# A Global Opportunity Cost Model for All

## Elucidating the economics of conservation versus conversion is crucial for mitigating the impacts of tropical deforestation

Rhett A. Butler, Lian Pin Koh, Javier Mateo-Vega and Jaboury Ghazoul.

Land-use and land-cover change are presently both the second largest source of global greenhouse gas emissions and greatest threat to terrestrial biodiversity[1,2]. Vast areas of tropical forests, even those within protected areas, continue to be converted for agriculture, wood extraction, oil and gas development, mining and infrastructure expansion[3]. Such land-cover changes are primarily driven by industry and rural peoples' responses to economic opportunities, as mediated by national and international markets and policies, including growth in world trade of agricultural products[4,5]. Despite much research and discourse on market-based mechanisms for conservation, notably payments for environmental services (PES) schemes, current economic models that inform land-use decisions still largely ignore or undervalue services provided by natural ecosystems, allegedly due to the high opportunity costs of foregoing concrete, profitable land-transforming economic opportunities for more amorphous conservation-derived benefits[6].

The recent emergence of novel forest carbon payment schemes for climate change mitigation, however, might help to shift the manner in which economic models value nature, namely natural forests. In particular, Reducing Emissions from Deforestation and Degradation (REDD) aims to provide a financially competitive income stream to those who conserve standing forests (and associated carbon stocks) under threat of conversion to another land use, through the sale of carbon credits derived from the protection of these ecosystems[7,8]. By incorporating REDD into economic models, land-use decisions will be better informed, and could favor conservation over conversion under certain land use and climate policy scenarios; more so if applied, for example, with other PES schemes and/or the sustainable commercialization of non-timber forest products (NTFP). There have been site specific efforts to do this[9], but a pan-tropical, standard yet flexible and widely- accessible mechanism that has the capacity to expose the trade-offs between REDD and other land uses does not yet exist and could prove crucial towards consolidating forest carbon and climate change conservation strategies at the global scale of the problem. Thus, the time is ripe for developing a Global Opportunity Cost Model (GOCM) that would reveal to land-users, managers and decision makers where and the degree to which REDD, individually or stacked with other complementary strategies, could financially compensate forfeiture of conventional land use activities.

**Recent emerging trends**

Over the past few decades, the underlying causes of tropical deforestation have shifted from state-initiated to enterprise-driven processes[10]. After the Second World War and until the 1970s, land settlement schemes were widely established in frontier forests of Latin America and Southeast Asia by governments keen to quell rural insurgencies, pacify communities and reinforce national sovereignty. From the 1980s, state-sponsored rural settlement schemes began to lose their political and social appeal, while agribusinesses began to consolidate and integrate their operations to maintain profitability. In Southeast Asia, Latin America and the tropics in general, this often took the form of clear-felling primary forests for timber followed by establishment of extensive plantations, including rubber, cocoa, coconut, coffee, banana, sugar cane and oil palm, as well as cattle production[4,5]. As a consequence, large agribusinesses and other industrial developers, often funded by timber revenues and/or stimulated by permissive government tax policies and subsidies, rather than rural subsistence farmers have become the dominant drivers of tropical deforestation today.

This trend creates opportunities for forest protection because environmental activists can now target their campaigns at large agribusinesses and trade groups, many of which are seeking access to international markets and therefore are likely to be compelled to address environmental concerns of consumers and shareholders[11]. Furthermore, many companies outright own or hold government-granted concessions of large tracts of yet unplanted and still forested lands – the sheer extent of which would contribute significantly to conserving biodiversity if they could be preserved. Driven by pressures from environmental groups, and also as part of corporate social and environmental responsibility programs that often include sustainability certification processes, some companies are already setting aside patches of forests as riverine buffer zones, habitat corridors or even private nature reserves[12]. More companies, as well as government agencies mandated with issuing land concessions for other uses, might consider adopting such conservation efforts if they could be adequately compensated for the opportunity costs of doing so. However, access to information regarding the economic trade-offs of conserving versus converting forested lands to other uses is still not readily available throughout the tropics to those whose decisions and actions determine the fate of forest ecosystems. And, therefore, opportunities to protect critical tracts of forests slated for conversion to agriculture and other land uses are potentially being passed up.

**A tipping point?**

The average annual loss of 11.6 million hectares of tropical forests worldwide accounts for ~1.5 Pg C/y or ~18% of global greenhouse gas emissions from human activities[2]. Recognizing this, climate change scientists, policy makers and environmental organizations have been working on the development of REDD as a financial mechanism to compensate individuals, communities, organizations or governments for the value of carbon stored in forests that would otherwise be released into the atmosphere by deforestation[7].

Currently, REDD credits can only be traded in voluntary carbon markets such as the Chicago Climate Exchange (www.chicagoclimatex.com), or be paid through designated carbon finance funds such as the World Bank's Forest Carbon Partnership Facility (www.forestcarbonpartnership.org). Carbon credits sold through these avenues do not fetch a high price. A recent study estimates that the net present value (NPV) of a REDD project would range from US$614 to US$994 per hectare over a 30-year project timeframe, as opposed to an agribusiness – i.e., oil palm operation – that could yield NPVs of US$3,835-$9,630 per hectare[9]. As a consequence, it remains more profitable to convert a natural forest to an oil palm plantation than to preserve it for a REDD project.

If in future climate change mitigation policies, REDD becomes recognized by the United Nations Framework Convention on Climate Change (UNFCCC) as a legitimate activity for reducing carbon emissions, REDD credits will then be traded in UNFCCC-sanctioned markets where they are valued at much higher prices. This could boost the profitability of REDD up to US$6,605 per hectare[9]. Under this scenario, protecting forests through REDD could become an economically competitive land-use option compared to oil palm agriculture or other profitable agribusiness activities, more so if stacked with other PES schemes, such as those that recognize and compensate for biodiversity and water values, and/or the commercialization of NTFPs. In this way, REDD could be a tipping point for mitigating the impacts of land-use change on biodiversity and greenhouse gas emissions. Demonstrating REDD's potential profitability versus other land uses to decision makers will be fundamental in promoting its application.

**Global Opportunity Cost Model**

REDD is expected to be a key agendum for discussion during the 15th Conference of Parties (CoP) of the UNFCCC to be held in Copenhagen, Denmark in December of this year. Given that a post-Kyoto Protocol REDD mechanism is likely to be adopted should an international climate agreement be reached, there is an urgent need to evaluate the opportunity costs of avoiding deforestation under various climate change mitigation policy and land-use scenarios. A GOCM that facilitates comparisons and trade-off analyses among the most financially profitable land-use activities such as permanent cropping, commercial logging, cattle ranching, and forest conservation under REDD (independently or with other conservation strategies) would be able to achieve just that.

To be useful to land-use decision makers, the model should be spatially explicit using the most current satellite imagery, distinguishing between old-growth forest, young secondary forest, timber production forest, current cropland distribution (e.g., sugar cane, soy, oil palm), areas of potential future agricultural expansion (e.g., based on crop suitability, land-use capacity, land tenure and zoning), anthropogenic non-forest vegetation (e.g., grassland, shrubland, barren land), and present and planned road networks and other large-scale infrastructure development such as hydroelectric dams, mining, and oil and gas exploitation. These various layers of information should serve as the basis for identifying, at various scales, the primary forested areas that would be most susceptible to conversion to other land uses (i.e., potential deforestation hotspots) and where efforts to implement REDD, along with complementary conservation strategies when warranted, must be focused. The model would also need to accommodate variables such as prices of commodities (including agricultural and timber products, and REDD carbon credits), the impact of new roads on agricultural suitability, and the effects of environmental stochasticities (e.g., tree die-offs caused by droughts or fires). The GOCM would be published in an open-access format, preferably with a multi-lingual and user-friendly interface such as data layers on Google Earth to enhance accessibility and promote adoption. The open-access nature of the model means that it will be continuously updated with new data, variables and computation scripts by contributions from end-users, improving its scale, scope and resolution. The model would also benefit from breakthroughs in remote sensing technology. Thus, the utility of the model does not depend on its completeness – it can be useful as it improves incrementally.

The benefits of a comprehensive GOCM are myriad. First, it will allow researchers to integrate typically undervalued services, including sustainable harvesting of forest products, ecotourism and watershed protection, into a spatial economic model. Model outputs from the GOCM will help inform policymakers and the public on various land-use allocation options. Second, as a practical application, the GOCM could increase transparency of land use decisions by demonstrating, for example, the true cost of underpricing land for development, revealing false claims by politicians or developers. At the same time, it can reveal the actual cost of setting aside an area for conservation, and thus would promote the application of fair mitigation and compensation measures for those affected. Third, by integrating biodiversity data to assess the potential collateral costs and benefits of land-use decisions for conservation, the GOCM could facilitate the development of new PES products such as biodiversity banking and offsets schemes[13]. The model could also identify scenarios whereby activities that enhance biodiversity, such as reforestation using native species to restore vegetation connectivity or entire habitats, may financially outperform other forms of land use on degraded lands. Fourth, given that the GOCM could reveal high conservation value areas where natural habitat conversion to other uses is likely to be more profitable than REDD (even when stacked with other complementary strategies), it could serve as an early warning mechanism of potential deforestation sites for environmental organizations and government agencies (i.e., a deforestation 'red flag'). The model would not only indicate where conservation efforts might be focused but could also encourage the application of other preemptive conservation strategies (e.g., declaration of a protected area). In this regard, the GOCM could also help to spawn the development of other innovative financial and nonfinancial incentives for conservation. Finally the GOCM would allow users to accurately track land-use changes. In the context of agriculture-driven deforestation in the tropics, the mapping and annual monitoring of rapidly expanding crops, such as oil palm, sugar cane and soy, would reveal conversion pathways, allowing blame and sanctions to be appropriately assigned to the perpetrators of illegal forest destruction.

Through the synthesis and analysis of existing data, the development of the GOCM would foster unprecedented opportunities for collaboration across multiple research disciplines (including economics, agronomy, ecology and remote sensing) and institutions working on conservation and development issues (including universities, nongovernmental organizations, government agencies and the private sector). In this way, the GOCM would serve as an overarching framework for guiding research, and aggregating and disseminating data and research outputs in a manner that is applicable to a real-world problem.

A GOCM would not be a panacea for halting tropical deforestation. Nevertheless, to the extent that environmentally-damaging land-use decisions are the result of inadequate information, or even disinformation, especially with regards to the potential of REDD and other conservation-oriented schemes for financial compensation, the GOCM would aid in better informing and guiding land-use decisions, and thus mitigating deforestation in the tropics.

Rhett A. Butler* is in Mongabay.com, P.O. Box 0291, Menlo Park, California 94026, USA.

Lian Pin Koh* is in the Institute of Terrestrial Ecosystems, ETH Zürich, CHN G 73.1 Universitätstrasse 16, 8096 Zürich, Switzerland. Email: lian.koh@env.ethz.ch

Javier Mateo-Vega is in Smithsonian Tropical Research Institute, Apartado 0843-03092, Balboa, Ancón, Panama, and Environmental Leadership & Training Initiative, Yale School of Forestry & Environmental Studies, 195 Prospect Street, New Haven, Connecticut 06511, USA.

Jaboury Ghazoul is in the Institute of Terrestrial Ecosystems, ETH Zürich, CHN G 73.1 Universitätstrasse 16, 8096 Zürich, Switzerland.

* These authors contributed equally to this work.

1. Sala, O. E. et al. Global biodiversity scenarios for the year 2100. *Science* **287**, 1770-1774 (2000)
2. Houghton, R. A. *Carbon Flux to the Atmosphere from Land-Use Changes: 1850-2005. In TRENDS: A Compendium of Data on Global Change* (Carbon Dioxide Information Analysis Center, Oak Rodge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee, 2008),
3. Geist, H. J. & Lambin, E. F. Proximate causes and underlying driving forces of tropical deforestation. *BioScience* **52**, 143-150 (2002)
4. Lambin, E. F. et al. The causes of land-use and land-cover change: moving beyond the myths. *Global Environmental Change* **11**, 261-269 (2001)
5. Donald, P. F. Biodiversity impacts of some agricultural commodity production systems. *Conservation Biology* **18**, 17-37 (2004)
6. Balmford, A. & Whitten, T. Who should pay for tropical conservation, and how could the costs be met? *Oryx* **37**, 238-250 (2003)
7. Miles, L. & Kapos, V. Reducing greenhouse gas emissions from deforestation and forest degradation: global land-use implications. *Science* **320**, 1454-1455 (2008)
8. Venter, O. et al. Carbon payments as a safeguard for threatened tropical mammals. *Conservation Letters* **2**, 123-129 (2009)
9. Butler, R. A., Koh, L. P. & Ghazoul, J. REDD in the red: palm oil could undermine carbon payment schemes. *Conservation Letters* **2**, 67-73 (2009)
10. Rudel, T. K. Changing agents of deforestation: from state-initiated to enterprise driven processes, 1970-2000. *Land Use Policy* **24**, 35-41 (2007)
11. Butler, R. A. & Laurance, W. F. New strategies for conserving tropical forests. *Trends in Ecology & Evolution* **23**, 469-472 (2008)
12. Koh, L. P. & Ghazoul, J. Designer landscapes for sustainable biofuels. *Trends in Ecology & Evolution*, in press, doi: 10.1016/j.tree.2009.1003.1012 (2009)
13. Bekessy, S. A. & Wintle, B. A. Using carbon investment to grow the biodiversity bank. *Conservation Biology* **22**, 510-513 (2008)