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PERSPECTIVE

REDD pilot project scenarios: are costs and benefits altered by spatial scale?

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Payments for reducing carbon emissions due to deforestation and degradation (REDD) have garnered considerable global interest and investments. These financial incentives aim to alter the drivers of land use change by reducing opportunity costs of retaining forest cover, and are often promoted as multipartite solutions that not only generate profits and reduce carbon emissions but provide benefits for human development and biodiversity. Currently, the United Nations Framework Convention on Climate Change (UNFCCC) is debating a post-Kyoto protocol with national or sub-national emission reduction targets. Anticipating the inclusion of REDD in this agreement, $>$ 80% of pilot REDD projects are being established in tropical regions (table 1). While the capacity of REDD projects to meet their stated objectives must be assessed post-implementation, land use change models are powerful tools for generating potential outcomes from these pilot initiatives.

Table 1. Extent and emissions reductions for all REDD projects as reported by Ecosystem Marketplace, which maintains a comprehensive and up-to-date inventory of REDD projects that are selling credits and/or are verified by a third-party verifier. Adapted from Forest Carbon Portal (2009).

Geographical zone	Continent	Projects (#)	Area (km^2)	Emissions reductions (Mt C)
Tropical and Subtropical	Africa	2	7750	19.50
	Asia	2	8100	109.60
	South America	9	183 880	278.24
Temperate	Australia	1	14	0.18
	North America	1	15	N/A
	Totals	**15**	**199 759**	**407.52**

In this issue of ERL, Gaveau *et al* (2009) use a spatially-explicit model to explore the potential of a REDD pilot project in northern Sumatra, Indonesia, to reduce deforestation and conserve orangutan biodiversity. This project is conceived by the Provincial Government of Aceh, financed by Merrill Lynch, and co-managed by carbon trading firm Carbon Conservation and NGO Flora and Fauna International. Project managers estimate CO_2 emissions reductions at 3.4 Mt y^{-1} over 30 years across a 7500 km^2 area (Forest Carbon Portal 2009). From a time-series of Landsat satellite images, Gaveau *et al* calculate deforestation rates from 1990–2000 and 2000–2006. They apply these annual rates to deforestation probability maps, generated from forest condition in 2006 and six static spatial variables, to predict potential locations of future deforestation through 2030 under three different scenarios: (i) a business-as-usual with no REDD project; (ii) the current 7500 km^2 project; and (iii) an extensive 65 000 km^2 REDD scheme extending across the Aceh and Sumatra Utara provinces.

Gaveau *et al*'s chief contribution is identifying locations where forest carbon projects potentially have the greatest benefits for forest and orangutan conservation. By processing Landsat satellite imagery—now freely available—with relatively few spatial model inputs, this approach also has great potential for widespread application in tropical countries developing historical deforestation baselines. Yet Landsat satellite data also impose limitations for REDD. For example, Gaveau *et al* are unable to calculate forest degradation, which is highly problematic both to define and detect with Landsat imagery, yet critical especially in Indonesia with extensive logged forests (Curran *et al* 2004, Ramankutty *et al* 2007, Asner *et al* 2006). Nevertheless, Landsat remains one of the most appropriate satellite data products available for countries calculating previous rates of forest change. Assuming that technical roadblocks to REDD are overcome, another challenge surrounds assessing the feasibility of emission reduction scenarios, including those presented by Gaveau *et al*. Their estimates show that carbon and biodiversity gains would be 6- to 7-fold greater if the pilot project encompassed the 65 000 km^2 northern Sumatra region. Yet, developers chose to implement this REDD project across 7500 km^2, $\sim$ 10% of Gaveau *et al*'s expanded scenario region. If REDD programs are to be realized across large spatial scales (e.g., provinces/states), what factors constrain effective implementation?

First, high transaction costs and investment risks appear to be major barriers to establishing carbon concessions across large, heterogeneous regions. Identifying who should receive compensation as well as negotiating transparent and effective payment arrangements, is at best challenging especially with ambiguous land use rights and government jurisdiction in Indonesia (Ebeling and Yasué 2008). Protecting fragmented forests from multiple threats of logging, agriculture, and fire is fraught with complexities; who should be held accountable for defending 65 000 km^2 from fire especially during ENSO-associated droughts (Siegert *et al* 2001, Langner and Siegert 2008)? REDD's effectiveness will require support from people who live in and near REDD projects; Gaveau *et al* address only biodiversity and forest loss in their paper, but incorporating the potential effects of REDD programs on livelihoods and social dynamics is one of the most critical components of effective assessments via scenario-building and modeling (Soares-Filho *et al* 2006).

Another major obstacle to establishing REDD across large regions is the opportunity costs of carbon concessions. Recent estimates show that profits from protecting aboveground biomass for carbon payments in Indonesian non-peat forests are far below the benefits garnered from converting these forests to plantation agriculture (Butler *et al* 2009). Yet in order to mitigate forest conversion as proposed by Gaveau *et al*, carbon must compete with alternative high-value commodities (e.g., palm oil). Although forest carbon credits currently are traded in voluntary markets, carbon prices are considerably higher in compliance markets than in voluntary markets (World Bank 2008). If the UNFCCC generates consensus in December 2009 incorporating REDD in formal market-based trading mechanisms to meet compliance targets, REDD may become a financially competitive land use option even in highly-threatened lowland forests, including those in northern Sumatra.

Ultimately, REDD implementation is an iterative process, requiring regular appraisals and improvements at local (i.e., REDD projects) through international (i.e., UNFCCC) levels. The overarching value of REDD pilot initiatives such as this groundbreaking Aceh project and Gaveau *et al*'s innovative assessments is to identify suitable approaches as well as shortcomings, allowing revised and refined efforts that will mitigate forest degradation via financial mechanisms. The next iteration of REDD program evaluations will also need to incorporate: (i) empirical measurements of carbon stock change attributed to forest degradation; (ii) evaluations of economic incentives for a diverse suite of agents such as local and urban communities as well as the private sector; and, (iii) explicitly consider the fluctuating price of carbon vis-à-vis competing commodity prices.

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