POLICY PERSPECTIVE

Opportunities for achieving biodiversity conservation through REDD

Celia A. Harvey[1], Barney Dickson[2], & Cyril Kormos[3]

[1] Center for Applied Biodiversity Science, Conservation International, 2011 Crystal Drive, Suite 500, Arlington, VA 22202, USA
[2] UNEP World Conservation Monitoring Centre, 219 Huntingdon Road, Cambridge, UK CB3 0DL
[3] The WILD Foundation, 717 Poplar Avenue, Boulder, CO 80304, USA

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Correspondence
Celia A. Harvey, Center for Applied Biodiversity Science, Conservation International, 2011 Crystal Drive Suite 500, Arlington, VA 22202, USA. Tel: (703) 342 2775; (703) 678 6277; fax: (703) 979 5419. E-mail: charvey@conservation.org

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Abstract

The United Nations climate negotiations on reducing emissions from deforestation and degradation (REDD) provide a rare opportunity for conservation of tropical forests and biodiversity. Here, we explore the implications of REDD design and implementation options on biodiversity conservation and ways to link REDD with biodiversity conservation. From both a mitigation and biodiversity perspective, the most important immediate steps are to ensure that REDD is included in the new global climate agreement and maximizes the area of tropical forest conserved. It may also be possible to include guidelines or incentives within a REDD framework or in national implementation to channel funding to areas of high biodiversity. However, if the immediate steps above are not taken first, REDD will reach neither its mitigation nor its biodiversity conservation potential.

Introduction

The United Nations climate negotiations are focusing unprecedented attention on tropical forests and the urgent need to reduce sharply rates of deforestation and degradation to help avert dangerous climate change. While the emphasis has been on reducing the approximately 1.5 Gt of carbon emitted annually from the clearing and degradation of tropical forests (Gullison *et al.* 2007) through reducing emissions from deforestation and degradation (REDD) in developing countries, these discussions also provide a rare opportunity to advance biodiversity conservation in tropical forests (Laurance 2008). Including REDD in the climate agreement that could result from the United Nations Framework Convention on Climate Change (UNFCCC) meeting in December 2009 could lead to financing for tropical forest conservation and sustainable management at scales never before seen (estimated at 1.2–10 billion U.S. dollars annually; Miles & Kapos 2008). It could also result in enhanced monitoring of tropical forest extent and condition globally and lead to a more sustainable paradigm of tropical land use.

While REDD should bring positive gains for tropical forest and biodiversity conservation (Miles & Kapos 2008; Venter *et al.* 2009), the extent of these gains will depend on its design and implementation. Parties to the UNFCCC have put forth multiple proposals for REDD, with differences in their scope, reference levels for carbon crediting, and other design features (Parker *et al.* 2009). Decisions on REDD framework design and implementation will determine where and how much tropical forest is conserved, with important consequences for biodiversity conservation. Whereas most design and implementation options should lead to the conservation of large areas of tropical forests—and biodiversity conservation gains—others entail risks to forests and biodiversity, resulting in tradeoffs between mitigation and conservation. Here, we consider the implications of REDD design and implementation, and explore options for achieving biodiversity conservation through REDD.

Table 1 Features of the global REDD architecture which will influence its potential contribution to biodiversity conservation

Design feature	Issues under discussion	Relevance to biodiversity conservation
Scope of REDD	Potential creditable activities include: emissions reductions from deforestation and degradation, forest conservation, sustainable management of forests and enhancement of forest carbon stocks	Determines how much and which areas of tropical forest are conserved and/or sustainably managed Determines whether protected areas can be included in REDD Determines whether countries with low historical deforestation rates can participate in REDD
Definitional issues	Definition of "forest"	Determines which land is eligible for REDD Determines if REDD could result in the conversion of natural forests to plantations or nonforest systems
Reference levels	Options include establishing reference levels based on current deforestation rates, historical data, models, or a negotiated level.	Determines how much and which areas of tropical forest are conserved and/or sustainably managed Determines whether countries with low historical deforestation rates can participate in REDD
Leakage	Means of reducing intranational and international leakage through REDD design	Determines how much deforestation is displaced and where
Financing of REDD	Market-based financing, nonmarket (fund), hybrid mechanism, or a combination thereof	Determines the amount, timing and sustainability of funds available to finance conservation and sustainable management activities in tropical forests

Implications of REDD design options for biodiversity conservation

Many of the REDD design features currently under negotiation have implications for biodiversity conservation. Critical design features include the scope of REDD, definitional issues, how reference levels are established, how leakage is dealt with, and how REDD is financed (Table 1).

Scope

The design feature that will likely have the greatest impact on biodiversity conservation is the scope of creditable activities. Whereas REDD was initially limited to reducing emissions from deforestation in developing countries, the concept soon expanded to include forest degradation. The Bali Action Roadmap further broadened REDD (commonly referred to as "REDD+") to include "the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries" (UNFCCC Decision 1/CP.13; UNFCCC 2002).

The biodiversity implications of REDD+ are positive and far-reaching. First and foremost, REDD+ would provide countries with incentives to reduce the high annual rate of tropical forest clearing (estimated at 13 million ha/year; FAO 2006) and forest degradation. If deforestation rates were reduced 50% by 2050 and maintained at this rate until 2100, this would avoid the release of up to 50 Gt C and result in 50% of the forested area still remaining by 2100 for most tropical countries (Gullison *et al.* 2008). If these forests are conserved over the long term, and "leakage" (the displacement of deforestation and degradation from one area to another) is avoided, the biodiversity benefits would be high, as many of the forests being cleared are located in Biodiversity Hotspots (Myers *et al.* 2000). In fact, forests conserved through REDD could dwarf the area of tropical forest currently under protected status (approximately 2 million km^2, Chape *et al.* 2005).

Including "forest conservation" as a mitigation option within REDD+ (FCCC 2009a,b,c; Parker *et al.* 2009) would also be promising for biodiversity conservation, as it would provide incentives for countries to conserve large areas of forests even if these forests are currently not threatened. There is increasing evidence that mature forests, which were previously thought to be carbon-neutral, in fact still have the capacity to sequester additional carbon (e.g., Luyssaert *et al.* 2008; Mackey *et al.* 2008), which means that conserving forests, even if they are currently not threatened, has a mitigation benefit. Including conservation within REDD would generate much needed additional funding for protecting standing forests (including those already designated as protected areas), would provide a hedge against future deforestation, and could help maintain the adaptive capacity of forests to climate change (Guariguata *et al.* 2008).

The impacts of other elements of REDD+ (carbon stock enhancement and sustainable management of forests) on biodiversity are less clear. The effects should be positive if carbon stock enhancement occurs through natural regeneration, diverse plantings of mixed, native species in degraded forest lands, or improved forest management, and if enhancement helps promote landscape connectivity (e.g., Kanowski *et al.* 2005), but could be negligible or negative if exotic monocultures are established (e.g., Brockerhov *et al.* 2008).

Sustainable forest management practices that reduce the depletion of carbon stock and enhance forest resiliency (e.g., through reduced impact logging and longer harvesting cycles; Canadell & Raupach 2008) could benefit biodiversity if they are applied in forests that have unsustainable harvest rates but would negatively impact forest biodiversity if applied in intact old-growth forests (Putz *et al.* 2008; Putz & Redford 2009). However, sustainable forest management provides fewer mitigation (Mackey *et al*. 2008) and biodiversity benefits than REDD conservation projects, which eliminate rather than simply reduce degradation.

Definitional issues

Because current REDD negotiations focus on forests, the definition of "forest" is critical for determining land eligibility and associated conservation impacts. The current UNFCCC definition of forests is based on minimal tree height, canopy cover and area (UNFCCC 2002, Decision 1/CP.7) and has several drawbacks. First, it fails to distinguish between natural forests and plantation forests, despite considerable differences in their species composition, ecology, biodiversity value, and safety as a carbon store (Sasaki & Putz 2009). Plantations are often monocultures of nonnative tree species with short rotation periods, and generally have less biodiversity value, lower carbon stocks, and lower resilience to climate change than intact, natural forests (Brockerhov *et al.* 2008). If this current definition is retained, REDD finance could be directed to forest plantations at the expense of natural forests.

A related concern is that many nonforest land uses (e.g., agroforestry systems) may classify as forests because they meet the structural definition (Schoene *et al* 2007; Sasaki & Putz 2009). Because these land uses have lower carbon stocks and less biodiversity, allowing these land uses to qualify as forests under REDD could have the perverse outcome of redirecting much-needed funds from forest conservation to modified ecosystems of far lesser conservation value. Of particular concern is the possibility that REDD could be used to promote oil palm plantations which have questionable mitigation benefits, and few, if any, biodiversity benefits (Righelato & Spracklen 2007; Danielsen *et al.* 2008). To prevent these perverse outcomes, REDD design should ensure that natural forests are neither converted to plantations or nonforest systems. A comprehensive and accurate carbon accounting system that keeps track of conversions of intact forest to nonforest land uses would also assist in preventing perverse outcomes.

Reference levels

Another key factor in REDD design will be how to establish reference levels (sometimes referred to as baselines). A reference level is an estimate of business as usual emissions in the absence of reductions from REDD activities (Angelsen 2008), and provides a critical measuring stick to assess whether REDD is reducing emissions. Most proposals use current or historical data as the least speculative approach to establish a reference level. However, some argue for a modeled approach, projecting emissions based on anticipated economic development, and others argue for a negotiated approach, where each country negotiates its reference level with the UNFCCC (Terrestrial Carbon Group 2009). The scale at which reference levels are set (subnational, "nested," national or global) is also still under debate (Parker *et al.* 2009).

The ways in which reference levels are established will determine which countries participate in REDD. If historical or current deforestation rates for reference levels are used, countries that have had or currently have high deforestation would benefit from REDD most (Parker *et al.* 2009). In contrast, countries that have high forest cover and low deforestation rates (i.e., those with >50% forest cover and deforestation rates of <0.22%, da Fonseca *et al.* 2007) would have low reference levels and would not stand to benefit. If a REDD framework fails to provide "high forest cover, low deforestation" (da Fonseca *et al.* 2007) countries with incentives to maintain their forests, deforestation that previously occurred in other countries will likely move into these intact forest areas, leading to increased greenhouse gas emissions and biodiversity loss. A global REDD framework should therefore allow reference levels to be adjusted or negotiated to accommodate "high forest cover, low deforestation" countries, or establish a compensation mechanism so that these countries do not become a target for logging or agricultural development.

A related question is whether protected areas are included in baselines and are eligible for carbon credits. While protected areas can serve as effective barriers to agricultural expansion (Andam *et al.* 2008; Campbell *et al.* 2008) if adequately funded and managed, some protected areas are "paper parks," in which enforcement is limited and deforestation and biodiversity loss continues (e.g., Curran *et al.* 2004). Including and financing protected areas within REDD could prevent ongoing and future deforestation within these areas.

Leakage

The way in which a REDD framework addresses leakage is also critical for both mitigation and biodiversity outcomes. From a mitigation perspective, leakage is problematic because it results in emissions reductions in one location being countered by increased emissions elsewhere, reducing or eliminating any mitigation gains. Leakage could even increase emissions if deforestation is shifted from forests with low carbon density to forests with higher carbon densities. Consequently, all REDD proposals attempt to minimize leakage within and across countries.

While the climate community is mainly concerned with reducing the amount of leakage, the conservation community is also concerned about where leakage occurs. For example, if deforestation moves from a tropical forest of low conservation value to one of higher conservation value, REDD could a negatively impact biodiversity conservation. In addition, if REDD displaces timber or firewood collection to other natural ecosystems—such as wetlands or savannas—it will threaten the species native to these ecosystems. Of particular concern is the potential for transnational leakage to cause deforestation to move into relatively intact areas of high biodiversity value—such as wilderness areas or protected areas—or into countries which currently have little deforestation (Putz & Redford 2009). While there are ways to reduce leakage (e.g., through careful monitoring and accounting of carbon stocks and broad country participation in REDD), these measures will not necessarily reduce leakage-related risks to biodiversity unless REDD is specifically designed to avoid perverse biodiversity outcomes.

Financing of REDD

A final feature of REDD design that will impact biodiversity conservation is the amount, timing, sustainability and distribution of REDD finance. Whether REDD is financed through a voluntary fund, a market mechanism, a hybrid mechanism (e.g., revenues from permit auctions in a cap and trade system), or a combination thereof, it must generate finance at the appropriate scale and to the appropriate stakeholders—and sustain it over time. Most importantly, funds must be directed quickly to on-the-ground activities that reduce deforestation and degradation or conserve or enhance carbon stocks. Cost estimates for halving deforestation by 2030 fall between US$15 and $35 billion/year (Eliasch 2008; Kindermann *et al.* 2008; Angelsen *et al.* 2009). Even the low end of these estimates dwarfs the roughly US$2 billion a year in overseas development assistance (Angelsen *et al.* 2009).

Table 2 Key decisions on REDD implementation within individual countries that will determine the impacts of REDD on biodiversity

Implementation decision	How it will influence biodiversity conservation
Policies and measures to used to reduce emissions from deforestation and degradation (e.g., improved forest governance, expansion of protected areas and indigenous reserves, reduced impact logging, prevention of wildfires, etc.)	Determines effectiveness in conserving forest and improving sustainable management
Site selection (i.e., where to implement REDD)	Determines which forests (and which species) are conserved
Stakeholder engagement strategy	Determines the potential success of long-term forest conservation and sustainable management

Implementation details that will influence biodiversity gains

Whereas REDD design is critical for establishing the *potential* delivery of both mitigation and conservation benefits, REDD implementation will determine the *actual* delivery. Key implementation decisions include determining which forest mitigation activities to pursue, where to apply these strategies, and how to successfully engage stakeholders (Table 2).

The mix of REDD strategies countries pursue, and their effectiveness, will vary. Possible approaches include improved forest governance, law enforcement, expansion or creation of new protected areas, community forests or indigenous reserves, land tenure reform, reduced impact logging, wildfire prevention, forest monitoring, payment for environmental services, and the establishment of alternative livelihood activities, among others (Angelsen *et al.* 2009). The mitigation and conservation benefits of each approach will depend on the social, ecological and economic context in which they are applied, and countries will need to select strategies carefully, monitor their effectiveness and use adaptive management.

Countries must also determine where to implement different strategies. Decisions of where to implement REDD will at least partly be determined by opportunity costs, with areas with high carbon content and low opportunity costs benefiting more quickly. Where forests of high carbon density and low opportunity costs overlap with areas of high biodiversity value, the dual objectives of climate change mitigation and biodiversity conservation can be achieved (UNEP-WCMC 2008). Multicriteria decision-making methods (e.g., Moffett & Sarkar 2006) could help identify and prioritize forests that provide both conservation and mitigation benefits.

A final critical aspect of REDD implementation is how countries engage stakeholders and promote good forest governance. REDD programs will only succeed if they engage stakeholders in program design and implementation, including decisions about forest management and revenue distribution, and provide appropriate, long-term and sustainable incentives for the indigenous groups, local communities, and land owners who implement forest conservation measures (Peskett *et al.* 2008; Lawlor *et al.* 2009). Incentives can include REDD revenues as well as nonfinancial incentives, such as securing property or land use rights, providing technical training, and developing alternative livelihoods options (Kanninen *et al.* 2007). An overarching challenge will be to promote good governance, including equitable allocation of carbon rights, a clear legal framework, effective local institutions, accountability and transparent mechanisms that promote equitable benefit sharing (Ebeling & Yasue 2008).

Options for REDD to deliver both mitigation and conservation benefits

To what extent should the conservation community encourage consideration of biodiversity concerns in REDD? There are three broad categories of approaches: (1) approaches that improve REDD as both a climate mitigation measure and a biodiversity conservation tool; (2) approaches that promote biodiversity conservation without affecting mitigation potential; and (3) approaches which may ensure additional benefits to biodiversity conservation but may weaken mitigation potential. These approaches can be applied both to the way in which the international REDD framework is designed, as well as how it is implemented within countries (Table 3).

Options that enhance the effectiveness of REDD as a mitigation tool

The first approach to linking REDD with biodiversity conservation is to support design and implementation features that contribute to climate mitigation, while also providing biodiversity benefits. The framework should ensure that REDD extends to as much tropical forest as possible, includes the broad range of mitigation activities (deforestation, forest degradation, conservation, sustainable management of forests and forest conservation and enhancement of forest carbon stocks; i.e., REDD+), and takes clear measures to minimize international and intranational leakage. Ensuring that "high forest low deforestation countries" are eligible for REDD and including protected areas in REDD will facilitate long-term gains for both mitigation and conservation by preventing deforestation from being displaced into areas that are not currently threatened. Other design features to ensure that REDD is effective in delivering mitigation and conservation benefits include designing baselines to ensure that emissions reductions from deforestation and degradation are real and measurable, and ensuring that sufficient immediate and long-term finance is available for countries to prepare and implement policies and measures to tackle deforestation and degradation.

Within REDD implementation, two key features could improve its ability to deliver both mitigation and conservation benefits: (1) prioritizing conservation and the protection of forests threatened with deforestation over other REDD activities, including sustainable forest management, as this will bring the greatest climate mitigation and biodiversity conservation gains and (2) ensuring that all stakeholders actively participate and benefit from REDD.

While the options discussed in this section will contribute to biodiversity conservation, they seek first to maximize the effectiveness of REDD as a mitigation tool, so there should be broad support within the UNFCCC negotiations for incorporating them into the new climate agreement.

Options that deliver more biodiversity benefits without undermining mitigation benefits

A more ambitious approach for linking biodiversity and REDD would be to add design or implementation components that promote biodiversity conservation without compromising mitigation potential, for example by developing a financing mechanism that provides countries with additional, non-REDD finance where they can deliver biodiversity benefits additional to emissions reductions (Bekessy & Wintle 2008). REDD finance would still target areas with the greatest emissions reductions potential, but the biodiversity incentive would encourage additional forest conservation in areas of high biodiversity—providing further gains for biodiversity without undermining mitigation. This additional "biodiversity" financing could be included within international REDD architecture, or at the national level.

REDD could also achieve more for biodiversity conservation without compromising mitigation potential if

Table 3 Different approaches for integrating biodiversity conservation into the design and implementation of a REDD framework

Approach	Design features	Implementation features
1. REDD options that contribute *both* to climate mitigation and biodiversity conservation	Promote REDD+ (deforestation, degradation, forest conservation, carbon stock enhancement, and sustainable management of forests) Ensure REDD includes countries with high forest cover and low deforestation rates (HFLD countries) Design REDD framework to minimize international and intranational leakage Carefully select appropriate reference levels to ensure real and measurable emissions reductions Increase amount, sustainability and availability of finance for REDD readiness and implementation Develop appropriate definition of "forests"	Use context-appropriate strategies to reduce deforestation and degradation Ensure active engagement and appropriate compensation of forest stakeholders to ensure long-term forest conservation. Within a given country, prioritize the reduction of deforestation (over the reduction of forest degradation and forest carbon stock enhancement)
2. REDD options that deliver more biodiversity conservation, without compromising mitigation benefits	Establish a financing mechanism that gives countries access to additional (non-REDD) finance in cases where they deliver biodiversity benefits additional to emissions reductions	Within forests of identical carbon stock, prioritize REDD implementation in those of greatest biodiversity value Within forests of identical carbon stock, prioritize forests which contribute most to landscape connectivity
3. REDD options that deliver more biodiversity conservation, but could weaken mitigation benefits	Implement biodiversity safeguards within REDD architecture to prevent potential negative impacts on biodiversity Prioritize REDD activities in areas of high biodiversity value Ensure REDD areas contribute to landscape connectivity, promoting biodiversity conservation Provide premiums for REDD credits that arise from the conservation of forests of high biodiversity value Create international certification standards for REDD that ensure positive impacts on biodiversity conservation Link the UNFCC to the Convention on Biological Diversity, the Ramsar Convention on Wetlands, and the Convention to Combat Desertification, requiring that REDD contribute to the biodiversity goals of these conventions	Within countries, prioritize REDD in areas of high biodiversity value Require Environmental and Social Impact Assessments (EAIAS) for REDD programs

countries prioritize REDD activities in forests of higher biodiversity value among forests of similar carbon stock. Existing information on critical forest areas for biodiversity conservation (e.g., key biodiversity areas and critical bird areas; Eken *et al.* 2004) could be overlaid with information on deforestation rates and carbon stocks to determine which forests offer the greatest mitigation and biodiversity potential. This information exists at the global level (UNEP-WCMC 2008), but finer scale maps are missing. Countries could also achieve greater conservation gains, without compromising mitigation potential, if they consider the spatial distribution of REDD areas, and within forests of similar carbon stock, prioritize those which contribute most to landscape connectivity.

These options will enhance the delivery of biodiversity benefits, but do not offer additional mitigation gains and therefore will be of less interest to climate negotiators focused on maximizing emissions reductions in the short term. However, since these options do not undermine mitigation gains, there should be little negative reaction to their eventual inclusion.

Options that deliver more for biodiversity but may weaken mitigation benefits

The most ambitious approach would be to promote REDD design and implementation options that deliver more for biodiversity, but may not improve (and might weaken) mitigation benefits. For example, safeguards within the global framework and national implementation plans could ensure that REDD does no harm to biodiversity, and preferably promotes biodiversity benefits. Such safeguards could prevent plantations being established at the expense of natural forest, avoid forestry projects in old-growth forests, or prevent reducing degradation being prioritized over reducing deforestation (which has greater conservation benefits). Similar safeguards have already been proposed for ensuring REDD does not harm indigenous or local communities (FCCC 2009d). Social and environmental impact assessments could also be required of REDD projects to avoid or mitigate negative impacts on biodiversity.

A related option would be to require that REDD activities meet international certification standards that ensure positive impacts on biodiversity conservation. Voluntary project-level standards designed to promote positive biodiversity and community outcomes from forest carbon projects exist (e.g., the Climate, Community, and Biodiversity Standards; CCBA 2008), and are being updated for REDD. The Forest Stewardship Council (FSC) certification program could also serve as a useful starting point for developing mechanisms to promote biodiversity conservation in managed forests (Subak 2002). If made mandatory, these standards would result in conservation gains. REDD could also be specifically linked to the biodiversity-focused Conventions (e.g., Convention on Biological Diversity, the UN Convention to Combat Desertification, the Ramsar Convention on Wetlands; Locke & Mackey 2009), with the requirement that it contribute to the biodiversity goals of these conventions.

Biodiversity considerations could also be integrated into a REDD framework by geographically targeting REDD to areas of high biodiversity value or to areas that form a biologically-coherent and connected network that promotes the persistence of biodiversity. This could be stipulated in the global REDD framework or through national-level legislation and implementation guidelines. Prioritization could also be reflected in the price of REDD carbon credits, with credits from high biodiversity forests receiving higher prices. Regardless of how it is achieved, the geographic targeting of REDD to forests of greatest biodiversity value and the careful consideration of the spatial pattern of REDD areas within countries would likely have long-term conservation impacts. However, it would also likely shift revenue flows from REDD, at least initially, toward megadiverse countries (such as Brazil, Ecuador, and others) or toward specific areas of high conservation value within individual countries, further polarizing the already contentious political debate around which countries and areas will benefit most from REDD.

While these approaches would provide additional gains for biodiversity beyond those obtained automatically by having REDD in place, they also add new dimensions to an already highly complex debate and could potentially slow down- or even prevent-agreements on an international REDD framework and actual implementation. If this is the case, a possibly unique opportunity for biodiversity conservation will have been missed.

Conclusions

An ambitious and broad REDD framework would be a catalytic step forward for forest conservation and would be largely beneficial for biodiversity conservation. There are many ways in which REDD could be designed and implemented to prioritize biodiversity conservation, by adding certification standards, guidelines or specific incentives for biodiversity conservation, all of which merit further exploration and discussion. However, given the sensitivity of the climate negotiations, the urgent need to reduce emissions from tropical forests, and the risk that adding biodiversity considerations may overcomplicate the already complex and contentious discussions, we suggest that the most urgent priority is to focus on establishing a global REDD mechanism that is as effective as possible in protecting as much tropical forest as possible, so that both mitigation and biodiversity objectives are being achieved (as in Option 1 earlier), and that also prevents the conversion of natural forests to plantations. This will set the stage for potentially huge gains in tropical forest conservation and sustainable management, at scales never before possible.

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References

Angelsen, A. (2008) *Moving ahead with REDD: issues, options and implications*. Center for International Forestry Research, Bangor, Indonesia.

Angelsen, A., Brown S., Loisel C., Peskett L., Streck C., Zarin D. (2009) *Reducing emissions from deforestation and forest degradation (REDD): an options assessment report*. Meridian Institute, Washington, DC, USA.

Andam, K.S., Ferraro P.J., Pfaff A., Sanchez-Azofeifa G.A., Robalino J.A. (2008) Measuring the effectiveness of protected area networks in reducing deforestation. *PNAS* **105**, 16089–16094.

Bekessy, S.A., Wintle B.A. (2008) Using carbon investment to grow the biodiversity bank. *Conserv Biol* **22**, 510–513.

Brockerhov, E.G., Jactel H., Parrotta J.A., Quine C.P., Sayer J. (2008) Plantation forests and biodiversity: oxymoron or opportunity? *Biodivers Conserv* **17**, 925–951.

Campbell, A., Clark S., Coad L., Miles L., Bolt K., Roe D. (2008) Protecting the future: carbon, forests, protected areas and livelihoods. *Biodiversity* **9**, 117–121.

Canadell, J.G., Raupach M.R. (2008) Managing forests for climate change mitigation. *Science* **320**, 1456–1457.

Chape, S., Harrison J., Spalding M., Lysenko I. (2005) Measuring the extent and effectiveness of protected areas as an indicator for meeting global biodiversity targets. *Phil Trans R Soc B* **360**, 443–455.

CCBA. (2008) *Climate community and biodiversity project design standards, 2nd Edition*. Climate, Community and Biodiversity Alliance, Arlington, USA.

Curran, L.M., Trigg S.N., McDonald K. *et al*. (2004) Lowland forest loss in protected areas of Indonesian Borneo. *Science* **303**, 1000–1003.

da Fonseca, G.A.B., Rodriguez C.N., Midgley G., Busch J., Hannah L., Mittermeier R.A. (2007) No forest left behind. *PLoS Biol* **5**, e216.

Danielsen, F., Beukema H., Burgess N.D. *et al*. (2008) Biofuel plantations on forested lands: double Jeopardy for biodiversity and climate. *Conserv Biol* **23**, 348–358.

Ebeling, J., Yasue' M. (2008) Generating carbon finance through avoided deforestation and its potential to create climatic, conservation and human development benefits. *Phil Trans R Soc B* **363**, 1917–1924.

Eken, G., Bennun L., Brooks T.M. *et al*. (2004) Key biodiversity areas as site conservation targets. *BioScience* **54**, 1110–1118.

Eliasch, J. (2008) *Climate Change: Financing Global Forests*. The Eliasch Review. Earthscan, London, UK.

FAO. (2006) *Global Forest Resources Assessment*. Food and Agriculture Organisation (United Nations), Rome, Italy.

FCCC. (2009a) FCCC/AWGLCA/2009/4 (Part II), Fulfillment of the Bali Action Plan and components of the agreed outcome, Note by the Chair. p. 12 para 43.

FCCC. (2009b) FCCC/AWGLCA/2009/9, Summary of views expressed during the fifth session of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention, Note by the Chair. p. 11 para 47(e).

FCCC. (2009c) FCCC/SBSTA/2009/L.9, Reducing emissions from deforestation in developing countries: approaches to stimulate action. Draft conclusions proposed by the Chair.

FCCC. (2009d) FCCC/SBSTA/2009/MISC.1, Issues relating to indigenous people and local communities for the development and application of methodologies. Submissions from Parties.

Guariguata, M.R., Cornelius J.P., Locatelli B., Forner C., Sanchez-Azofeifa G.A. (2008) Mitigation needs adaptation: Tropical forestry and climate change. *Mitig Adapt Strategies Global Change* **13**, 793–808.

Gullison, R.E., Frumhoff P.C., Canadell J.G. *et al*. (2007) Tropical forests and climate policy. *Science* **316**, 985–986.

Kanninen, M., Murdiyarso D., Seymour F., Angelsen A., Wunder S., German L. (2007) *Do trees grow on money? The implications of deforestation research for policies to promote REDD*. CIFOR, Bogor, Indonesia.

Kanowski, J., Catterall C.P. & Wardell-Johnson G.W. (2005) Consequences of broad scale timber plantations for biodiversity in cleared rainforest landscapes of tropical and subtropical Australia. *For Ecol Manage* **208**, 359–372.

Kindermann, G., Obersteiner M., Sohngen B. *et al*. (2008) Global cost estimates of reducing carbon emissions through avoided deforestation. *PNAS* **105**, 10302–10307.

Laurance, W.F. (2008) Can carbon trading save vanishing forests? *BioScience* **58**, 286–287.

Lawlor, K., Olander L.P., Weinthal E. (2009) *Sustaining livelihoods while reducing emissions from deforestation. Options for Policymakers*. Working Paper, Nicholas Institute, Duke University, North Carolina.

Locke, H., Mackey B. (2009) The nature of climate change: reunite international climate change mitigation efforts with biodiversity conservation and wilderness protection. *Int J Wilderness* **15**, 7–13, 40.

Luyssaert, S., Schulze E.D., Borner A. *et al*. (2008) Old-growth forests as global carbon sinks. *Nature* **455**, 213–215.

Mackey, B., Keith H., Berry S., Lindenmayer D. (2008) *Green Carbon: the role of natural forests in carbon storage, Part I*, Australian National University Press, Australia.

Miles, L., Kapos V. (2008) Reducing greenhouse gas emissions from deforestation and forest degradation: global land use implications. *Science* **320**, 1454–1455.

Moffett, A., Sarkar S. (2006) Incorporating multiple criteria into the design of conservation networks: a minireview with recommendations. *Diveristy Distrib* **12**, 125–137.

Myers, N., Mittermeier R.A., da Fonseca G.A.B., Kent J. (2000) Biodiversity hotspots for conservation priorities. *Nature* **403**, 853–858.

Parker, C., Mitchell A., Trivedi M., Mardas N. (2009) *The Little REDD+ Book: a guide to governmental and non-governmental proposals for reducing emissions from deforestation and degradation*. Global Canopy Programme, Oxford, UK.

Peskett, L., Huberman D., Bowen-Jones E., Edwards G., Brown J. (2008) *Making REDD work for the poor*. Poverty Environment Partnership. Overseas Development Institute, London, UK.

Putz, F.E., Zuidema P.A., Pinard M.A. *et al*. (2008) Improved tropical forest management for carbon retention. *PLoS Biology* **6**(7), 1368–1369.

Putz, F.E., Redford K.H. (2009) Dangers of carbon-based conservation. *Global Environ Change* **19**, 400–401.

Righelato, R., Spracklen D.V. (2007) Carbon mitigation by biofuels or by saving and restoring forests? *Science* **317**, 902.

Sasaki, N., Putz F.E. (2009) Critical need for new definitions of "forest" and "forest degradation" in global climate change agreements. *Conserv Lett* **2**, 226–232.

Schoene, D., Killmann W., von Lupke H., Loyche Wilkie M. (2007) *Definition issues related to reducing emissions from deforestation in developing countries*. Forests and Climate Change Working Paper 5. FAO, Rome, Italy.

Subak, S. (2002) Forest certification eligibility as a screen for CDM sink projects. *Climate Policy* **2**, 335–351.

Terrestrial Carbon Group. (2009) *Tools for Setting Reference Emissions Levels*. Policy Brief #2, London, UK.

UNEP-WCMC. (2008) *Carbon and biodiversity: a demonstration atlas*. V. Kapos, C. Ravilious, A. Campbell *et al*. editors. UNEP-WCMC, Cambridge, UK.

UNFCCC. (2002) United Nations Framework Convention on Climate Change, Report of the Conference of the Parties Seventh Session held at Marrakesh. Decision 1/CP.7, FCCC/CP/2001/13/Add.1, p. 58. Available from: http://unfccc.int/resource/docs/cop7/13a01.pdf. Accessed October 29–November 10, 2001.

UNFCCC. (2007) United Nations Framework Convention on Climate Change, Conference of the Parties, Thirteenth Session, Bali, Indonesia, December 3–15. *Decision 1/CP.13: Bali Action Plan*, U.N. Doc. FCCC/CP/2007/6/Add.1. Available from: http://unfccc.int/resource/docs/2007/tcop13/eng/06a01.pdf#page=3. Accessed 14 March, 2008.

Venter, O., Meijaard E., Possingham H. *et al*. (2009). Carbon payments as a safeguard for threatened tropical mammals. *Conserv Lett* **2**, 123–129.

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