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A Rainforest Divided [1]

by Laura Naranjo

If a tree falls in the Amazon rainforest, biologist William Laurance just might hear it. And as human activity encroaches on the forests, Laurance is finding that a lot of trees are falling.

As people penetrate the Amazon interior, they build roads and clear large expanses of land. Over time, this process of deforestation creates forest fragments, islands of trees surrounded by a sea of pastures, farmland, and other degraded habitats. Laurance and his colleagues at the Smithsonian Tropical Research Institute are studying what happens to the forests when trees lose ground to agriculture, logging, and roads. By tracking the results of forest fragmentation, the researchers hope to assess the impacts of land-use change on forest dynamics and study how ecosystems respond.

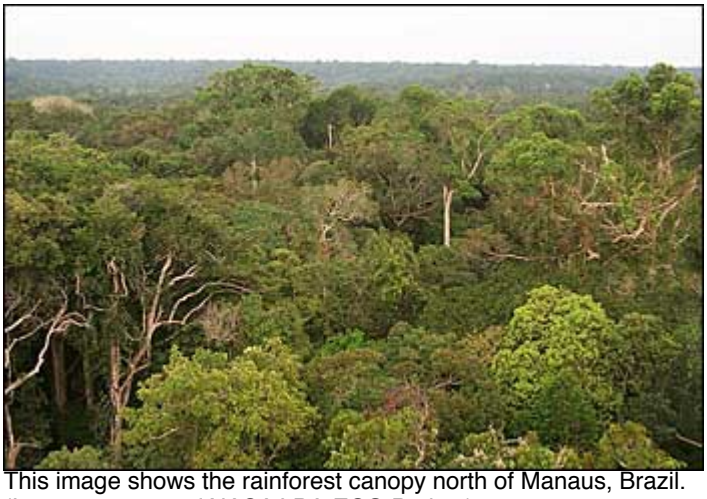
The Amazon rainforest is losing ground as human activity fragments the forests.

- About Oak Ridge National Laboratory (ORNL) DAAC [2]

Image in title graphic: Deforestation in Rondonia, Brazil. (Image courtesy of Visible Earth [3])

To support Amazon rainforest research, the Brazilian government launched an international effort in 1993, called the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA). LBA project investigators study a wide range of Amazon ecosystem dynamics, such as the movements of nutrients through the ecosystem, the chemistry of the atmosphere among and above the canopy, and changes in the sources and sinks of carbon. Laurance is an investigator for a component of the LBA Project, called LBA-ECO, which focuses on the effects of land use changes in the Amazon.

In the Amazon rainforest near Manaus, Brazil, Laurance's team monitored both fragmented and pristine portions of a 1,000-square-kilometer area that was sectioned into plots. Field technicians collected data for each plot at least five times over a 20-year period, counting, classifying, and measuring the diameters of all living and dead trees each time. Laurance's colleagues at the Biological Dynamics of Forest Fragments Project inventoried animal, bird, and insect populations before and after fragmentation.



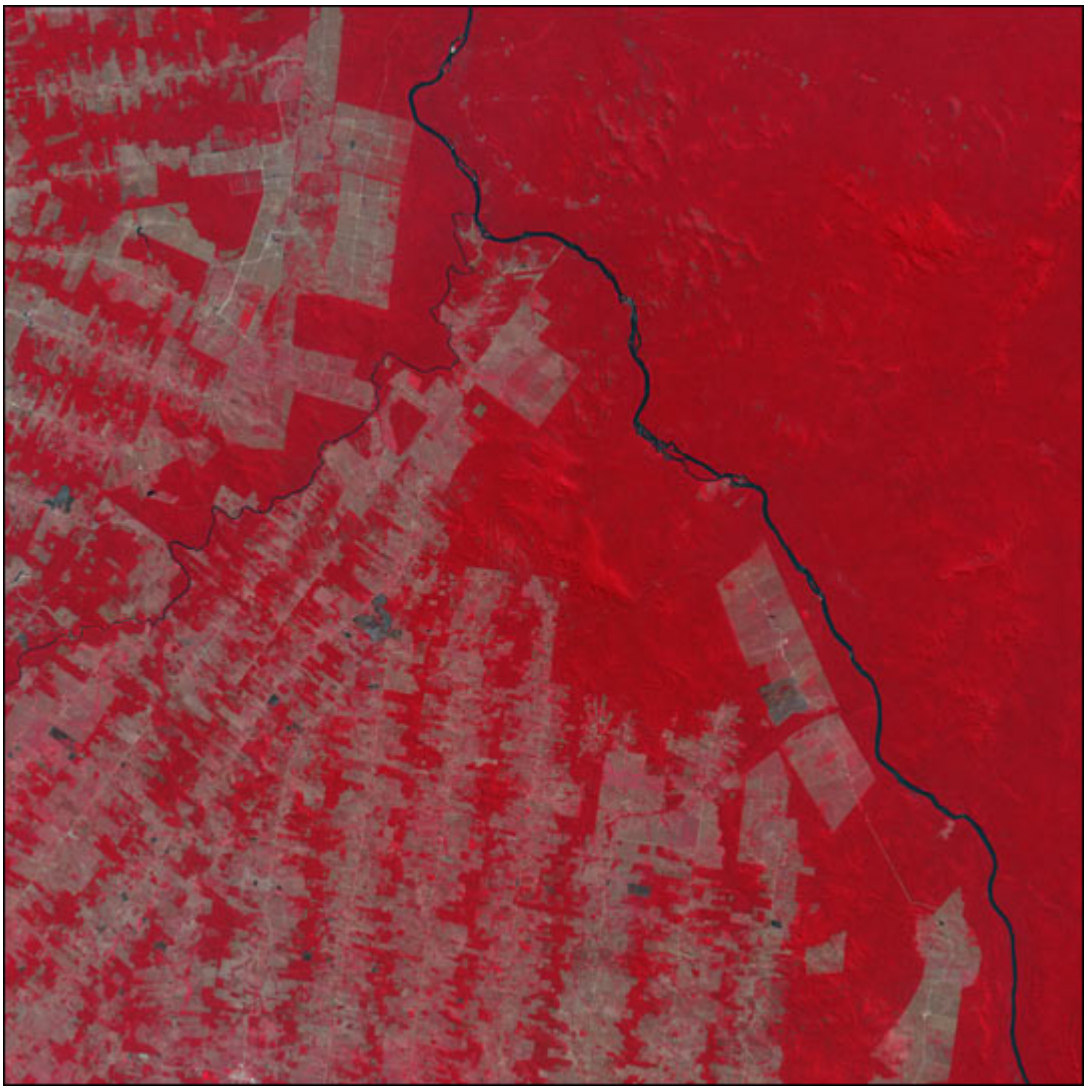
This image shows the rainforest canopy north of Manaus, Brazil. (Image courtesy of NASA LBA-ECO Project)

Their long-term study was unusual in that they carefully surveyed most of the plants and animals in each of the fragments before clear-cutting isolated the fragments from the continuous forest. "That was the big advantage of

our study. We built up a very good picture of what species existed before the habitat was fragmented," said Laurance. This picture provided a basis against which to assess changes in the forest ecosystem in its fragmented state.

Laurance admits that his study represents a best-case scenario, since a presidential decree protects the study area from the damaging activities that most other fragmented rainforests endure: logging, hunting, and fire-based agriculture. "These four processes together can be pretty devastating for some species, and certainly for the forest ecosystem as a whole," he said.

But even in the protected study area, the team found that forest dynamics in fragments were changing dramatically. Trees were dying along the forest edges, and the biggest trees — with trunks greater than 60 centimeters (24 inches) in diameter — were dying the fastest. As the larger trees died off around the edges of fragments, the remaining trees were more exposed to temperature changes and dry, hot winds that left them vulnerable to drought. These "edge effects" impacted not just the forest edges, but penetrated as far as 300 meters (nearly 1,000 feet) into the forest.



Extensive deforestation and fragmentation are visible in this satellite image, acquired by the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on August 24, 2000, of the state of Rondonia, Brazil, along the Jiparaná River. Tropical rainforest appears bright red, while pale red and brown areas represent cleared land. Black and gray areas have probably been recently burned. The Jiparaná River appears blue. (Image courtesy of NASA and the U.S./Japan ASTER Science Team)

Aside from providing habitat for rainforest flora and fauna, the Amazon plays an important role in storing and removing carbon dioxide from the atmosphere. Carbon dioxide is a gas that contributes to the Earth's

greenhouse effect, in which atmospheric gases trap thermal energy and cause surface and air temperature to rise. Adding more carbon dioxide to the atmosphere magnifies this greenhouse effect.

The Amazon rainforest covers an area more than seven times the size of Texas, populated with nearly half a billion hectares (1.2 billion acres) of trees and vegetation that are critical to the Earth's carbon cycle. However, high rates of deforestation in the Amazon (reaching 2.4 million hectares, or nearly 6 million acres, per year in 2002 and 2003) are diminishing the rainforest's ability to store carbon.

Each hectare of destroyed forest releases around 200 tons of carbon into the atmosphere — worsening, rather than slowing, the greenhouse effect, Laurance explained. The extreme mortality of trees in forest fragments means that the fragments are losing considerable amounts of carbon, perhaps as much as 150 million tons per year in the world's tropical regions.

In the fragments Laurance studied, less dense, faster-growing trees replaced old-growth trees, and lianas (woody vines) proliferated around forest edges. Both lianas and faster-growing trees store less carbon than large, dense trees. "The denser the wood, the more carbon a tree can store. A lot of the new trees coming in tend to be lighter wooded pioneer species that store less carbon," said Laurance. "So fragmentation is reducing the amount of stored carbon in two ways. There are fewer trees and smaller trees, and the composition of the forest is changing."

Birds and other animals are often specially adapted to living in the cool, dark habitat below the thick rainforest canopy. (Image courtesy of William Laurance)

Besides impacting tree populations, fragmentation alters habitat vital to rainforest animals, particularly in the forest understory — the small trees and vines between the forest floor and the upper canopy. Protected from wind and rain, the shaded understory provides a dark, cool, humid environment for a variety of specialized mammals, birds, frogs, and insects. "A lot of the understory birds are sensitive to fragmentation. They're adapted to deep, dark forest conditions, and they won't come out anywhere near a road or clearing," said Laurance.

Because the rainforest ecosystem supports complex webs of interactions, when extinction claims one animal, plant, or insect, other creatures suffer as well. For instance, explained Laurance, a number of frog species use the little wallow ponds made by peccaries (wild pigs). The peccaries need large areas for foraging, so when fragmentation reduces their range and drives them out of the ecosystem, frogs in the area start disappearing.

Fragmented forests also isolate animal populations, which can be a driving force behind extinction. Animals such as jaguars and pumas require large areas, and fragmentation can limit their ability to hunt or force them deeper into the forest. In addition, fragmentation increases human access to the forests, attracting hunters who kill jaguars, monkeys, deer, and agoutis (giant rodents), Laurance said.

Laurance cited road building as one of the main culprits behind forest loss and fragmentation. The Brazilian government currently plans to pave about 7,500 kilometers (about 4,600 miles) of new highways that will provide more access to the Amazon interior, and Laurance's research indicates that this will increase fragmentation of the rainforest.

Fragmentation begins when a paved highway penetrates undisturbed forest. Loggers and colonists then build

numerous roads branching off of the highway, creating a pattern of land use that fragments long strips of forest. "Once you get a major highway providing year-round access, then all kinds of things happen — colonization, logging, and a lot more road development," Laurance said. And once the colonists reach their pristine destination, fire-based agriculture then poses a problem for the Amazon's remaining forests. Colonists hoping to tame a piece of the rainforest often clear the land for agriculture with slash-and-burn techniques.

Laurance also blames "surface fires," annual fires that farmers light in their pastures to destroy weeds and produce fresh grass. These fires burn not only the pastures, but often spread into the surrounding forest as well.

"Because fire is foreign to the rainforest ecosystem, the plants there are just not adapted to it. Even a little fire that's only 10 or 20 centimeters (4 to 8 inches) high will slowly burn through the forest understory, killing 20 to 50 percent of the trees and all of the vines," said Laurance. Dead trees and vines then accumulate on the forest floor, becoming tinder that fuels the following year's fire.

"Every time there's a new fire, it creates more flammable material. So at the end of the cycle there is just a scorched landscape of completely destroyed forest," Laurance said. "You can literally see the fragments imploding over time." The problem worsens when El Niño years bring drought to the region, making the forests even more vulnerable to fire.

Data from Laurance's study, along with a variety of other data sets generated by the LBA project, will be archived and available from the LBA web site in Brazil and the Oak Ridge National Laboratory Distributed Active Archive Center. As scientists gather more data, they will gain a clearer understanding of how land use change affects the Amazon and its ability to store carbon.

Laurance hopes that his research will ultimately promote policy change. The Brazilian government is trying to develop sustainable economic strategies for the rainforest, but land in the rainforest is so cheap that once a farmer's soil is depleted, he can simply purchase another patch of forest to clear and burn. "Rather than relying on very destructive fire-based agriculture," Laurance said, "we're advocating a system in which there are more incentives for farmers to invest in their land and develop more sustainable kinds of agricultural strategies." By making currently cleared land more productive, he suggests, farmers could work closer to existing markets, and the government could then set aside larger tracts of pristine rainforest, preserving the rich flora and fauna of the Amazon.

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