Carbon Management (2013) 4(2), 129–133

Designing nature-based mitigation to promote multiple benefits

Jonah Busch*, Jorge Ahumada, Free de Koning, Celia A Harvey, Jenny Hewson, David Hole, Miroslav Honzák, Steven N Panfil, Emily Pidgeon, Rosimeiry Portela, Marc Steininger, Karyn Tabor & Will R Turner

By promoting the conservation and restoration of natural ecosystems, policymakers have a unique opportunity to mitigate climate change while providing social and environmental benefits. Here we highlight how nature-based mitigation strategies for multiple benefits can be supported by three key areas of scientific research, drawing upon examples of research by Conservation International and its partners. First, monitoring of ecosystems can quantify the magnitude of emissions released from conversion and degradation, and can inform prioritization and planning efforts. Second, understanding the synergies and tradeoffs between climate change mitigation and other ecosystem benefits can aid in designing policy instruments, selecting management techniques and geographically targeting actions. And third, research on the design of policies, incentives and practices can enhance mitigation initiatives' provision of both climate and noncarbon benefits. Achieving multiple benefits can in turn increase the sustainability of and investment in nature-based mitigation.

Conserving and restoring forests, wetlands, mangroves and other natural ecosystems offers sizeable, cost effective and immediately available sources of GHG emission reductions and removals needed to mitigate climate change [1]. These climate change mitigation actions also provide noncarbon benefits that are unmatched by mitigation actions in other sectors. For example, conservation and restoration of natural ecosystems provides habitats for biodiversity, clean water for agriculture and consumption, and protection of populated areas from storm impacts, among other benefits. Arguably, the noncarbon benefits of natural ecosystems are as responsible as the carbon benefits for the heightened public interest, political support and funding for nature-based mitigation mechanisms such as REDD+.

Numerous policy efforts are currently underway to ensure that strategies for mitigating climate change promote the multiple benefits provided by natural ecosystems. These efforts are taking place in international negotiating bodies such as the UNFCCC and Convention on Biological Diversity, in multilateral funding initiatives such as the Forest Carbon Partnership Facility Carbon Fund, by national governments through their REDD+ strategies and National Biodiversity Strategies and Action Plans, and by proponents of subnational REDD+ projects.

Success in implementing climate change mitigation strategies that promote multiple benefits is supported by three key areas of scientific research: monitoring of changes in ecosystems; synergies and tradeoffs among ecosystem services; and the design of incentives and practices for achieving climate, social and environmental results. This article spotlights research on these topics by Conservation International (CI), an NGO working in more than 30 countries, and its partners, to advance the scientific evidence base on how conservation and restoration of natural ecosystems can promote both mitigation and other social and environmental benefits.

Monitoring ecosystem changes

Monitoring changes in the extent and state of ecosystems is necessary to quantify the magnitude of emissions released from the conversion and degradation of natural ecosystems, as well as the potential to mitigate climate change by conserving and restoring these ecosystems. Standardized, replicable, spatially explicit estimates of land cover change, combined with emission factors derived from estimates of biomass, are used to

Conservation International, 2011 Crystal Drive, Arlington, VA 22202, USA
*Author for correspondence: E-mail: jbusch@conservation.org

10.4155/CMT.13.14

calculate both historical reference emission levels and emission reductions caused by mitigation actions. This is true for both national efforts and local pilot activities. For example, monitoring of deforestation in coastal Tanzania documented a reduction in the regional deforestation rate and associated GHG emissions, from 1.0%/year (0.63 Mt CO_2/year) in 1990–2000 to 0.4%/year (0.20 MtCO_2/year) in 2000–2007 [2].

Forest monitoring serves several purposes beyond regular reporting of emissions and their reductions. Data on past land cover change and associated models of potential future change can inform REDD+ prioritization and planning. The same study of deforestation in Tanzania showed that deforestation rates inside of protected areas were 0.2%/year from 1990 to 2000 and from 2000 to 2007, versus deforestation rates outside of protection of 1.3% from 1990 to 2000 and 0.6% from 2000 to 2007, suggesting, although not proving, that protected areas were the cause of the lower rates. Monitoring in near-real time can enable time-sensitive alerts to government agencies and project management for rapid management responses [3]. Subscribed users to CI's near-real time Fire Alert System use the daily fire alert information to control active fires, to study the influence of climate change on fire frequency and to support policy enforcement inside protected areas [101]. For example, in 2011 a fire inside Indonesia's Kerinci Seblat National Park was detected by satellite observation. Within 24 h an email alert from the Fire Alert System informed the park manager, who then dispatched rangers to investigate. The discovery of illegal clearing deep inside the park resulted in 81 arrests the same day.

Applying standardized forest inventory methods in a network of permanent field plots, as promoted by the Tropical Ecosystem Assessment and Monitoring Network, can be used to monitor changes in forest carbon stocks over time. Inventory methods can detect subtle yet important changes in biomass that may be occurring over large areas that have not necessarily undergone a conversion in use. Such monitoring improves understanding of the impacts of climate change and land use change on tree species composition, aboveground carbon stocks and productivity. For example, such monitoring contributed to the discovery that a 2005 drought turned the Amazon rainforest from a net carbon sink to a net carbon source (1.2–1.6 more PgC emitted compared with predrought conditions) [4].

Monitoring has also revealed nonforest ecosystems as important potential sources of climate change mitigation. Initial results from monitoring carbon in coastal ecosystems (i.e., seagrasses, salt marshes and mangroves) suggest that although these ecosystems cover only an estimated 33–115 million ha globally, the high soil carbon densities and high estimated rate of loss of these ecosystems of 0.4–3.0%/year are responsible for emissions of 0.15–1.02 Pg CO_2/year [5].

Data on forest change can be combined with data on biodiversity or ecosystem services to analyze the noncarbon benefits of REDD+ activities. By providing indicators of biodiversity trends and the status and preservation of carbon stocks over time, monitoring of carbon and biodiversity in Tropical Ecosystem Assessment and Monitoring field plots can be used to inform National Biodiversity Strategies and Action Plans and to measure progress toward the Aichi Biodiversity Targets under the Convention on Biological Diversity. Continual technological advances in mobile devices and online data sharing platforms can enable community-based data collection initiatives to achieve greater spatial coverage of ecosystems' multiple benefits at increasingly fine spatial scales.

Synergies & tradeoffs among ecosystems' multiple benefits

By conserving and restoring natural ecosystems for climate change mitigation, many other ecosystem services are provided as well. Tropical rainforests provide habitat for extraordinary biodiversity; they are home to 23 of Earth's 35 biodiversity hotspots [6]. Tropical forests and wetlands improve downstream water quality by reducing soil erosion, nutrient depletion and sedimentation [7]. Mangrove ecosystems provide coastal protection from storms, sediment regulation, coastal water quality control, fisheries and fiber production [8]. Furthermore, the conservation and restoration of natural ecosystems can help people adapt to climate change impacts across multiple human development sectors, including disaster risk reduction, food security, sustainable water management and livelihood diversification [9]. However, in some cases there may be trade-offs between ecosystems' carbon and noncarbon benefits. For instance, areas of highest carbon densities may not always spatially coincide with areas of highest biodiversity. And without appropriate planning, climate change mitigation activities could have a variety of unintended, negative consequences for biodiversity [10].

Understanding the synergies and tradeoffs between climate change mitigation and ecosystems' other benefits can aid in designing policy instruments, selecting management techniques and geographically targeting actions. For example, joint consideration of the values

provided by sites for biodiversity conservation, water provision and carbon storage can help identify a network of sites that provides the most desirable bundle of services [11]. For a given budget or constraint on total management area, one selection of sites might provide slightly less carbon than another, but produce much higher biodiversity conservation or water value. For example, in an evaluation of alternative global networks of conservation sites, a shift in priorities from only carbon to multiple services reduced the optimal network's carbon storage by just 7% while increasing biodiversity representation more than tenfold [12].

Synergies and tradeoffs may even exist between conservation and restoration activities. In some cases restoration can enhance the value of maintained ecosystems, for instance by enhancing connectivity through the creation of new habitat corridors [13]. Conversely, in other cases funds spent on restoration efforts could be more cost-effectively used to prevent ecosystem loss. For example, restoring forests in community-managed areas of Madagascar costs an estimated net present US$962–3226/ha, while avoiding deforestation in the same areas costs an estimated $252–1069/ha [14].

Policies, incentives & practices for multiple benefits

Well-designed policies can enhance the provision of climate and nonclimate benefits. While most international REDD+ policies can be expected to provide some level of biodiversity co-benefits by reducing forest habitat loss, some policies can lead to even greater biodiversity benefits. Such policies include greater finance for REDD+, as well as broader participation among countries so that deforestation is not displaced across borders [15,16].

One commonly suggested international policy to increase the biodiversity benefits of REDD+ is to supplement carbon payments with biodiversity payments based on the biodiversity conservation value of countries' or sites' avoided deforestation. Paradoxically, spending money on a mixture of carbon payments and biodiversity payments has the potential to incentivize the provision of greater climate benefits than spending an equal amount of money on carbon payments alone [17]. This unexpected result arises when diversifying payments across multiple services allows a funding agency to spend less on surplus payments to sites that would choose to avoid deforestation even with lower payments and to spend more on payments to sites where only combined carbon and biodiversity payments are sufficient to incentivize avoided deforestation.

Countries participating in REDD+ may choose to tailor incentives and benefit-sharing systems to promote multiple benefits. For example, Ecuador's Socio Bosque is a national conservation agreement program through which the national government provides direct monetary payments to landowners and communities for each hectare of native forest or other ecosystem they agree to protect and monitor [18]. Areas are prioritized for inclusion not only on the basis of deforestation threat and carbon storage, but also on water cycle regulation, biodiversity habitat and contribution to poverty alleviation. More than 126,000 beneficiaries have entered more than 1.1 million ha in the program. The program is being replicated in the department of Pando and the municipality of San Ignacio de Velasco, both in Bolivia.

The sustainability of REDD+ initiatives is likely to depend upon the extent to which these initiatives avoid harm and instead create benefits for local people and the environment. Methods for promoting better outcomes for local people and the environment include social impact assessments that are participatory and integrated into the design of REDD+ initiatives and systems to monitor noncarbon impacts and promote adaptive management. Third-party standards such as the Climate, Community and Biodiversity Standards and the REDD+ Social and Environmental Standards are intended to ensure that REDD+ initiatives not only deliver mitigation benefits, but also provide positive impacts on biodiversity and local communities [19]. Documented social and environmental benefits can boost investors' confidence in REDD+ initiatives, which can in turn increase funding available for mitigation activities.

Future perspective

Nature-based climate change mitigation is an emerging field. The last half-decade has seen a rapid proliferation of nature-based mitigation initiatives seeking to generate multiple benefits, ranging from government programs to site-level REDD+ projects. Rigorous monitoring and evaluation of these early initiatives can enable retrospective analyses of their effectiveness in achieving multiple benefits. Documenting the successes and failures of these efforts can provide a vital body of information for adaptive management and to inform the next generation of policy initiatives. For example, an initial synthesis of lessons learned from early REDD+ pilot projects found that success in delivering biodiversity and social benefits depended on effective on-the-ground partnerships, sustained financing, successful stakeholder engagement and government support, high-quality technical analyses of

carbon benefits and other ecosystem services, and the extent to which the projects were specifically designed with multiple benefits in mind [20]. In the 3 years since that initial synthesis, dozens of new initiatives have started, and there is a need to analyze and learn from their successes and failures.

This paper has highlighted selected examples of research on monitoring ecosystems, analyzing synergies and tradeoffs across ecosystem benefits, designing policies and practices, and evaluating initiatives conducted by CI. With the exception of Davies *et al.* [3] and Donato *et al.* [8], all works cited had lead authors or co-authors from CI. Continued research in these fields can help decision-makers conserve and restore ecosystems in ways that not only mitigate climate change but also promote multiple social and environmental benefits. Achieving multiple benefits can in turn increase the sustainability of and investment in nature-based mitigation.

Financial & competing interests disclosure

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

No writing assistance was utilized in the production of this manuscript.

Executive summary

- Conserving and restoring forests, wetlands, mangroves and other natural ecosystems can reduce GHG emissions while providing habitats for biodiversity, clean water for agriculture and consumption, and protection of populated areas from storm impacts, among other noncarbon benefits.
- Arguably, the noncarbon benefits of natural ecosystems are as responsible as the carbon benefits for public support for nature-based mitigation mechanisms such as REDD+.
- Monitoring of ecosystems can quantify the magnitude of emissions released from conversion and degradation, and can inform prioritization and planning efforts.
- Understanding the synergies and tradeoffs between climate change mitigation and other ecosystem benefits can aid in designing policy instruments, selecting management techniques and geographically targeting actions.
- Research on the design of policies, incentives and practices can enhance mitigation initiatives' provision of both climate and noncarbon benefits.
- Achieving multiple benefits can increase the sustainability of and investment in nature-based mitigation.

References

1 Turner WR, Oppenheimer M, Wilcove DS. Biodiversity: a force to fight global warming. *Nature* 462, 278–279 (2009).

2 Godoy F, Tabor K, Burgess N, Mbilinyi B, Kashaigili J, Steininger M. Deforestation and CO_2 emissions in coastal Tanzania from 1990 to 2007. *Environ. Conserv.* 39, 62–71 (2012).

3 Davies DK, Ilavajhala S, Wong MM, Justice CO. Fire information for resource management system: archiving and distributing MODIS active fire data. *IEEE Trans. Geosci. Remote Sens.* 47(1), 72–79 (2009).

4 Phillips OL, Aragao LE, Lewis SL *et al.* Drought sensitivity of the Amazon rainforest. *Science* 323, 1344–1347 (2009).

5 Pendleton L, Donato DC, Murray BC *et al.* Estimating global 'blue carbon' emissions from conversion and degradation of vegetated coastal ecosystems. *PLoS ONE* 7(9), e43542 (2012).

6 Mittermeier RA, Turner WR, Larsen FW, Brooks TM, Gascon C. Global biodiversity conservation: the critical role of hotspots. In: *Biodiversity Hotspots*. Zachos F, Habel JC (Eds). Springer, Berlin, Germany (2011).

7 Butler RA, Wong GY, Metcalfe DJ *et al.* An analysis of trade-offs between multiple ecosystem services and stakeholders linked to land use and water quality management in the Great Barrier Reef, Australia. *Agric. Ecosyst. Environ.* doi:10.1016/j.agee.08.017 (2011) (In press).

8 Donato DC, Kauffman JB, Murdiyarso D, Kurnianto S, Stidham M, Kanninen M. Mangroves among the most carbon-rich forests in the tropics. *Nat. Geosci.* 4, 293–297 (2011).

9 Jones HJ, Hole DG, Zavaleta E. Harnessing nature to help people adapt to climate change. *Nat. Clim. Chang.* 2, 504–509 (2012).

10 Turner WR, Bradley BA, Estes LD, Hole DG, Oppenheimer M, Wilcove DS. Climate change: helping nature survive the human response. *Conserv. Lett.* 3(5), 304–312 (2010).

11 Wendland KJ, Honzák M, Portela R, Vitale B, Rubinoff S, Randrianarisoa J. Targeting and implementing payments for ecosystem services: opportunities for bundling biodiversity conservation with carbon and water services in Madagascar. *Ecol. Econ.* 69, 2093–2107 (2010).

12 Larsen FW, London MC, Turner WR. Global priorities for conservation of threatened species, carbon storage, and freshwater services: scope for synergy? *Conserv. Lett.* 4, 355–363 (2011).

13 Chomitz KM, Da Fonseca GAB, Alger K *et al*. Viable reserve networks arise from individual landholder responses to conservation incentives. *Ecol. Soc.* 11(2), 40 (2006).

14 Busch J, Dave R, Hannah L *et al.* Climate change and the cost of conserving species in Madagascar. *Conserv. Biol.* 24(3), 408–419 (2012).

15 Harvey CA, Dickson B, Kormos C. Opportunities for achieving biodiversity conservation through REDD. *Conserv. Lett.* 3, 53–61 (2010).

16 Busch J, Godoy F, Turner W, Harvey C. Biodiversity co-benefits of reducing emissions from deforestation under alternative reference levels and levels of finance. *Conserv. Lett.* 4(2), 101–115 (2011).

17 Busch J. Supplementing REDD+ with biodiversity payments: the paradox of paying for multiple ecosystem services. *Land Econ.* 89(4) (2013) (In press).

18 de Koning F, Aguiaga M, Bravo M *et al*. Bridging the gap between forest conservation and poverty alleviation: the Ecuadorian Socio Bosque program. *Environ. Sci. Policy* 11, 531–542 (2011).

19 Richards M, Panfil SN. Towards cost-effective social impact assessment of REDD+ projects: meeting the challenge of multiple benefit standards. *Int. For. Rev.* 13(1), 1–12 (2011).

20 Harvey CA, Zerbock O, Papageorgiou S, Parra A. *What is Needed to Make REDD+ Work on the Ground? Lessons Learned from Pilot Forest Carbon Initiatives?* Conservation International, Arlington, VA, USA (2010).

▪ Website

101 Conservation International. Fire alert system. https://firealerts.conservation.org/fas