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## Deep in the Amazon Forest, Vast Questions About Global Climate Change

By LARRY ROHTER

TAPAJÓS NATIONAL FOREST, Brazil — Viewed from the top of a tower 150 feet over an exuberant canopy of green, the vast Amazon jungle appears to be a neatly functioning organism. Trees in immeasurable numbers stretch away to the horizon here, their leaves open to the sun, eager to feed on the light that streams down from the sky and perforates the stifling tropical heat.

Down on the ground, however, the longstanding debate about the Amazon's role in global climate change is intensifying. The Amazon is the largest tropical forest in the world — bigger than all of Europe, with Brazil's section alone more than half the size of the continental United States. And it has always been assumed to be essential to inhibiting global warming by drawing in carbon dioxide during photosynthesis.

Carbon dioxide is one of the main gases that contribute to global warming and the much-dreaded greenhouse effect. But it has never been established whether the rain forest here is in fact functioning as a giant sink that "sequesters," or traps and absorbs, carbon.

Some scientists have suggested that indiscriminate deforestation has turned the Amazon into a net source of such gases, spewing huge amounts of carbon dioxide into the air.

Scientists have been investigating that question for a decade now, and the answer is sure to have important political and scientific ramifications both for Brazil and the rest of the world.

If in fact the Amazon is a net source of carbon gas emissions, or if the amounts of gas emitted and sequestered are in a rough permanent equilibrium, some of the fundamental assumptions of the 1998 Kyoto Protocol on climate change may have to be reconsidered. No one knows precisely the amount of greenhouse gases that Brazil is already pumping into the atmosphere. A national inventory of carbon emissions, due to have been announced four years ago, has still not been made public. And although the new left-wing government that took power in Brasília early this year was elected with the support of environmentalists, it has given no indication when it intends to publish those figures.

Scientists at the National Institute for Amazon Research in Manaus estimate that carbon emissions in Brazil may have risen by as much as 50 percent since 1990. By their calculations, what is euphemistically called "land use changes" now produce annual emissions of 400 million tons of greenhouse gases, dwarfing the 90 million tons generated annually by fossil fuel use in Brazil and making this country one of the 10 leading emitters of greenhouse gases in the world.

All across the Brazilian Amazon, the jungle is being razed for cattle pasture, crops, logging, highways and human settlements at an increasingly faster rate, contributing to fears that the climate balance here may soon be permanently tipped. Last year alone, the land that was deforested rose by 40 percent over 2001, to nearly 10,000 square miles, an area larger than New Jersey.

Brazilian scientists, in conjunction with American and European colleagues, are engaged in what is known as the "Large-Scale Bio-Atmosphere Experiment in the Amazon," or L.B.A. The goal is to resolve uncertainties about carbon emissions. Begun in the mid-1990's, the program gathers data at 15 sites, including two in this national forest about 50 miles south of the confluence of the Tapajós River and the Amazon.

At each location, a tower 195 feet high measures the jungle's emissions of carbon dioxide and other gases and also collects readings of wind velocity and direction. To get a picture as broad and accurate as possible, some measuring posts have been placed on flat land, some in sloping areas, others in virgin forest and others still in "disturbed forest," where logging has occurred and secondary growth is present.

"Right now we cannot provide a definitive answer to the question of whether the Amazon is source or sink," Dr. Flavio Luizão, president of the International Scientific Committee of the L.B.A., said in an interview in Manaus. "But in another three or four years, I think we will be able to reach a consensus."

Initial readings published in 1995 were so extraordinarily high, showing up to nine tons of carbon sequestered yearly on each 2.5 acre plot, that scientists began to question both their results and their methodology. For one thing, they could not find the forest itself growing at the rapid rate implied by those figures.

Since then, years of additional measurements point to a more modest but still crucial role for the Amazon in absorbing emissions of carbon dioxide. Even if the forest were storing one ton per 2.5 acres, the estimate now most commonly cited by researchers, it would be trapping nearly 100 million tons of carbon dioxide each year.

"Each locale has its own specificities," said Dr. Antônio Manzi of the Amazon research institute, who oversees the data-gathering program. "But generally there is a bit of sequestering of carbon" by the forest in its natural state.

If that is true, the jungle's ability to store carbon gas diminishes as deforestation advances and may eventually reach a saturation point as the amount of land razed grows. But researchers stress that the Amazon is important in climate change because the jungle plays an additional role in the global warming debate that is independent of the question of whether it traps and absorbs carbon gases.

"Deforestation itself is a major contributor to global warming," said Dr. Stephan Schwartzman, senior scientist at the Washington-based group Environmental Defense.

"Just deforestation in the Amazon and fires, especially in El Niño years, are themselves perfectly capable of annulling any gains from the Kyoto Protocol as it now stands."

Natural factors may hurt the forest as well, contributing to the problem. The threat posed by the extremely dry conditions that prevail in the Amazon during increasingly frequent El Niño years is being documented in an experiment conducted by the Amazon Institute for Environmental Research, or IPAM. Extended dry periods can hurt the forest and diminish its capacity to grow and store carbon.

"Even with current rainfall systems, many forests are coming close to the limit where they shed their protective layer and become vulnerable to burning or slowed-down growth and die," said Dr. Dan Nepstad, an American scientist who works both with IPAM and the Woods Hole Research Center in Massachusetts. "By replacing the forest with pasture, you will clearly exacerbate drought and contribute to lower levels of fixed carbon."

Brazil has not put forth a consistent position on how to handle global warming, although both officials and the popular press criticize the United States as the principal culprit. Brazil is not a signer of the section of the Kyoto Protocol that promises reduced carbon emissions and has also opposed some important aspects of the "clean development mechanism" in the convention.

"As a developing country and in observance of the principle of common but differentiated responsibilities, Brazil is not obliged to reach targets in the reduction of greenhouse effect gases," the Brazilian Foreign Ministry said in a statement released in response to a request for comment on its position.

But perhaps the aspect of government policy that scientists here and abroad find most puzzling is Brazil's two-pronged position on the issue of so-called carbon credits.

Brazil supports the notion of awarding such payments for replanting in areas where forests have already been razed, but opposes the granting of such credits for "avoided deforestation" and in fact has itself passed up opportunities to take advantage of those credits itself.

The Environmental Ministry is on record favoring such credits, but the Foreign Ministry is officially opposed for reasons that are not fully clear, and it is the Foreign Ministry that ultimately controls Brazilian policy on the issue.

The issue of carbon emissions is a politically charged issue here. Brazil bristles at any suggestion by foreigners that its stewardship over the bulk of the world's largest remaining tropical forest is in any way deficient, and many Brazilians also believe that global efforts to monitor and limit deforestation are merely a smoke screen to bring about the "internationalization" of the Amazon, along the lines of Antarctica.

Some government officials have gone so far as to argue that Brazil produces no emissions whatsoever from deforestation, maintaining that crops planted after deforestation absorb all of the carbon produced. But studies by the National Institute for Amazon Research indicate that only 7 percent of carbon emissions are reabsorbed by planted crops.

"The rest of the tropics is going to run out of forest before the Amazon does," Dr. Philip M. Fearnside, director of the ecology program at the Amazon research institute, predicted. "The last acres, the last big areas of tropical carbon stocks left standing in the world, are here. That is why what happens here in Brazil, what the government eventually decides to do, is more important than ever."