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Helping curb tropical forest degradation by linking REDD+ with other conservation interventions: a view from the forest

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Interventions designed to reduce emissions of atmospheric heat-trapping gases from tropical forest degradation are more likely to succeed if based on previous experiences and if they are clearly linked to other on-going conservation and development initiatives. Links between forest management certification, climate change mitigation, and forest product legality assurance already being made on the ground by forest auditors should be recognized and enhanced. Similar synergies are also important at the international policy level, but we focus at the forest level and on the decisions of individual workers and the effectiveness of forest auditors. We stress how designs of linked conservation interventions should be based on theories of change that recognize the complexity of issues at stake across the hierarchy of actors and re-contextualize the processes so as to direct them towards emission-reductions and other desired outcomes. We posit the need to invest in building the capacity of both those responsible for and affected by forest loss and degradation for more efficient and accountable implementation of REDD+ and related conservation interventions.

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Introduction

A fundamental challenge confronting REDD+ and other climate change mitigation initiatives is that they are formulated at the global scale to address global issues but need to be implemented at local scales by local actors with their own problems, aspirations, and priorities. Working at the planetary level on issues emerging from anthropogenic emissions of atmospheric heat trapping gasses unfortunately requires a degree of de-contextualization that obscures these local issues [1]. While perhaps unavoidable, de-contextualization diminishes the value of the local and can lead to disregard of the pivotal roles played by local actors in the implementation of climate change mitigation and adaptation interventions. Similarly, efficient communication about climate change requires acceptance of gross biophysical simplifications including the expression of emissions in carbon dioxide equivalents (CO_{2e}), regardless of whether they derive from land-use practices or automobile exhaust. Homogenization of carbon units and commodification of that carbon, in turn, can endanger biological diversity [2]. When contexts and their dynamics are recognized and the various actors and activities are linked in ways expected to lead to the hoped-for outcome of reduced emissions of atmospheric heat-trapping gases, the rudiments of a theory of change for REDD+ have been assembled [3]. A theory of change is a dynamic conceptual framework that, in this case, describes how a RIL-based REDD+ intervention needs to be designed and implemented to reduce emissions from forest degradation. It describes who needs to be involved, whose interests are at stake, and the expected cobenefits and required safeguards. The process of building a theory of change includes identification of the short, medium, and long-term intended outcomes and establishment of specific indicators to be monitored [4–6]. When further elaborated, the theory of change framework allows for consideration of embedded systems and relationships across scales. We present a blueprint for such a theory with the hope that it can inform the collaborative and iterative processes needed to design efficient emission reduction interventions. Along this path, we highlight windows of opportunity where coordinated implementation of related conservation initiatives aimed at forest sustainability can further shared goals.

We address a small set of challenges to REDD+ by focusing at the ground level on the implementation of a climate change mitigation intervention designed to reduce tropical forest *degradation* through improvement of forest management practices and enhancement of carbon stocks (i.e., the second D and the + in REDD+, respectively). Given the substantial contributions to global carbon emissions from forest degradation due to logging [7,8] and the frequency with which this phenomenon is not distinguished from deforestation [9], our emphasis on degradation seems justified. In particular, we focus on efforts to capture the demonstrated carbon benefits of employment of reduced-impact logging (RIL) techniques in selectively logged tropical forests as a step

towards sustainable forest management (SFM; [10]). Our stress on degradation and the enhancement of forest carbon stocks reveals realized and potential synergies between a variety of conservation and development interventions that overlap in their intentions. Although we re-contextualize climate change mitigation by focusing on an individual worker making a decision about the fate of a carbon-containing tree, our scenario involves mostly legal activities by people who were market integrated long before anyone considered using 'sky money' to curb global warming. We therefore side-step many of the potential pitfalls associated with the totally informal sector and the imposition of market-based conservation programs on societies that are only marginally market-oriented [1].

An example of a local agent-level approach to REDD+

To illustrate the importance of local contexts to the success of REDD+ interventions, we present detailed aspects of one seemingly simple but relevant scenario. In full recognition of the fact that any single REDD+ intervention will involve dozens of types of agents (i.e., actors and institutions) with diverse and often shifting attitudes, agendas, and expectations [11••], we focus on an individual forest worker and the cascade of effects that his actions will have for securing REDD+ benefits. As our example broadens from the forest worker to other actors, less detail is provided, but the intention is to show some of the relevant connections that need to be recognized if REDD+ interventions are to have their intended impacts.

Our hypothetical forest worker, the proximate agent of forest degradation in this case, is a chainsaw operator from Sulawesi employed in Kalimantan by a logging subcontractor who works for a Javanese concession owner. The concessionaire, a co-owner of a furniture factory in Java, is ostensibly moving towards forest management certification, as indicated by his having contracted for a 'scoping' visit by a forest auditing firm. His 145 000 ha concession is included in a regional REDD+ project being designed with the aid of a big international non-governmental environmental organization (NGO). The concessionaire sent one of his few forestry degree-holding subordinates to a REDD+ readiness stakeholder workshop in Jakarta that involved representatives from the regional government, forest, and oil palm industries, the mining sector, social-advocacy groups, and NGOs. He has also lobbied for RIL-based REDD+ in Jakarta but at the same time applied to have a large portion of his concession excised from the Permanent Forest Estate for the purposes of converting it into an oil palm plantation.

Our hypothetical forest worker is confronted with a decision that has carbon and many other consequences [12]; he needs to decide whether or not to cut down a huge *Eusideroxylon zwageri* (known locally as *ulin* or Bornean ironwood). This 98 cm dbh (diameter at breast height, 1.3 m) tree was somehow spared when the forest was selectively logged about 15 years before the current entry when the land was part of a different concession. The worker detects some outward indications that the tree might be at least partially hollow, but even if it is, it might yield merchantable quantities of the high density ($\rho = 0.96$ g/cm^3) and naturally rot-resistant wood for which it is so famous.

In making his decision, the worker will ponder a number of probable and less probable consequences based on criteria that are substantially different from those of other stakeholders. First of all, it would technically be illegal for him to cut this tree; *ulin* is CITES listed and, in Indonesia, can only be harvested legally by local people for roofing, carving, and related subsistence uses [13]. Most of the feller's income is based on the volumes of timber from trees he fells that are yarded to roadside log landings, but he does not believe that his employer will be concerned enough about the legal restriction to reject the wood from the *ulin* tree. If the trunk is solid, the tree might yield 5 m^3 of timber for which he will receive about US$3 as his 'felling bonus.' If the suspected hollow is extensive, in contrast, the log will be rejected by the company and not even yarded from the felling site. If this happens, he could arrange 'on the side' with local villagers to have the log bucked up into manageable pieces, sold locally, and perhaps earn more than from the felling bonus. Counterbalancing his potential financial profit are the costs of fuel, lubricants, and wear-and-tear on his chainsaw plus the time that he might use to fell sound legal trees. At least in the back of his mind he might also consider that the already substantial dangers of felling a tree of this size are compounded if it is indeed hollow. What probably does not cross his mind but would need to if REDD+ is going to work is the chance that the company's middle-aged harvest block supervisor will get out of his truck where it sits up on the primary haul road, walk 0.8 km down the steep and muddy skid trail to where he is working, and point out that the tree in question is not indicated for felling on the harvest plan and should therefore not be cut. Members of the felling crew, which includes the feller and skidder driver along with their assistants, have seen harvest plans but they do not carry any such documents with them in the field. They have never seen the supervisor that far off the road. The feller also does not anticipate any appearances of government inspectors or forest auditors from the certification body, about whom he has heard but never seen.

Among the many challenges confronting efforts to improve tropical forest management is the limited availability of trained and reliable personnel who inspect and then honestly report their findings. This is a challenge that REDD+ through RIL shares with other initiatives designed to promote the retention of biodiversity and other forest values. For example, if legality of marketed

timber is to be assured, it must be traceable back to the stump, which necessitates the existence of someone willing and able to do that tracing.

In addition to the expected presence of diligent and uncorrupted inspectors at felling sites and elsewhere along market chains, many other factors, processes, and actors could influence the decisions made by forest workers. For example, training in the recognition of heart-rotted and hollow trees would help minimize mistakes in felling [14]. Also, environmental education campaigns that successfully increase sensitivity about the conservation values and other benefits of large, hollow, fleshy-fruited, and legally-protected trees, backed with proper incentives, might influence decisions about felling. Finally, if local villagers participate in forest monitoring, they might assert their rights to a tree species that is protected on their behalf.

Although ground-based monitoring is a prerequisite for success of interventions designed to enhance climate benefits, ensure legality, and promote sustainability (e.g., REDD+, FLEGT, and forest management certification), remote sensing can be used because logs skidded from felling sites expose mineral soil and cause stand damage that is detectable for at least several months on cloud-free satellite images and for longer periods with airborne LiDAR. Unfortunately, due to high costs and limitations in local technical capacity coupled with frequent cloud cover and bureaucratic impediments, up-to-date satellite images are seldom available [15]. Hopes for airborne LiDAR need to be tempered by the recent failure in the region of externally supported pilot-project flights to get off the ground for regulatory or other reasons that remain unclear (Putz, personal observation). But even where these sophisticated tools are available, determination of the integrity of tree trunks remains a technical challenge.

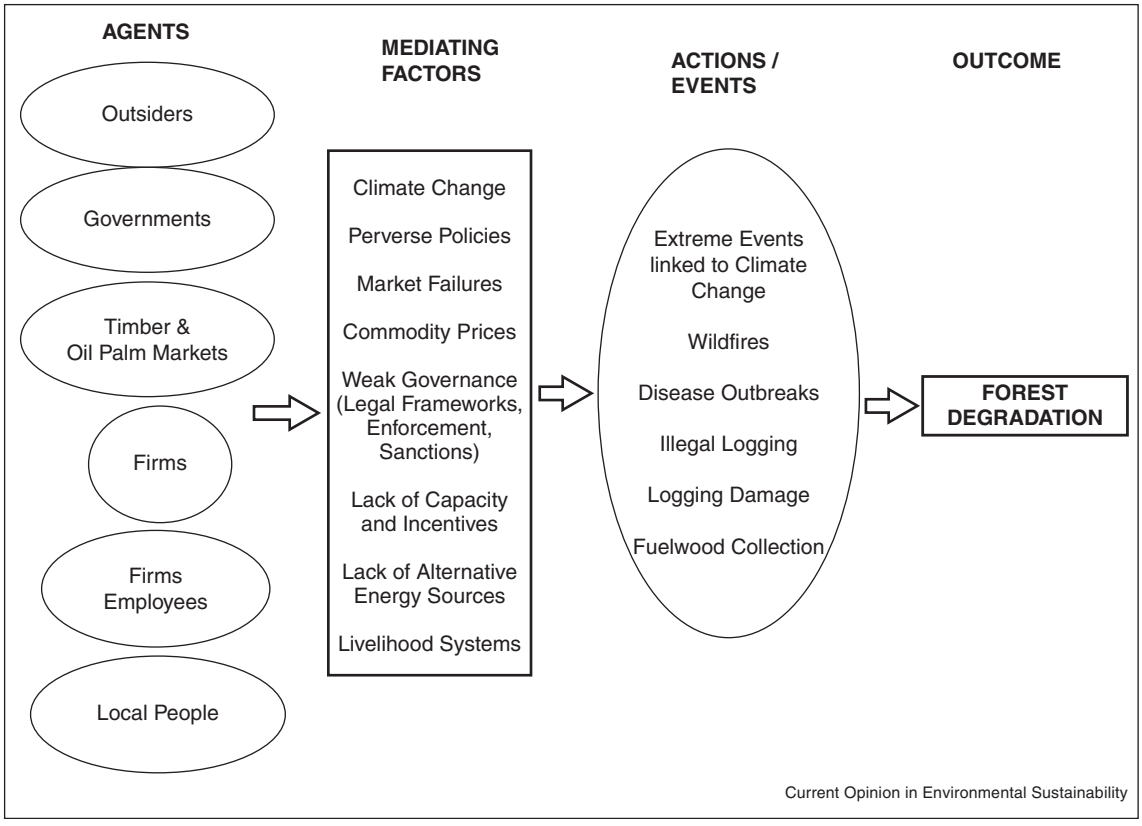
Scaling up from the feller's perspective, the *ulin* tree's fate does have some consequences for the concessionaire and therefore might be of some interest to the logging subcontractor. First of all, if the illegal felling was discovered by government inspectors, it might result in the levying of a fine, or at least the need to pay yet more bribes along the market chain. If the action was discovered by the certification body, which is even less probable given the short time that auditors spend in the forest, that discovery should have some negative consequences such as the issuance of a corrective action request that might delay certification or revoke the certificate. In terms of carbon emissions, the *ulin* tree's estimated 44 Mg of CO_{2e} (predicted using an allometric equation based on dbh and wood density [16]), plus the 10 Mg CO_{2e} of expected collateral damage due to its harvest (estimated through size-specific relationships for a felling site in Gabon [17]) amounts to 54 Mg CO_{2e}. Of this volume, perhaps 1 Mg CO_{2e} ends up in products with multi-decadal carbon retention times. Assuming a log price of US\$300/m^3 and a harvest cost of \$80/m^3 [18], the profit to the concessionaire from the sale of the wood from this tree would be \$1000. At US\$5 per Mg CO_{2e}, not harvesting this tree should be valued at \$220, of which some portion might be paid to the concessionaire over an as yet-to-be-determined period spanning at least several years. The flaw in this logic is that because harvesting this tree would be illegal, the logger would presumably not be eligible for compensation for the carbon retained by not doing so.

A complex systems approach to building a theory of change for reducing forest degradation

From a focus on the decision-making of an individual forest worker we will now explore other factors that will influence the success of REDD+ interventions designed to reduce forest degradation. To this end we need a flexible theory of change that is sufficiently but not unduly complicated that captures the perspectives of other agents, depicts the relevant activities, and indicates the strategies to be employed to redirect or stop the drivers of forest degradation. At the very least, it has to promote anticipation of the many possible unintended but predictable consequences of the intervention. This tool needs to be balanced between being so focused at the local scale that more general learning is precluded, and being so general that it does not guide strategic thinking about practical aspects of the intervention's design, implementation, and impact evaluation [19]. A starting point for the formulation of a proper theory of change for REDD+ is a model that depicts the drivers of forest degradation in ways that windows of policy intervention can be identified for strategically addressing the problem (Figure 1).

In developing a theory of change that will inform efforts to reduce emissions from forest degradation due to poor logging it must be recognized that the challenge is complex, like raising a child, and is not just complicated, like sending a rocket to the moon, and certainly not simple, like following a recipe [20]. Our hypothetical worker, for example, is embedded in a culture that influences his rent-seeking and other behaviors, thus his social context needs to be considered if the REDD+ intervention is going to influence his choices as intended. The history of inconsistent and often failed governance shapes his decisions as well, and the legacy of previous logging operations affects whether the canopy gap that his felling would create will be closed by future crop trees or end up as a liana tangle. Unknown and often unknowable factors beyond his control often appear as surprises, such as episodes of strict rule enforcement or rule changes, extreme weather events, or wildfires like the one that burned much of the region (but not this concession) in 1997.

Figure 1



A generic model depicting the causes of tropical forest degradation. Agents include individuals and organizations that influence decisions that lead to forest degradation. Mediating factors refer to the realm of interacting elements of the context in which agent decisions are embedded. Actions represent activities of agents and events that lead to forest degradation.

To scale up from the proximate causes of forest degradation, the decision-making of our hypothetical chainsaw-wielding worker, to the policies that might ultimately influence his behavior, we obviously need to consider a more elaborate change process underlying the REDD+ intervention (Box 1). This more specific theory of change model should recognize the nested realities of the local within the global, and thus facilitate proper contextualization of local processes and dynamics at larger scales. By recognizing local and regional voices during the theory of change development process, the intervention design becomes legitimate, pertinent, and grounded on the understanding of perceptions and needs of relevant stakeholders [21].

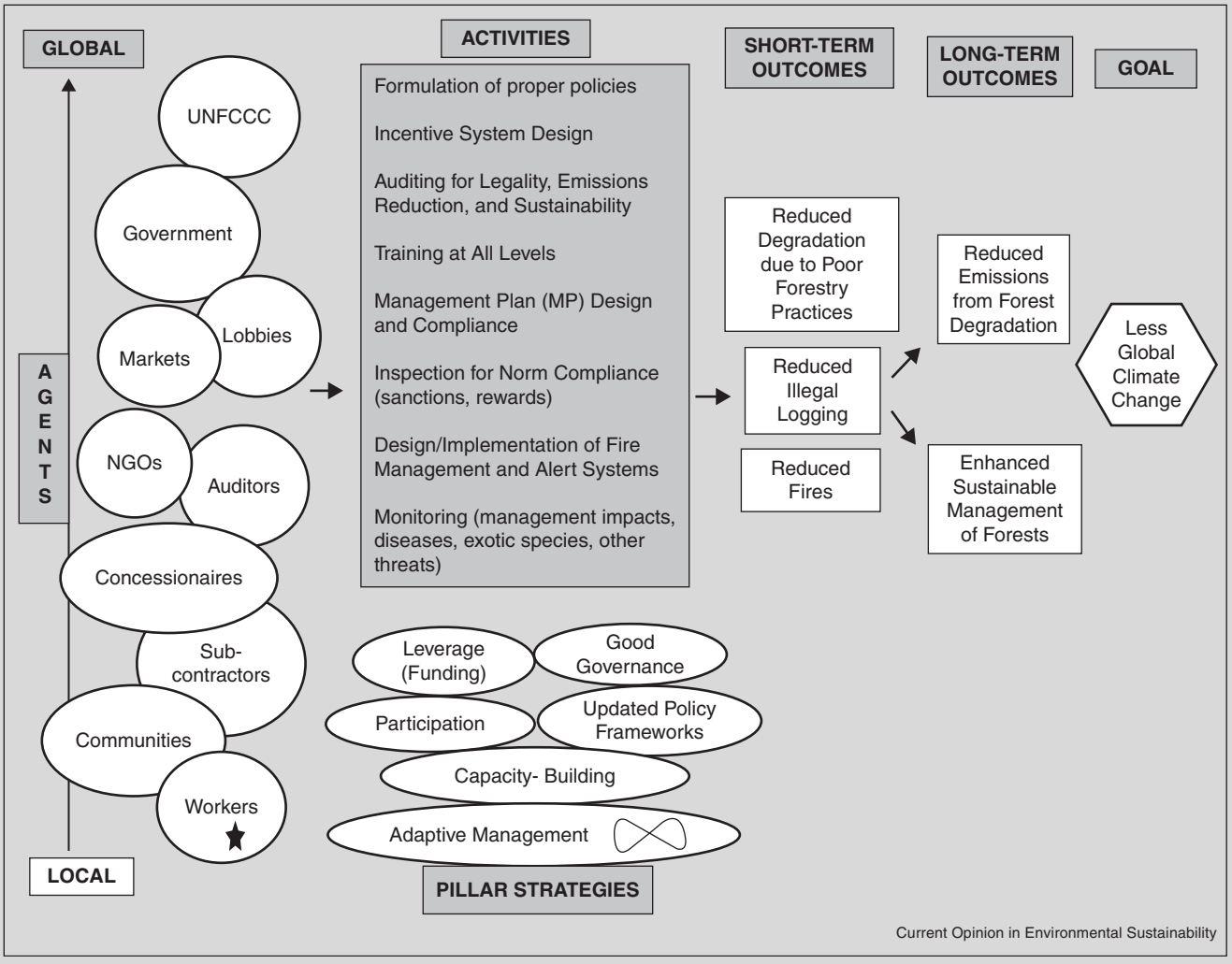
To enhance the likelihood of delivering the hoped-for outcomes, REDD+ and other tropical forest conservation interventions need to avoid the many pitfalls revealed by previous and generally less-than-successful experiences with similar goals [22]. While the approaches championed over past decades have much to teach us, it is now widely recognized that forest degradation in the tropics will not be halted *solely* by establishing more protected areas, marketing non-timber forest products, enhancing ecotourism, providing alternative income sources to local communities, novel governance models (e.g., decentralization or devolution of control over resources and territories), or by regulating timber industries [23]. Fundamental flaws shared by these earlier interventions include lack of sufficient reflection on the complexities of underlying problems and lack of proper consideration of the dynamics and roles of contextual factors across the range of actors (i.e., lack of explicit theories of change).

Increasing the challenge of constructing theories of change on which to build successful conservation and development interventions is the need to evolve rapidly in response to new knowledge and experience (i.e., adaptive management; [24]). On-going changes to be considered in designing REDD+ interventions that need to be reflected in the attendant theories of change include: climate change itself along with its associated extreme events, fires, and other surprises; increased access to information and the media; and, enhanced profitability of commercial agriculture in the tropics due partly to advances in agronomy (e.g., new

Box 1 Blueprint of a theory of change to address forest degradation.

The architecture of the intervention should be modified to reflect the drivers and dynamics of forest degradation in each focal region. Pathways of influence of the intervention can be direct or indirect. The agents represent an interconnected conglomeration of stakeholders that influence the outcomes. For example, the feller to whom we refer in this article (indicated by a star in the worker circle) is one player in this social-ecological system. NGOs might be predominantly social or environmental in focus and represented by their national or international staffs but, in any case, promote a variety of interests. Governments include different levels in the hierarchy of power as well as ministries and other institutions with often competing visions for the future of now forested landscapes. Lobbies represent the interests of timber, oil palm, and other commercial sectors. Markets operate at different scales to shape decisions about future land-uses that are implemented by various agents. The ovals under Activities denote strategies needed to make change possible. Participatory processes leading to formulation of effective policies and systems of incentives provide a foundation for enhanced governance and accountability. A 'pillar' strategy is capacity-building at all levels (i.e., to improve forest management design and implementation skills, to recognize impacts, and to adapt approaches in response to short-term outcomes). At the core of the approach is adaptive management that, through experimentation and continued learning, enhances progress towards the goal (Figure 2).

Figure 2



soybean genotypes), improvements in soil husbandry, and the expansion of markets for palm oil and other products of industrial agriculture [25]. Accelerated efforts to alleviate poverty and improve governance coupled with the cessation of armed conflicts, which opens formerly off-limits territories to land-use changes [26], will also continue to alter the viability of different conservation interventions and thus need to be reflected in updated theories of change. Fundamentally, land-use intensification is being rendered financially feasible by increased road construction and upgrading [27••], which serves to increase the opportunity costs of maintaining forests and avoiding degradation. In the particular case of RIL-based REDD+, income from selective logging reduces these opportunity costs somewhat [28], even if the hoped-for financial benefits from RIL [29] prove elusive [30•]. For REDD+ to be successful, more complete and locally tailored theories of change will be needed that incorporate direct

as well as indirect drivers of forest loss and degradation and their multiple interactions that play out in locally relevant and frequently changing biophysical, social, cultural, economic, and political contexts.

Sustainability-enhancing interventions

International policy processes have evolved from being single-sectored and essentially top-down, such as the forest industry reforms called for by the Tropical Forestry Action Plan, to the substantially more encompassing stakeholder-led approach of REDD+. For example, the architecture of national programs specified in REDD+ readiness guidelines (e.g., UN REDD: http://www.un-redd.com/; World Bank's Forest Carbon Partnership: http://www.forestcarbonpartnership.org/) calls for each country to tailor its own plan to address its own particular drivers of forest loss and degradation in its own way through consultation with a wide range of stakeholders. This focus on the intervention development process is to be commended, but in-depth analyses of the complex dynamics that lead to deforestation and degradation are needed if effective and efficient interventions are likely to emerge. Consequently, the theories of change on which these interventions should be based need to recognize the nature of the problems to be solved and the timescales over which they should be addressed, identify the potential synergies with other conservation and development interventions, and then capture these synergies in accountable manners through efficiency-enhancing collaborations in a process that leads to social learning.

Among the sustainability promoting efforts that have recently become prominent are interventions designed to verify the legality of forest products [e.g., the European Union's due Diligence Regulation and its linked FLEGT (Forest Law Enforcement, Governance and Trade) Voluntary Partnership Agreements (http://www.euflegt.e-fu.int), as well as the 2008 Amendment of the Lacey Act in the USA (http://www.forestlegality.org)] and those that certify products derived from responsibly managed forests (e.g., the Forest Stewardship Council — FSC and the PEFC [31••,32]). All of these interventions require chain-of custody audits that start in the forest. If third-party auditors audit simultaneously for the purposes of certification, legality assurance, and carbon emissions reductions, the substantial costs of monitoring, verification, and reporting will be reduced. During the several days allocated for forest inspections, for example, auditors might check forest conditions against guidelines provided by FSC, PEFC, other forest management certification bodies, the Climate Community Biodiversity Alliance (http://www.climate-standards.org/), and the Voluntary Partnership Agreements of the EU's FLEGT process. Once carbon sampling protocols and emissions factors are available, the auditors could also verify emission reductions due to employment of RIL guidelines, at least if the methods are practice-based. Requiring local inspectors and outside auditors to record their movements using GPS devices, as they do in Suriname [33] could provide verification of physical performance of the field inspections. Resolving the auditing problem and thereby increasing the risk of discovery of illegal felling would help, but is probably insufficient to assure that the *ulin* tree in our example will remain standing — for that and the bigger issues confronting REDD+ through RIL, many other factors, processes, and agents require consideration.

Synergies and impediments among interventions that promote sustainable forestry and REDD+

There is increasing attention to the potential synergies and barriers among sustainability initiatives [34,35]. At local scales, there are benefits to be derived from enhanced collaboration among sectors that influence land use within each country (e.g., agriculture, forestry, infrastructure development, and mining sectors; [36,22]). Alignment will also help reveal and deal with tradeoffs while rendering objectives more realistic and compatible.

The interconnectedness of the problems of climate change, unsustainable forest management, and illegal logging is such that control efforts should be linked. It is necessary to identify actors and institutions involved with each of these initiatives within each country, and to establish dialogs that lead to collaborative work in a consolidated manner [30•]. Because national governments are often pressured by donors to participate in programs with specific agendas while NGOs opportunistically seek funding to respond to donor plans, these platforms need to be developed at every level (e.g., local, regional, and beyond) but driven from within the countries by the relevant constituencies (i.e., civil society, academic institutions, and governments).

After the initial sources of resistance and other hurdles are overcome, the alignment of interventions designed to promote sustainability and legality, and to mitigate climate change should increase cost effectiveness and decrease bureaucratic complexity. When the theories of change for these programs are more explicit and strategic, opportunities for collaboration among these interventions will be clarified and concerted implementation will be possible [15].

REDD+ initiatives, like those in forest certification and legality verification, need to be designed to allow evolution of both projects and theories of change in response to experience. Every effort needs to be made to assure that the decentralized implementation approach, which REDD+ has adopted to accommodate local diversity, fosters recursive learning [37]. Murdiyarso *et al.* [38] provide evidence that this experimentalist regime (i.e., an explicit adaptive management approach [24]), has

been adopted by REDD+ proponents in both the formal and informal senses, which bodes well for the overall initiative.

Tailoring REDD+ interventions to local conditions requires a great deal more human capacity than is typically available. Instead of employing locals in the design of local programs and in the oversight of pilot programs, the services of international experts are often relied upon. Locals are typically trained, but only in the technical aspects of program implementation, not in program design. The reality is that international consultants and consulting companies are not in the business of building capacity to the point that their services are no longer needed. Even worse, some experts of both local and foreign origin withhold information and impede development of local expertise seemingly to avoid competition. For example, due partly to the lack of competition, the exorbitant fees charged to write forest management and carbon offset verification plans may preclude participation by poorer forest owners. Training of local stakeholders is the job of national and regional universities in the developing world, which should be wellsprings of expertise and local innovation but have too often been disregarded in efforts to build REDD+ capacity. These institutions are important sources of the individuals who can wield the intellectual tools needed to bridge disciplines so as to develop innovative approaches for addressing the complex challenges posed by forest loss and degradation. Trained tropical foresters are particularly scarce, especially the broadly educated foresters needed to steer REDD+ programs and related interventions.

Conclusions

As we develop understanding of the barriers to sustainability we will increase our ability to avoid or circumvent them. What is needed are informed and innovative approaches framed by robust and dynamic theories of change that promote linkages among the different players who influence the fates of tropical forested landscapes and resources. The required insights will emerge most efficiently from what until recently were unprecedented levels of involvement in multi-stakeholder discussions about tropical forests. The social capacity needed for such dialogues is growing as policy-making processes evolve from top-down, command-and-control methods through the increasingly participatory approaches utilized by the Forest Stewardship Council and the Voluntary Partnership Agreements negotiated under FLEGT Action Plan. Like no time in the past we can now benefit from opportunities provided by the confluence of different policy mechanisms that are all intended to stimulate transformative changes that sustain forests. We now have golden opportunities to make linkages among actors from forest auditors to global policy-makers. Yet, more efforts are needed in building the capacity of social actors involved and concerned with forest loss and degradation so that the resulting proposals for addressing these threats can build on each other and make way for enduring solutions.

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References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- • of special interest
- •• of outstanding interest

1. Gupta A, Lovbrand E, Turnhout E, Vijge M, Visseren-Hamakers I: **Constituting the forest: carbon accountability and the politics of REDD monitoring, reporting and verification practices**. *COSUST*, this volume

2. Putz FE, Redford KH: **Dangers of carbon-based conservation**. *Glob Environ Change* 2009, **19**:400-401.

3. Annie E: *Theory-of-change: a Practical Tool for Action, Results and Learning*. Casey Foundation; 2004 http://www.aecf.org/upload/publicationfiles/cc2977k440.pdf.

4. Furman R: **Lessons from implementing a Theory-of-change M&E system in the livelihoods and landscapes strategy initiative (draft version)**. *Forest Conservation Program*. Gland, Switzerland: IUCN; 2005.

5. GAO: *Program Evaluation: a Variety of Rigorous Methods can help Identify Effective Interventions*. Washington, DC: United States Government Accountability Office; 2005.

6. Gertler PJ, Martinez S, Premand P, Rawlings LB, Vermeersch CMJ: *Impact Evaluation in Practice*. Washington, DC: World Bank; 2011 http://siteresources.worldbank.org/EXTHDOFFICE/Resources/5485726-1295455628620/Impact_Evaluation_in_Practice.pdf.

7. Asner GP, Knapp DE, Broadbent EN, Oliveira PJC, Keller M, Silva JN: **Selective logging in the Brazilian Amazon**. *Science* 2005, **310**:480-482.

8. Huang M, Asner GP: **Long-term carbon loss and recovery following selective logging in Amazon forests**. *Glob Biogeochem Cycle* 2010, **24** Art. GB3028.

9. Sasaki N, Putz FE: **Critical need for new definitions of 'forest' and 'forest degradation': in global climate change agreements**. *Cons Lett* 2009 http://dx.doi.org/10.1111/j.1755-263X.2009.00067.x.

10. Putz FE, Sist P, Fredericksen TS, Dykstra D: **Reduced-impact logging: challenges and opportunities**. *Forest Ecol Manag* 2008, **256**:1427-1433.

11. •• Purnomo H, Suyamto D, Irawati RH: **Harnessing the climate commons: an agent-based modelling approach to making reducing emission from deforestation and degradation (REDD+) work**. *Mitigat Adapt Strategy Glob Change* 2012 http://dx.doi.org/10.1007/s11027-012-9370-x.
This paper examines the design of REDD+ intervention in Indonesia through the use of an Arena-Actor-Institution approach.

12. Putz FE: **Complexity confronting tropical silviculturalists**. In *Complex Adaptive Systems and Forestry.* Edited by C. Messier C, Puttermann K, Coates D. Earthscan Books; 2012.

13. Effendi R: **Kayu ulin de Kalimantan: potensi, manfaat, permasalahan dan kebijakan yan diperlukan untuk kelestariannya**. *Jurnal Analisis Kebijakan Kehutanan* 2009, **6**: 161-168.

14. Kennard DK, Putz FE, Niederhofer M: **The predictability of tree decay based on visual assessments**. *J Arboricult* 1996, **22**:249-254.

15. De Sy V, Herold M: **Synergies of multiple remote sensing data sources for REDD+ monitoring**. *COSUST*, this volume

16. Chave J, Andalo C, Brown S, Cairns MA, Chambers JQ, Eamus D, Fölster H, Fromard F, Higuchi N, Kira T *et al.*: **Tree allometry and improved estimation of carbon stocks and balance in tropical forests**. *Oecologia* 2005, **145**:87-99.

17. Medjibe VP, Starkey M, Ndouna AA, Memiaghe HR, Putz FE: **Impacts of timber extraction on above-ground forest biomass on Monts de Cristal in Gabon**. *Forest Ecol Manag* 2011, **262**:1799-1806.

18. Ruslandi, Venter O, Putz FE: **Over-estimating the costs of conservation in Southeast Asia**. *Front Ecol Environ* 2011, **9**:542-544.

19. Ling T: **Evaluating complex and unfolding interventions in real time**. *Evaluation* 2012, **18**:79-91.

20. Glouberman S, Zimmermann B: *Complicated and Complex Systems: What Would Successful Reform of Medicare Look Like?* 2002. Commission on the Future of Health Care in Canada, Discussion Paper 8

21. Rogers PJ: **Using programme theory to evaluate complicated and complex aspects of interventions**. *Evaluation* 2008, **14**: 29-48.

22. Pfaff A, Sills EO, Amacher GS, Coren MJ, Lawlor K, Streck C: **Policy impacts on deforestation: lessons learned from past experiences to inform new initiatives**. *Nicholas Institute Report. Nicholas Institute for Environmental Policy Solutions*. NC, USA: Duke University; 2010.

23. Ullsten O, Salleh M, Montague Y: **The Tropical Forestry Action Program**. *Report of the Independent Review*. Kuala Lumpur: FAO; 1990.

24. Holling CS: *Adaptive Environmental Assessment and Management*. London: John Wiley and Sons; 1978.

25. Persson UM: **Conserve or convert? Pan-tropical modeling of REDD-bioenergy competition**. *Biol Conserv* 2012, **146**:81-88.

26. Álvarez MD: **Forests in the time of violence: conservation implications of the Colombian war**. *J Sust Forest* 2003, **16**: 49-70.

27. •• Chomitz KM, Buys P, De Luca G, Thomas T, Wertz-Kanounnikoff S: **At loggerheads? Agricultural expansion, poverty reduction, and environment in the tropical forests**. *A World Bank Policy Research Report*. Washington, DC: The World Bank; 2007.
An insight of review of factors affecting the fates of tropical forests.

28. Fisher B, Edwards DP, Giam X: **The high costs of conserving Southeast Asia's lowland rainforests**. *Front Ecol Environ* 2011, **9**:329-334.

29. Holmes TP, Blate GM, Zweede FC, Perrera R, Barretto P, Boltz F, Bauch R: **Financial and ecological indicators of reduced-impact logging performance in the eastern Amazon**. *Forest Ecol Manag* 2002, **163**:93-110.

30. • Medjibe VP, Putz FE: **Cost comparisons of reduced-impact and conventional logging in the tropics**. *J Forest Econ* 2012, **18**: 242-256.
Of 10 studies comparing the costs of reduced-impact and conventional logging (RIL vs. CL), 3 reported lower costs for RIL, 6 reported lower costs for CL, and 1 showed no difference.

31. •• Auld G, Gulbrandsen LH, McDermott CL: **Certification schemes and the impacts on forests and forestry**. *Annu Rev Environ Res* 2008, **33**:187-211.
Reviews the development of voluntary third-party forest certification.

32. Proforest: FLEGT: **REDD+ linkages: working together effectively**. *Program of Forests*. 2011. Briefing Note 3.

33. Werger MJA: *Sustainable Management of Tropical Rainforests: The CELOS Management System*. Paramaribo, Suriname: TROPENBOS International; 2011.

34. Bernstein S, Cashore B: **Complex global governance and domestic policies: four pathways of influence**. *Int Affairs* 2012, **88**:585-604.

35. Visseren-Hamakers IJ, McDermott C, Gupta A, Vijge A, Cashore B: **REDD+ co-benefits + safeguards: current debates on the breadth of REDD+**. *COSUST*, this volume

36. Olander, LP, Galik SC, Kissinger GA: **Operationalizing REDD+: Scope of reduced emissions from deforestation and forest degradation**. *COSUST*, this volume

37. Overdevest C, Zeitlin J: **Assembling an experimentalist regime: transnational governance interaction in the forest sector**. *Regul Govern* 2012 http://dx.doi.org/10:1111/j.1748.

38. Murdiyarso D, Brockhaus M, Sunderlin W, Verchot L: **Lessons learned from the first generation of REDD+ activities**. *COSUST*, this volume