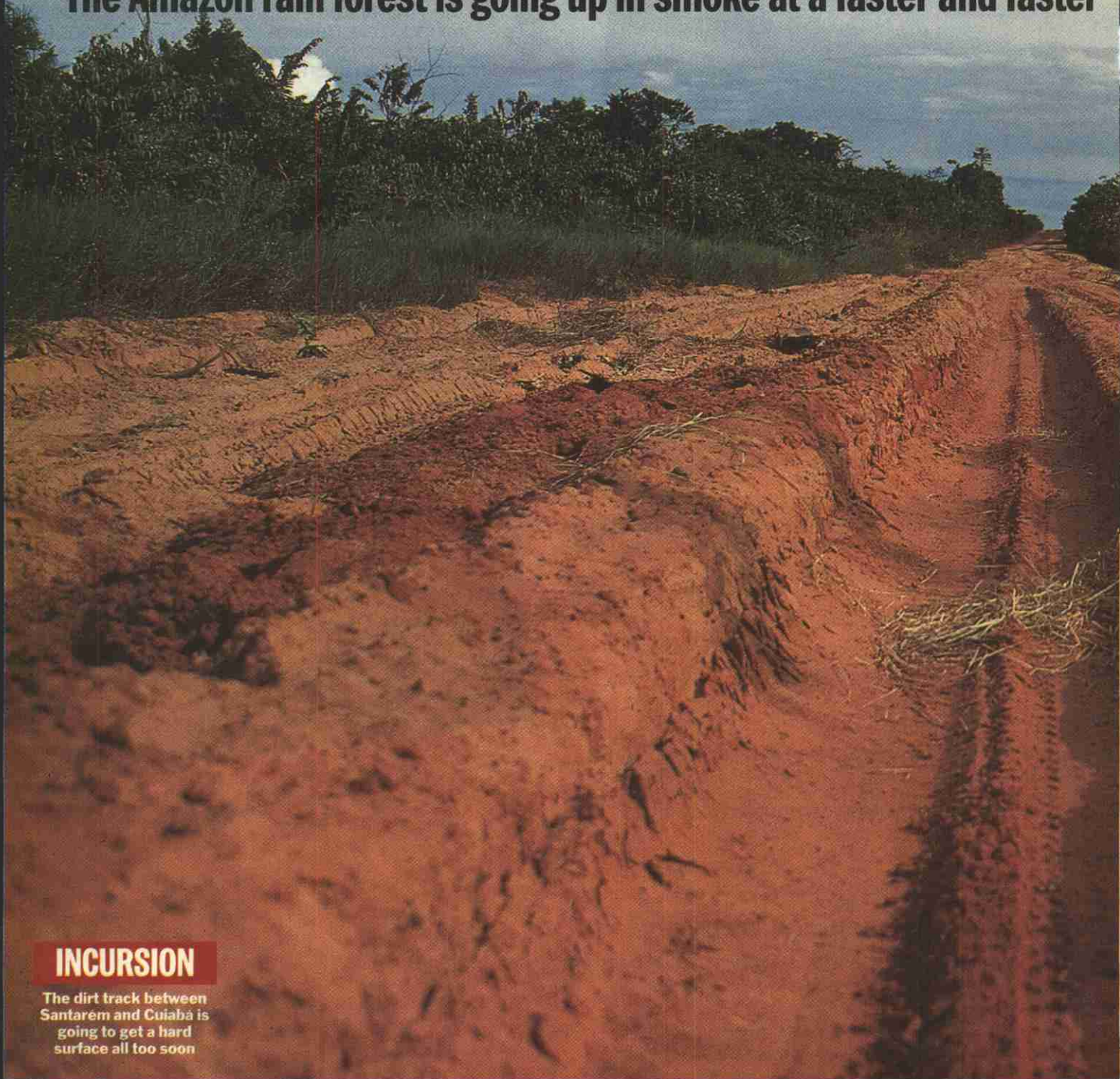


The Road t

The Amazon rain forest is going up in smoke at a faster and faster



INCURSION

The dirt track between Santarém and Cuiabá is going to get a hard surface all too soon

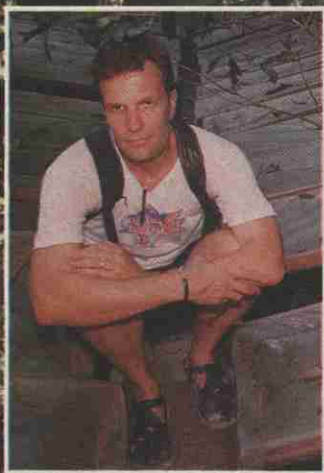
0 Disaster

rate, and the paving of a highway underlines why

By EUGENE LINDEN SANTAREM

MY DESTINATION WAS A tiny area in the midst of the Amazon basin, a few hectares of land in the middle of a preserve called the Tapajós National Forest, 67 km south of Santarém in the Brazilian state of Pará. After a tooth-loosening ride along a cratered, flooded jungle road and a short but slippery hike into the 25-year-old preserve, I finally got to my goal—a surreal scene in the heart of the rain forest. As far as the eye could see, transparent plastic tents covered the forest floor, which was crisscrossed by a complicated network of trenches and pits. I lowered myself to the bottom of one

ENVIRONMENT



EXPERIMENT

Seeking to mimic drought conditions in the Amazon, Dan Nepstad covered the ground with water-repelling plastic

of the holes and discovered that despite the intermittent downpours that sweep the region, the earth was relatively dry. The plastic tarps and the trenches were designed to carry almost all rainfall out of this patch of forest. As a result—and according to plan—the Brazil nut, tropical cedar and other great trees of the affected zone were beginning to suffer from thirst, even as rainwater doused the leafy forest canopy.

This deliberate tree murder—call it selvicide—was the very purpose of the Christo-like covering of the rain-forest floor. The eerie area was the center of a \$700,000, U.S.- and Brazil-financed experiment to slowly starve a patch of rain forest of life-sustaining moisture and see what happens as a result. The seemingly sadistic effort was a controlled version of what biologists fear happens periodically all across the Amazon, the precursor of a disaster that could be only a few years, or even months, away.

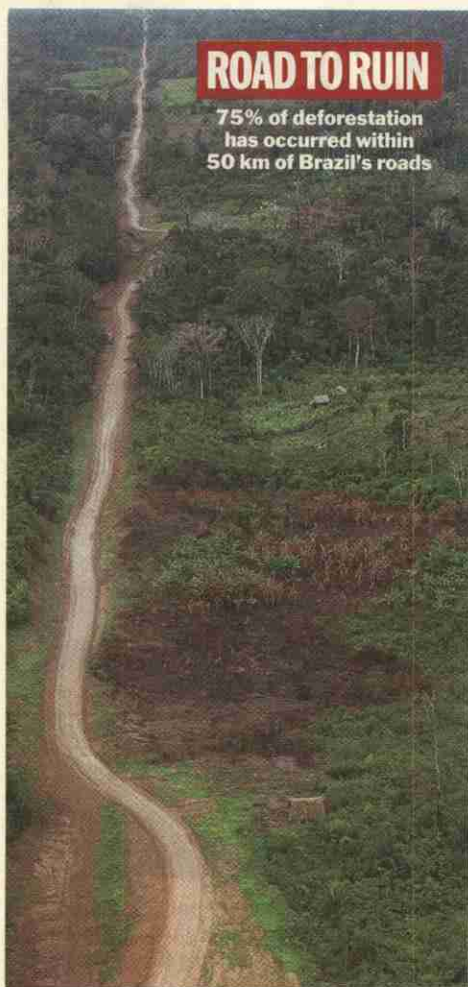
The man behind the bizarre experiment is Daniel Nepstad, 42, a personable and laconic American ecologist who divides his time between the Woods Hole Research

Center in Massachusetts and the Amazon Institute for Environmental Research (IPAM), based in Belém, near the mouth of the Amazon. The 16th century philosopher Francis Bacon wrote that nature best reveals her secrets when tormented; Nepstad is doing just that to help save 150 million hectares—an area three times the size of France—that are in imminent danger of destruction by firestorms that would dwarf anything ever seen before. “For the first time,” says Nepstad, “we can see the ingredients for the beginning of the end of the Amazon.”

THERE IS PLENTY OF EVIDENCE to support Nepstad’s concern. Almost every year, more and more of the rain forest is going up in smoke. In 1998, in the wake of the weather shifts brought on by El Niño’s warming the Pacific waters off South America, some 40,000 sq km of the Brazilian Amazon was scorched. Smoke-related ailments killed 700 people, put more than 10,000 in the hospital, according to IPAM,

and afflicted tens of thousands of others who did not show up in official statistics. The following year, when Brazilian President Fernando Henrique Cardoso tried to become the first chief executive in 30 years to visit the northwestern state of Acre, the forest was burning again. Cardoso was forced to cancel his trip. Now Nepstad estimates that fully one-third of the remaining dense forest in the Brazilian Amazon will be vulnerable in the near future. The deforested area could grow big enough to swallow Alaska and California combined. And soon: during the past two decades, El Niños, which set the stage for fires, seem to have become stronger, more frequent and longer lasting. If this pattern holds, the next powerful El Niño is not far in the future.

The dry soil at the bottom of the Tapajós pit is one clue to the nature of this potential catastrophe. Rain-forest trees suck moisture from as deep as 18 m beneath the fragile surface of the land. During periodic droughts, such as occurred during 1998’s El Niño, vegetation can rapidly deplete this groundwater, desiccating trees



ROAD TO RUIN

75% of deforestation has occurred within 50 km of Brazil's roads

THE FLAMMABLE FOREST

Vast areas of the Amazon, especially those near highways, are highly vulnerable to fire



and turning them into potential torches.

El Niño provides the tinder, but humans provide the match. Human penetration of the Amazon, rather than lightning or other natural phenomena, sparks most of the huge fires, and that penetration is increasing, along with deforestation and slash-and-burn agriculture. Fire, deforestation and roads are linked in an unholy trinity. In 1998, Brazilian authorities found themselves battling enormous fires in the states of Pará (where 40% of the southeastern forests burned), Roraima and Mato Grosso. Most blazes started near roads as settlers burned accessible forest to clear land for farms. The only reason even bigger stretches of the dense forest around Tapajós did not go up in flames is that no paved roads penetrate the most vulnerable areas. But they are coming.

Around the world, scientists have found that roads are the single best (but not infallible) predictor of tropical deforestation. In the Brazilian Amazon, roughly 75% of the deforestation that has taken place has occurred within 50 km of a paved road. In the

26 years after the 1965 paving of the slender highway between the Amazon city of Belém and Brasília, 58% of the forests disappeared in a 100-km swath on either side of the road. The paving of 1,460 km of highway BR-364 between the city of Cuiabá in Mato Grosso and Porto Velho in Rondônia caused the disappearance of a third of the forest bordering the highway in just 15 years.

And now the highway menace is coming to this part of Pará. Brazil's ministries of planning and transportation have ignored or forgotten the trauma of 1998 and, without consulting the federal Ministry of Environment, have approved paving the last dirt stretch of BR-163, which runs 1,741 km north and east from Campo Grande in Mato Grosso do Sul to the city of Santarém in Pará. The 700-km unpaved section runs directly past Tapajós National Forest and on through millions of hectares of the most vulnerable parts of the rain forest. Says Nepstad: "Brazilian scientists call this area the 'corridor of drought,' and it becomes kindling when El Niño roars through."

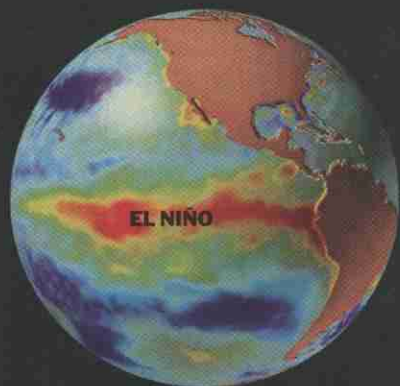
The unpaved stretch takes six days to

drive in the rainy season. It would require less than a day on an all-weather surface. The decision to pave the highway is largely the product of vigorous lobbying by giant agribusinesses, which see the route as a more profitable way to export soybeans. (After the U.S., Brazil is the world's largest exporter of the crop.) A Brazilian-American consortium is planning to build an enormous dock-and-loading system in Santarém, the sleepy port that lies at the junction of the Tapajós and Amazon rivers, 700 km from the Atlantic Ocean. Exporting through Santarém might save agribusinesses \$1 per 30-kg bag of soybeans.

Nepstad argues that the costs to the forest will far offset those gains. More settlers will flood in, and fires will follow the settlers. Moreover, fire begets fire in the Amazon. Dead trees provide the fuel for successive burnings, and cleared areas are often 12°C hotter than the rain-forest floor, which has a leafy canopy that blocks and absorbs as much as 99% of incoming sunlight.

Indeed, if paving BR-163 goes ahead, the soybean exporters could become vic-

EL NIÑO'S EFFECTS



1. WIND REVERSAL

First, winds that usually push warm air from the coast of South America west to Australia weaken or even reverse

2. CONVECTION CURRENTS

Convection currents form that push warm air from the seas off Chile and Peru into northeastern South America

3. RAIN DISPELLED

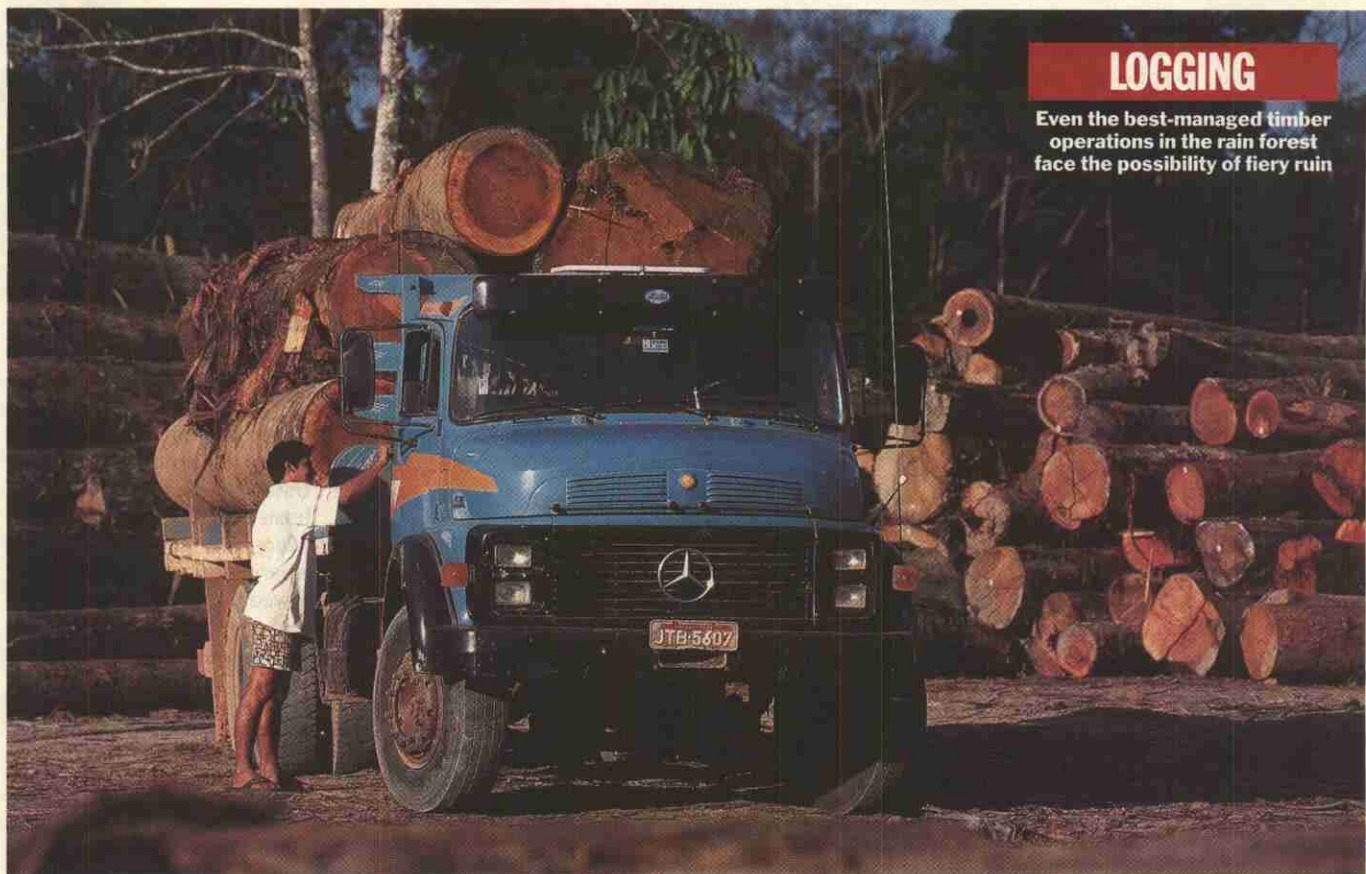
This dynamic replaces the hot, wet air that would usually be rising off the Amazon and then cooling and falling as rain, causing drought instead

tims of their development plans by helping produce a drought. Through evaporation, the forest recycles 7 trillion tons of water annually from the ground back into the atmosphere—as much as 50% of all the moisture it receives from rainfall. A good portion of that water vapor is carried by air currents that bounce off the Andes and head southward to drop rain on farming regions in the southern states of Mato Grosso and Goiás, both part of Brazil's breadbasket. In other words, no Amazon forest in Brazil's north, no rain in the south. The possibility of calamity threatens far more than isolated trees.

Scientists have long studied the horrendous impact that fire has on the rain forest. Alberto Setzer of the Brazilian space agency, INPE, shocked the world when he used satellite imagery to show the extent of the burning in 1988. Out-of-control burning first brought me to Brazil in 1989 when I wrote the cover story for the Sept. 18 issue of TIME called "Torching the Amazon." I have made several trips to parts of this giant ecosystem in neighboring countries since then, but this was my first trip back to the Brazilian Amazon, and there was, amid the rising cause for concern, some good news to report.

DRY-OUT

Trees drowned by the Samuel Dam in the '80s are now fodder for flame



LOGGING

Even the best-managed timber operations in the rain forest face the possibility of fiery ruin

A decade ago, for instance, few people would have predicted that in the year 2000, the huge state of Amazonas, next door to Pará, would be the least deforested region in the ecosystem—especially since in earlier administrations the Governor, Amazonino Mendes, had offered to hand out chain saws to anyone wanting one, in order to spur land clearing. (In recent years, Mendes has adopted a slightly softer approach toward the forest.) Manaus, the capital of Amazonas, has grown rapidly in wealth and size in the past 10 years, but without massive tree cutting in surrounding areas. Local soils are notoriously bad, for one thing, which discourages agriculture, and besides, most immigrants can make more money in town.

There has also been a remarkable turnaround in Brazilian public opinion about the rain forest. In 1989, then President José Sarney was defensive and defiant about criticism of Brazil's failure to protect the Amazon; last June, by contrast, an outpouring of popular protest forced the Brazilian Congress to drop a plan to reduce from 80% to 50% the amount of forest to be set aside as nature preserves in future Amazonian development projects. Among the most vocal opponents of the rollback was José Rapley Filho, the federal Envi-

ronment Minister and son of the pro-development former President. In Acre, the frontier state where environmental martyr Chico Mendes was assassinated in 1988 by ranchers angered by his efforts to halt deforestation, change is more drastic. The current Governor, Jorge Viana, was elected in 1988 in an explicitly environmentalist campaign. He has since shelved plans from the previous administration to pave 2,000 km of roads in the state. (Viana was chosen by TIME in 1999 as one of its regional Leaders for the New Millennium.)

BUT SOME NIGHTMARES THREATENING the rain forest have grown worse. While Brazil's Congress has eliminated some subsidies that promoted indiscriminate cattle ranching and forest clearing and passed laws prohibiting new settlements in virgin forests, it has turned a blind eye to other forms of destruction. Politicians have encouraged some of the 10 million landless poor to migrate into the interior, torching forest as they go. Settlers persist in using fire to clear land for their subsistence farms because it is cheap and easy.

But the rain forest is not good agricul-

tural land, to put it mildly: the very nature of the ecosystem is to recycle organic matter without enriching the underlying soil. Once cleared, the acidic dirt of the forest floor is exhausted after a few harvests. That in turn causes peasant farmers to keep moving and sell their barren holdings to cattle ranchers looking to buy cleared land on the cheap. So the devastation continues to creep forward. All over the Amazon, I saw vast areas of degraded land where before there was a virtually unbroken expanse of trees. In all, the Amazon contains some 550,000 sq km of deforested land, one-third of which has been abandoned.

Human attempts to remold the land for agriculture on a grand scale have also failed. In 1989 I flew over the catchment area for the Samuel Dam, a hydroelectric project just outside Porto Velho in Rondônia. The land there is so flat that the newly built dam flooded 46,500 hectares of forest, leaving behind a wilderness of dead trees sticking out of shallow water and a vast breeding ground for mosquitoes. The dead trees and mosquitoes were still there when I flew over the area again. But now the talk in Porto Velho is that the dam is silting up and its water supply is diminishing—as was predicted by critics when it

ENVIRONMENT

was built. If this continues, the dammed lake could become a fire hazard.

Each year, despite all strategies to curb the fires, more and more of the Amazon has burned. During and after the 1998 El Niño disaster, Nepstad discovered that the damage was far greater than initially estimated. Even where the forest canopy remained unscathed, ground-hugging fires burned thousands of square kilometers of vegetation beneath the treetops. This burning, invisible to satellites, roughly doubled the reported deforestation by land clearing.

Nepstad and his colleagues learned the ways in which fires during the first year of a drought encourage further fires even if rains return the next season. During the first year of a disruption by El Niño, the plant life of the rain forest will suck all the water from the upper 5 m of the soil that supports it. Unless a series of biblical deluges recharges that soil, the water deficit will not be overcome in the next rainy season, so that by the following dry season, soil moisture will be drawn down even further, beyond the reach of the rain-forest root network.

Trees respond to this stress by shedding leaves, creating openings in the forest canopy and adding tinder to the forest floor. With sunlight streaming through these openings and into clearings created by earlier fires, the stage is set for the incineration of larger trees that survived fires in the previous cycle. When the giants fall, even more fuel is deposited on the forest floor, and more sunlight bakes the land.

The direct and indirect effects of fire reduce moisture and rainfall and further enhance the prospects of more burning. Cleared land releases less water to the skies than forest does, while smoke inhibits rainfall by saturating the air with vast numbers of tiny particles, each of which can become the basis of a water droplet. But the droplets remain tiny, and do not become heavy enough to fall to the ground, according to a study by David Rosenfeld at Israel's Jerusalem University. Instead, they stay in the sky, in effect as sterile clouds. This enhances the prospects of more fire, more smoke and even less rainfall.

Repeated over the years, the combination of drought, human despoiling and fire can transform wet tropical forest into permanent savanna. So argues Bruce Nelson, an ecologist who has worked since 1979 with INPA, the Brazilian institute for the study of the Amazon. Nelson believes pre-

PROBLEM PROJECT

The Samuel Dam flooded huge areas of forest, but now its lake is starting to silt up



AGRIFRUSTRATION

Silted dams and subsistence farming are signs of failure to accommodate the land

Columbian Indians created the Gran Sabana in Venezuela, a 75,000-sq-km area of veld stretching across the southeast corner of the country, by repeated burning of the forest. As evidence, he points out that unlike neighboring natural grasslands, the Gran Sabana lacks fire-tolerant tree species. In other words, forests burned down hundreds of years ago have been permanently eliminated.

A drive south from Porto Velho on BR-364 offered a dramatic example of a similar process under way in the 21st century. In 1989 many small farms in the area were interspersed with patches of forests. Now much of the land is open pasture, dotted with some of Rondônia's 6 million cattle. About an hour out of the city, a series of illegal clearings begins in one of the few remaining stands of primary forest along the road. Settlers have invaded from every road or path, including the right of way for electrical lines that run through the forest.

Remarkably, this unsanctioned invasion took place in plain view on one of the most traveled stretches of the busiest highway in Rondônia. Moreover, the dozen or so clearings were cut in less than a week, a coordinated assault that bespeaks organization and planning. Antonio Alves, one of the settlers, says he came here because he was told the land did not belong to anyone. In fact, it belongs to a nonprofit organization that has not been able to produce clear title to the land; IBAMA officials guess that the settlers were tipped to this opportunity by a local politician.

Multiplied by a factor of thousands, this is what Nepstad fears will happen after the paving of BR-163. Only this time the invasions will take place in the most fire-prone region of the dense tropical forest. The forest could disappear along the road in the blink of an eye. A single El Niño-inspired drought could do the trick if the road were paved and settlers had invaded. If this happens, scientists estimate that one burning season could destroy 100,000 sq km of forest, more than twice what was destroyed in all Brazil in 1998.

Across the board, Brazilian environmentalists and officials I spoke with were perplexed by how the paving of BR-364 was approved without normal review and comment. It is part of the 6,245-km road network that is scheduled to be paved in the Amazon as a section of the government's Avanço Brasil infrastructure program for economic development. Marina Silva, a federal senator from Acre and one of a handful of environmentally oriented

members of the Congress, says the entire plan went through with virtually no debate, and the decision to pave BR-163 was made without debate, public review or public hearings. The rushed-approval process backfired, however, since the failure to produce an environmental-impact assessment has given opponents an opportunity to stall the project while they regroup. Public-interest lawyers and conservation groups have adopted a strategy of challenging the government to provide assurances on the impact of each aspect of the road, such as its potential effect on various waterways.

There is the remote possibility that the road will still be blocked, since everyone loses when fires get out of control. José Baranak, for example, is one of the owners of a wood-products company called Cemex, and BR-163 runs right by his forest subsidiary's 11,000-hectare property. He has had to take extraordinary steps, including creation of firebreaks and programs to pick up flammable forest litter, to prevent fire from destroying the timber operation he has built up over 22 years. Cemex's wood-processing plant has the largest payroll in Santarém, and the company's timber property south of town is a model of forest management, which Baranak hopes to get officially certified as eco-friendly in the near future.

Not so much an environmentalist as a conservationist—he loathes waste of any sort—Baranak gets 70% of the 1,200 cu m of wood Cemex exports monthly from lands where he has aggressively pushed replanting from the outset. His partners and employees try to encourage neighbors to reduce their vulnerability to fire. But most lack the means to take effective action even if they have the will. He wonders why the government can't settle the landless on land that is not virgin forest. "INCRA dumps people in the forest and thinks they are finished with their responsibilities," he says. Yet Baranak still sees the road as inevitable, and a good thing. "You can't stop progress," he says and shrugs, "and it will connect Santarém to the rest of Brazil."

Nonetheless, Baranak stands out as a relative skeptic in his region, where everyone else speaks of the advent of the paved road as a magic pill for economic development. While all fear fire, few make the connection with the highway, and even fewer in this part of Pará are aware that they live in a potential tinderbox.

The best friend of the forest may be social inertia. After more than three decades, Brazil's vaunted Trans-Amazon Highway

has yet to be completely paved, and other roads in the Amazon have been all but abandoned. The road that once linked Porto Velho and Manaus becomes impassable a mere two hours outside Porto Velho. Ecologist Nepstad argues that a more limited network of paved roads could give Santarém all-weather access to the rest of Brazil, while forestalling incursions of unauthorized settlers from the south. The soybean exporters have already paved access to Amazon waterways through Porto Velho.

In those parts of the Amazon where people have seen the effects of paving, attitudes are also changing. Governor Viana and many of Acre's citizens don't want to see uncontrolled development spread through the rest of their wild and beautiful

“Our struggle is to make sure that what happened in Rondônia won't happen here.”



—JORGE VIANA
Governor of Acre

state, as it did through neighboring Rondônia. "Our struggle here," says Viana, "is to make sure that what happened in Rondônia won't happen here."

Viana does not so much come out against roads—suicide for any politician—as offer alternative ways to meet the aspirations of Acre's citizens. He argues that Acre's many navigable waterways offer a commercial connection to markets without the risk of deforestation. To deal with emergencies, the state is expanding a system of airports in remote villages. Viana is promoting a "forest economy" that profits from the wilderness without destroying it. In one town, for instance, a condom factory is being built that will provide a market for latex collected by local rubber tappers. By capturing more of the value of the rubber trees, Viana hopes to ward off logging.

Viana's government, along with others,

is exploring every opportunity to find profit in standing forest. In fact, with the world increasingly alarmed about global warming, state governments in the Amazon see a potential gold mine in the use of virgin forest as a storehouse for atmospheric carbon. The Amazon Basin releases between 100 million and 300 million tons of carbon a year into the atmosphere through deforestation; the amount doubles in years when fires devastate the forest. The U.N.-sponsored greenhouse-gas agreement, worked out in Kyoto in 1998 to combat the threat of climate change (not yet ratified by the U.S.), calls for a rollback of greenhouse gases—almost all of them carbon compounds—to below 1990 levels.

One way of helping do that is to set aside forests as carbon "preserves," called carbon sequestration in wonk-speak. If a market developed to package and sell certified reductions in greenhouse emissions, money might flow to states that took action to reduce deforestation. By one calculation, if Acre would commit to cutting in half the expected deforestation along a 500-km stretch of BR-364, the state might ultimately gain \$37 million a year from the sale of greenhouse credits. The concept is risky because it might perversely encourage governments to launch development projects in the hope of selling credits to stop their work. Moreover, the Brazilian federal government has not yet embraced the concept because it contains implications that federal attempts to control deforestation have failed. But the idea has merit as one of the few comprehensive schemes to bring economic incentives to bear on the notion of forest preservation.

Viana's ideas deserve international attention because at least he recognizes the devil's bargain in the extension of roads in the Amazon, and is trying to grapple with the problem of providing for people while protecting the forest. They also deserve attention because something vitally important to the entire world is now clearly threatened by forces that could destroy it wholesale. When I first visited this great green engine of life, scientists and environmentalists recognized the vast array of threats, but also assumed that the Amazon was too big to be destroyed by one generation's folly. The vulnerability revealed by El Niño of 1998 shows the world that this isn't true. The decision to pave 700 km of road in the rain forest doesn't seem like a global issue, but the holocaust that might follow that seemingly innocuous transportation decision could well contribute to a global disaster. ■