



Domino Effect: Roads for logging or farming make untouched forest accessible to the ravages of chainsaws.

The Fractured Landscape

A road here and a cattle ranch there imperil more than the immediate vicinity.

BY PHILIP M. FEARNSIDE

THE LANDSCAPE IN AMAZONIA IS rapidly becoming fractured, weakening the rainforest's capacity to withstand the escalation of ever-stronger assaults, ranging from chainsaws to climate change. The forest is not only being crisscrossed by highways, pipelines, and other kinds of infrastructure. It is also riddled with clandestine logging roads and the scars of forest fires.

DIRECT DESTRUCTION

The dominant form of rainforest destruction is still deforestation, the deliberate cutting of trees with chainsaws, followed by burning to prepare the land for planting. Cattle pasture is the principal land use replacing forest, and large- and medium-sized ranches account for around 70 per-

cent of the clearing. The portion that is cleared by small farmers is often planted for a year or two in annual crops such as manioc or rice, but after this initial use the land winds up converted to cattle pasture just the same.

In some parts of the Brazilian Amazon, highly capitalized soybean plantations are making inroads in the forest. However, the greatest impact of soybeans is not the land directly cleared for this crop, but rather the highways that are built or improved to transport the harvest to deepwater ports, most importantly the BR-163 (Santarém-Cuiabá) Highway that is expected to bring soybeans from Mato Grosso state to the Amazon River. Highways like these set in motion a process of deforestation for ranching and for secur-

ing speculative claims to the land that suddenly becomes much more valuable due to the presence of the road. The road also brings logging, landless migrants, and investments in all sorts of forest-destroying activities, both legal and illegal. In addition to highways, other kinds of infrastructure projects lead to forest fragmentation and destruction. These include pipelines for oil and gas, industrial waterways, electrical transmission lines, and hydroelectric dams.

Logging is one of the most pernicious activities. Most Amazonian logging is still illegal and is done with no regard for the damage it causes to the remaining forest when logs are removed. Even legal logging in forest management areas has significant impacts. In Amazonia, the extraordinary diversity of tree species means that most of the trees are not commercially valuable. Clear-cutting for timber, as in the coniferous forests of North America, is not economically viable. Future technologies may change this: Biofuels represent a potential threat

to the forest not only for plantations of crops like sugarcane and oil palm, but also for direct production of alcohol from wood cellulose of any species if methanol production technologies advance as some expect in the coming decades. The future threat of clear-cutting apart, today's selective logging has major consequences.

Logging spreads to vast areas, and the expansion of the highway network dramatically increases the area affected. Logging spreads deforestation by providing access to a vast network of "endogenous roads," by motivating clearing in order to establish land claims to timber-rich forests, and by providing money to pay the costs involved. The aftermath of logging is a forest with many holes in the canopy, allowing sun and wind to dry out the forest floor. A large stock of fuel for forest fires is created by the dead trees killed by machinery or pulled over by vines when neighboring trees fall, together with the branches and other debris left from the harvested trees. This sets the stage for a vicious cycle of degradation by fire that can destroy the remaining trees, leaving a bare area that will appear as deforested on satellite imagery. Logged areas are much more likely to burn than are unlogged areas, and when a fire does occur it is more destructive in the logged area.

Forest fires in Amazonia are very different from those in North America, where fires in coniferous forest like the one portrayed in Walt Disney's film, *Bambi*, rush through the crowns of the trees. In Amazonia, forest fires take the form of a thin line of flames slowly moving through the forest understory. While the size of the flames may appear unimpressive, their effect on the trees is devastating. Damage is worse because the fire front advances so slowly: Just as you can pass your finger quickly through the flame of a candle and not get burned, if you hold your finger there for a minute the result is entirely different. The fire heats the cambium beneath the bark at the base of each tree trunk, killing many of the trees. These dead trees provide the fuel for the next fire, which will be hotter and will kill more trees. After fire has passed through an area of forest three or more times, the forest is basically destroyed.

INDIRECT DESTRUCTION

Loss of forest to deforestation, logging, and fires contributes to another increasingly apparent threat—climate change. Climate change and forest loss reinforce each other in a positive feedback relationship: Climate change kills forest, leading to more climate change that kills still more forest. Half of the dry weight of the forest is carbon, and when the trees burn or rot they release greenhouse gases such as carbon dioxide and methane. These emissions add to the increases in the atmospheric loads of the gases that come from fossil-fuel combustion and other human activities all over the world. The resulting global warming kills Amazonian trees through a combination of increased temperature and decreased

New highways are spreading deforestation to previously inaccessible areas.

rainfall. When temperatures increase, trees need more water just to survive. Several global climate models indicate that continued global warming would lead to decreased rainfall in Amazonia, along with greatly increased temperature.

A key factor in the changes in Amazonia is the effect of the El Niño phenomenon, which occurs in today's climate when the surface waters in the tropical Pacific warm past a critical threshold. This event has been occurring at increasingly frequent intervals since 1976. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), released earlier this year, indicates that there is now general agreement that "El Niño-like conditions," meaning warm water in the Pacific, will be more frequent with continued global warming. The climate models do not yet agree as to the link to El Niño itself—that is, to the droughts and floods that occur at different locations around the world as a result of the phenomenon triggered by the warm water.

Unfortunately for us in the Amazon, this is the part that we know from direct experience, without depending on climate models. Whenever the water in the Pacific warms, we have droughts and forest fires in Amazonia. If a model shows

the Pacific warming up and nothing happening in Amazonia, it means that there is something missing from the models, not that we are safer in Amazonia.

In 2005 Amazonia was hit by a very severe drought that was not caused by El Niño, but was related to global warming. While El Niño is triggered by warm water in the Pacific, in 2005 the drought was the result of a patch of warm water in the Atlantic—the same one that gave rise to hurricane Katrina. A study by Kevin Trenberth and Dennis Shea at the U.S. National Center for Atmospheric Research, published in the journal *Geophysical Research Letters* in 2006, indicates that half of the higher-than-normal temperature of the Atlantic water was directly due to global warm-

ing, and much of the remainder was an indirect effect. Continued warming will make such droughts more severe when they occur.

Another indirect effect that reinforces the damage from droughts driven by global warming is the effect of deforestation on water cycling. Two models published in 2007 confirm that deforestation makes the climate over the remaining forest both hotter and drier. These effects augment both the impact of El Niño and the direct effects of global warming, further weakening the forest's resistance to water stress and fire. All of these effects act to intensify and lengthen the natural dry season in Amazonia, shifting the climatic zones so that more of the region becomes climatically appropriate for savanna rather than forest.

PROSPECTS

The course of development in Amazonia is rapidly weakening the remaining forest both through projects directed by development plans and by uncontrolled social processes that advance into new areas regardless of what the government might wish. The infrastructure projects in Brazil's January 2007 "Plan for the Acceleration of Growth" (PAC) have



The Cutting Edge: Sawmills blossom along highway BR-163, in the heart of the Arc of Deforestation.

enormous environmental consequences, though these accorded no weight when the plans were announced.

The BR-163 (Santarém-Cuiabá) and BR-319 (Manaus-Porto Velho) highways are prime among these. Until now, at least 70 percent of the deforestation activity in Amazonia has been confined to the Arc of Deforestation, a crescent-shaped area along the eastern and southern edges of the forest. These two highways will connect the Arc of Deforestation to the Amazon River, as well as providing entry points to new frontiers north of the Amazon River. The BR-319 is particularly pernicious in opening large, previously inaccessible areas to migration. Planned side roads would open the vast undisturbed block of rainforest in the western part of the state

of Amazonas, while the flow of people along the already-existing BR-174 Highway from Manaus to Boa Vista would bring the land conflicts and squatter invasions that are commonplace in the Arc of Deforestation to new areas in the far northern portion of Amazonia.

On the positive side, there are continued advances in forest protection. An important process is the “demarcation” of indigenous areas, that is, marking the boundaries on the ground as opposed to merely drawing them on a map. Another area of progress is the creation of an increasing number of such protected lands, both by the federal and the state governments. These are essential in securing the long-term future of the forest. Maintaining the forest will require more than the usual knee jerk

deploying of guards and upping of fines for unauthorized clearing.

The connection of deforestation to infrastructure decisions, however, is the fact that nobody in Brazil wants to face. One can't have both a decline in deforestation and the construction of ever more roads opening up new areas of forest, no matter how many plans for sustainable development and governance are announced simultaneously. Fortunately, the economic force of destruction is not the unstoppable juggernaut that many people unquestioningly assume.

Most of Brazil's deforestation is for cattle ranches that contribute very little to either the national economy or to supporting the Amazon's human population. The number of cowboys needed to maintain the pasture and cattle on these ranches is minimal once the trees have been felled. Some of the infrastructure projects that would be most damaging are highly questionable on purely financial grounds, independent of the astronomical cost they would have if their environmental impact were counted in the calculation. The rationale for the BR-319 Highway is to transport products to São Paulo from the factories in Manaus. Expanding the port in Manaus and sending the products by ship could accomplish this more cheaply and with incomparably less environmental impact.

The processes that fracture the Amazon landscape, such as deforestation, logging, and climate change, all have a momentum of their own that carries them forward even after efforts are begun to alter the course of change in the region and, in the case of climate, in the world as a whole. This means that there is no time to waste before actions are taken. Foreseeing the consequences of continuing on our current course in Amazonia can only help prevent the collapse of the forest if the actions are taken in time. **TAP**

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