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News

Seeing the Forest for the Carbon – From Space

by Robin Kraft

Brazil may lead the world in deforestation, but it's also a leader in using technology to try and reverse the process. The next step is measuring the amount of carbon captured in trees – and making sure it stays there. ***Ecosystem Marketplace*** *examines the latest developments.*

Sixth in a Series leading up to the 14th Katoomba Meeting in Mato Grasso, Brazil.

20 March 2009"We have only God to protect us here," said a Brazilian farmer recently in the Washington Post, referring to the constant threat of being kicked off farmland he had cleared in the Bom Futuro protected area in the Amazon basin.

"I fought for this. I gave my blood and my sweat," he continued. "They can't take it away."

This vision of deforestation as an engine of job creation and economic growth is compelling in a country like Brazil, where poverty remains widespread. But deforestation also represents the destruction of priceless ecosystems and valuable carbon sinks.

Although reconciling these two visions will not happen overnight, payments for Reduced Emissions from Deforestation and Degradation (REDD) are being considered as part of a future climate agreement, and would help shrink the estimated 20% share of annual global CO2 emissions attributed to deforestation.

The REDD idea is simple: Provide monetary incentives to stimulate popular and political will to preserve forests and their capacity to store carbon emissions. Ensuring that this actually happens is far from straightforward, but Brazil is well-placed to participate. The country has at once the largest rainforest, the highest rate of clearing, and the best deforestation monitoring systems in the world.

Measuring Deforestation in Brazil

Indeed, thanks to state-of-the-art, satellite-based monitoring systems, we find out each December in excruciating detail exactly where detectable deforestation has happened in Brazil over the previous 12 months. And with lesser detail but every two weeks, the environmental ministry receives a report on where large-scale destruction is taking place. Finally, if you've ever wondered whether your teak coffee table was sustainably produced – well, the Brazilians can't tell you that, but as of December 2008 they can tell you exactly where their forests are being whittled away due to selective logging and other forest degradation activities.

Still, there are limits to the capabilities of Brazil's eyes in the sky. And as we will see, this has implications for the design of a global REDD payment system designed to stimulate sustainable forestry.

Early Eyes in the Sky

The origins of Brazil's use of satellite-based remote sensing systems to monitor forests stretch back to the 1960s, when astronauts aboard the Gemini spacecraft first snapped photos of Earth from orbit. This spurred NASA to launch, in 1972, Landsat 1, the first of seven Landsat satellites dedicated to photographing the earth's surface. As part of its nascent aerospace program, Brazil built a Landsat receiving station in 1974 that would acquire and analyze raw data as the satellite passed overhead.

In 1988, Brazil's government started PRODES (Programa de Cálculo do Desflorestamento da Amazônia), charging the National Institute for Space Research (Instituto Nacional de Pesquisas Espaciais, or INPE) with systematically estimating annual deforestation in the Amazon and establishing a baseline for Amazonian forest cover.

Fourteen Years of Paper Maps

For the next fourteen years, analysts would pore over printouts of Landsat images taken during every year's August dry period, looking for areas of new deforestation. Adding up each 30-meter pixel of deforestation, they generated an annual report of the thousands of square kilometers of forest lost since the previous year.

With the advent of faster and cheaper computers, as well as the launch of the first Sino-Brazilian CBERS satellite in 1999, PRODES went digital.

The Digital Advantage

Since 2002, after digitizing its historical data archive, INPE's analysts have been able to focus their efforts on areas with high probability of deforestation. A digital workflow allows INPE to map incremental deforestation more quickly, isolate hotspots of deforestation, and better understand the drivers of deforestation. This ability to quickly visualize and spatially analyze clear-cutting over wide areas and over time, then mash it up with other data such as maps of population density or conservation areas, makes satellite monitoring of forests all the more compelling.

Still, it's one thing to know how much deforestation is happening, and another to actually stop it. By the time INPE takes its detailed calculations of deforestation to the government, it's too late.

Timely Information Means Deterrence

But since 2004, the DETER system (Sistema de Detecção de Desmatamentos em Tempo Real) has helped overcome this limitation, using lower resolution satellite data to provide far more timely information to the government. DETER leans heavily on data updated every one to two days by the MODIS sensor aboard NASA's Terra satellite platform, and automatically feeds Brazil's environmental ministry (IBAMA) alerts of flagrant cases of deforestation or forest degradation larger than 250 square meters every two weeks. While striving for accuracy, INPE recognizes that DETER cannot be perfect in such a short timeframe.

"We are much more interested in helping the government, giving them support for their [enforcement] actions," says Thelma Krug, spatial statistician and director of international affairs at INPE.

Measuring Degradation: the Next Challenge

Krug explains that clear-cutting is fairly obvious with a decent sensor, and doesn't require slow, expensive ground-truthing to ensure that estimates from space match the reality on the ground.

"Once you see forest turning into ground, you don't need to go and check," she says.

Identifying small-scale forest degradation, on the other hand, requires another level of technical sophistication, as well as a working definition of the term.

Often referred to as "the 'second D'" because of the acronym REDD, degradation occurs where only a few trees may have been harvested, but where lasting damage to the ecosystem and the forest's capacity for carbon sequestration may exist.

It's the kind of damage that's difficult to detect from space, and, according to Matthew Hansen, a senior remote sensing scientist at South Dakota State University, it's also difficult to define.

Whether it's removing a few trees per hectare or measuring ecosystem quality, "the second 'D' in REDD for me is really difficult," he says.

Undaunted, INPE launched its DEGRAD program last year to provide a detailed, annual estimate of degraded forest area, which according to the December 2008 report is actually more widespread in the Amazon than is clear-cutting.

The Insidious Danger of Degradation

Whatever the problems with measurement, environmental geographer Ruth DeFries of Columbia University points out that the danger of degradation is "not so much the direct carbon emissions" – after all, your coffee table will remain in good condition for decades – "but what it does to the forest – it makes it more susceptible to fire" that can level huge areas of forest.

And once logging roads are built for selective logging, degradation can lead to future deforestation as loggers push deeper into the forest and farmers take over at the forest edge. According to Krug, a 1999 study showed that 30% of forests degraded in the 1990s were already clearcut by the end of the decade.

New Advances in Measuring Degradation

While detecting degradation is not as straightforward as detecting clear cutting, it is within the capabilities of current technology and will surely improve as more experimental systems are refined.

Japan's new ALOS radar satellite, for example, can "see" through clouds, and Carlos Souza, a researcher at the research institute Imazon (Instituto do Homem e Meio Ambiente da Amazonia), has developed a system to identify degradation much more quickly than INPE.

Of course, as with deforestation, knowing how much degradation is happening is not the same thing as stopping it, as can be deduced from Brazil's status as a leader in both forest monitoring and forest loss. Souza argues that the difficulty of stopping degradation in near real time "is not the sensor's capability, but the political will to do so."

The Biomass Challenge

Politics aside, satellite monitoring falls flat when it comes to measuring changes in carbon sequestered in biomass. Such measurements are essential to tracking emissions reductions, so the challenge is twofold: how do you measure change in biomass on a meaningful scale in a country like Brazil, where the Amazon basin covers some 4 million square kilometers? And how do you ensure reasonable accuracy?

Patrick van Laake, assistant professor at the International Institute for Geo-Information Science and Earth Observation in the Netherlands, is not alone when he argues that biomass cannot currently be measured very reliably. Change in biomass representing sequestered carbon is slow, as a percentage of total forest biomass.

"We're talking about several percent per year maybe," says van Laake. Annual estimates would be swamped by the margins of error in current techniques for estimating biomass from remotely sensed data.

Biomass Solutions

There are at least three solutions. At one end of the spectrum is simplicity. Hansen believes REDD policy discussions are ahead of operational capabilities. While helpful for pushing remote sensing science forward, ambitions for REDD "are squarely in research and development on the remote sensing side," he says. For example, measuring biomass using satellite-based LIDAR (Light Detection and Ranging, also known as laser radar) is promising but can't be done yet because such satellites are still on the drawing board.

In any case, Hansen would "not go for the full unified field theory of carbon accounting. I just don't think that's doable right now" outside of experimental research contexts. Still, he thinks decent carbon stock reference maps would be useful for starting to set up REDD.

Krug highlights the urgency of action to reduce emissions and also urges simplicity as a starting point. After all, by the end of a quest for measurement perfection, she says, "the forests will be gone". Instead, she calls for a REDD system that supplies useful data now but has room for "a progressive increase of knowledge" of what is happening on the ground.

Combining the Remote and the Immediate

At the other end of the spectrum are companies like **ImageTree**, a US-based firm that combines advanced LIDAR and high-resolution aerial photography with field measurements to analyze forest structure at the sub-meter level. The company doesn't measure all biomass directly, rather it uses improved on-the-ground forest-sampling techniques to estimate the carbon stored in individual trees. Extrapolating to entire forests, ImageTree claims it can provide estimates of carbon stocks with unparalleled accuracy.

Chuck Anderson, Image Tree's vice president of ecomarket development, argues that such fine detail will be essential to track the progress of "literally tens of thousands of individual projects going on within countries to meet national objectives to reducing emissions."

Investors are likely to need the more detailed information that ImageTree can provide, and the company recently announced plans to start mapping Central American forests. But even if the logistics of scaling up to the Amazon basin, let alone the entire tropics, were practical, this level of detail could be overkill for a REDD system.

Building up a Presence on the Ground

A third solution for large-scale monitoring depends heavily on people on the ground. Van Laake says that instead of using questionable biomass estimates from distant satellites or rough averages for entire ecoregions, countries should invest in capacity building and on-the-ground measurements by the people who live in and depend on forests – give them tape measures and clipboards and pay them to measure biomass, something he is trying to do with the NGO Kyoto: Think Global Act Local.

To those who suggest that this would be a logistical nightmare, or that the numbers might be inflated to increase REDD payments, he reminds us that "what we're interested in is reversing the emissions." Indeed, "rather than asking how you can organize the measurement, ask yourself how we can organize the emissions reductions." The logistics of the latter are more difficult, and ultimately more important.

Ben Vickers has been working on ensuring sustainable, local management of forests as senior program officer for the Regional Community Forestry Training Center for Asia and the Pacific. He argues that governance reform and behavior change must be at the center of REDD, supplemented by remote sensing. "There is an absolute need for accuracy at the highest level using remote sensing, but it's not going to be any good if you're not changing patterns on the ground."

After all, if there's no change on the ground, if real people in Bom Futuro trying to feed their families keep cutting down trees, there won't be REDD revenue for anyone. Or many trees.

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