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A framework for integrating biodiversity concerns into national REDD+ programmes

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ABSTRACT

The UNFCCC mechanism for Reducing Emissions from Deforestation and Degradation in developing countries (REDD+) represents an unprecedented opportunity for the conservation of forest biodiversity. Nevertheless, there are widespread concerns surrounding the possibility of negative environmental outcomes if biodiversity is not given adequate consideration throughout the REDD+ process. We propose a general framework for incorporating biodiversity concerns into national REDD+ programmes based on well-established ecological principles and experiences. First, we identify how biodiversity distribution and threat data, together with data on biodiversity responses to forest change and management, can be readily incorporated into the strategic planning process for REDD+ in order to identify priority areas and activities for investment that will deliver returns for both carbon and biodiversity. Second, we propose that assessments of changes in biodiversity following REDD+ implementation could be greatly facilitated by paralleling, where possible, the existing IPCC architecture for assessing carbon emissions. A three-tiered approach is proposed for biodiversity assessment, where lower tiers can provide a realistic starting point for countries with fewer data and lower technical capacities. Planning and assessment of biodiversity safeguards for REDD+ need not overburden an already encumbered UNFCCC process. Immediate progress is already possible for a large number of developing countries, and a gradual, phased approach to implementation would minimise risks and facilitate the protection of additional biodiversity benefits from REDD+ activities. Greater levels of coordination between the UNFCCC and CBD, as well as other agencies and stakeholder groups interested in forest conservation are needed if biodiversity safeguards are to be fully adopted and implemented.

1. Introduction

One of the most significant developments arising from the 2010 16th Conference of the Parties (COP 16) of the United Nations Framework Convention on Climate Change (UNFCCC), was the adoption of a set of policy approaches and positive incentives to reduce greenhouse gas emissions through the conservation and management of forests in developing countries (the Cancun Agreements; Decision 1; Paragraphs 68–79 of COP 16, and associated annex). Commonly known as REDD+, this mechanism includes five sets of activities or interventions, namely; reducing emissions from deforestation, reducing emissions from forest degradation, conservation of (existing) forest carbon stocks, sustainable management of forests, and enhancement of

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forest carbon stocks (e.g. through regeneration and planting in previously forest land). Taken together this set of recommendations represents a major and positive shift in the attention given to the potential role of forests in the developing world (non-Annex 1 countries, UNFCCC) in helping to stabilise the global climate, and offers the prospect of unprecedented levels of funding for forest conservation.

REDD+ also has the potential to deliver enormous benefits for biodiversity conservation because forests in the developing world harbour much of the world's terrestrial and freshwater biota, and are also threatened by ongoing forest clearance and degradation. As a result, REDD+ has generated significant attention in the conservation science community (e.g. Stickler et al., 2009; Harvey et al., 2010; Strassburg et al., 2009; Busch et al., 2011), as well as within the Convention on Biological Diversity (CBD) itself (CBD, 2011a). However, despite this considerable potential, concerns have been raised about possible negative environmental outcomes of REDD+ if key safeguards are not observed and integrated into the design and implementation of REDD+ activities (Ghazoul et al., 2010; CBD, 2011a; Epple et al., 2011; Pistorius et al., 2011). These concerns were formally recognised in the Cancun Agreements through the adoption of guidance and safeguards for policy approaches and positive incentives (Appendix 1 Decision 1/CP.16) which state that REDD+ activities should "*Be consistent with the objective of environmental integrity and take into account the multiple functions of forests and other ecosystems*" and, further "*That actions are consistent with the conservation of natural forests and biological diversity, ensuring that* [REDD+ activities] *are not used for the conversion of natural forests, but are instead used to incentivize the protection and conservation of natural forests and their ecosystem services, and to enhance other social and environmental benefits*".

Progress has also been made outside the UNFCCC process to develop more elaborate environmental standards and safeguards for organisations involved in advising on, verifying and funding the development of REDD+ activities. These include the Forest Carbon Partnership Facility's Strategic Environmental and Social Assessment Framework; the REDD+ Social and Environmental Standards of the Climate, Community and Biodiversity Alliance (CCBA) and CARE International (CCBA, 2008), and a growing set of guidance documents from the UN REDD programme (e.g. Epple et al., 2011), and independent research institutions (e.g. Pistorius et al., 2011; Pitman, 2011).

Environmental concerns surrounding REDD+ can be broadly divided into three, overlapping categories: ensuring that no further harm is done to natural forests, maintaining the long-term ecological integrity of forests, and capitalising on opportunities to secure net-positive impacts for biodiversity (CBD, 2010). The first set of concerns relates primarily to the risk of conversion of natural forests, the displacement (leakage) of deforestation and forest degradation activities to areas of lower carbon but high biodiversity value (including non-forest ecosystems such as savannahs), and the potential for afforestation of non-forest land (currently under negotiation ahead of COP 17), all as a direct or indirect result of REDD+ activities. The second set of concerns is focussed on ensuring the permanence of forest carbon stocks and emphasises the importance of considering the functional significance of biodiversity (Diaz et al., 2009; Thompson et al., 2009) and lessons from landscape ecology and the ecosystem approach (Gardner et al., 2009) as enabling conditions for maintaining ecological resilience in human-modified forest ecosystems. The third type of concern relates to the risk of failing to exploit significant economies of scale and deliver additional benefits for biodiversity if REDD+ activities are not designed strategically, and with due consideration of forest conservation and biodiversity targets and incentives outside the strict remit of the UNFCCC negotiations (Miles and Kapos, 2008).

In spite of their recognised importance, there is an urgent need for clear operational guidance on how the biodiversity safeguards adopted by the Cancun Agreements can be integrated into REDD+ activities (as well as voluntary carbon projects) in practice (Epple et al., 2011; Pitman, 2011). Both the UNFCCC and the CBD have made formal requests (through the Subsidiary Body for Scientific and Technical Advice; SBSTA, and COP 10 (Decision X/33 paragraph 9)) for advice on implementing biodiversity safeguards ahead of the UNFCCC COP 17 and CBD COP 11 in Durban (2011) and Hyderabad (2012) respectively. The main purpose of this paper is to help respond to these calls, and to provide some suggestions on a possible way forward.

The UNFCCC calls for the development of a "*system for providing information on how safeguards are being addressed and respected through the implementation of [REDD+] activities*" (Decision 1/CP.16 p71d). In addition the CBD has identified itself as having a key role in supporting the work of the UNFCCC, and in September 2011 made a submission to the UNFCCC regarding methodological guidance for developing such information systems (CBD, 2011b). Here we propose a general framework for incorporating the biodiversity concerns encompassed in the safeguards of the Cancun Agreements into the planning and assessment (used here to describe the post-implementation monitoring and assessment process in general) of REDD+ activities that is based on established ecological and conservation principles and experience (Fig. 1). By doing so we hope to demystify some of the challenges surrounding the integration of biodiversity concerns into REDD+ programmes, and demonstrate that tangible progress can already be made towards respecting safeguards using techniques and data that are already available. Whilst our proposal is focussed on national-level REDD+ programmes under the UNFCCC process the same basic framework can be readily applied to sub-national projects funded within the voluntary carbon market.

Our proposed framework is underpinned by two key arguments. First, safeguards can be most effectively addressed if explicit consideration is given to biodiversity concerns during all of the planning and design, implementation and assessment stages of the REDD+ process. Second, treatment of biodiversity can be made more cost-effective by linking any new planning and assessment work as closely as possible to the existing architecture for planning and assessing forest carbon conservation programs as laid out by the UNFCCC guidelines (see UNFCCC 2006, and also Meridian Institute, 2009a; GOFC-GOLD, 2010). We believe that the successful integration of biodiversity concerns within the REDD+ process could be facilitated by the adoption of a tiered approach that is partially analogous to the IPCC guidance on tiered-emissions reporting, in which lower tiers can provide a realistic starting point for countries with fewer data and lower technical capacities. The partial integration of concerns about both carbon and biodiversity within a common framework can help generate significant economies of scale in data collection and synthesis, while also facilitating communication and understanding of safeguards to a wider audience.

This paper is divided into two main sections. First, we outline the basic elements of our proposed framework with respect to REDD+ planning and assessment, and then use this framework to suggest approaches that could help to protect biodiversity, including integrating work with conservation programmes and funders outside the UNFCCC process. We finish by identifying priorities for future research that can facilitate future planning and action. Although this paper only deals with the integration of biodiversity concerns, we recognise that the successful implementation of REDD+ requires careful consideration of a wider range of social and economic factors to ensure that any investments are sustainable and result in socially just outcomes for local people (Ghazoul et al., 2010).

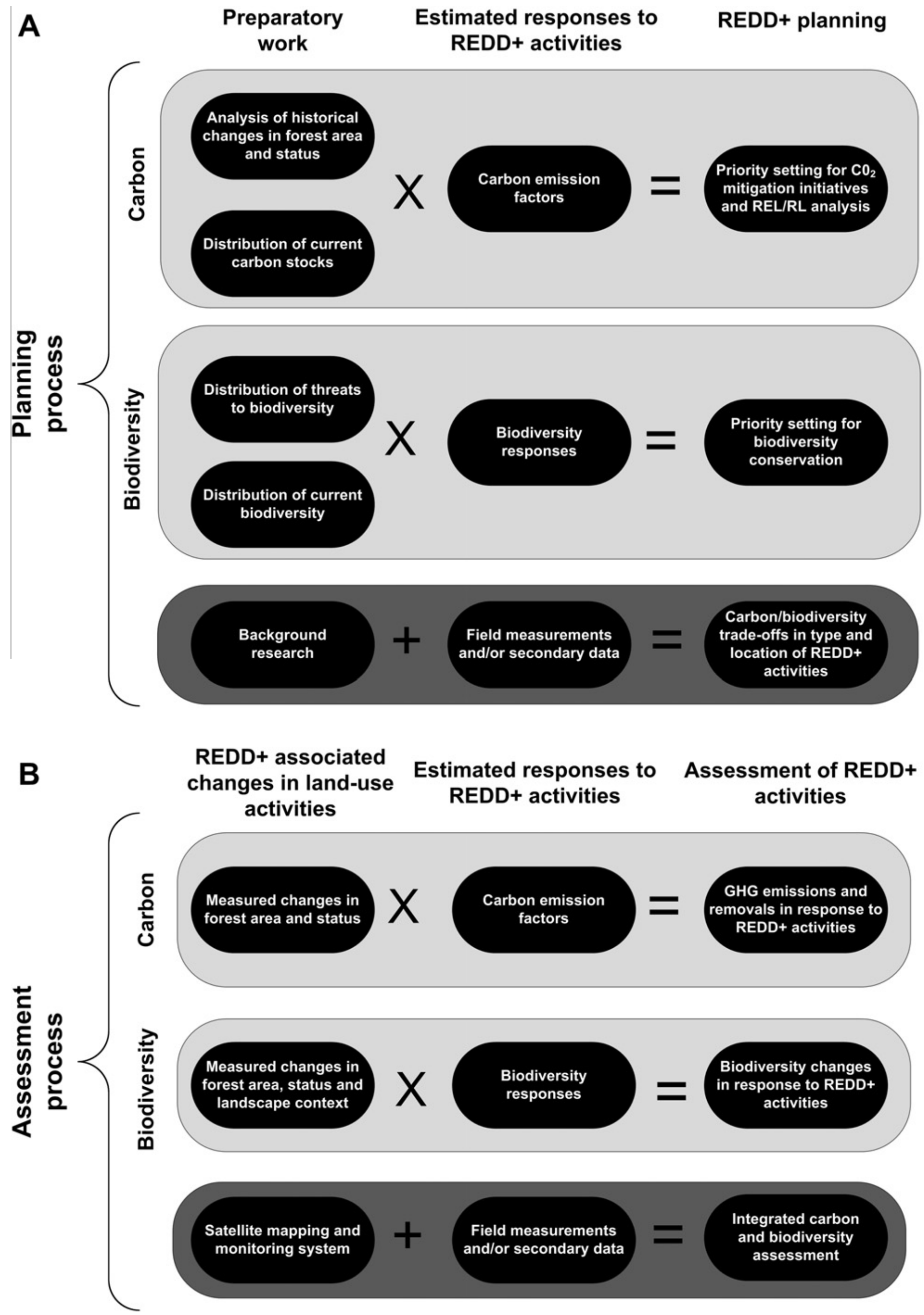

Fig. 1. A unifying framework for addressing concerns about both carbon and biodiversity into the planning (A) and assessment (B) processes of a national REDD+ programme. Biodiversity work maps closely onto the existing IPCC system for carbon, and makes use of many aspects of the same basic system for data collection and analysis. REL/RL refers to Reference Emissions Levels/Reference Levels. The level of specificity for all inputs (e.g. resolution of biodiversity distribution and response data, assessment of changes in landscape context) depends on the tier at which data are being collected and analysed (see Table 1). As well as being a mechanism for reporting and verification the assessment process should be viewed as an opportunity for learning – with outputs for both carbon and biodiversity contributing towards the ongoing revision of REDD+ planning and implementation.

2. Towards a framework for integrating biodiversity concerns into REDD+

2.1. Learning from carbon

A key step in the initial planning and design of national REDD+ programmes is to decide upon priority regions for investment in emissions reductions through forest conservation and management, and the types of REDD+ activities that should be implemented in such regions (Meridian Institute, 2011). To maximise emissions reductions this task is guided by an assessment of historical emissions from deforestation and degradation and information on the distribution of existing carbon stocks, in addition to considerations of the effectiveness, cost, social implications and the feasibility of REDD+ implementation.

In addition to such a strategic planning exercise, a carbon Monitoring Reporting and Verification (MRV) system is needed to assess and verify greenhouse gas (GHG) emissions reductions and removals from the atmosphere due to human activities. The national MRV systems that are currently being developed vary across nations. Yet, in general terms, and by analogy with GHG emissions monitoring and reporting, a comprehensive national forest MRV system is likely to consist of two main data components: activity data to describe changes in forest cover, type and level of degradation and restoration, and 'emissions factors' which estimate likely changes in carbon stocks and emissions resulting from these activities. These data are then combined to calculate overall GHG emissions and removals as part of a National GHG Inventory (Meridian Institute, 2009a; GOFC-GOLD, 2010) (Fig. 1).

The specific requirements for REDD+ MRV systems have yet to be decided. However, the IPCC has defined a tiered approach to carbon emissions assessments in its Guidelines, with different tiers relating to differences in data requirements and analytical complexity (IPCC, 2006; Table 1). In the IPCC system Tier 1 employs default emissions factors (biomass estimates from different ecoregions) from the IPCC Guidelines (IPCC, 2006), Tier 2 includes country-level emission factors and a more detailed assessment of forest strata as well as explicit consideration of data uncertainties, and Tier 3 uses actual inventory data and repeated measurements of forest plots by national scientists and local people to directly measure and model changes in carbon stocks and individual pools. The tiered approach to assessment and monitoring enables countries to assess and report on emissions even when national data and capacities are limited, and makes clear how improvements can be achieved. It provides a clear structure for promoting transparency, consistency and accuracy.

We propose that biodiversity considerations can be readily incorporated into national REDD+ programs using a similar logic and framework to cover both planning and assessment (Figs. 1 and 2). Moreover, we argue that some level of integration is essential if biodiversity considerations are to be viable within REDD+ and neither overburden national capacity, nor become ignored because they are too costly to implement. Fig. 1 illustrates the three sets of inputs for planning and assessment of both carbon and biodiversity aspects of REDD+, namely; preparatory "status" data (analyses of historical changes in forest area and condition, distribution of existing carbon stocks and the distribution of biodiversity and biodiversity threats), activity (land-use) data, and response factors (emissions factors or biodiversity disturbance-responses). These inputs, together with a combined satellite and forest plot–based monitoring system can deliver integrated guidance on spatial land-use planning (i.e. which REDD+ activities to implement and where) and performance assessments (GHG emission assessment and estimates of change in the status of forest biodiversity). In an analogous way to carbon MRV, it is possible to identify different tiers of data requirement and analytical complexity for biodiversity assessments (Table 1). The next two sections discuss in more detail ways in which biodiversity concerns can be incorporated into REDD+ planning and assessment.

2.2. Incorporating biodiversity concerns into strategic REDD+ planning

Under the Cancun Agreements, countries wishing to enter the REDD+ mechanism need to undertake a thorough situation analysis and develop a national REDD+ action plan (i.e. accounting for national circumstances within the UNFCCC framework), a national reference level analysis and a national forest monitoring system. Tens of tropical developing countries are currently undertaking such REDD+ readiness activities, the majority of which are funded by one or more international programmes (including the Norwegian Climate and Forest Initiative programme of bilateral funding, which is also the main financier of the global UN-REDD programme, and the World Bank's Forest Carbon Partnership Fund and Forest Investment Programme). As noted above, key tasks within this work include deciding on priority regions for investment, and the types of REDD+ activities that should be implemented in such regions. Consideration of biodiversity can be incorporated into both sets of decisions using information on the spatial distribution of biodiversity and its threats, as well as known responses of species (or species group) to different forms of forest disturbance and management.

2.2.1. Spatial mapping of trade-offs and synergies between carbon and biodiversity

Reference levels provide a benchmark for estimating emissions reductions from REDD+ implementation in a given geographic area, and are developed by taking into account historical emissions (deforestation and degradation) and emissions reductions (sustainable forest management and enhancement of forest stocks) (Meridian Institute, 2011). By estimating the spatial distribution of threats facing forest ecosystems the reference level analysis, together with information on the distribution of existing carbon stocks and the effectiveness of different possible REDD+ activities helps guide coarse-scale priorities for investments in forest conservation (Fig. 1a, and see Busch et al., 2011 for a similar global-scale analysis). However, biodiversity poses a particular challenge for land-use planning and management because the composition of species and habitat types can vary greatly from place to place. Spatial data on the distribution of biodiversity, its threats, and/or proxies of these are therefore vital in helping to identify priorities for conservation investments that can be compared against spatial priorities for carbon investment (whilst also considering other social, economic and political factors).

Spatial carbon-biodiversity overlay analyses (Fig. 1a) can be conducted at various scales (where possible incorporating cost data as well) to identify either carbon–neutral solutions that offer varying benefits for biodiversity, or high return-on-investment opportunities where relatively minor adjustments to carbon objectives can deliver disproportionate benefits for biodiversity (Venter et al., 2009). Analyses can range from a very simple visual comparison of lookup tables of the ecological distinctiveness of different forest types to spatially explicit optimisation modelling within GIS environments (Wilson et al., 2010). Irrespective of the analytical approach used the key feature is the existence of comparable carbon and biodiversity information and its use to make more informed choices within national REDD+ programmes.

For example, one spatial overlay analysis of carbon and biodiversity using currently available global data (5-degree data on carbon stocks, and vector data on birds, mammals and amphibians, weighted by threat status) together with opportunity cost data has been prepared for Madagascar, to demonstrate cost-efficient approaches to bundling payments at the national scale (Wendland et al., 2010). Further work of this type for other countries (including DR Congo, Indonesia, and Tanzania) is underway at UNEP-WCMC with support of the UN-REDD programme. Here, we present an example map for Tanzania showing how carbon and biodiversity concerns can be effectively illustrated on the same map, potentially identifying regions where the conservation of forest carbon stocks would also maximise returns for the conservation of mammals (see Fig. 3) (Khan, 2011).

Spatial analyses such as these should ideally employ the best biodiversity and threat data that are available for that country, without embarking on costly new field surveys. Where country specific spatial data on biodiversity are not available, standardised global data sets can be employed, including maps of globally consistent biogeographical regions (e.g. WWF and TNC's Ecoregions), areas of particular importance for conservation identified at different scales (e.g. Endemic Bird Areas, Biodiversity Hotspots, Global 200 ecoregions (large areas) and Important Bird Areas, Alliance for Zero Extinction Sites and Key Biodiversity Areas (smaller areas), Schmitt, 2011), and systematically mapped species distribution data (e.g. NatureServe, IUCN Red List and species group-specific

Table 1
Example of a tiered approach to integrating biodiversity concerns into assessment (MRV) frameworks for national REDD+ programmes. This builds upon, and uses, data collected in the REDD+ planning stage. It also mirrors the tiered approach for MRV of carbon established by the IPCC. Higher level tiers will in general involve increasing levels of accuracy but also greater complexity and requirement for technical expertise. Implementation could be achieved by a variety of agencies and has clear linkages to the work programmes and goals of both the UNFCCC and CBD.

Tier of assessment	Description of carbon elements at analogous tiers as defined by IPCC protocol	Corresponding approach for biodiversity assessment	Strengths and weaknesses	Suggestions for appropriate lead agencies
1. Derived using globally available data on changes in the area and type of forest and relevant biodiversity attributes	IPCC default values obtained from the IPCC Emission Factor Data Base (i.e., biomass in different forest ecoregions). Biomass estimates provide limited resolution of how forest biomass varies sub-nationally and have a large error range. Uses simplified assumptions (including instantaneous losses) to calculate emissions	Employs best available biodiversity data coupled with rates of change in forest area within and between regions of known ecological distinctiveness. Relies upon coarse-scale estimates of forest type and levels of disturbance. Assumes instantaneous changes in biodiversity values when moving between land-use classes, and discounts any possible landscape-scale processes	*Strengths*: Measures of forest loss and change in area can be readily calculated from the forest benchmark map required to establish carbon baselines for REDD+. Comparison with crude spatial proxies of biodiversity uniqueness, derived from globally available databases is then a relatively trivial process (e.g. WWFs Ecoregions database, Endemic Bird Areas, Biodiversity Hotspots, Key Biodiversity Areas/Important Birds Areas databases or species data from Nature Serve, IUCN-SSC, Herpnet, Antweb etc.) *Weaknesses*: Limited to interpretation of changes in forest area, and does not capture estimates of biodiversity change in areas of forest that stay as forest (either through degradation or restoration). Relies on proxy measurements of biodiversity value rather than validated data	Joint assessment by national REDD+ assessment units in partnership with government CBD focal points, and with technical assistance from biodiversity specialists in NGOs and research organisations
2. Derived using nationally generated remote sensing data to produce refined assessment of changes in biodiversity value and ecological condition across forest types and landscapes	Static forest biomass information which uses country-specific data and a delineation of more detailed forest strata (types and levels of degradation). Uses disturbance matrices that model carbon retention, transfers and releases among pools (instead of assuming instantaneous losses).	Uses biome and national scale biodiversity response and spatial data, coupled with rates of change in forest area, condition, and landscape-scale fragmentation. Does not involve any collection of new biodiversity data. Can employ a range of remote-sensing techniques to estimate changes in forest degradation, fragmentation and regeneration processes at local and landscape scales	*Strengths*: National data has national and even local ownership and is thus more likely to reflect national conservation priorities. Can capitalise on global biodiversity data compilation efforts and improve them through national expertise. Provides more detailed proxies of changes in forest biodiversity beyond simple changes in forest area and type, including estimates of degradation status, and forest fragmentation. *Weaknesses*: Relies on proxy measurements of biodiversity value that are not validated with ground data. Good, recent national level spatial data on biodiversity may be unavailable, or limited to certain species groups	Joint assessment by national REDD+ assessment units in partnership with government CBD focal points, and with technical assistance from biodiversity specialists government, NGOs and research organisations
3. Derived using data collected from ground-based forest and biodiversity surveys	Employs actual inventories with repeated measures of permanent plots to directly measure changes in forest biomass. Uses carbon models parameterised with plot data. Employs modelled estimates of transfers and releases among pools to more accurately reflect how carbon emissions are realised over time. In many countries, Tier 3 level forest biomass data can in practice only be compiled across large	Uses nationally derived field data on biodiversity, deforestation, degradation and fragmentation. Incorporates direct monitoring of biodiversity responses to REDD+ activities. Monitoring work is ideally stratified across land-use classes and areas exhibiting greatest changes (i.e. deforestation and forest degradation, or changes in forest management). Field data are ideally calibrated against	*Strengths*: Links biodiversity data directly to REDD+ activities and forest management, and is the only tier that allows the development of an improved understanding of forest degradation and the ecological resilience of human-modified forest landscapes. Can integrate closely with the field surveys required under tier 3 MRV for carbon. Provides information on threats to	National forest inventory teams from relevant government departments working with a joint REDD+/CBD steering committee. Tier 3 assessment of biodiversity safeguards offers significant potential for involvement (and co-funding) by the research community. Depending on the type of REDD+ activity and location, biodiversity monitoring could also be conducted by forestry

(continued on next page)

Table 1 (*continued*)

Tier of assessment	Description of carbon elements at analogous tiers as defined by IPCC protocol	Corresponding approach for biodiversity assessment	Strengths and weaknesses	Suggestions for appropriate lead agencies
	areas if local communities and organisations are involved in the collection of field data (see www.ciga.unam.mx/redd/events.php)	remote-sensing information allowing results of monitoring to feedback into an improved understanding and classification of the implications of different REDD+ activities for biodiversity. Should also include monitoring of local scale threatening processes that are likely to impact biodiversity	biodiversity and potential solutions. Can be linked directly to threat reduction and forest decision-making if involving community members in collecting and interpreting data *Weaknesses*: If carried out fully it requires a significant investment in the compilation of national databases, and in particular the collection and analysis of new field data	concessionaires and local communities, including indigenous people using participatory monitoring approaches. Technical oversight by a national steering committee is highly desirable to ensure data meet minimum standards of rigour and comparability

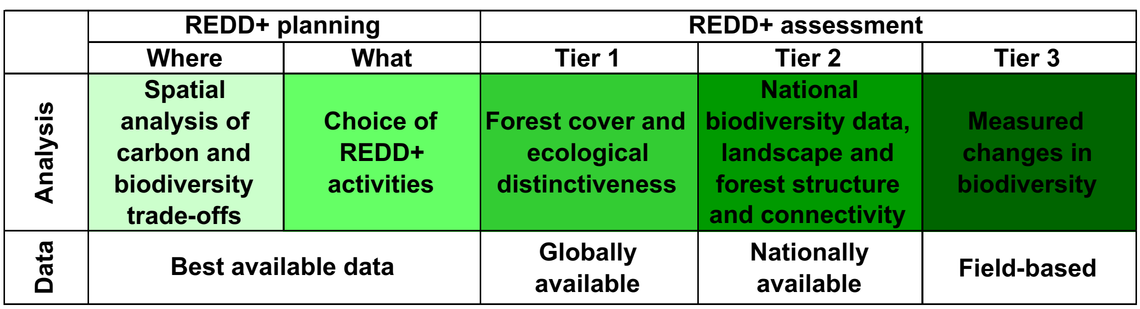

Fig. 2. Summary of ways in which concerns related to biodiversity safeguards can be incorporated into REDD+ planning and assessment. The strategic planning stage determines where REDD+ investments will be made and for which activities. The assessment process occurs at an operational level in areas that have received REDD+ investments; it can be implemented through different tiers of data requirement and complexity (see also Table 1). Assessment tiers relate broadly to the scale at which data are collected and summarised (globally, nationally and locally) but also include considerations of analytical complexity and uncertainty. Applying the framework outlined in this paper during the planning stage has the potential to deliver significant and cost-effective benefits for biodiversity, while assessment work is essential for verifying that plans have been appropriately implemented, and to provide much needed new information for the refinement of future planning processes.

geographic databases such as Herpnet and Antweb). In some parts of the world, region-wide collaborative efforts are emerging to document information on the distribution and threat status of certain species groups, such as the ASEAN Biodiversity Information Sharing Service (http://bim.aseanbiodiversity.org/biss/). To aid analyses of such data, a number of free online tools are being developed to allow coarse scale analyses that integrate information on biodiversity, carbon and costs to help identify high priorities for REDD+ investments (e.g. InVest – http://www.naturalcapitalproject.org/InVEST.html, and Marxan – http://www.uq.edu.au/marxan/). A comprehensive review of currently available biodiversity and forest degradation data, and observational systems has been compiled by the Group on Earth Observation Biodiversity Observation Network (GEO BON, 2011).

2.2.2. Considering the impacts of different REDD+ activities on biodiversity

For both planning and assessment it is important to understand how different REDD+ activities may impact (positively or negatively) forest biodiversity, and their consequences for the long-term integrity and conservation of forest ecosystems (Fig. 1). The best available data should be used to assess the biodiversity impacts (positive or negative) of implementing different combinations of REDD+ activities. Many studies have compared changes in biodiversity following different types of tropical forest modification or conservation (Gardner et al., 2009), with an increasing number of quantitative synthesis becoming available. Gibson et al. (2011) recently presented a global meta-analysis of studies across the tropics, while Sodhi et al. (2008) gave a similar summary focussed on the South East Asian biota. Other reports have focussed on biodiversity responses to specific types of land-use change, such as natural regeneration of tropical secondary forests (Dent and Joseph Wright, 2009), agroforestry (Beukema et al., 2007) and forest restoration (Rey Benayas et al., 2009), as well as region-specific syntheses on topics such as the effects of logging, fragmentation and fire on Amazonian birds (Barlow et al., 2006). Assessments of biodiversity responses to land-use change are also available for specific taxonomic groups, such as tropical forest dung beetles (Nichols et al., 2007). Finally, large-scale multi-taxa field surveys can often provide valuable information on the likely consequences of particular REDD+ activities for regional biodiversity; examples include the assessment by Barlow et al. (2007) on the biodiversity consequences of conversion of primary forest to secondary and plantation forests in the eastern Amazon, and work by Berry et al. (2010) on biodiversity responses to regeneration of logged forests in Borneo.

As our understanding of tropical forest biodiversity improves, estimates of the biodiversity consequences of specific forest conservation or restoration activities can be complemented by information on changes in the wider landscape context. Landscape-scale characteristics, such as total forest cover, levels of fragmentation and historical disturbances can have a major impact on local biodiversity and the ecological resilience of modified landscapes (Gardner et al., 2009; Pardini et al., 2010), and therefore need to be considered when prioritising and assessing REDD+ investments. Consideration is also needed for aquatic habitats that

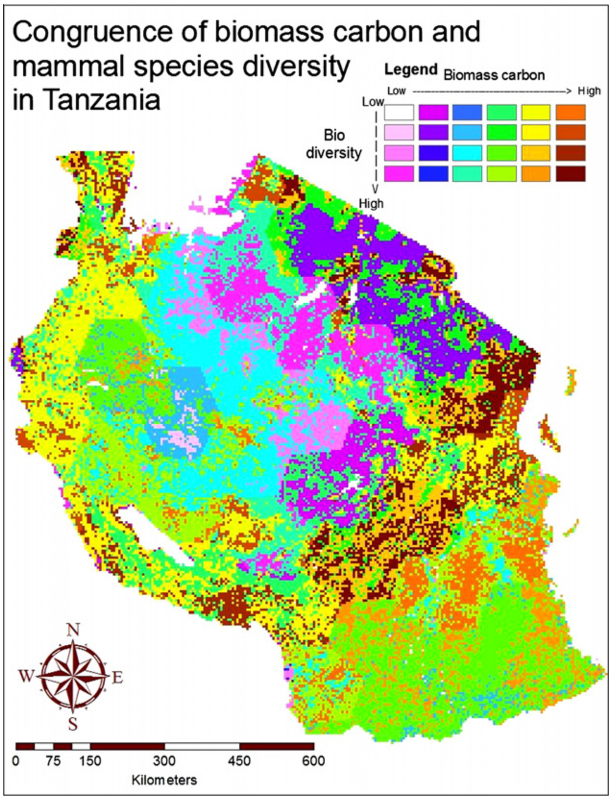

Fig. 3. Example national scale map for Tanzania displaying congruence values between carbon and biodiversity at the scale of a 5 km grid and across all vegetation types. Map generated using freely available landcover data from MODIS, mammal data from the freely available African mammal databank (African Mammals Databank (AMD) and African carbon data provided by UNEP-WCMC, based on multiple sources (Khan, 2011). This kind of simple overlay map can help in identifying those areas of both high opportunity (strong positive correlation in carbon and biodiversity values) and risk (low in carbon but high in biodiversity) in the REDD+ planning process.

can be seriously degraded through erosion and unsustainable forest land-uses.

Prioritising REDD+ investments should ideally consider data on both the spatial distribution of biodiversity and estimates of species responses to different forms of forest degradation and land-use change. Such analyses can help to identify the risks to biodiversity (and hence to the permanence of carbon stocks) from poorly designed REDD+ investments, as well as the 'low-hanging fruits' – where marginal adjustments to carbon-based priorities may deliver significant benefits for biodiversity conservation. Although they did not include carbon data, Wilson et al. (2010) provide an example of this approach, combining existing spatial data on 1086 mammals from the Asian Mammal Databank with expert- and literature-derived estimates of mammal sensitivity to different land-use classes to identify optimal zoning strategies for forest conservation in Kalimantan. Ultimately, such strategic planning exercises should also take into account threats to biodiversity that are currently beyond the remit of REDD+ activities, such as impacts from over-hunting and unsustainable extraction of non-timber forest products (Putz and Redford, 2009).

2.3. A tiered approach to assessing biodiversity change in REDD+ programs

We suggest that work to assess biodiversity concerns in REDD+ programmes should ideally perform two functions: provide transparency regarding the attainment of minimum standards (e.g. ensuring that REDD+ activities do not result in harm to biodiversity), and provide a learning mechanism for the refinement of future REDD+ investments. Table 1 describes in detail a possible three-tiered approach to assessing biodiversity concerns for the REDD+ assessment process, and illustrates the kinds of biodiversity indicators and measurements that could be employed for each tier, together with suggestions for lead agencies with relevant capacities. Much of the same biodiversity information can be used to inform both the planning and assessment processes. This combination of approaches mirrors in part the three-tiered IPCC scheme for assessing GHG emissions. Different tiers are distinguished largely by the scale at which biodiversity data are derived (global, national or project) and by a gradient of data quality, from coarse scale proxies of forest type, through remote-sensing derived indices of landscape structure and forest condition to field-derived biodiversity data (Fig. 2).

In our proposed Tier 1 approach coarse-scale and often readily available data are employed to track changes in forest type and area, and coupled with globally available biodiversity distribution and response data (as used during the planning stage, see Section 2.2). This assessment is focussed on highlighting possible threats to biodiversity as a consequence of REDD+ activities (e.g. an increase in the clearance or degradation of rare forest types that are low in carbon but ecologically distinct – a headline concern of the environmental safeguards in the Cancun Agreements).

The proposed Tier 2 approach provides an assessment of remote-sensing derived indicators of landscape structure (e.g. fragmentation indices such as average area of forest patches and total forest edge) and forest structural degradation (satellite-based indicators of logging scars and forest fires) (see Gardner, 2010; FAO, 2011; Herold et al., in press for a detailed review). Current IPCC guidelines lack consideration of forest fragmentation processes, landscape connectivity and resilience, yet these factors are of critical importance for biodiversity conservation and the maintenance of ecological resilience in human-modified landscapes (Gardner et al., 2009; Pardini et al., 2010). In addition to incorporating these indicators of forest condition, Tier 2 assessments should replace Tier 1 global datasets on biodiversity distribution and disturbance responses with national-level information, as well as give consideration to questions of data uncertainty.

The proposed Tier 3 differs from the others by including the collection of new biodiversity data. We believe it is unfeasible to suggest that biodiversity monitoring programmes are conducted at all (or even the majority of) REDD+ sites, or in a large number of sample sites within each forest type across a nation, yet the collection of data at a sub-sample of sites is important for validating indicators based on remote sensing data. The selection of sites and methods for on-the-ground biodiversity monitoring needs to proceed with considerable care because if it is not designed and implemented appropriately, biodiversity monitoring can be both a distraction and a waste of precious resources (Gardner, 2010), and risks overburdening the limited capacity available to support most REDD+ programmes. The sub-sample of sites selected for biodiversity monitoring should be targeted towards areas of forest that are undergoing the greatest changes (whether through clearance, degradation or restoration) so that monitoring data can help improve estimates of biodiversity responses to REDD+ activities. Stratification of sampling work can be guided by mapping and landscape analyses proposed at Tier 2. Care is needed in selecting appropriate monitoring teams, biodiversity and forest structure indicators and sampling sites (including reference sites; see Gardner, 2010; Pitman, 2011 for more detailed guidance on biodiversity monitoring, and Danielsen et al., 2000 for an example of a simple community-led monitoring scheme). Finally, it is possible that the most cost-effective way in which on-the-ground biodiversity monitoring can be achieved in many countries is by integrating the collection of biodiversity data with the collection of carbon stock data from the same set of forest monitoring plots that are required under Tier 3 of the IPCC system (Teobaldelli et al., 2010), and ensuring the effective involvement of local people (Danielsen et al., 2011). If designed appropriately (i.e. stratified towards areas of greatest forest change), pre-existing National Forest Inventory plots may be suitable for this task.

3. Implementation aspects

Implementing robust biodiversity safeguards ultimately depends upon carrying out specific actions throughout the REDD+ planning and implementation process, including making choices about the type and location of REDD+ activities, and options for linking biodiversity concerns within ongoing carbon assessment work (Moss and Nussbaum, 2011). In addition, it may be necessary to consider additional management interventions (beyond exclusively carbon-focussed activities and national environmental legalisation that is already in place) in order to ensure the long-term conservation of biodiversity.

3.1. Assessing costs and benefits of integrating biodiversity concerns into REDD+ programmes

Commonly cited barriers to the implementation of biodiversity concerns in REDD+ are high cost and limited access to technical expertise. The fact that our proposed framework mirrors the existing IPCC system for carbon assessments significantly reduces these barriers, while the tiered approach to assessment allows some progress to be made in all tropical countries, regardless of their current capacity and data availability. Nevertheless, some costs and constraints will remain, and these may be significant for many developing countries.

Including biodiversity considerations through either Tier 1 or Tier 2 level assessments (Table 1) would often add only a fraction to the costs of the overall REDD+ MRV system, as the major additional requirements are in the systematic compilation of secondary data on biodiversity and the analyses of these data alongside existing forest cover and carbon measurements. The major costs of incorporating biodiversity concerns into national REDD+ programmes come from strategic adjustments to the REDD+ planning process (Figs. 1a and 3, and see Section 2.2), and Tier 3 level assessment where new field data are required to refine and report on changes in forest condition, integrity and biodiversity trends. These costs vary enormously depending on several inter-related factors. For the planning processes this includes the opportunity and management costs that are likely to come from any adjustments to the spatial priorities of REDD+ programmes that are concerned exclusively with carbon (e.g. Fisher et al., 2011), while for the assessment processes it includes consideration of whether monitoring work depends exclusively on scientists or involves/is led by local communities (Danielsen et al., 2011), the choice of species or indicator groups (Gardner et al., 2008), the design of the surveys (Garden et al., 2007) and whether biodiversity sampling can be included as part of existing or planned forest carbon plots (Teobaldelli et al., 2010). Finally, an additional cost in implementing biodiversity safeguards for REDD+ is likely to come from opportunity and management costs that are incurred during implementation if additional (i.e. non-carbon focussed) interventions are necessary (e.g. regulation of hunting and unsustainable timber harvesting).

A more comprehensive assessment of the costs of planning, implementing and assessing biodiversity safeguards in REDD+ programmes is urgently needed, including recognition of the significant economic benefits that are provided by the protection of biodiversity itself (TEEB, 2010). It is also important to identify the conservation benefits that may come from additional investments in biodiversity related work (whether in planning, implementation or assessment). Benefits are perhaps most clearly evident when analysing trade-offs in the spatial planning process. Indeed, one of the most powerful arguments for climate-biodiversity co-financing initiatives (see below) is the observation that the trade-off curve between carbon and biodiversity values is non-linear, such that significant improvements (as well as cost-savings) in biodiversity returns may be possible to achieve while incurring only relatively small carbon penalties (Venter et al., 2009).

A more systematic assessment of both the carbon and biodiversity consequences of different REDD+ activities in different places around the world would help further clarify the potential for cost-effective investments in implementing biodiversity safeguards. These opportunities may not necessarily be focussed on avoided deforestation. For example recent work demonstrating the rapid recovery of both carbon stocks and biodiversity through enrichment planting and rehabilitation of degraded forests (Edwards et al., 2010; Ansell et al., 2011; Sasaki et al., 2011) suggests that this relatively low-cost activity could provide substantial multiple benefits for many areas of the tropics where forests are heavily degraded. Another example is in passive forest restoration which can be much cheaper than active reforestation but may, depending on the intensity of past disturbance regimes, permit a significant recovery of both carbon and biodiversity (Holl and Aide, 2011). If made readily available, Tier 3 biodiversity assessments would provide an invaluable source of data to improve our understanding of different REDD+ options.

Within the context of international agreements, the primary responsibility for the conservation of forest biodiversity lies, not with the UNFCCC, but with the CBD. The recently agreed Aichi targets of the CBD, developed at the COP 10 meeting in Japan in 2010, lay out a series of targets within a strategic plan for the period to 2020 that match almost perfectly with the aspirations of the REDD+ mechanism. This includes specific targets to halve deforestation and reduce degradation and fragmentation (Target 5), manage all forests sustainably (Target 7), effectively conserve at least 17% of all terrestrial areas (Target 11), and restore at least 15% of degraded ecosystems to enhance both biodiversity and carbon (Target 15) (http://www.cbd.int/sp/targets/). However, irrespective of how responsibility is apportioned, biodiversity remains at the interface between multiple international and national agendas. Coordination between the Conventions, as well as amongst national level agencies and non-governmental organisations, will therefore be an important component of helping individual nations to maintain biodiversity through the conservation and responsible management of tropical forests (Pistorius et al., 2011).

We foresee considerable scope for progress through taking integrated action. For example, a lot of work relevant to our proposed approach has already been conducted at the national level as part of existing CBD commitments, including the development of National Biodiversity Strategy and Action Plan reports, and national gap analysis for the CBD Program of Work on Protected Areas (CBD, 2011a). Moreover, the CBD Aichi Target 17 commits countries to develop and start implementing an updated biodiversity strategy and action plan by 2015. Integration of these programmes of work with REDD+ programmes would achieve enormous cost savings, as well as streamline the technical assessments of both Conventions. Beyond the CBD, considerable synergies can be found with other organisations at both global (e.g. International Union for the Conservation of Nature, International Tropical Timber Organisation, major conservation organisations) and local scales (individual bilateral funding arrangements for sustainable forest conservation projects). In all these cases, strategic partnerships that link biodiversity policies with carbon emissions mitigation policies such as REDD+ may reveal major cost-sharing opportunities for both areas, help ensure the long-term ecological integrity of carbon stocks, and aid in alleviating the chronic inadequacy of conservation budgets (Ring et al., 2010; Scharlemann et al., 2010). Further work is needed on the most appropriate mechanisms and scales at which climate-biodiversity strategic partnerships could work, with options including global funds (perhaps linked to the World Bank or Global Environment Facility) that can provide strategic top-ups to REDD+ funding to enable more detailed biodiversity safeguard components, and a case-by-case combination of bilateral and voluntary arrangements (Peterson et al., 2011).

3.2. A phased approach to integrating biodiversity concerns into REDD+

The UNFCCC process has recommended a phased approach to REDD+ implementation (see Paragraph 73 of Decision 1/CP.16, and Meridian Institute, 2009b) beginning with readiness planning, policy development and capacity building, followed by implementation of national strategies and results-orientated demonstration activities, and evolving into a full programme of results-orientated activities that should be fully measured, reported and verified. This framework has appeal as it promotes engagement by countries with weak capacity and low levels of resources, while encouraging a gradual increase in commitment over time.

The incorporation of biodiversity safeguards and concerns into REDD+ is still being negotiated, and approaches to implementation are likely to be left to the discretion of individual countries. Nevertheless, it is logical that a comparable phased system could be adopted for the integration of biodiversity concerns into the overall REDD+ process. Similar to the case for carbon, it may be appropriate that only planning aspects are considered within a REDD+ start-up phase. Even crude spatial overlay analyses and look-up tables with rough estimates of the carbon and biodiversity impacts of alternative REDD+ activities could help greatly to identify ways of enhancing biodiversity safeguards. Subsequent phases could then employ different tiers of biodiversity assessment, from coarse-scale monitoring of changes in the cover of different forest types and indicators of fragmentation and canopy disturbance to fully developed validation monitoring of biodiversity (Table 1 and Fig. 2).

Requirements for more detailed consideration of biodiversity could also be linked to differences in the levels and types of threat facing forest ecosystems. For example, in countries, regions or landscapes where forests are threatened by rampant clear-felling, priority needs to be given to measuring changes in the area and type of forest being lost (and on-the ground biodiversity monitoring would add little information). By contrast, in more consolidated and fragmented landscapes remaining areas of forest may be threatened by a multitude of interacting stressors, including logging, fire and over-harvesting of wildlife and non-timber forest products – thereby requiring a higher tier of assessment, and introducing greater need for ground-truthed data to interpret changes.

The tiers presented in our framework ultimately relate to varying levels of assurance that biodiversity safeguards are being addressed and respected (Fig. 2). The different tiers also serve complementary functions, and should be viewed as part of a nested system where Tier 3 monitoring is most effective if assessments at Tier 1 and 2 are already in place. Tiers 1 and 2 serve primarily as an audit function for reporting against minimum standards for implementing biodiversity safeguards, whilst Tier 3 helps guide local decision-making on forest management (at the scale of the individual forest area) and at the same time contributes to refining our understanding of coarse-scale proxies of biodiversity and helps guide future national strategic planning processes. The UNFCCC process is unlikely to formalise a multi-tiered approach to the assessment of biodiversity safeguards within REDD+ (although Tier 1 assessment would go a long way towards helping minimise risks). As a consequence movement towards higher level tiers will require increased investment from outside the UNFCCC process (e.g. through national biodiversity programmes, and donor funding).

4. Research priorities

Although our proposed framework rests on the argument that considerable progress can be made towards accounting for biodiversity safeguards in REDD+ using existing data and approaches, there are clearly many areas where improvements and new information and understanding is needed. Efforts to integrate biodiversity concerns into REDD+ would benefit in particular from:

1. Syntheses of existing spatial data on biodiversity (focussing in the first instance on forest types and vertebrate groups for which the best information is currently available) for countries and regions where this is still lacking (including much of sub-Saharan Africa), as well as completion of global assessments for other well-studied species groups such as reptiles, plants and well-studied insect taxa (e.g. Odonata, some Lepidoptera).
2. Syntheses and meta-analyses of existing data on biodiversity responses to different types of REDD+ activities. This process should also include the compilation of comparable data on climate (carbon) benefits as well as management and opportunity costs.
3. An improved understanding of the spatial congruencies between carbon and biodiversity in different forest types, and across degradation gradients (essential for our understanding of trade-offs; Baker et al., 2010; Talbot, 2010). This work would probably require the collection of additional field data.
4. An improved understanding of the functional importance of biodiversity in maintaining the long-term resilience of carbon stocks (Thompson et al., 2009).
5. Improved (simplified, robust and replicable) validation procedures for comparing remote-sensing and ground-level biodiversity data to more effectively update and refine our definitions and understanding of different levels of forest degradation, including time-delays in the responses of carbon stocks and biodiversity to forest disturbances.
6. Improved (simplified, robust and replicable) analytical frameworks and software routines for analysing carbon-biodiversity-cost trade-offs over space and across different REDD+ activities, building where appropriate on existing software such as InVest, Marxan and Zonation.
7. Testing and developing (simplified, robust and replicable) Tier 3 field monitoring of biodiversity with the involvement of indigenous people and other local communities (so as to encourage local, evidence-based decision-making and threat reduction), and exploring suitable approaches to link participatory monitoring approaches with national-level monitoring (Danielsen et al., 2011).

Priorities 1 and 2 represent a comprehensive options assessment exercise. Priorities 3 and 4 are genuine research programmes requiring the development of new theory and field data to test existing theory. Priorities 5, 6 and 7 are more technical and are focussed on the development of practical tools that can make effective use of available data and scientific understanding to guide planning and implementation.

Research Priority 4 underpins an important issue in the justification of biodiversity safeguards as part of the REDD+ mechanism

– the notion that biodiversity is critical in maintaining ecological resilience, and hence the long-term permanence of carbon stocks. It is unquestionable that certain threats to biodiversity can have cascading impacts on forest carbon stocks, including the effects of fragmentation (e.g. Laurance et al., 2006) and fire (Barlow and Peres, 2008) on shifts in tree species composition, the effects of herbivore density on tree productivity (Feeley and Terborgh, 2005), and the effects of unsustainable hunting on dispersal processes and the composition of tree recruits (Terborgh et al., 2008). This list is merely indicative, and there are many more relevant studies that have identified strong relationships (Diaz et al., 2009; Thompson et al., 2009). Nevertheless, research attempting to understand the relationship between biodiversity and ecological resilience has been ongoing for more than two decades, and it is extremely difficult to draw firm conclusions owing to the sheer complexity of the problem, and our inability to conduct realistic field-scale experiments in forests. It is very likely that we will still have a poor mechanistic understanding of the links between biodiversity and ecological resilience long after the date when we hope REDD+ will be implemented and operational in developing countries across the tropics. Nevertheless, what is important is that we identify easily quantifiable threatening processes (e.g. unsustainable logging, fragmentation, over-grazing and over hunting and extraction of non-timber resources) that can be linked to key functional elements of a forest ecosystem (e.g. tree density and large mammal abundance) and identify predictable (if not fully understandable) relationships that can be mapped onto estimates of forest degradation with a minimal amount of ground-truthing data. Research is also needed to identify potential thresholds in the relationship between tropical forest biodiversity and forest resilience to climate-related threats such as reduced rainfall or increased temperature.

Finally, it is important to reemphasize that the monitoring of biodiversity safeguards must be viewed not only as a compliance exercise (whatever the verification authority) but also as an invaluable mechanism for learning. Achieving this adaptive cycle is not easy (Gardner, 2010) but essential if new information on forest degradation and relationships between forest carbon and biodiversity is to be cycled back to refine future REDD+ planning and implementation efforts.

5. Conclusions

The challenge of integrating biodiversity concerns into REDD+ is significant. We identify a pathway for progress by distinguishing between different stages of action and requirements for biodiversity data, while also making effective use of the existing IPCC framework for assessing carbon emissions. The main advantage of our framework for integrating biodiversity concerns into the REDD+ process is its viability. Exercises in the spatial mapping of biodiversity and biodiversity-related assessment and monitoring need not be viewed as so complex or expensive that they run the risk of overburdening an already encumbered UNFCCC process. Instead, we argue that progress is already possible for a large number of developing countries, and a gradual, phased approach to implementation can help minimise risks and facilitate the protection of additional biodiversity benefits from REDD+ activities, while encouraging an increased commitment to biodiversity conservation as national capacities improve and develop. Greater coordination between the UNFCCC and CBD, as well as other agencies and stakeholder groups interested in forest conservation are needed if biodiversity safeguards are to be fully adopted and implemented, with appropriate reporting and verification. The biodiversity safeguards adopted in the Cancun Agreements need to be viewed as an opportunity – for securing both the long-term resilience of carbon stocks and additional benefits for biodiversity – rather than a burden. We hope that this paper provides a roadmap for some of the next steps in achieving this vision, and in helping REDD+ programmes to conserve forest biodiversity across the developing world.

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