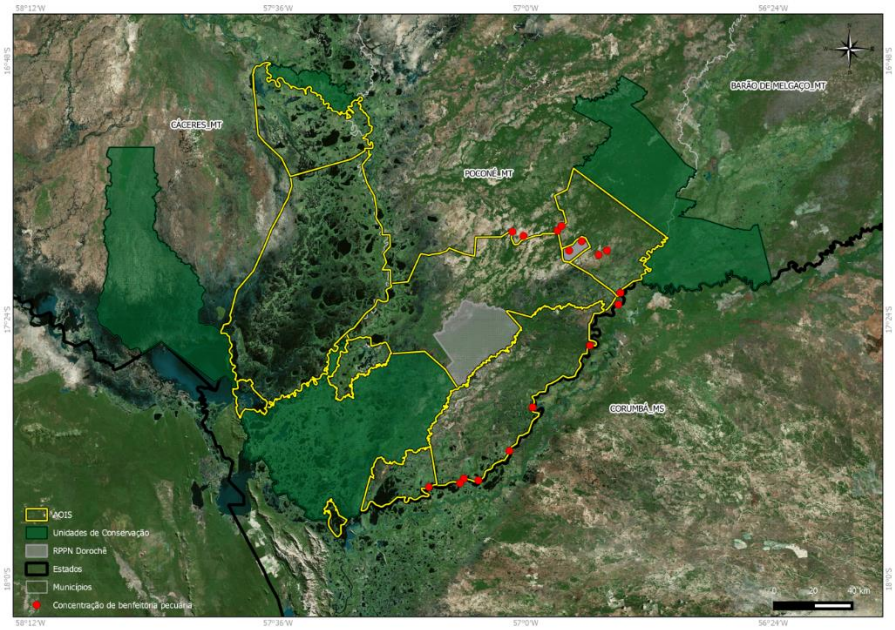


Figura ilustrativa | CONCENTRAÇÃO DE BENFEITORIA PECUÁRIA NAS AOIs (mapa de calor)

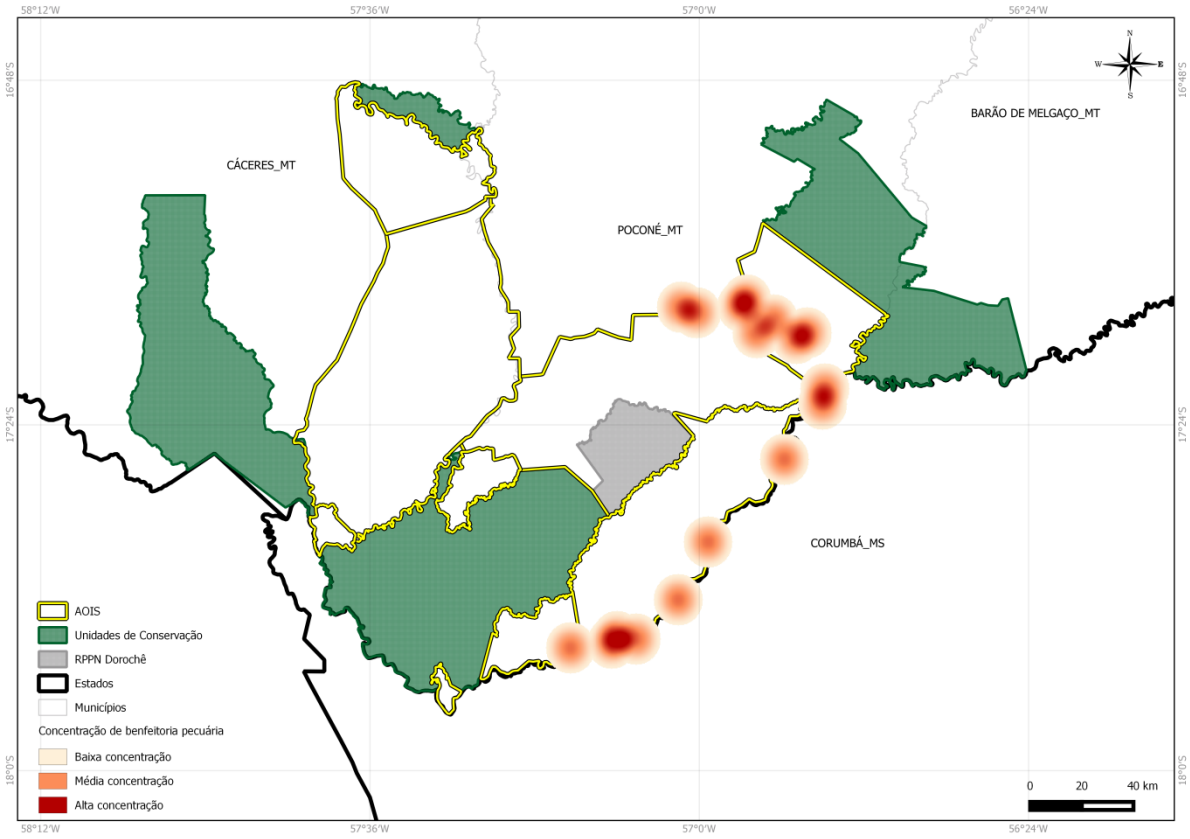
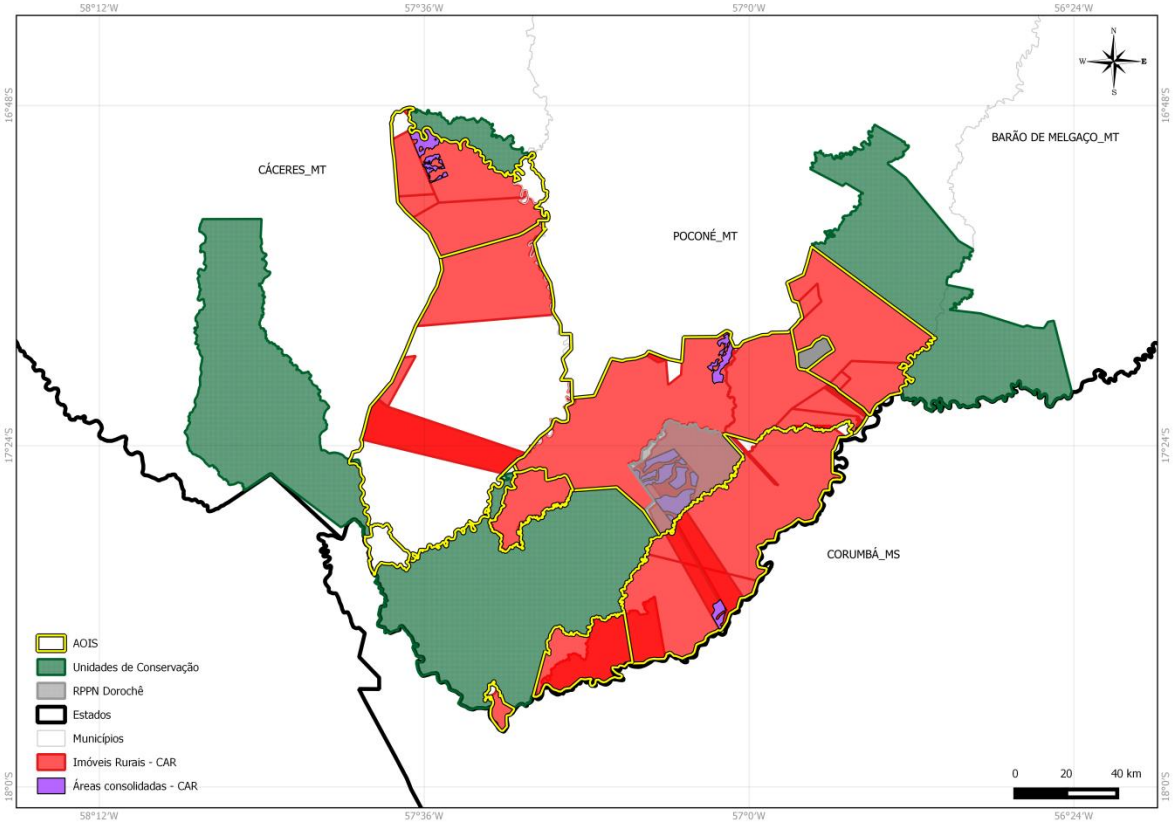
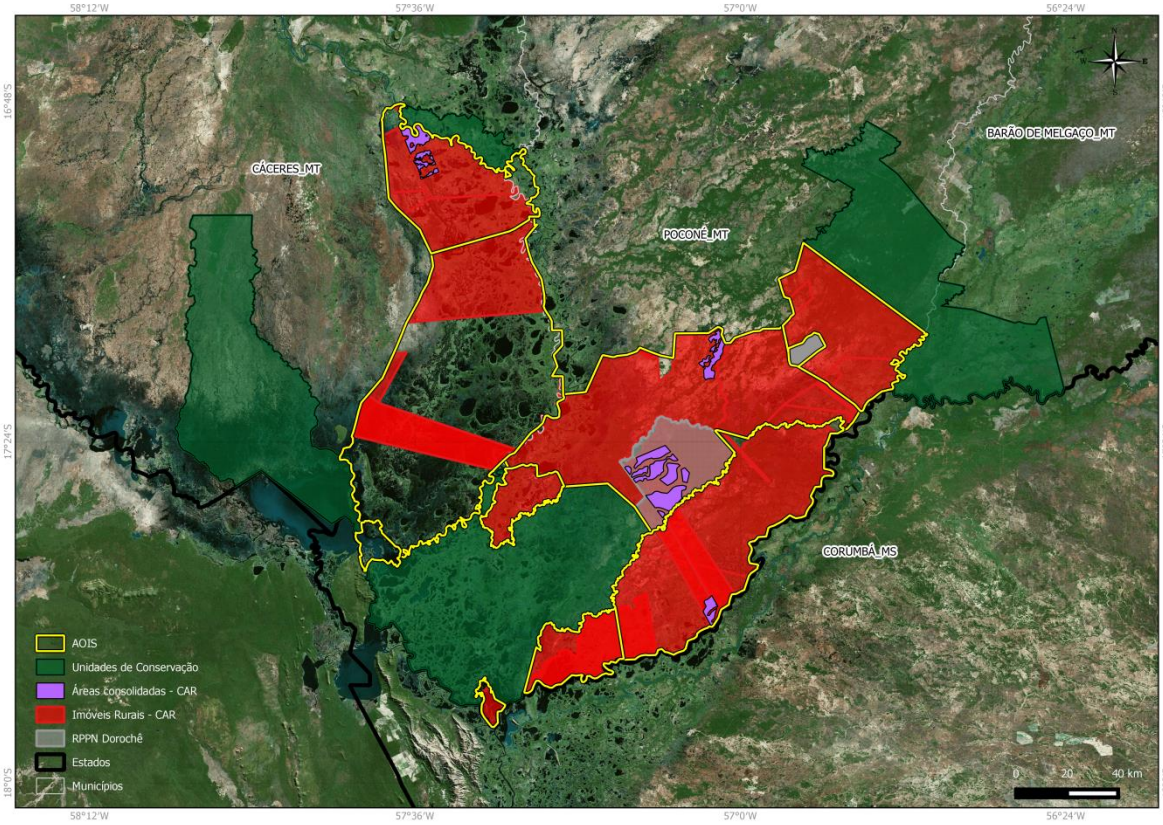


Figura ilustrativa | DISTRIBUIÇÃO ÁREAS CONSOLIDADAS NO CAR POR AOI





As figuras acima demonstram que praticamente todas as áreas compreendidas pela proposta de ampliação do Mosaico de UCs, estão com registro no CAR, com exceção da AOI 1 – B, que têm sua maior porção de terras não cadastrada na base CAR.

No entanto, o fato dos próprios cadastrantes (proprietários na sua maioria) não terem registrado área de uso consolidada, demonstra que as áreas, muito provavelmente, não estão sendo exploradas economicamente. Pode-se perceber pela cor roxa no mapa, que há pouca área de uso consolidado registrado, sendo que a maior parte está dentro da RPPN Doroché.

CONCLUSÃO

O estudo realizado para a região do Pantanal Norte, concentrou-se em uma área denominada de Mosaico das UCs, mais especificamente para um conjunto de 5 áreas denominadas de AOIs (Áreas Objeto de Interesse) com o objetivo principal de qualificar estas AOIs quanto ao seu potencial em desempenhar as funções de conexão entre 4 (quatro) UCs existentes e servir como massa crítica para sustentar a ampliação deste conjunto de UCs, de modo a consolidar uma área única e interligada, com mais de 800.000 hectares.

O olhar lançado neste estudo foi estritamente técnico, e teve como foco principal, o processamento de grandes volumes de dados geográficos e espaciais, visando reunir em uma única base de dados, as informações mais relevantes na caracterização destas AOIs.

O alcance das análises permitiu chegar a algumas conclusões interessantes, as quais podem servir como uma boa ferramenta e embasamento para processos decisórios no âmbito do referido mosaico.

Neste sentido, podemos destacar os pontos abaixo, como aqueles de maior importância:

1. O território tem baixa aptidão agrícola em toda sua extensão.
2. O território tem topografia plana com dinâmica de inundação cíclica.
3. O território tem poucos indícios de antropização.
4. O território encontra-se predominantemente registrado no CAR.
5. Os registros do CAR praticamente não declaram áreas de uso consolidado.
6. As áreas aproveitáveis nas secas são esparsas e residuais.
7. As estimativas de rebanho neste território são pouco significativas.
8. A ocupação humana é pouco populosa e principal sazonal por ribeirinhos.
9. Os acessos são limitados e principalmente fluviais.
10. Possui alta importância ambiental pelo seu grau de preservação e posicionamento estratégico na conexão do conjunto das 5 (cinco) UCs estudadas.

Em complemento a este cenário constatado, a tabela a seguir demonstra que quase em sua totalidade as AOIs estão mapeadas e classificadas como área prioritárias de conservação, conforme levantamento realizado pelo MMA (Ministério do Meio Ambiente).

AOI	Município Relacionado	Area Total (há)	ALTA (há)	MUITO ALTA (há)	EXTREMAMENTE ALTA (há)	Areas Prioritarias MMA (Total)	% Area Total
AOI 01 - A	Cáceres	50,710	25,297	498	22,139	47,933	95%
AOI 01 - B	Cáceres	165,343	164,472			164,472	99%
AOI 02 - A	Poconé	12,678	12,350			12,350	97%
AOI 02 - B	Poconé	18,452			18,249	18,249	99%
AOI 02 - C	Poconé	2,394			2,277	2,277	95%
AOI 02 - D	Poconé	4,873	4,849			4,849	99%
AOI 03	Poconé	131,184	75,502	55,768	1	131,271	100%
AOI 04	Poconé	94,421	328	44,674	49,405	94,407	100%
AOI 05	Poconé	47,527	9,613	37,489		47,102	99%

ENCERRAMENTO

Concluímos desta forma este relatório e esperamos ter correspondido a confiança em nós depositada, colocamo-nos ao inteiro dispor para quaisquer outros esclarecimentos.

Equipe AGT

Nestes termos,

São Paulo 26 de Setembro de 2018

Agrotools Gestão e Monitoramento GeoEspacial de Riscos Ltda.

CNPJ 08.808.179/0001-10

FONTE DE DADOS UTILIZADOS NO ESTUDO

Fonte dos dados socioeconomicos:

IBGE, Censo Agropecuário 2017 - Resultados preliminares. Disponível em: <https://censos.ibge.gov.br/agro/2017/>

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