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Win–win REDD+ approaches belie carbon–biodiversity trade-offs

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ABSTRACT

Recent practise has revealed that conservation interventions that seek to achieve multiple benefits generally face significant, if under-recognized trade-offs. REDD+ policies present prospective win–win solutions for climate change mitigation, rural development and biodiversity conservation. Notably, protecting, enhancing and restoring forests for their carbon sequestration services has the potential to additionally promote the conservation of imperiled tropical biodiversity. However, it has become increasingly apparent that efforts to design a REDD+ mechanism that optimizes emissions reductions and associated co-benefits face significant environmental and economic trade-offs. We provide a framework for conceptualizing the major related policy options, presenting the associated trade-offs as a continuum and as functions of two key factors: (1) geographic targeting, and (2) the selection of specific forest management activities. Our analysis highlights the challenges of assessing trade-offs using existing data and valuation schemes, and the difficulty of paying for and legislating biodiversity co-benefits and safeguards within a future REDD+ mechanism.

1. REDD+ as a win–win solution

Tropical forests face a new set of win–win expectations. REDD+ policies under development through the United Nations Framework Convention on Climate Change (UNFCCC) would financially reward countries that reduce their carbon emissions through interventions to reduce deforestation and forest degradation, and conserve, sustainably manage and enhance forest carbon stocks (UNFCCC, 2010). These policies could provide large-scale carbon emissions reductions at comparatively low abatement costs (Stern, 2006), while also promoting sustainable forest sector development, enhancing rural livelihoods and protecting biodiversity—multiple objectives reaffirmed during the UNFCCC 17th Conference of Parties (2011a).

A future REDD+ mechanism could transfer billions of dollars from industrialized nations to tropical developing countries each year (e.g., Ballesteros et al., 2011). Funds would be used to protect threatened forests, restore degraded forests, improve forest sector planning and governance, and incentivize sustainable management in order to reduce forest-based carbon emissions. They may further generate social co-benefits through conservation payments to landholders and sustainable development initiatives that both improve rural livelihoods and reduce pressures on forests (e.g., Palmer, this issue). REDD+ policies may also deliver significant, additional biodiversity co-benefits by better protecting, managing and enhancing forests. Although generally considered ancillary to emissions reductions, biodiversity co-benefits have proved important to early REDD+ project developers (Cerbu et al., 2011; Dickson et al., 2009). Sites where conservation priorities geographically overlap with high carbon density forests are especially likely to deliver win–win outcomes (Busch et al., 2011; Kapos et al., 2008; Strassburg et al., 2010; Venter et al., 2009b). Similarly, REDD+ investments in carbon stock enhancement through reforestation can benefit biodiversity (Kettle, this issue), and REDD+ support for sustainable forest management strategies may provide economically competitive, more biodiversity-friendly alternatives to conventional logging (e.g., CBD and GIZ, 2011).

A number of prospective REDD+ interventions may deliver win–win solutions, generating considerable optimism (e.g., Busch et al. 2011; Christophersen and Stahl, 2011; CI, 2010; Djoghlaf, 2010; UNFCCC, 2011a; Viana, 2009). However, there is growing evidence that even where multiple benefits are possible REDD+ policy decisions face significant carbon–biodiversity trade-offs (Hirsch et al., 2010). We provide a framework for conceptualizing the major policy options currently available for a REDD+ mechanism that seeks joint emissions reduction and biodiversity conservation outcomes, and for anticipating the associated trade-offs. The framework facilitates more realistic assessments of the win–win opportunities afforded by REDD+.

2. Acknowledging conservation trade-offs

Environmental management often seeks multiple benefits, of which biodiversity conservation is often implicitly or explicitly a

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desired outcome (e.g., Kareiva et al., 2008). The tension between maximizing multiple benefits and accepting trade-offs in previous initiatives is instructive to the REDD+ debate. Integrated conservation and development projects, and community-based management initiatives have traditionally linked livelihood development and biodiversity conservation (e.g., Kremen et al., 1994). Agricultural intensification programmes have jointly promoted enhanced productivity and land sparing for conservation (e.g., Avery, 1997). Similarly, sustainable forest management and reduced impact logging initiatives have sought to maintain forest-based biodiversity alongside profitable extractive industries (e.g., Gascon et al., 1998). Perhaps most recently, the evolution of payment for ecosystem services schemes has presented opportunities to jointly address biodiversity conservation and poverty alleviation (Wunder, 2008). Experience with these programmes has shown that while multiple benefits are possible in some contexts, win–win solutions remain the source of considerable debate (see McShane et al., 2011; Hirsch et al., 2010; for debates surrounding the win–win examples above, see Adams et al. 2006; Agrawal and Redford, 2006; Bowles et al., 1998; Garcia-Fernandez et al., 2008; Matson and Vitousek, 2006; Redford and Adams, 2009; Robinson and Redford, 2004). These examples offer ample precedents for REDD+ efforts that seek to both maximize carbon sequestration and biodiversity conservation.

Accepting trade-offs explicitly requires a decision to forego the maximum return of one outcome in exchange for an increase in another outcome. Trade-offs present difficult decisions for policy makers, and often require a reassessment of priorities and expected outcomes (Minteer and Miller, 2011), or even a new definition of intervention success. There is increased recognition that conservation interventions suffer where trade-offs are overlooked (prompting unrealistic expectations), while honest assessments of trade-offs can facilitate problem-solving, improve planning (Hirsch et al., 2010; McShane et al., 2011) and increase conservation success.

There have been recent calls to evaluate the trade-offs of REDD+ policy options (e.g., Ghazoul et al., 2010; Harvey et al., 2010; Hirsch et al., 2010), as it has become increasingly apparent that REDD+ interventions are more complex than depicted by win–win representations alone (e.g., Ebeling and Fehse, 2009; Paoli et al., 2010; Phelps et al., 2010b). For example, evidence suggests that a REDD+ mechanism will not automatically yield significant, geographically-distributed biodiversity co-benefits (Ebeling and Yasue, 2008; Paoli et al., 2010; Strassburg et al., 2010; Venter et al., 2009a). Moreover, in some circumstances REDD+ policies may lead to unintentional biodiversity loss, for example if REDD+ policies displace deforestation pressures into other forests (leakage), or if REDD+ redirects funds away from other conservation objectives (Grainger et al., 2009; Miles and Kapos, 2008; Putz and Redford, 2009). Thus, while most REDD+ policies have the potential to deliver multiple benefits (Fig. 1), a future mechanism (1) requires environmental regulations and safeguards in order to protect against unintended biodiversity loss, and (2) would have to be specially designed in order to maximize additional biodiversity co-benefits (Harvey et al., 2010; Pistorius et al., 2010).

3. Conceptualizing carbon–biodiversity trade-offs

In general, sites where carbon and biodiversity priorities geographically overlap (e.g., Congo Basin), and where land management approaches favor both carbon and biodiversity conservation (e.g., protected areas), represent prospective win–win outcomes. However, once the obviously attractive investments are implemented, the selection of 'second-tier' investments will involve carbon–biodiversity trade-offs (e.g., Miles and Kapos, 2008; Price et al., 2008). Importantly, interventions designed to maximize biodiversity co-benefits may yield less carbon benefits than interventions that prioritize maximum carbon outcomes (Fig. 1; Harvey et al., 2010; Paoli et al., 2010). The associated trade-offs are not binary (all biodiversity or all carbon benefits). Fig. 1 reveals that many of the strategies under consideration for REDD+ support have the potential to deliver win–win outcomes. However, there is a range of prospective safeguards and investment options that offer varying degrees of environmental protection, a continuum of prospective biodiversity co-benefits (Miles and Dickson, 2010) and a range of prospective carbon benefits.

Fig. 1 depicts the trade-offs facing forest management interventions that seek to (1) maximize carbon emissions reductions, (2) avoid unintended biodiversity loss through the adoption of safeguards, and (3) maximize additional biodiversity co-benefits. The trade-offs between these three conservation objectives are represented as the function of two key policy dimensions: (1) geographic targeting of where REDD+ interventions are located, and (2) the planning, selection and implementation of forest management interventions. The figure is explained using six scenarios (A–F), which represent specific examples of prospective investments intended to reduce forest-based carbon emissions, although not all are necessarily eligible for REDD+ finance based on the existing UNFCCC rules. The scenarios are broadly characterized by whether they deliver high, medium or low carbon and biodiversity benefits, highlighting the diversity of potential win–win outcomes.

3.1. Geographic targeting

Mapping carbon–biodiversity overlaps reveals that synergies are not evenly distributed, and that some high biodiversity countries and forests could be overlooked by investments that maximize carbon benefits (Ebeling and Yasue, 2008; Venter et al., 2009a; Strassburg et al., 2010). Madagascar, the Brazilian *cerrado* and the Philippines are global conservation priorities, but have comparatively low carbon values (Scenarios B and C; Obersteiner et al., 2009; Venter et al., 2009a; Phelps et al., 2010a; Stewart et al., 2010). Moreover, biodiversity and carbon priorities do not always overlap at the sub national scale. For example, at the subnational level carbon conservation priority sites in Indonesia (peat swamp forest) fail to match biodiversity conservation priorities (lowland terrestrial forest; Paoli et al., 2010; Murdiyarso and Koh, this issue).

Efforts to optimize biodiversity co-benefits are likely to involve geographic targeting. While targeted investments can deliver full win–win outcomes (Scenario A), they often involves trade-offs in terms of carbon benefits (Scenario B). Similarly, investments to enhance and sustainably manage carbon stocks can involve geographic targeting to enhance biodiversity outcomes. Interventions can be pursued for a range of different forest types, and in forests with land use histories ranging from pristine to heavily degraded, yielding different biodiversity outcomes (Scenarios D and F; e.g., Edwards et al., 2011; Venter et al., 2009b).

Geographic targeting involves decisions at multiple scales; carbon and biodiversity analyses conducted at global, regional, national and sub-national scales can point to different priorities (e.g., Kapos et al., 2008 vs. Paoli et al., 2010). Conservation priorities also vary, whether based on indices of endemism, species diversity, threat of extinction, or gap analysis (e.g., Myers et al., 2000). Prioritization may also vary depending on whether interventions are expected to conserve specific genetic pools, minimum viable areas for threatened species, or broader ecosystems and landscapes.

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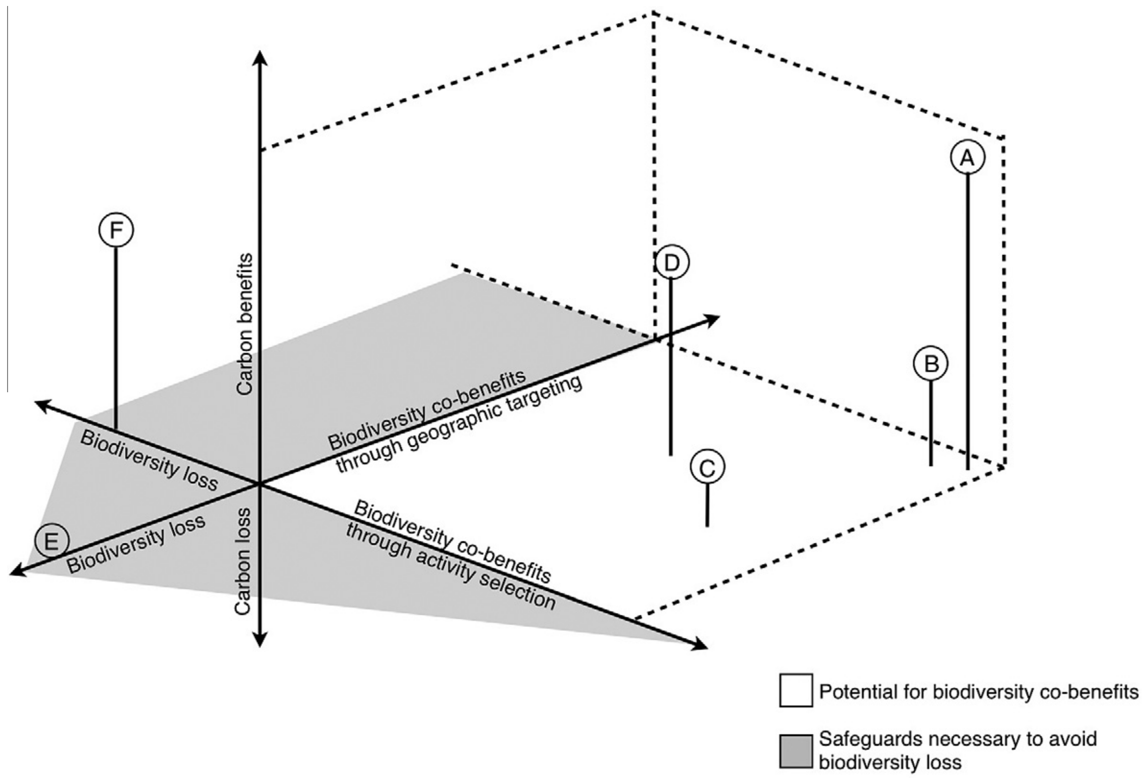

Fig. 1. Biodiversity and carbon trade-offs of prospective forest management interventions (based on Price et al., 2008; Miles and Kapos, 2008) showing approximate relative positions of six scenarios of specific investment decisions.

Scenario A - high biodiversity, high carbon benefits*:* Investment as part of a national-level REDD+ programme is used to establish a large, traditional protected area in the threatened lowland tropical forests of the Choco Darien in western Ecuador. ***Benefits:*** Scenario targets investment into a relatively high carbon forest-type that is heavily threatened with deforestation, and is a global biodiversity conservation priority. The scenario involves a conservation action with high, additional biodiversity benefits. National-level planning and safeguards avoid the likelihood of unintended biodiversity loss resulting from in-country leakage. ***Trade-offs:*** Scenario faces no trade-offs, as carbon and biodiversity are maximized. However national-level safeguards represent the additional costs of environmental regulation. ***REDD+ Implications:*** Scenario exemplifies the ideal REDD+ win-win proposal.

Scenario B - high biodiversity, low carbon benefits: Investment as part of national-level REDD+ programme provides co-financing for a Biodiversity Fund that supports a new community conservation project in the threatened dry forests of western Madagascar. ***Benefits:*** Scenario targets investment into a priority biodiversity conservation site and selects a conservation action with additional biodiversity benefits. National-level planning and safeguards avoid the likelihood of unintended biodiversity loss resulting from in-country leakage. ***Trade-offs:*** Scenario targets investment into a forest-type with a relatively low carbon values, yielding limited carbon benefits. National-level safeguards represent the additional costs of environmental regulation. ***REDD+ Implications:*** Scenario would be eligible for REDD+ funding, but may not attract investors seeking high carbon outcomes. However, the leveraging of REDD+ finance as co-financing helps to overcome local opportunity costs.

Scenario C - moderate biodiversity, low carbon: Investment is used to improve monitoring and border enforcement of an existing, stand-alone protected area of lowland tropical forest in Mexico that has experienced some local encroachment. ***Benefits:*** Scenario targets a forest of moderate biodiversity conservation priority, and selects a conservation action with additional biodiversity benefits. ***Trade-offs:*** Scenario targets a park that was already under some level of protection and so represents relatively limited additional carbon or biodiversity benefits. Scenario targets investment into a site of moderate priority, while there may be other "more important" sites for biodiversity conservation. Scenario represents a stand-alone, project-based approach to REDD+ that potentially allows for leakage and displacement of encroachment pressures into other forests (not shown in figure). ***REDD+ Implications:*** Scenario would be eligible for REDD+ funding, but might not attract investors seeking high carbon outcomes or to maximize biodiversity co-benefits.

Scenario D - moderate biodiversity, moderate carbon benefits: Investment is used to promote sustainable forest management in a relatively undisturbed lowland tropical forest in Indonesia that was originally designated for intensive logging. ***Benefits:*** Scenario targets a forest that is a high biodiversity conservation priority and has relatively high carbon values. Scenario promotes forest management strategies that protect the majority of carbon stocks, compared with traditional logging. Scenario activity leads to more biodiversity conservation than would result from "business as usual" logging. ***Trade-offs:*** Scenario allows some harvest over more complete protection that could maximize biodiversity and carbon outcomes. ***REDD+ Implications:*** Scenario would likely be eligible for REDD+ finance. Any moderate carbon benefits could be financially offset because the scenario accommodates multiple revenue streams.

Scenario E - high biodiversity loss, no net carbon loss: Investment is used to protect a threatened, lowland tropical forest in central Democratic Republic of Congo (DRC), but without effective national-level planning or regional participation in REDD+, leading to significant local and transnational leakage. ***Benefits:*** Scenario targets a threatened, high biodiversity conservation priority region with moderate carbon density, and represents additional, local carbon benefits and biodiversity co-benefits in DRC. ***Trade-offs:*** Scenario allows displacement into unprotected forests in the high biodiversity areas of Eastern DRC and into high biodiversity areas of neighbouring Republic of Congo that did not participate in REDD+, leading to unintended biodiversity and carbon losses, despite gains made during the initial investment. ***REDD+ Implications:*** Scenario may be eligible for REDD+, despite existing UNFCCC safeguards, and represents prospective unintended biodiversity loss resulting from REDD+.

Scenario F - moderate biodiversity loss, moderate carbon benefit: Investment used to establish a plantation of *Acacia mangium* that replaces degraded secondary forests in Vietnam. ***Benefits:*** Scenario represents carbon gains through planting of fast growing trees (carbon stock enhancement), and allows for multiple use through cyclic harvest. ***Trade-offs:*** Scenario leads to the replacement of degraded forest with a plantation of exotic trees, negatively affecting local biodiversity. ***REDD+ Implications:*** Scenario would not likely be eligible for REDD+ financial support based on existing UNFCCC safeguards.

3.2. Type of forest management intervention

Biodiversity co-benefits are further a function of what forest management strategies are selected, and how they are implemented and planned. REDD+ is expected to reward a wide range of forest interventions (UNFCCC, 2010), with diverse carbon and biodiversity outcomes (Miles and Dickson, 2010; Collins et al., 2011). For example, creating a new protected area in a threatened forest is likely to offer both greater carbon and biodiversity benefits than efforts to improve management of an existing protected area (Scenarios A vs. C) or to facilitate sustainable management of a multiple-use forest.

Forest management interventions can also differ based on how they are implemented. For example, carbon stock enhancement/reforestation based on diverse native species will likely yield greater biodiversity co-benefits compared to carbon stock enhancement through planting a monoculture or use of exotic species (Scenario F; Lamb et al., 2005). Sustainable forest management interventions (Scenario D) might include different types and intensities of silviculture practise and/or timber harvesting using different techniques and regimes, yielding different carbon outcomes (e.g., Mund and Schulze, 2005; Pinard, 1996) and different biodiversity outcomes (e.g., Pearce et al., 2003; Fredericksen and Putz, 2003; Peters et al., 2006). There is thus a diversity of REDD+ implementation choices that involve distinct carbon and biodiversity outcomes.

REDD+ activities can also be planned and implemented at different scales, ranging from project-based approaches to national and regional strategies (Angelsen et al., 2008). While individual projects (Scenario C) often operate outside the context of larger land use planning and trends, some central planning (Scenarios A and B) can help to harmonize interventions and maximize outcomes across the country. In addition to national-level forest monitoring and reporting, cross-sectoral coordination, harmonization of natural resource laws, national-level prioritization schemes, and regional/national-level land use planning can help maximize the biodiversity co-benefits of REDD+ interventions (Harvey et al., 2010; CBD, 2011; CBD and GIZ, 2011).

3.3. Biodiversity safeguards

The scenarios highlight the importance of safeguards to avoiding unintended biodiversity loss (Fig. 1 area shaded in grey; Scenarios E and F), which can also be conceptualized in terms of geographic targeting and activity selection.

Safeguards are necessary to govern the scope of REDD+ planning and implementation; especially in the absence of national-level planning, REDD+ interventions could allow leakage, including displacing deforestation pressures into unprotected high-biodiversity sites (Scenario E, possibly Scenario C; Angelsen et al., 2008; Harvey et al., 2010; Paoli et al., 2010). Similarly, a REDD+ mechanism that lacks broad geographic participation could unintentionally allow transnational leakage (Scenario E; Mudiyarso et al., 2008; Strassburg et al., 2010). Safeguards are also necessary to guide appropriate REDD+ activity selection. Plantation development, for example, potentially increases carbon stores, but may replace existing natural forests in the absence of adequate safeguards (Scenario F; Pistorius et al., 2010; Thiha et al., 2007). There is thus widespread recognition that a REDD+ mechanism must include regulations to prevent biodiversity loss, with initial safeguards already recognized through the UNFCCC (see Section 5.2).

4. Weighing trade-offs

Trade-off analyses are helpful for envisioning potential policy choices and their associated costs and benefits. The exercise of considering different investment scenarios allows for more nuanced and realistic REDD+ planning. Fig. 1 highlights that, although many REDD+ interventions offer prospective win–win outcomes, their exact carbon and biodiversity consequences can differ substantially.

4.1. Quantifying trade-offs

The detailed trade-offs assessments needed to make actual REDD+ policy decisions involve weighing values, which is only possible where co-benefits can be first quantified and mapped (Faith and Walker, 2002; Naidoo et al., 2008; Troy and Wilson, 2006). Moreover, quantification, and subsequent valuation are imperative to integrating biodiversity co-benefits into REDD+ monitoring and reward schemes (Karousakis, 2009; WB, 2011).

While the need for ecosystem service valuation for natural resource decision-making is well known (Wallace, 2007), their quantification at any scale remains challenging (Naidoo et al., 2008; Daily et al., 2009), and relies on the availability of multiple accurate datasets (e.g., Troy and Wilson, 2006), which are less likely to exist in the data-poor tropical regions that will benefit most from REDD+. Importantly, we know little about the precise carbon and biodiversity outcomes of the different forest management strategies and land use decisions that are at the center of REDD+ policies (Miles and Dickson, 2010; Phelps et al., 2010b). While some debate continues regarding techniques to accurately estimate carbon sequestration rates, there is little agreement over how the biodiversity outcomes of REDD+ initiatives will be monitored, reported, verified and valued (CBD, 2011; WB, 2011; Merger et al., 2011). Thus, decision-makers are forced to assess the trade-offs between a variable that can fairly readily assigned a value, and one that often cannot.

Biodiversity is multi-dimensional and measured using a number of different indices and proxies (e.g., species richness, Shannon index, V index), with debate ongoing about which indices are most appropriate (Chavas, 2009). Measures for assessing conservation priorities are similarly variable (Brooks et al., 2006; e.g., Conservation International's "biodiversity hotspots", Alliance for Zero Extinction's priority sites). As such, in most tropical contexts it remains exceedingly difficult to conduct detailed trade-off analyses involving biodiversity co-benefits. Moreover, while global carbon emissions reductions are highly transferable—losses at one site can be directly compensated with gains elsewhere—biodiversity transfer is problematic (Scenario E). There are significant practical and ethical challenges associated with justifying biodiversity losses at one site with gains elsewhere (i.e., Transferable Development Rights), especially in heterogeneous landscapes, among ecosystems and across regions (Walker et al., 2009; Wissel and Wätzold, 2010; Phelps et al., 2011). The strategies and costs associated with managing landscapes to deliver biodiversity co-benefits are thus distinct from those associated with managing for maximum carbon outcomes.

Despite the challenges associated with quantification, the UNFCCC Subsidiary Body for Scientific and Technological Advice has been tasked to continue providing guidance for reporting on REDD+ biodiversity safeguards (UNFCCC, 2011b). The Convention on Biological Diversity is also leading a consultative process to identify potential biodiversity indicators, in parallel with external agencies and voluntary certification schemes (CBD, 2011; Merger et al., 2011).

4.2. Valuing trade-offs

The framework depicts carbon and biodiversity gains and losses without ascribing monetary value, but carbon and biodiversity losses represent very different costs. Carbon is widely commoditized and traded, such that carbon losses and suboptimal carbon outcomes represent immediate opportunity costs for REDD+ participants (Scenarios B and C). Similarly, biodiversity safeguards that restrict certain types of REDD+ interventions (e.g., current UNFCCC limitations on Scenario F) constrain financial opportunities.

In contrast, biodiversity is not widely commoditized, with a clear and agreed monetary value (Nunes and van den Bergh, 2001). Early REDD+ financiers have demonstrated some willingness to pay for biodiversity co-benefits (Karousakis, 2009; Cerbu et al., 2011), and examples such as biobanking in Australia (Burgin, 2008), mitigation banking in the US (BenDor et al., 2009), and Brazil's FunBio biodiversity fund (FunBio, 2011) provide precedents for the broader monetization of biodiversity. However, unless a credible demand emerges for biodiversity (e.g., a biodiversity market, *sensu* Berkessey and Wintle, 2008) that is capable of generating sustained large-scale finance, biodiversity has limited direct monetary value, especially if compared with carbon or against the financial incentives of harvest and land use conversion. Ecosystem service valuation is often contingent on 'willingness to pay', which is prone to ill-informed views and inadequately incorporating issues such as social fairness and ecological sustainability (Costanza et al., 1997), as remains the case for most tropical biodiversity. As such, REDD+ policies that allow biodiversity loss or fail to maximize biodiversity co-benefits face few immediate or direct monetary costs (Scenario F). The major potential cost of biodiversity co-benefits is any reduction in profit that could have been achieved through interventions that maximize carbon benefits. In addition, biodiversity co-benefits introduce additional direct costs related to monitoring, reporting, enforcement and certification (Merger et al., 2011), and could place considerable financial and logistical demands on participating countries (CBD, 2011). Identifying funding sources capable of integrating biodiversity into a sustainable part of REDD+ programming remains a leading policy challenge (see Section 5.1).

Even so, it is naïve, and ultimately impossible to reduce every aspect of the REDD+ decision-making process to monetary value. Sound policy decisions must encompass intrinsic and more abstract values (Akerman and Heinzerling, 2002), as well as downstream effects (Ghazoul et al., 2010), and the social and political contexts of REDD+ interventions (Hirsch et al., 2010). Notably, biodiversity is intrinsically important, provides a range of indirect benefits to humans, and is linked to the function and stability of numerous ecosystem services (Balvanera et al., 2006), potentially including carbon sequestration (see Miles et al., 2010).

5. Trade-offs in a policy context

The increased costs, burdens and non-monetary values associated with biodiversity co-benefits are contentious because stakeholders value biodiversity and accept trade-offs in different ways (McShane et al., 2011). Furthermore, international efforts to promote biodiversity co-benefits may conflict with existing national development objectives and commitments. There is a need for more critical analysis about who loses and who benefits from biodiversity co-benefits through REDD+ (Hirsch et al., 2010). In particular, there is a real need to consider both who pays for biodiversity co-benefits, and how to establish a regulatory framework for addressing carbon–biodiversity trade-offs.

5.1. Paying for trade-offs

Although the costs of biodiversity safeguards remain poorly defined (see Section 4.2), they will likely be absorbed into REDD+ operational budgets as "costs of doing business", akin to environmental regulations in other sectors (Pistorius et al., 2010; UNFCCC, 2011b). Polluting industries and countries that use REDD+ to offset their emissions will likely bear these costs, passing them onto consumers and taxpayers.

Unlike with environmental regulations, recruiting finance to pay for additional biodiversity co-benefits through REDD+ is a more contentious policy prospect, which is not yet guaranteed under existing UNFCCC agreements. REDD+ policy makers face ethical disputes over the degree to which reduced carbon benefits are acceptable in order to achieve biodiversity co-benefits (Minteer and Miller, 2011; OECD, 2008). Decisions on co-benefits thus vary by constituency, shift with the economic climate, and depend on who is expected to shoulder the burden of increased costs.

There are diverse options for recruiting the additional funds necessary to support biodiversity co-benefits through REDD+ (Dickson et al., 2009; Harvey et al., 2010; Obersteiner et al., 2009; Venter et al., 2009a), including:

(1) Industrialized country donors might provide subsidies to offset the costs of ensuring biodiversity co-benefits, as a form of overseas aid.
(2) Polluting industries, and individuals and governments of industrialized countries might voluntarily invest in REDD+ initiatives that also deliver demonstrable biodiversity co-benefits, as a form of social responsibility. Ensuing market demand could ensure that biodiversity co-benefits are integrated into REDD+.
(3) A portion of REDD+ carbon funds might be redirected towards low-carbon, high-biodiversity priority sites, in order to ensure that these sites are also protected. This would represent a biodiversity tax within the REDD+ mechanism itself.
(4) A specific biodiversity tax on polluting industries and/or individual and governments of industrialized countries might be used to recruit the additional resources necessary to integrate biodiversity co-benefits.
(5) Similarly, carbon emissions abatement costs might be increased so that they internalize the costs of biodiversity co-benefits, potentially including a standard biodiversity certification scheme.
(6) REDD+ carbon finance might serve as a source of co-financing for existing conservation funds (Scenario B), parallel marketing of other ecosystem services, or multiple use (Scenario D). Such joint financing could help offset local opportunity costs in favor of conservation.

Independently, funding recruited from these types of sources may not be politically feasible, reliable or adequate to meaningfully integrate biodiversity co-benefits into REDD+ at the present time: Funding that relies on voluntary investment, including preferential market demand for co-benefits, donor aid and social responsibility, is likely to vary with the broader economic situation, and may not be of the scale required to meaningfully integrate biodiversity co-benefits into REDD+ (Collins et al., 2011; Ebeling and Fehse, 2009; Phelps et al., 2011). Taxes and increased emissions abatement costs, although potentially more reliable, remain politically contentious, and could reduce investment and the attractiveness of REDD+ as a cost-effective emissions mitigation strategy (Harvey et al., 2010; Phelps et al., 2011). The REDD+ co-benefits debate thus largely hinges on a pragmatic discussion about conservation finance. It has become increasingly clear that diverse financing sources will be crucial to REDD+ implementation (UNFCCC, 2011a), and that combining multiple financing streams may have the potential to incentivize biodiversity co-benefits.

5.2. Legislating safeguards and co-benefits

Most countries have a foundation for REDD+ safeguards and co-benefits, including national biodiversity plans and international commitments to protect biodiversity, notably through the CBD. The 2010 UNFCCC Cancun Accord and 2011 Durban text on safeguards introduced additional international statutory incentives. These outlined initial safeguards for REDD+ development, encouraging Parties to ensure that interventions support and promote biodiversity conservation; preserve environmental integrity; avoid creating perverse incentives for interventions that could lead to the conversion of natural forests, and report to the UNFCCC on how safeguards are being addressed and respected (UNFCCC, 2010, 2011a,b). Importantly, existing safeguards limit REDD+ from incentivising carbon plantation development within existing natural forests (Scenario F). The UNFCCC has further promoted national-level carbon accounting and forest sector strategies, which potentially reduce threats arising from misplaced geographic scale (Scenarios A and B vs. Scenarios C and E; UNFCCC, 2011a). However, UNFCCC negotiations face ongoing definitional debates that directly affect biodiversity (e.g., *natural forest*, *plantations;* see Pistorius et al., 2010). Moreover, UNFCCC guidelines lack specificity and are fully contingent on Parties' national sovereignty, legislation, circumstances and capabilities (UNFCCC, 2011b), which has facilitated consensus but dilutes the safeguards. Nor has the UNFCCC been explicit on the role of biodiversity co-benefits within REDD+, or how safeguards and co-benefits will be operationalized (monitored, reported or verified). There remains a need for a more explicit regulatory REDD+ framework through which to address minimum requirements (safeguards), additional co-benefits, and the associated carbon–biodiversity trade-offs.

There is a range of prospective regulatory approaches to integrating biodiversity co-benefits into REDD+ (Dickson et al., 2009; Harvey et al., 2010; Paoli et al., 2010), including:

(1) Existing, broad UNFCCC guidelines could encourage participating countries to maximize biodiversity outcomes, potentially with the prospect of additional financial support for compliant initiatives. These might be bolstered through the voluntary adoption of 3rd party certifications (e.g., Climate, Community and Biodiversity Alliance; UN-REDD Social and environmental Principles and Criteria; Forest Stewardship Council) and/or accomplishment of local biodiversity objectives.
(2) Donors could provide technical, financial, and capacity-building support to encourage participating countries that voluntarily maximize co-benefits as they develop and implement REDD+ strategies.
(3) Donors could provide performance-based financial incentives for REDD+ initiatives that integrate and successfully deliver co-benefits.
(4) The UNFCCC could explicitly integrate biodiversity co-benefits into a future REDD+ mechanism, establishing benchmarks and making funding contingent on compliance. Standards for co-benefits could be determined globally or, more likely, at the national level based on global guidelines.

As further evidenced by the 17th UNFCCC Conference of Parties, international mandates and strict requirements regarding co-benefits and safeguards are unlikely to gain political momentum. Future co-benefits policies may be largely country-specific, although shaped by UNFCCC guidelines and international donor requirements and pressure (Phelps et al., 2010b; e.g., CBD and GIZ, 2011; UNFCCC, 2011b). The availability and source of funding, especially during the preparatory REDD+ readiness period when safeguards and co-benefits policies are established, may thus largely determine the degree to which biodiversity conservation is meaningfully integrated into a REDD+ mechanism. Engagement with participating governments and donors on the development of rigorous safeguard and co-benefit policies thus presents a priority among biodiversity conservation advocates. Similarly, harmonization of voluntary standards for REDD+ biodiversity monitoring and reporting presents the opportunity to raise minimum expectations for the biodiversity outcomes of REDD+ interventions (Merger et al., 2011; CBD, 2011).

6. Conclusion

REDD+ policies have the potential to reform tropical forest management and to deliver multiple benefits. Considering the geographic scope, financial scale and diversity of interventions proposed under a future REDD+ mechanism, we need to consider the implications for biodiversity in greater detail. Our framework highlights the huge challenges of making informed REDD+ decisions using existing data and valuation schemes. Most likely, the majority of REDD+ interventions lie along a continuum of win–win outcomes. However, the "rhetorical elegance of the win–win paradigm" (McShane et al., 2011) obscures trade-offs and difficult choices about REDD+ activity selection and geographic targeting. The associated policy decisions—notably over how to cover the additional costs of co-benefits and how/whether to legislate co-benefits—remain controversial.

Trade-offs are inherently contentious. Where REDD+ affects not only climate change and biodiversity conservation, but also the livelihoods of millions of forest-dependent communities, extractive industries and national economies, trade-offs become even more challenging. Trade-offs frameworks and scenario-based exercises are important to anticipating and working through conflicts, identifying data gaps, and reducing the risks of unintended biodiversity loss and sub-optimal biodiversity outcomes. They can help to advance the REDD+ debate and bring forward honest acknowledgment and analysis of benefits and costs, which are inevitable, even within win–win interventions.

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