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PERSPECTIVE

Painting the world REDD: addressing scientific barriers to monitoring emissions from tropical forests

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In December 2010, parties to the United Nations Framework Convention on Climate Change (UNFCCC) agreed to encourage reductions in greenhouse gas emissions from forest losses with the financial support of developed countries. This important international agreement followed about seven years of effort among governments, non-governmental organizations (NGO) and the scientific community, and is called REDD+, the program for Reducing Emissions from Deforestation and Forest Degradation. REDD+ could achieve its potential to slow emissions from deforestation and forest degradation either as a new market option to offset emissions from developed nations, or as a mitigation option for developing countries themselves. Aside from representing an important step towards reducing greenhouse gas emissions, a growing list of potential co-benefits to REDD+ include improved forestry practices, forest restoration, sustainable development, and biodiversity protection. Indeed the agreement is heralded as a win–win for climate change mitigation and tropical forest conservation, and it could end up contributing to a global economy based on carbon and ecosystem services.

That's good news, and some governments are now working to become 'REDD ready' in preparation for the forthcoming international program. This is important because, according to the agreements made by governments in the UNFCCC, developing countries which voluntarily decide to take part in REDD+ must establish their own national forest monitoring system to report changes in emissions from forests (UNFCCC 2009). But as of today, no developing country has implemented a system for monitoring, reporting and verifying (MRV) emission reductions for REDD+. Of course, it is all still very new, but many REDD-type projects have been underway for years now (Parker *et al* 2008), and many MRV practitioners involved in those projects are the same people being asked to help with government-led, national MRV programs. Yet going from the project scale to program readiness is a big step for all involved, and many are finding that it is not easy.

Current barriers to national monitoring of forest carbon stocks and emissions range from technical to scientific, and from institutional to operational. In fact, a recent analysis suggested that about 3% of tropical countries currently have the capacity to monitor and report on changes in forest cover and carbon stocks (Herold 2009). But until now, the scientific and policy-development communities have had little quantitative information on exactly which aspects of national-scale monitoring are most uncertain, and how that uncertainty will affect REDD+ performance reporting. A new and remarkable study by Pelletier, Ramankutty and Potvin (2011) uses an integrated, spatially-explicit modeling technique to explore and quantify sources of uncertainty in carbon emissions mapping throughout the Republic of Panama. Their findings are sobering: deforestation rates would need to be reduced by a full 50% in Panama in order to be detectable above the statistical uncertainty caused by several current major monitoring problems.

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The number one uncertainty, accounting for a sum total of about 77% of the error, rests in the spatial variation of aboveground carbon stocks in primary forests, secondary forests and on fallow land. The poor quality of and insufficient time interval between land-cover maps account for the remainder of the overall uncertainty. These findings are a show-stopper for REDD+ under prevailing science and technology conditions.

The Pelletier *et al* study highlights the pressing need to improve the accuracy of forest carbon and land cover mapping assessments in order for REDD+ to become viable, but how can the uncertainties be overcome? First, with REDD+ nations required to report their emissions, and with verification organizations wanting to check on the reported numbers, there is a clear need for shared measurement and monitoring approaches. One of the major stumbling blocks actually starts with the scientific community, which needs not only to develop highly accurate deforestation, degradation and carbon emission monitoring methods, but also to make those methods available to national governments and the supporting organizations orbiting those governments. This 'giving away' of the methods starts, but does not end, with the training provided by the scientific experts on the use of the monitoring tools. This effort must also involve a commitment to sustained support and capacity building until non-expert monitoring and reporting becomes routine.

The scientific community must also make clear what is operational and what is research. Operational does not necessarily mean less accurate. Rather, achieving both operational status and high accuracy requires innovation. While an innovative, but one-time or infrequent, mapping of forest cover or carbon stocks has been the most common scientific contribution to REDD+, it alone does not constitute operational monitoring. However, it can contribute to a portfolio of techniques and products that must come together to form an operational monitoring and modeling approach. Australia's National Carbon Accounting System (NCAS; www.climatechange.gov.au/) is one such approach, and there are others developing (www.csr.ufmg.br/simamazonia/). Importantly, carbon accounting models can meet the REDD+ challenge, but only if the observations—the measurements—are high quality, high resolution, and synoptic in geographic scale (Asner 2009).

Is there hope, and if so, is it based on real and present scientific progress? Real progress is being made, but much of the innovation has not landed in the reports provided by and for the UN and Intergovernmental Panel on Climate Change (IPCC). Yet this innovation is breaking serious barriers that extend and/or replace traditional forest inventory techniques, that use the latest satellite and aircraft technology on a cost-effective and repeated basis, and which simultaneously produce non-expert users of those technologies. And some government and academic science organizations are making their previously expert-only deforestation monitoring software widely available. For example, the Carnegie Institution's CLASlite system routinely tracks deforestation and degradation, and is now in use by more than 150 organizations throughout nine countries (http://claslite.ciw.edu). Carbon stock and emissions mapping is also becoming routine, but still involves combined effort by government and expert science partners to get it right (http://geoservidor.minam.gob.pe/intro/). Data accessibility is also critically important, and a few countries, such as Brazil and the United States, are leading the way by providing satellite imagery essential to lowering the uncertainties documented by Pelletier *et al* (2011).

Finally, the uncertainty in MRV may be addressed faster at the sub-national level. Developing states and provinces are often responsible for implementing forest policies and land-use zoning, and many have their own forest monitoring programs. Thirteen tropical states and provinces, from Mexico to Brazil and

Indonesia, are forging ahead in developing their own jurisdiction-wide REDD+ programs in collaboration with the US State of California, which has created the world's first greenhouse gas emission cap-and-trade policy that allows international offsets. In fact, this collaboration may soon create the first regulated REDD+ carbon market as California (USA), Acre (Brazil) and Chiapas (Mexico) forge an historic linkage agreement under the auspices of the Governors' Climate and Forest Task Force (http://gcftaskforce.org). Once created, this REDD+ market, in which regulated California industries achieve a portion of their emissions reductions through investments in Acre and Chiapas REDD+ programs, could expand to include new buyers and new providers. A key component of this program involves highly accurate, operational MRV on both sides of the carbon trading table, and at these state-level geographic scales, the science and technology are proving to be the most robust and accurate. Scientific innovation, combined with appropriate up-scaling from jurisdiction to jurisdiction, will likely prove most effective in bringing REDD+ to fruition.

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