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Conserving carbon in tropical forests: pitfalls and possibilities*/

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Widespread concern about global climate change has drawn attention to tropical forests, both as sources of atmospheric heat-trapping gases when they are degraded or destroyed and as sinks for these same compounds when they are well-managed or restored. Although it is encouraging that improved forest management is being considered by international policy-makers as a way to mitigate climate change, there are some concerns about how carbon-based policies will be implemented. With the objective of informing the policy-making process, this paper describes some of the avoidable pitfalls after first highlighting some of the ways improved forest management can mitigate climate change by reducing the emissions from deforestation and forest degradation (REDD) while simultaneously promoting biodiversity protection and enhancing social welfare.

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Although much of the debate about the REDD option has centered on deforestation, this paper focuses on degradation, both how it can be avoided and how it can be rectified. Although many tropical forests are degraded due to over-hunting and unsustainable harvesting of non-timber forest products, other forms of degradation have direct and measurable effects on standing stocks of carbon and on the capacities of ecosystems to sequester additional carbon. For the purposes of this article, "degradation" is defined as loss of carbon from forests that remain forests, according to the national definitions of "forest" as agreed upon by the UNFCCC (Sasaki and Putz 2009). Although the tremendous stocks of soil carbon and the threats to these stocks are recognized, especially when natural wetlands are drained, the focus of this paper is biomass carbon.

One of the first lessons learned by anyone trying to estimate forest biomass is that most of it resides in large trees. Fundamentally, this simple fact means that the story of forest carbon is largely the story of trees; generally, what is good for trees is good for carbon stocks (Harmon, Ferrell and Franklin 1990). Unfortunately, what is good for trees, timber and carbon is not always good for biodiversity, other ecosystem functions or social welfare (Nelson et al. 2008; Putz and Redford 2009a and b). The many problems that derive from efforts to maximize timber yields (Ludwig, Hilborn and Walters 1993) are shared with efforts to maximize carbon stocks rates of uptake. That said, there are many ways that tropical forest lands can be managed for carbon without causing undue losses to other forest values.

Illegal logging

One way a REDD program could help maintain tropical forest carbon stocks while protecting biodiversity and other ecosystem functions would be to contribute to efforts at controlling illegal logging. For example, investments in the EU's Forest Law Enforcement, Governance and Trade (FLEGT) program could very well translate into reduced emissions (Tacconi 2007). While it will be challenging to determine just how much additional carbon is retained due to reductions in illegal logging resulting from investment of REDD funds, these monitoring and verification efforts would be worthwhile. The only potential pitfall in curbing illegal logging pertains to that slippery slope of activities, from outright illegality through activities better characterized as part of the socially accepted "informal sector" of timber harvesting that was criminalized by governments unwilling to grant legitimate owners tenure over their forests.

Reduced impact logging

In forests destined for timber harvesting, switching from unplanned logging by untrained and unsupervised crews to reduced-impact logging (RIL) appears to be a win-win transition (Putz et al. 2008a). With less collateral damage to the residual stand after RIL, carbon stocks are more effectively retained and recuperate more rapidly than after conventional logging (Putz et al. 2008b). Biodiversity also benefits from decreased damage to stand and soil. In addition, trained workers are less likely to be injured or killed. Whether firms profit more or less from RIL seems to depend mostly on whether the guidelines restrict access to "deleted areas," environmentally sensitive areas that would otherwise be harvested (Healey, Price and Tay 2000; Holmes et al. 2002). Given the training costs of RIL, the possibility of foregone profits from these deleted areas, and the slow rate of adoption of RIL in many tropical countries, there is justification for the use of REDD funds to stimulate improved timber harvesting practices.

Fire management

Given the large quantities of carbon released by forest fires, investments in fire management could contribute substantially to mitigating climate change while simultaneously preserving biodiversity, protecting stocks of timber and other forest products and avoiding the many health problems associated with smoke. To control forest fires in the tropics, support is needed on many fronts, from detection using remote-sensing techniques to institutional support for rapid deployment of trained firefighting crews. The only downside to fire control for enhancing carbon would be if these well-intended interventions were applied to fire-maintained natural ecosystems such as savannas and woodlands. Successful fire suppression in such ecosystems might result in increased carbon stocks, but only at the cost of large biodiversity losses.

Silvicultural approaches

While RIL is the first and perhaps the most important step towards sustainable forest management — and the most effective way to retain carbon in managed stands — even more carbon can be sequestered if RIL is combined with silvicultural treatments that concentrate growth in trees that are large at maturity. For example, liberating future crop trees (i.e. trees of commercial species less than the minimum cutting diameter) from overtopping neighbours or crown-infesting lianas can substantially enhance their growth rates (Wadsworth and Zweede 2006; Peña-Claros et al. 2008; Villegas et al. 2009). These increases in tree growth rates mean that overall carbon stocks can also be substantially increased by such interventions. Unfortunately, silvicultural treatments that favour future crop trees do so at the expense of non-commercial trees and lianas, which contribute substantially to biodiversity maintenance by providing food, cavities for nesting animals and intercrown pathways. In other words, there is clear trade-off between retaining biodiversity and maximizing carbon and timber yields.

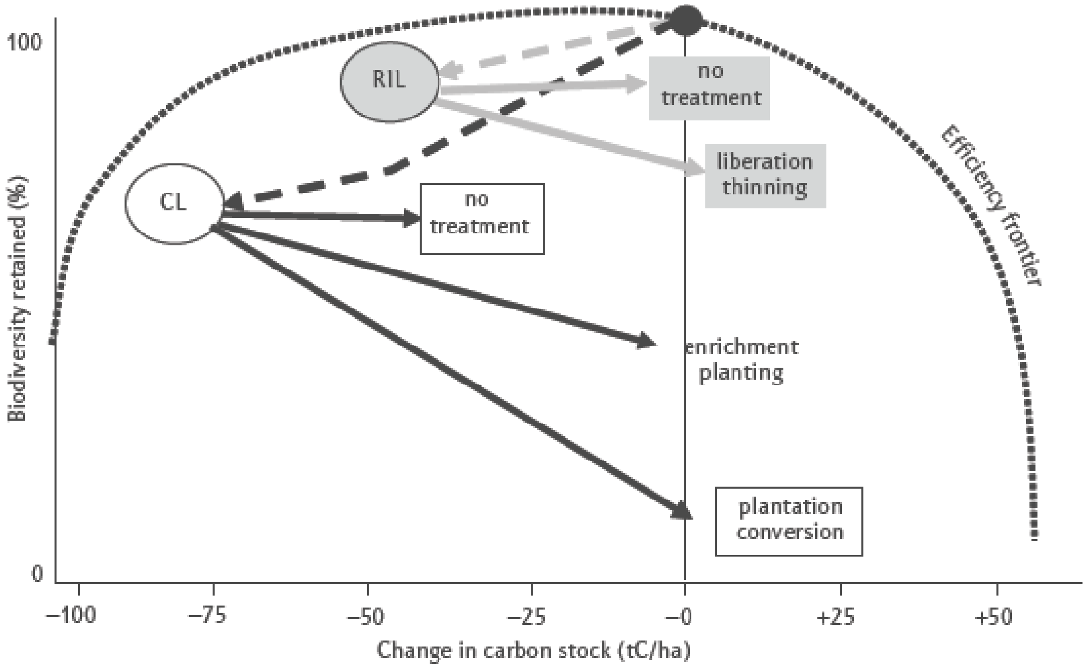
By promoting tree growth and restoring stand structures more akin to mature forest, silvicultural treatments applied to badly degraded and secondary forests can both increase standing stocks of carbon and enhance biodiversity. Again, the magnitude of the trade-off depends on the intensity of the treatment. Nevertheless, even major interventions can be justified if restoring ecosystem functions results in substantial and enduring benefits to long-term carbon and biodiversity. One danger here is in selecting reference conditions that are inappropriate in light of societal preferences and climate change, but as long as restoration is intended for multiple benefits and not just carbon, major trade-offs can be avoided.

Reforestation and afforestation

Tree planting is one of those human occupations about which it is politically dangerous to speak ill. In a census of investors in the voluntary carbon market, for example, tree planting (but not industrial tree plantations) figured prominently in their preferences (Neeff et al. 2009). Simply browsing an in-flight magazine these days reveals how much tree planting appeals to the environmentally concerned. While planting trees can be a very worthwhile endeavour from the perspectives of carbon, biodiversity, ecosystem function and financial and social welfare, naturally treeless or tree-scarce ecosystems also deserve protection, even if they have low carbon densities. There are also many people, including most farmers, for whom trees constitute a livelihood impediment. Unfortunately, under the climate change agreement currently in operation (the Kyoto Protocol), tropical landscapes are portrayed as either forested or deforested. Areas deforested since before 1990 are eligible for carbon funding for reforestation under the Clean Development Mechanism (Locatelli et al. 2008); areas that have not supported forests since before 1940 are eligible for afforestation in the name of carbon.

Reforestation and afforestation can be great ways to sequester carbon and can make wonderful contributions to rural livelihoods and biodiversity conservation. They can also have the opposite effect, depending on the context. For example, reforestation can have 1.4 Conserving carbon in tropical forests: pitfalls and possibilities socially deleterious consequences if what carbon project managers perceived as marginal or degraded lands actually contribute substantially to local livelihoods (Dove 1983). As for afforestation, biodiversity concerns loom large, making it more of a spectre than an opportunity; planting trees in species-rich woodlands, thickets, savannas and grasslands can increase their carbon density, but at great cost to biodiversity (Putz and Redford 2009a). Trade-offs are possible between biodiversity retention and carbon sequestration relative to an efficiency frontier at which both benefits are maximized (Figure 1; see Nelson et al. 2008 for a more elaborate and informed example). At that frontier, any increase in carbon requires a decrease in biodiversity and vice versa. Given that most managed forests are far less efficient than that (i.e. more biodiversity is lost and less carbon gained than possible), there is plenty of room for improvement. For example, adoption of RIL practices would serve to increase both biodiversity retention and carbon sequestration. In contrast, if a forest degraded by conventional logging or fire were “improved” by enrichment planting, carbon stocks would increase but potentially at the expense of biodiversity; the trade-off associated with plantation conversion would be even more deleterious to biodiversity. Obtaining the data needed to draw an actual efficiency frontier as well as to depict real vector directions and lengths is a waiting challenge for researchers.

Figure 1. Changes in standing stocks of biomass carbon



Changes in standing stocks of biomass carbon after a hypothetical tropical forest with 200 Mg C/ha (black dot) is logged at an intensity of 50 m^3/ha using reduced-impact logging (RIL, grey symbols) or conventional logging (CL, white symbols) techniques (dashed lines) and then over the subsequent 30-year period (solid lines) with either stand abandonment (no treatment), liberation of future crop trees, enrichment planting, or plantation conversion. The stippled curve represents the best possible trade-off between carbon sequestration and biodiversity retention.

Enjoying the climate change mitigation potential of improved tropical forest management, while promoting biodiversity protection and enhancing social welfare, will require a system of monitoring and verification that applies to more than carbon stocks. The challenge is to avoid burdening the new climate change agreement with too many restrictions that are not directly related to climate (Putz and Redford 2009b). It is also doubtful that negotiators could agree on globally relevant and otherwise appropriate restrictions on interventions made for the sake of carbon. What is needed is a general set of principles and criteria that can be interpreted to suit local or regional conditions through the choice of specific indicators. The Carbon Community Biodiversity Alliance (CCBA) recently developed such principles, and the Forest Stewardship Council (FSC) has been using and improving theirs for the past 15 years (Subak 2002). It is hoped that whatever mechanism emerges to minimize the often unavoidable trade-offs between carbon, biodiversity and social welfare, it benefits from the experience of the FSC.

Recommendations

These are the major recommendations for avoiding the pitfalls of carbon-based forest conservation:

1. All REDD programs should be explicitly and directly connected to efforts at controlling illegal logging (e.g. EU-FLEGT).

2. Investments in forest fire management, reduced-impact logging, post-logging silvicultural treatments and tree planting can all help mitigate climate change and make forest ecosystems more resilient (Guariguata et al. 2007).

3. It is important not to lose sight of the fact that there are often clear and substantial trade-offs between maximizing carbon stocks and maintaining biological diversity. That said, given that most managed forests fall far below the “efficiency frontier” at which biodiversity losses are minimized for the carbon gained, there is plenty of room for improvement in management practices.

4. There is a need for a system for monitoring and verification that attends to more than carbon stocks by explicitly recognizing the social and environmental principles and criteria of sound ecosystem management.

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