Seeing the Forest for the Carbon

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CARBON DATING AND AGE STRUCTURE

It's hard to see the Amazon—the oldest, largest, most productive forest and hydrological system on the planet—for all the superlatives. The Amazonian ecosystem is so complex that scientists are finding that, paradoxically, the more they know about it, the more they realize they don't know.

In the last few years, Brazil has put together an international collaboration to study the Amazonian system. The Large-Scale Biosphere–Atmosphere Experiment in Amazonia (LBA) is a large network of environmental study sites that integrate hydrological, climatological, ecological, and biogeochemical research in an effort to understand, among other things, the flow of carbon through the Earth system.

Research from LBA-related studies has yielded some surprises. In a study published in the *Proceedings of the National Academy of Sciences* (see the 20 December 2005 issue), a group of Brazilian and American scientists measured the age and growth rate of trees in three different regions of Amazonia. They found the trees are much older and more slow growing than anyone realized.

Until recently, the ages of tropical trees, which typically lack annual growth rings, have been based on estimates from multiyear surveys of permanent plots. Those age estimates, according to the current study, have been way off. By measuring the diameters of trees in three size classes and radiocarbon-dating core samples, LBA researchers determined that up to half of all trees greater than 10 centimeters in diameter are over 300 years old. A few of the analyzed trees, which were randomly selected within each size class, are over 700 years old—leaving one to wonder how old the largest trees might be.

Monthly dendrometer measurements over several years revealed another surprise. The central Amazon study site had the slowest-growing trees, on average growing at half the rate of trees in the western and eastern sites. Growth rates of trees in all three of the sites in the LBA study are slower than those reported for Central American forests.

The slower growth of Amazonian trees means that carbon is taken up at roughly half the rate previously supposed, throwing off models currently used to predict global carbon cycles. As a result, the authors conclude, models based on the assumption that all forests are alike and interact with the atmosphere in the same way may overestimate the Amazon's role in sequestering carbon dioxide from the atmosphere.

CARBON SEQUESTRATION AND WATER USE

Afforestation, or the creation of forests on open land, is one of the predominant strategies currently used to sequester carbon. Other strategies include methods to restore organic carbon in agricultural soils, such as converting cropland to pastures or no-till management. Though forests have the potential to sequester more carbon, storing it both in soil and as wood, there may be trade-offs, according to a new study published in *Science* (see the 23 December 2005 issue).

Tree plantations around the world use fast-growing pine and eucalypt species to help remove carbon dioxide from the atmosphere. An international team led by Robert Jackson, of Duke University's Nicholas School of the Environment and Earth Sciences, looked at the hydrologic and biogeochemical changes associated with tree plantations at local and regional levels.

From catchment records, the scientists found that streamflow dropped dramatically within a few years of planting evergreens on grasslands, shrublands, or croplands. Streamflow dropped an average of 42 percent annually for 6 to 10 years, 10- to 20-year-old plantations lost 52 percent, and 13 percent of streams dried up completely for at least a year.

The greater nutrient demands of trees (over shrubs or crops) also changed the soil chemistry in plantations. From previously published studies, the researchers determined that, compared with shrublands or grasslands, tree plantations take more nutrients such as calcium, magnesium, and potassium from the soil and exclude more sodium, resulting in higher soil salinity and acidity and lower fertility.

The researchers also used models to evaluate the impact of economically driven carbon sequestration scenarios in the United States. The models showed that, at the regional scale, climate feedbacks are not likely to make up for the water lost to tree plantations. Not only was there no evidence that conversion of more land to forest resulted in increased rainfall, the model showed there is a potential for increased evapotranspiration and a drop in rainfall.

In some cases tree plantations improved water quality, such as in southwestern Australia, where forests were replanted on cropland that had once been forest. Tree plantations can also benefit waterlogged soils and alleviate flooding, particularly where past forests have been replaced by cropland.

Strategies for sustainable sequestration of carbon from the atmosphere, say the authors, will have to balance the benefits with the costs to other ecosystem services provided by the environment.

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