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OPINION ARTICLE

Opportunities and Challenges for Ecological Restoration within REDD+

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Abstract

The Reducing Emissions from Deforestation and Forest Degradation (REDD+) mechanism has the potential to provide the developing nations with significant funding for forest restoration activities that contribute to climate change mitigation, sustainable management, and carbon-stock enhancement. In order to stimulate and inform discussion on the role of ecological restoration within REDD+, we outline opportunities for and challenges to using science-based restoration projects and programs to meet REDD+ goals of reducing greenhouse gas emissions and storing carbon in forest ecosystems. Now that the REDD+ mechanism, which is not yet operational, has expanded beyond a sole focus on activities that affect carbon budgets to also include those that enhance ecosystem services and deliver other co-benefits to biodiversity and communities, forest restoration could play an increasingly important role. However, in many nations, there is a lack of practical tools and guidance for implementing effective restoration projects and programs that will sequester carbon and at the same time improve the integrity and resilience of forest ecosystems. Restoration scientists and practitioners should continue to engage with potential REDD+ donors and recipients to ensure that funding is targeted at projects and programs with ecologically sound designs.

Key words: **carbon emissions, carbon sequestration, ecosystems services, forest-dependent communities, forest restoration, forested wetlands, reducing emissions from deforestation and forest degradation, tree plantations.**

Introduction

In forested ecosystems around the globe, ecological restoration can assist with climate change mitigation and adaptation while providing other tangible co-benefits to humans and natural systems. The contribution of afforestation and reforestation to reducing greenhouse gas emissions was first recognized under the Clean Development Mechanism of the Kyoto Protocol. More recently, the UN Framework Convention on Climate Change (UNFCCC) introduced reducing emissions from deforestation and forest degradation (REDD) as an international fund- or credit-based mechanism for reducing carbon emissions and protecting forest ecosystems. Now known as REDD+, it embraces "policy approaches and positive incentives on issues relating to REDD in developing countries; and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries" (UNFCCC 2010). Although ecological restoration is not explicitly mentioned, the inclusion of sustainable management and carbon-stock enhancement has opened the door to REDD+ funding for forest restoration activities that reduce emissions, sequester carbon, and provide important benefits to communities and biodiversity. To date, nine developing nations have submitted Readiness Preparation Proposals to the World Bank's Forest Carbon Partnership Facility for initial monies to

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build capacity, broaden stakeholder engagement, and support readiness efforts for REDD+ activities (FCPF 2009). Most of these proposals include the restoration of forest ecosystems (UN-REDD 2009); however, a lack of explicit policy and technical guidance may limit the potential benefits of these projects and programs.

The purpose of this article is to highlight opportunities and challenges for forest restoration activities within REDD+ and stimulate discussion about its role in national strategies or action plans. There are at present few peer-reviewed articles evaluating the role of restoration within REDD+ (Campbell 2009) and, as a consequence, scientists and practitioners may be unaware of the potential. Here, we aim to inform the restoration community about the key opportunities and challenges in implementing successful ecological restoration within the REDD+ mechanism and make recommendations that will strengthen restoration outcomes.

Potential Restoration Benefits and Trade-Offs

Ecological restoration (also ecosystem restoration) is defined as the "process of assisting the recovery of an ecosystem that is damaged, degraded, or destroyed" (SER 2004). Effective restoration projects and programs manage or manipulate biotic and abiotic variables in order to remove threats to an ecosystem, facilitate or accelerate its recovery, and reinstate connectivity within the larger landscape. The restoration of degraded forests often includes the reintroduction of native species, removal of non-native invasive ones, reestablishment of appropriate fire regimes and soil and hydrologic conditions, and other activities that facilitate natural regeneration. Successful restoration activities also require integration with social, cultural, and economic frameworks so as to account for the needs and desires of key stakeholders, including local and indigenous communities.

Although the primary goals of REDD+ are to reduce emissions and sequester carbon in forest ecosystems, the recent UNFCCC Cancun Agreements endorse activities that provide other benefits to people, ecosystems, and biodiversity. Forest restoration projects and programs—when designed to integrate ecological functions within wider social, cultural, and economic priorities as outlined in the Ecosystem Approach (SCBD 2010)—have the potential to deliver the multiple co-benefits that many REDD+ participants aspire for, including:

(1) reducing greenhouse gas emissions and increasing carbon sequestration and long-term stability;
(2) enhancing resilience and the ability of ecosystems and communities to adapt to adverse impacts of climate change;
(3) increasing or enhancing the delivery of critical ecosystem services, equitable development, and sustainable livelihoods in forest-dependent communities;
(4) slowing and reversing land and water quality degradation and desertification; and
(5) conserving biodiversity and fostering species recovery.

A recent meta-analysis of over 200 restoration studies from nine major biomes showed consistently positive benefit-cost ratios (Neßhöver et al. 2011). Thus, forest restoration activities may indeed be a cost-effective way to meet a variety of REDD+ subnational, national, and global objectives and, in fact, many existing forest restoration projects and programs would meet REDD+ criteria for sustainable management and carbon-stock enhancement.

Although the multiple objectives of REDD+ could be synergistic or complementary, in practice there may be trade-offs among these with respect to restoration activities. For example, although fuel-reduction treatments (thinning and burning) are frequently used in fire-adapted forests in an attempt to restore fire regimes and prevent catastrophic wildfires and their associated carbon emissions, these activities generally increase emissions in the short term (Wiedinmyer & Hurteau 2010). Whether or not these short-term increases outweigh expected longer term benefits depends on whether or not wildfire occurs during the relevant treatment lifespan. Given the complex trade-offs associated with managing ecosystems for multiple objectives, it is critical that restoration projects and programs be based on an accurate assessment of treatment efficacy as well as ecological and social impacts.

Another potential trade-off is between the needs and priorities of forest-dependent communities and those of public and private stakeholders with vested economic interests. Inadequate governance of REDD+ projects could result in short-term benefits for a few stakeholders, rather than long-term benefits to ecosystems and communities. The marginalization and limited land-tenure rights of forest-dependent communities may reduce stakeholder involvement and access to benefits (Skutsch & McCall 2010). Traditional or community forest management is one proven approach to balancing these trade-offs; securing tenure and land titling is another potential cost-effective solution. In Mexico, for example, long-term assistance in promoting sustainable management practices within forest communities has helped achieve the desired co-benefits for biodiversity and human livelihoods (Bray et al. 2007).

Opportunities for Ecological Restoration within REDD+

Reducing and eliminating the drivers of forest degradation (i.e. poverty, inequity, and perverse government policy/regulation) should be a critical first step in any REDD+ actions (Campbell 2009). Clearly, avoiding deforestation through conservation activities is often the most time- and cost-effective method for reducing emissions, sequestering carbon, and providing other societal and biodiversity benefits. However, restoration interventions can effectively enhance ecosystem services in degraded forest ecosystems where conservation and avoidance alone is not sufficient to meet multiple REDD+ objectives. The circumstances in which restoration might be cost-effectively employed depend on the type and level of degradation (Skutsch & McCall 2010). Forest restoration may be an important tool for those ecosystems experiencing a substantial loss of biodiversity and original species richness (including those with endangered species), invasion by non-native invasive flora or fauna, altered fire regimes or hydrologic cycles, loss of culturally important plants and animals, and high susceptibility to climate change.

It is estimated that over 1 billion hectares of previously forested lands—approximately 6% of the earth's total land area—are presently suitable for broad-scale or mosaic restoration that could sequester approximately 140 GtCO2e (gigatons or billions of tons of carbon dioxide equivalent) by the year 2030 (GPFLR 2009). This is a highly significant amount as global greenhouse gas emissions in 2000 were estimated at 42 GtCO2e (Stern 2006). Several recent large-scale restoration programs have been proposed or initiated with the explicit goal of reducing carbon emissions. For instance, in May 2010, India's Ministry of Environment and Forests released a plan (called the Green Mission) to afforest or restore 5 million hectares of degraded and cleared forests, and improve the quality of another 5 million hectares over the next 10 years (Government of India 2010). These activities are estimated to sequester 43 million tCO2e annually, an amount equal to 6% of India's total greenhouse gas emissions. However, there is a high degree of uncertainty surrounding these carbon estimates because they are based on general data, rather than estimates for specific forest types and their ability to reduce emissions (e.g. moist forests have the capacity to sequester more carbon than do dry forests).

There are other examples of large-scale restoration programs designed to achieve multiple societal and ecosystem objectives. The Atlantic Forest Restoration Pact (AFRP), launched in 2009, aims to restore 15 million hectares of degraded lands in the Brazilian Atlantic Forest biome by 2050, and to sustainably manage the remaining forest fragments (Calmon et al. 2011). The AFRP has the potential to generate more than 3 million direct and indirect local jobs through restoration-related activities such as seed collection and processing, seedling production, planting, maintenance, monitoring, and basic and applied research. Moreover, it is expected that the 15 million hectares of restored forests will sequester approximately 200 million tons of CO_2 per year and store more than 2 billion tons of CO_2 by 2050 (Calmon et al. 2011).

These examples serve to illustrate the potential benefits of restoration in the context of REDD+. However, in these and other developing countries, there are valid concerns addressed below that restoration is merely code for continued agribusiness exploitation and industrial tree plantations that are not likely to enhance biodiversity and ecosystem services or benefit local communities.

Forested Wetland Restoration

Although restoration can lead to reduced emissions and increased carbon sequestration in many forested ecosystems, the magnitude and timescale of the response varies by ecosystem type. The restoration of mangrove, peatland, and bottomland forests has the potential to make relatively large contributions to global emission reductions. Although these ecosystems represent only a small percentage of the world's forests, they are some of the most productive in terms of carbon storage and other vital ecosystem services. This is largely a result of high aboveground biomass or standing carbon stocks and the capacity to store carbon belowground in soil and sediment (Donato et al. 2011). For instance, average aboveground biomass in mangrove forests is 247.4 tons/ha, similar to that of tropical terrestrial forests, while carbon burial averages 181.3 gC m^{-2} yr^{-1} or a total of 29.0 TgC/year (Alongi 2009). This potential for significant long-term carbon storage (Cebrian 2002) suggests that REDD+ funding for restoration activities in these forested wetland ecosystems could lead to reductions in emissions and increases in global carbon storage, perhaps even more than in upland forests on a per hectare basis (Laffoley & Grimsditch 2009). In addition to carbon benefits, the tangible co-benefits of revitalized mangrove forests extend to local and indigenous communities that depend on their goods and services (e.g. timber, fisheries, water treatment, and storm/climate protection). It is important to note that, given high failure rates in past attempts to restore mangroves, there is a need to ensure that projects and programs are based on sound science, including the principles of Ecological Mangrove Restoration (Lewis 2009).

Forested peatland restoration can also contribute to reducing emissions, while simultaneously protecting biodiversity and improving livelihoods. For instance, the Central Kalimantan Peatlands Project (CKPP) in Indonesia—a large-scale restoration effort aimed at reinstating critical ecosystem services, reducing carbon emissions, and safeguarding biodiversity—reduced annual emissions of peat-carbon on the order of 70 tCO2e/ha (SER 2010). The project involved damming drainage canals to restore natural hydrologic conditions, revegetating denuded areas with commercially important native tree species, and introducing sustainable agricultural techniques. Most importantly, the CKPP partners worked closely with local communities and authorities to address emerging issues and solicit their expertise and experience to resolve them. There are also examples of bottomland forest restoration that would meet various REDD+ objectives. One project—the 478-ha Red River Habitat Restoration Project (LA, U.S.A.) designed to conserve biodiversity, wildlife habitat, and community values by restoring ecosystem function and storing carbon 133 tCO2e/ha over a 100-year period—has received certification from The Climate, Communities, and Biodiversity Alliance (CCBA).

Challenges for Ecological Restoration within REDD+

There are a number of challenges to ecological restoration that need to be addressed within the REDD+ mechanism. First and foremost is the question of which types of activities should be implemented: monocultures, limited mixed-species plantings, or full-fledged efforts to reestablish native forests. Other challenges include the development of practical and sound procedures for monitoring restoration activities, the integration of the informal forestry sector and subnational programs into national strategies or action plans, and the distribution of benefits to local and indigenous communities.

Monocultures, Mixed-Species Plantings, and Ecological Restoration

One of the biggest challenges for REDD+ recipients is to design reforestation or restoration projects and programs that are effective in sequestering carbon and promoting biodiversity conservation while also economically beneficial to communities and landowners. There is clear evidence that, in many forested ecosystems, restored natural forests afford multiple benefits not provided by plantations. A recent study in Australian rainforests confirmed that restoration plantings stored significantly more carbon in aboveground biomass than monocultures and mixed-species plantations (Kanowski & Catterall 2010). In some forest ecosystems, species diversity is positively associated with resistance to disturbances from pests and pathogens. In comparison, tree monocultures or industrial plantations may increase run-off from fertilizers and pesticides; deplete groundwater; be vulnerable to wildfires, pests, and diseases; have limited belowground carbon sequestration; be less resilient due to low species diversity; and have impoverished food webs. In addition, these monocultures often provide virtually no cultural and subsistence resources for local and indigenous communities. Other things being equal, the restoration of resilient and sustainable forest ecosystems should promote the reestablishment of diverse assemblages of native species best adapted to particular site conditions rather than single species plantations (Gerber 2011). In sum, from an ecological, social, and cultural standpoint, monocultures on previously forested land may not contribute as much to REDD+ goals as would the restoration of natural forests and, to a lesser extent, the establishment of mixed-species plantations (Paquette & Messier 2010).

Despite the multiple benefits of forest restoration, private landowners will only use ecologically sound reforestation practices if, and when, it is financially attractive: when the benefits they receive exceed those from alternative land uses. Likewise, payments via REDD+ will only change reforestation approaches from monocultures to restoring native forests when the benefits received exceed the opportunity costs of these alternative forms of reforestation (Wunder 2008). Fortunately, there are situations where forest restoration may already be more attractive than monocultures (and other land uses) for both ecological and economic reasons, such as locations where communities or landholders have steep or infertile land that is marginal or unsuitable for monocultures. In these circumstances, the opportunity cost of native reforestation may be low and payments for ecosystem services quite high.

The time frame for and type of reforestation or restoration activities implemented will in part be driven by the carbon financing scheme associated with the project: fund-based versus credit-based mechanisms or a combination of the two. Fund-based mechanisms, which rely on international donors, are more likely to favor sustainable harvesting and long rotation cycles (i.e. more than 80 years), and therefore should be expected to include the planting of native species (Lamb 1998). The long-term timescale of a fund-based mechanism allows for multiple restoration interventions as well as for indigenous and other forest-dependent communities to continue intergenerational forest protection and maintenance without being subject to the vagaries of short-term credit markets.

Although, in general, biodiverse forests of native species may have greater conservation value than monoculture plantations, the extent to which co-benefits such as biodiversity or watershed protection can be generated by restoration depends as much on site-specific conditions and the landscape context as on type of planting. For instance, extreme degradation in a forest ecosystem may result in site conditions that are too stressful for many native species; under these circumstances, planting novel assemblages, including non-native species, may prove to be the most ecologically sound management intervention. Moreover, strategically located plantings that enhance connectivity between forest remnants or form healthy riparian corridors will be much more effective for biodiversity and watershed protection (Lamb 1998).

Measuring, Reporting & Verification

In order to be eligible for REDD+ funding, restoration projects and programs will need to demonstrate cost-effectiveness, additionality (i.e. would not be otherwise funded), and the capacity for and verification of long-term carbon sequestration. However, there are still a number of important unresolved issues related to carbon leakage, reporting, and verification. For example, in current REDD+ agreements, a nation can opt out of reporting soil carbon emissions if it is determined that its greenhouse gas emissions are not substantial; thus, reported emissions can be intentionally underestimated. Although measuring, reporting and verification (MRV) systems are being developed to assist developing nations with REDD+ activities, there is a need for greater input from scientists and practitioners on appropriate carbon, biodiversity, and socioeconomic indicators. One potential source for this input is the CCBA, which has developed voluntary standards to support land management activities, including conservation and restoration that simultaneously minimize impacts of climate change, foster sustainable development, and conserve biodiversity. The CCBA standards for third-party validation of carbon sequestration projects are being increasingly used and could inform the design of REDD+ MRV protocols.

More than 10 restoration, reforestation, and afforestation projects have already been certified by the CCBA, with a similar number undergoing validation at the time of writing. The most recent is the Monte Pascoal-Pau Brasil Ecological Corridor reforestation project, which aims to establish a corridor of about 1,000 ha joining two large remnants of Atlantic Forest, namely the Monte Pascoal and the Pau Brasil National Parks, in the Caraíva Watershed, Bahia State, Brazil.

Over its 30-year lifespan, this project should sequester 12 $tCO2e\ ha^{-1}\ yr^{-1}$ (Siqueira & Mesquita 2007), and possibly up to 360,000 tCO2e in total (CCBA 2010).

The Informal Forestry Sector and Subnational Integration

In developing countries, a large percentage of individuals earn wages as part of an informal economy that does not operate under government regulation and is not included in national accounts (Blunch et al. 2001). This so-called informal sector is usually community-based and often not subject to the same systematic private/public management found within the formal forestry sector (e.g. timber concessions, national parks, and other protected areas). An important challenge is how to include this sector in REDD+ national strategies or action plans, especially as it could provide significant labor for restoration, sustainable management, and other activities. Furthermore, REDD+ activities within the informal sector are highly desirable as the sustainable management of timber and non-timber forest products is vital to the health and well-being of many local and indigenous communities. Restoration activities in this sector will require effective coordination and stakeholder participation, integration of traditional and community forestry management practices, and a commitment to low-emissions rural development.

In addition, REDD+ needs to place greater emphasis on subnational activities as many existing forest restoration projects and programs in the developing nations come under the jurisdiction of local and state/provincial authorities. The Governors' Climate and Forest Task Force (GCF), which includes states/provinces from the United States, Brazil, Indonesia, Mexico, and Nigeria, is a coalition that was recently formed to link subnational activities to the REDD+ program. The GCF is working to ensure that REDD+ includes state/provincial restoration efforts that will "generate numerous environmental and social co-benefits" (GCF 2009).

The Distribution of Benefits to Local and Indigenous Communities

In the light of the 2007 UN Declaration on the Rights of Indigenous Peoples, another challenge is to safeguard the rights and land tenure of local and indigenous communities, and to gain their full, voluntary participation in restoration activities funded via REDD+. Local and indigenous communities are often the traditional stewards of forest ecosystem services that not only benefit them but also benefit the rest of the world. Policy approaches to and positive incentives for reducing emissions, such as REDD+, will undoubtedly increase the market value of local, community, and indigenous lands. Therefore, it is essential that REDD+ donors and recipients openly address rising land values that have already resulted in illegal land grabs, the appropriation of natural resources, reversals in land reform initiatives, food/water insecurity, and compromised and corrupt governance (Hatcher 2009).

Land titling is key to indigenous and local forest dwellers' ability to secure and defend a full bundle of rights, known as "clear tenure rights," which include access, use, and benefits. These rights are critical for reducing emissions and providing co-benefits as communities with secure land tenure have greater incentives to protect and restore their forests. Land titling can be significantly more cost-effective than the overall project costs of administering, implementing, and financing REDD+ projects: granting land tenure is estimated to cost US$10−40 per hectare, while a REDD+ project can cost US$700−20,000 per hectare per year (Hatcher 2009). In addition, there is empirical evidence that suggests community-managed forests may be subject to less degradation than other land management types, resulting in 1.5−3.5 tCO2e reduced emissions per hectare per year (Skutsch et al. 2009). Clearly, REDD+ will be more effective in reducing forest emissions, which now account for 20−25% of worldwide emissions (Nepstad et al. 2006), if the UN and international donors insist on nations granting and enforcing land rights to local, indigenous, and forest-dependent communities.

A final challenge is ensuring that funding by international donors actually reaches communities and individual landholders. This may be difficult when large numbers are involved. In such cases, some form of cooperative or even a government-sponsored management agency might be necessary to coordinate the distribution of funds and the MRV of restoration activities. Unless this is done, communities and landowners are likely to lose faith in REDD+ and make land-use decisions based on immediate priorities and/or other market signals. One concept that seems to hold great potential for equitable distribution and the engagement of local and indigenous communities is that of "nested governance" whereby there is a hierarchy of decision-making processes and multi-sectoral coordination that guides and accounts for REDD+ activities at multiple spatial and temporal scales (Sikor et al. 2010).

Conclusion

The REDD+ mechanism has the potential to provide significant new opportunities for developing nations to receive funding for much-needed forest restoration projects and programs. Given that conservation and avoiding deforestation is no longer sufficient in certain ecosystems to stem the loss of biodiversity and ecosystem services (including carbon sequestration), forest restoration activities should be considered as an important component of REDD+ national strategies or action plans. Therefore, REDD+ donors and recipients need to place more emphasis on, and increase their knowledge of, forest ecosystem restoration so as to create a quantifiable, cost-effective, and participatory approach to sustainable management and carbon-stock enhancement while simultaneously enhancing biodiversity values and the delivery of ecosystem services to nations and communities alike. The restoration of these vital services will help us address the future challenges of climate change, biodiversity loss, land degradation, and sustainable development (Chazdon 2008; Wright et al. 2009).

Implications for Practice

- Restoration scientists and practitioners, in collaboration with the biodiversity-related conventions and Multilateral Environmental Agreements (MEAs), are in an excellent position to facilitate the development of science-based tools, technologies, and practical guidance on ecological restoration for REDD+ recipients.
- The Millennium Ecosystem Assessment is an established platform that clearly demonstrates how this future guidance could be used to generate cost-effective and integrated restoration strategies at various scales and among different sectors that result in shared outcomes and mutual co-benefits. Once operational, the recently approved Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES) should also play an important role in bridging the restoration science–policy interface.
- There is an immediate need for restoration scientists and practitioners to establish a framework for identifying national and global restoration priorities, promoting results-based management and restoration interventions that address the interlinked objectives of REDD+ programs, and assessing the relative merits of restoration activities within and across ecosystems.

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