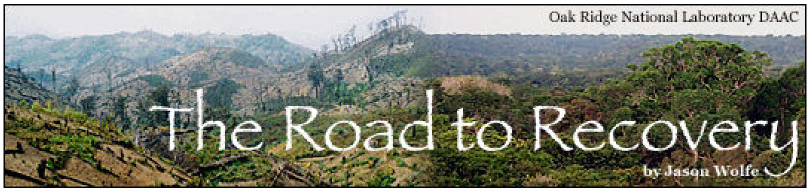

According to a recent report in *Science*, the Amazon rain forest has lost nearly two million acres to logging each year since 1996. This alarming loss of trees in the world's largest rain forest could increase the amount of atmospheric carbon dioxide by roughly 200 tons each year, raising the threat of global warming. But a recent study in the Amazon rain forest shows that some types of logging may not negatively impact the carbon cycle as originally thought.

Michael Goulden, an associate professor in the Department of Earth Systems Science at the University of California at Irvine, found that six to eight months after a 1,700-acre (700-hectare) forest plot was logged in Tapajos National Forest, Brazil, fast-growing trees repopulated the forest, and photosynthesis levels returned to normal. His study suggests that logging selective areas is a way to use the forest efficiently without disrupting the carbon cycle.

According to Goulden, the forests develop a natural tendency to withstand minor tree cutting and soil disturbance. "The forest is adapted to deal with these activities. But we were still surprised at how *quickly* it recovered," said Goulden.

Goulden participates in the Large-Scale Biosphere-Atmosphere Experiment (LBA) in Amazonia, an international research project led by Brazil's Ministry of Science and Technology. Goulden works specifically with LBA-Ecology (LBA-ECO), a NASA-funded component of LBA, to understand how land use change in the Amazon affects the carbon cycle, nutrients, and movement of trace gases in the Amazon tropical forest. These factors work together to maintain a healthy ecosystem.

The Amazon region contains about 40 percent of the world's remaining tropical forest, and its large diversity of plants and animals makes it a prime target for preservation efforts. "Tropical forests have incredible biodiversity. If you look at a hectare of tropical forest, you may see hundreds of different species of trees, compared with a pine forest in the western United States, which may only contain about 10 or 20 species," said Goulden.

Because the Amazon is rich with trees, it contains a massive stock of carbon, the building block of life. Carbon is essential for ecosystem development and plays a lead role in regional and global climate. Logging leaves behind dead plant material, or slash, which decomposes and provides a food source for invertebrates. Respiration and microbial activity within the slash eventually releases carbon dioxide into the atmosphere, increasing atmospheric carbon dioxide levels. At the same time, organic carbon within the soil column is depleted. Scientists study the carbon cycle by

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Scientists are ultimately concerned with preserving the Amazon region, since it contains about 40 percent of the world's remaining tropical forest with a large diversity of plants and animals.

The Multi-angle Imaging Spectroradiometer (MISR) captured this image of deforestation near Rio Branco, Brazil, on July 28, 2000. Click here for more information. (A new browser window will open.)

For more information, visit:
Oak Ridge National Laboratory DAAC
LBA Project from ORNL DAAC
LBA-ECO
(A new browser window will open for each.)

From the Earth Observ atory:
A View from Above
Amazonia

Images in title graphic courtesy of NASA and the CIA World Factbook.

looking at the "net carbon exchange" between the biosphere and the atmosphere, which is the difference between carbon that the ecosystem removes from the atmosphere for photosynthesis and carbon that it releases to the atmosphere by respiration and decomposition.

Goulden wanted to know how selective logging would affect net carbon exchange. Selective logging is a low-impact activity that involves cutting only two to four trees per acre (five to ten trees per hectare) of forest. It is meant to minimize disturbance of the forest ecosystem. "Selective logging creates a mosaic in the forest with patches of trees interspersed with small gaps from logging," said Goulden.

Goulden measured carbon dioxide exchange and evaporation in Tapajos National Forest, Brazil, using 200-foot (61-meter), NASA-constructed observation towers that rise high above the forest canopy. In addition to being part of LBA, the towers contribute data to FLUXNET, a global network of research sites that measure regional carbon, energy, and water vapor exchange between terrestrial vegetation and the atmosphere. FLUXNET is managed by the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC). According to Robert Cook, a scientist at the ORNL DAAC, there are currently 215 towers worldwide, some in the Amazon. "Data from these LBA towers will be added to data from other networks of towers around the world. The FLUXNET collection aids research on the global carbon cycle and also contributes to validating Moderate Resolution Imaging Spectroradiometer (MODIS) photosynthesis products," said Cook.

This map shows the study area of the Large Scale Atmosphere-Biosphere Experiment in Amazonia (LBA). (Image courtesy of the LBA. A new browser window will open.)

The observation tower that Goulden used in his research has several instruments that measure wind direction and carbon dioxide levels in gusts of air. On a sunny day when photosynthesis conditions in the forest are optimal, updrafts of air contain less carbon dioxide than downdrafts. That difference in carbon dioxide indicates how much carbon is taken up by the forest during photosynthesis.

Goulden observed carbon dioxide exchange in a 1.5-square-mile (4-square-kilometer) plot of healthy forest near Santarem, Brazil, starting in July 2000. In September 2001, logging contractors selectively logged 1,700 acres (700 hectares) of the forest. Goulden compared carbon dioxide exchange after the logging to prior levels. He expected that logging would reduce photosynthesis in the forest because many of the leaves were removed. He also expected to see more carbon lost to the atmosphere, since logging creates dead material that is transported to the atmosphere.

But what Goulden found surprised him. For the first six to eight months after logging, the forest did lose carbon to the atmosphere, but it then recovered to the point where photosynthesis levels were back to normal. Even more surprising was that fast-growing, young trees with short life spans, such as balsa, quickly colonized the gaps created by logging. “I wouldn’t say the forest is back to what it was before, but with respect to photosynthesis, I would say it *has* recovered,” said Goulden.

But was this fast recovery a pure coincidence, or was it typical of forest behavior?

Alan Townsend, assistant professor with the Department of Environmental, Population, and Organismic Biology at the University of Colorado, has also studied the effect of logging on carbon exchange in the Amazon. He was not surprised by Goulden’s findings. “If the forest is not too heavily disturbed during the logging, rates of regrowth and carbon accumulation can be quite rapid following a clearing,” he said.

Both scientists agree that the method by which the forest is logged affects the status of the carbon balance, and that recovery rates are dependent on the intensity of the disturbance. So the more the soil is disturbed from logging, the slower the recovery will be.

Townsend cautions, however, that while it is exciting to see photosynthesis levels recover quickly after selective logging, the long-term implications of any forest disturbance must be considered. “The overall integrity and structure of a forest that has been selectively logged will be nothing like that of a healthy, non-disturbed forest for a very long time, especially with repeated disturbances,” said Townsend.

Townsend cited research by Daniel Nepstad, a scientist with the Woods Hole Research Center, who studies the relationship between selective logging and fire potential in forests. According to Nepstad, any type of logging, including selective logging, can change the small-scale climate of the forest such that the ground dries out and the chance for fire increases. In areas where forests were cleared for pasture, Nepstad observed several fires that started from the heat of the logging equipment. “Does that mean that every logged place is going to burn? No. But logging increases that chance, so it is worth looking at the pros and cons of selective logging,” said Townsend.

Logging for the purpose of clearing land for agriculture continues to threaten the Brazilian rainforest. (Image courtesy of the United Nations Environment Programme, USGS, and NASA.)

Still, Goulden believes his findings may help answer general questions about carbon dioxide, such as its sources, movement, and whether or not tropical logging increases atmospheric carbon dioxide. But he believes the more practical implications of his results relate to land management. “There is a wide range of opinions on logging in tropical forests: some people believe the forests should be left alone, and others want to cut down the forests and convert them to pastures,” he said. “There are also people who say that if we don’t do something economically useful with these forests, we will lose them.

“I think our findings indicate that selective logging is not necessarily a bad thing. It’s not as if the logging was so aggressive that the forest couldn’t recover, for example, if 10 or 20 percent of the wood were to be removed,” said Goulden.

Goulden will continue to collect data from the observation towers for at least the next two years. Data collected from LBA-ECO research in the Amazon will be sent to the ORNL DAAC when the data are finalized. The same data will also be archived at the Brazil Center for Weather Prediction and Climate Studies in Sao Paulo. “The research is in full swing right now, and we are really beginning to synthesize the data,” said Michael Keller, project scientist for LBA-ECO. “We clearly have a better appreciation for things we didn’t know about when we started.”

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