THE WOODS HOLE RESEARCH CENTER

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World's Largest Rainforest Drying Experiment Completes First Phase

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Scientists with The Woods Hole Research Center are analyzing the surprising results of the first phase of a drydown experiment occurring in the Amazonian rainforest.

Overhead view of the panels

From January 2000 to July 2004, rainfall was excluded from a one-hectare (2.2 acre) plot in the middle of the Tapajós National Forest, in Brazil. A total of 6 feet of rainfall was diverted with six thousand 2′ by 6′ clear plastic panels suspended 3 to 12 feet above the soil. The panels were removed during the five-month dry season each year. To sort out the forest responses to the "umbrellas" from the normal variation in tree growth, tree death, leaf production, and other aspects of forest behavior, researchers compared this dry plot of forest with a similar plot, from which rainfall was not excluded. These two forest plots were compared for a year prior to installation of the plastic panels to register any differences in behavior that already existed when we began the experiment.

According to Daniel C. Nepstad, a senior scientist with The Woods Hole Research Center, "This experiment provides researchers with a peek into the future of this majestic forest, a future that will most likely be drier because of global warming, El Niño episodes, and even the drying effects of rainforest clearing and burning itself."

First, the biggest surprise noted thus far has been the great tolerance that this forest presented in the face of the severe drought that was created. As the moisture stored in the soil that sustained the forest during prolonged dry seasons was depleted in the dry plot, the trees simply absorbed water from deeper in the soil with their extensive root systems, avoiding most of the visible symptoms of drought stress. By the end of the five-year period of exclusion, many trees in the forest were drawing in water from more than 40 feet deep in the soil.

Second, it was anticipated that when the trees ran out of water in the soil, they would shed their leaves. In fact, this study shows that the reaction to drought is instead a decrease in the rate at which tree trunks grew in diameter. Many small trees, measuring 4 to 10 inches in diameter, simply stopped growing during the end of the dry season of 2000, following the first period of rainfall exclusion, as the trees of similar size continued to grow in the "control" forest plot. The trees slow down the amount of water that they lose from their leaves by closing their stomates. The trees adjust to the resulting reduction in photosynthesis by diverting less of the sugar and other carbohydrates that they make to wood production. This finding has important implications for climate change since the amount of carbon removed from the atmosphere during tropical droughts will decrease significantly. In addition, there are implications for sustainable forest management, because the time one must wait after harvesting timber from a forest before a second harvest will increase.

Third, the observed sensitivity of large canopy trees in the forest to drought is greater than expected. Once the moisture that is stored in deep soil is depleted, then the large trees that tower 130 to 150 feet above the ground, basking

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in full sunlight, begin to falter and die. The death of large trees – trees that may take centuries to reach the top of the forest canopy and have trunks greater than 10 inches in diameter -- increased from about one percent per year before the rainfall exclusion began to nine percent in the fourth year of the experiment, when soil water was depleted. This sensitivity of large trees to drought means that a decline in rainfall will likely push this tall, green, lush rainforest towards a shorter, more stunted forest.

As the forest becomes shorter and its leaf canopy more open, compromising its remarkable resistance to fire, it is clear that drought in tandem with fire can swiftly push the tall, dense rainforests of the region towards savanna scrub. The amount of carbon that could be released to the atmosphere by this savannization process is significant —equivalent to several years of worldwide carbon emissions — and could accelerate climate change processes already in place. But beyond these global effects, drought and fire, which is a tool of choice among the Amazon's farmers and ranchers, pose a serious threat to a forest that is home to more plant and animal species, and more indigenous cultures, than any other forest in the world.

According to Nepstad, with the completion of this first phase of the experiment, attention will turn to another future scenario for the world's tropical rainforests. Namely, how does the forest recover, or not, after prolonged drought? Although it is difficult to imagine a reversal of the current trend in rainforest drying, it is important to understand the forest's response to this scenario nonetheless. What types of trees will invade the forest that has now been "released" from its imposed drought? And are the trees that survived somehow damaged, and unable to respond to this release? Have the vessels that conduct water from their roots to their leaves become clogged with water vapor bubbles, restricting their growth for years to come? These are just some of the questions that will be explored during the final two years of this experiment.

Collaborating organizations in this effort include IPAM (Instituto de Pesquisa Ambiental da Amazonia), EMBRAPA (Empresa Brasileira de Pesquisa Agropecuaria), University of Georgia, Stanford University, Universidade de São Paulo/Centro de Energia Nuclear na Agricultura, University of Miami, Tulane University, and University of California, Irvine. The US National Science Foundation, the US Agency for International Development, NASA, and the Gordon and Betty Moore Foundation, provide funding for this experiment.