



RUTH DEFRIES

## Consequences of Land Use

**As long as there has been civilization, humans have changed the landscape around them, converting forests to pasture, farmland and cities. As human populations have grown, so have the consequences of land use. Ruth DeFries, professor of geography with a joint appointment in Earth System Science Interdisciplinary Center, sets as her goal understanding—in fact, quantifying—all the consequences of people’s changing use of land.**

In recent years, one of DeFries’s projects has been studying deforestation in the Amazon as part of the Large Scale Biosphere-Atmosphere Experiment in Amazonia, or the LBA, a joint scientific project of NASA and the Brazilian government. Since 2003, she has visited the Brazilian Amazon each year for an on-the-ground perspective to validate and supplement NASA satellite data.



Guided by satellite data, DeFries visits sites mostly in the southern Amazon. She confirms what satellites suggest—that forests have been cleared in particular places—and takes note of what the land is being used for, whether pasture, farmland or roads. Each use has different consequences on the local and global environment. “It also helps reveal what’s driving deforestation,” says DeFries.

DeFries’s goals with these visits are to improve the interpretation of information from satellites and to gather data for evaluating the consequences of changing land use. In particular, she studies how the changes affect the Earth’s carbon cycle. Clearing forests releases carbon to the atmosphere as forests burn or decay. “There’s big uncertainty in exactly how much carbon is released,” DeFries says, although deforestation appears to be responsible for about a quarter of the increase in global carbon dioxide emissions in recent decades, a smaller factor than the burning of fossil fuels.

“People are modifying land for multiple reasons, in multiple ways, with multiple consequences,” DeFries says. In her work, she looks at the environmental consequences of changing use of land, while recognizing the benefits for society. Clearing land for agriculture or damming rivers for electricity clearly helps people. DeFries aims to quantify the cumulative consequences, including unintended effects on biodiversity, runoff and soil chemistry, as well as the emission of carbon to the atmosphere.

“The long term goal is to quantify all the consequences of land use changes, both positive and negative, to inform decisions,” she says. For her work, she was elected to the National Academy of Sciences in spring of 2006.

“For decades, Brazil has had an impressive record of tracking deforestation using satellites,” says DeFries. Working with the Brazilian space agency, she has helped them incorporate new types of satellite information into their monitoring system. High-resolution data take time to analyze, and DeFries has worked with Brazilian

researchers to use coarser-resolution data to rapidly see where forests are being cleared. The information can then be given to the Brazilian agency responsible for granting and enforcing land-use permits.

Tracts of cleared forest in the Amazon are most often converted to pasture by small-scale cattle ranchers. DeFries and her colleagues recently evaluated the extent to which forests in the Brazilian state of Mato Grosso are also being cleared for soy production. Brazil is the world’s largest exporter of soy, and companies grow the crop on large swaths of land cleared for mechanized agriculture. She and her coworkers concluded that the expansion of cropland is directly responsible for about 20 percent of new deforestation.

Patches of land cleared for agriculture tend to be larger and to fragment the surrounding forest into smaller pieces than land cleared for pasture. Because soy is grown for export, primarily to China and Europe, rainforest is also increasingly being converted into paved roads. “We’re not making a moral judgment, but it’s important to assess what future deforestation [concerns] may be,” says DeFries.

Her work highlights the continuing need for site visits to complement satellite data. Remote sensing gives evidence but with enough ambiguity that the impressions have to be validated on the ground. When not in the field, DeFries and the students and research assistants in her lab analyze the digital data that comes from satellites and use them with computational models to track changes in land use through the seasons and year to year. Going on the ground yields “calibration data” to train the algorithms used in analyses.

In her project looking at deforestation in Mato Grosso, DeFries is now using the data she’s gathered to analyze how the changes there will affect global carbon emissions and climate. Geography is a field with vast scope, she says. “We’re trying to understand how people affect the landscape and how the landscape affects people.” —Karin Jegalian



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