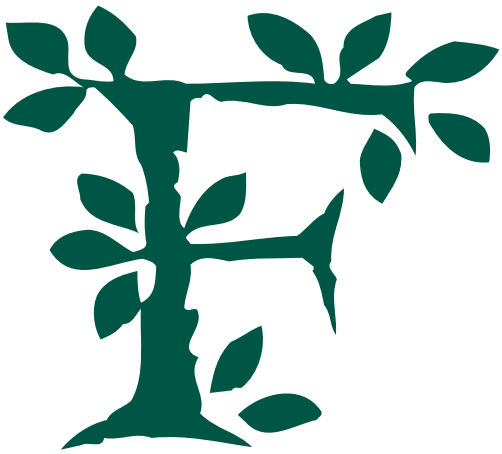
Why We Need Accurate Maps of the World's Forests

Daniel Morris, Molly K. Macauley, and Roger A. Sedjo



Forests are playing a starring role in ongoing international climate negotiations because curbed deforestation and forest degradation are considered some of the lowest-hanging fruit available to reduce global greenhouse gas emissions. Policymakers, however, have their work cut out for them because data are often ad hoc, imprecise, and inadequate. Today, there are higher-resolution maps of the Moon and Mars than of Earth's forests.

Outlining the total area coverage of forests is difficult because there are myriad definitions of what actually constitutes a forest, while no consensus exists about deforestation rates across the globe. As an illustration, the Intergovernmental Panel on Climate Change (IPCC) estimated that emissions from forests in 2007 represented about 17 percent of total international emissions, whereas studies published in fall 2009 estimated a range from 6 to 17 percent.

While the total deforestation picture in tropical forests remains fuzzy, even less attention is paid to reforestation and forest preservation occurring in boreal and temperate forests. Reducing emissions from deforestation and degradation (REDD)—which is strongly dependent on reliable measurement and monitoring—is a prominent aspect of the Bali Road Map, established by the UN Framework Convention on Climate Change (UNFCCC) processes in 2007. REDD was also prominent on the agenda at the UNFCCC Conference of Parties meeting in Copenhagen in December 2009.

Measurement Error

Ambiguous forest measures are the result of nonstandard reporting methodologies and a patchwork of substandard tools and techniques. Nations self-report these data, differ in their political and fiscal priorities regarding accurate assessment, and vary widely in technical capacity to inventory their forests. Data are updated every five years or so and even then are often extrapolated from past trends.

Most uncertainties in measurement manifest in four variables: forest area, timber volume, forest biomass, and carbon. Because these variables are interrelated, uncertainties in their measures compound and potentially result in a final estimate that has significantly more uncertainty than any single variable. Highlighting these discrepancies can help policymakers and practitioners develop robust measurements

that are good enough and consistent enough for all stakeholders interested in forests.

New RFF research documents major discrepancies in forest measures across the globe. For example, El Salvador's forested land shrank 14 percent from 1990 to 2000 according to a UN Food and Agriculture Organization (FAO) assessment, but another study reported that dense forested land area expanded 25 percent in the same time period. The figures below show disagreements between forest surveys on deforestation hot spots and illustrates the gaps among global forest datasets. Even measurement best practices approved by the IPCC, currently the most authoritative source on climate science, are not without measurement uncertainties.

The purpose of pointing out these discrepancies is not to develop perfect measurement of forests, but rather to develop measurements that are good enough and consistent enough for parties interested in forests. These measurements have to be sound for scientific debates, timber sales, and carbon credits. From there, economical methods for meeting them must be established.

Existing and Emerging Technologies

Satellite technology has recently advanced to a point where it can improve the reliability and accuracy of measures of different forest attributes. Monitoring programs have been using satellite data since the U.S. Landsat program got off the ground in the early 1970s. Landsat is the longest continuously operating satellite remote-sensing system in the world, and many organizations, including the UN FAO, incorporate Landsat data into forest assessments, partially

Measuring and Monitoring the World's Forests

One significant lesson from the recent financial crisis is the need for institutions that are transparent and can be monitored effectively. The world's forests, on which many people in poor and developing countries depend, suffer from a similar lack of oversight institutions that can accurately and regularly report their status. As environmental conservation and climate change help focus the international policy community's attention on forest ecosystem issues, the current inability to answer the question "What is the current state of the world's forests?" becomes more troubling.

In 2009, RFF scholars Roger Sedjo and Molly Macauley, with support from the Alfred P. Sloan Foundation, embarked on a project to begin answering that very question. Together with forestry and remote-sensing experts from across the globe, they began a major research initiative to investigate the economic, technical, and institutional issues associated with improving global forest measurement and monitoring.

The project focuses on three major issues: major discrepancies in current forest accounting and measurements, the technical capabilities of remote-sensing technologies, and the level of accuracy and precision required for forest measurements to be useful for scientists, policymakers, and practitioners.

Forest cover from Mexico to Panama classified by GLC2000 (far left) and by MODIS (left, top and bottom) and the disagreement between them. The red circle identifies a hot spot of disagreement in Guatemala and El Salvador.

SOURCE: GEO-WIKI 2009.

because it remains the least expensive option.

Despite Landsat's obvious benefits, the availability of its data in the future is in question due to federal budgetary limits. Additionally, newer technologies can provide more accurate and more complete monitoring coverage, though at present, at a much higher price. Recent improvements in analytical techniques for distinguishing distinct land cover and the combination of different types of satellite imagery can generate forest maps that are 80 to 90 percent accurate.

Encouraging technical progress is not limited to optical satellite sensors, such as those on Landsat. Other technologies, such as radar and LIDAR (light detection and ranging) also show great promise. LIDAR scans are conducted by sending laser pulses to the ground and measuring the returning radiation to penetrate the forest canopy, facilitating three-dimensional accuracy. Such data could provide unprecedented accuracy and understanding of forest area, volume, and biomass. The ability of LIDAR to measure both forest canopy height and ground elevation can increase accuracy in measurement of volume by at least 80 percent.

Unfortunately, LIDAR's potential is limited because at present, the remote-sensing equipment is carried on an airplane. This approach drives up expense and does not guarantee global coverage. Airborne LIDAR can collect only a narrow swath of information on one pass, much smaller than one pass from a satellite; moreover, flights require permission to fly over a country's airspace. Right now, radar technology is only a small part of the satellite fleet, and the first satellite-based LIDAR is not scheduled to be launched until 2015 or later.

Despite some shortcomings, new global satellite measurement and monitoring capabilities hold promise for providing accurate, periodic, and cost-effective global forest datasets. Satellite technology's unique advantages include the potential for improvement in temporal and spatial resolution, standardized measurement protocols, regularly updated global observations, and transparent, replicable methodology. Any regime for advanced data collection will need to be buttressed and validated with extensive "ground-truthing" (through field surveys, for example) and supported by proper institutions to enable accurate global monitoring of forests.

The global reach and frequent coverage enabled by the space-based vantage point of satellites may assist in providing information to monitor several concerns associated with use of forest carbon as part of climate policy. Satellite observations from Landsat may provide a historic baseline from which to measure changes in forested acreage. Accurate baselines are important for addressing additionality, which refers to actions that are taken to preserve forests in addition to actions that might be taken in the absence of any policy. Satellite observations that are periodic, with at least complete yearly coverage, may help monitor permanence or whether forests intended to serve as offsets are indeed maintained. Moreover, satellites provide global coverage to monitor deforestation that may take

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place in one area in response to avoided deforestation elsewhere, a problem known as leakage.

Solutions and New Institutions

To truly gain understanding of the state of the world's forests, measurements must advance beyond the current system of ad hoc, inconsistent data collection. The ultimate goal of RFF's Measurement and Monitoring of the World's Forests project is to construct a potential framework for developing and conducting a global forest "census," which can provide for the first time an accurate, expansive, and universally accessible database of forest attributes.

Advancing a state-of-the-art forest census will require a strong network of expertise, easily understood and achievable standards, and an international coordinating framework to organize many ongoing data collection and ground-truthing efforts. Recognition of the need for an independent, coordinated institution or set of institutions to gather and manage quality datasets is growing. As early as 2002, the G-8 recognized the desirability of coordinating myriad Earth-observing systems to enhance stewardship of the world's natural and environmental resources.

The G-8's response was to form the Global Earth Observation System of Systems (GEOSS), directed by the Group on Earth Observations (GEO), which has over 75 national governments as members. Coordinating and networking the efforts of GEO, which has a draft forest carbon tracking program in place for 2009 through 2011, with international experts and other organizations active in forest monitoring and measurement will result in major advances in observing the state of forests across the globe.

The timing for these efforts could not be more advantageous. In the lead-up to the15th Conference of the Parties meetings in Copenhagen, British Prime Minister Gordon Brown emphasized the critical role satellite observations will play in monitoring forest carbon systems established by the COP negotiation process. According to Brown, "…satellite navigation systems are going to be very important to the developing of a forest policy. Either you're planting more forests, of course, which is obvious, you can monitor that; or that what is agreed to be protected is actually protected. And I think we're getting better means by which we can have satellite observance of what's going on." ■

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Further Reading

This article is based on work by several contributors to RFF's Measurement and Monitoring of the World's Forests initiative, available at rff.org/worldsforests.

Fagan, Matthew and Ruth DeFries. 2009. *Measurement and Monitoring of the World's Forests: A Review and Summary of Remote Sensing Technical Capability, 2009–2015*. December. Washington, DC: Resources for the Future

Waggoner, Paul. 2009. Forest Inventories: Discrepancies and Uncertainties. Discussion paper 09-29. Washington, DC: Resources for the Future