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ABSTRACT

Stable forests – those not already significantly disturbed nor facing predictable near-future risks of anthropogenic disturbance – may play a large role in the climate solution, due to their carbon sequestration and storage capabilities. Their importance is recognized by the Paris Agreement, but stable forests have received comparatively little attention through existing forest protection mechanisms and finance. Instead, emphasis has been placed on targeting locations where deforestation and forest degradation are happening actively. Yet stopping deforestation and forest degradation does not guarantee durable success, especially outside the geographic scope of targeted efforts. As a result, today's stable forests may be at risk without additional efforts to secure their long-term conservation.

We synthesize the gaps in existing policy efforts that could address the climate-related benefits derived from stable forests, noting several barriers to action, such as uncertainty around the level of climate services that stable forests provide and difficulties describing the real level of threat posed. We argue that resource and finance allocation for stable forests should be incorporated into countries' and donors' comprehensive portfolios aimed at tackling deforestation and forest degradation as well as resulting emissions. A holistic and forward-looking approach will be particularly important, given that success in tackling deforestation and forest degradation where it is currently happening will need to be sustained in the long term.

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Stable forests; climate services; incentives gap; Consolidation; long-term conservation

Key policy insights

- Climate policies, finance, and implementation have tended to focus on areas of recent forest loss and near-term threats of anthropogenic disturbance, resulting in an imbalance of effort that fails to adequately address stable forests.
- In some contexts, policy measuresintended to secure the climate-related benefits of stable forests have competed poorly against more urgent threats. Policymakers and finance mechanisms should view stable forests as a complementary element within a holistic, long-term approach to resource management.
- International mechanisms and national frameworks should be adjusted and resourced to promote the long-term sustainability and permanence of stable forests.
- Beyond additional resources, the climate benefits of stable forests may be best secured by pro-actively designing implementing policies that recognize the rights and interests of stakeholders who are affected by land management decisions.

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Introduction

Deforestation and forest degradation have contributed significantly to historical greenhouse gas emissions, accounting for at least 861.7 ± 80.2 Tg C yr^{-1} of emissions between 2003 and –2014 (Baccini et al., 2017). These processes have been driven by a number of causes, including agriculture, logging, mining, and infrastructure development (Armenteras, Espelta, Rodríguez, & Retana, 2017; Hosonuma et al., 2012; Kissinger, Herold, & De Sy, 2012). Policies have been undertaken to protect forests against proximate sources of anthropogenic disturbance, with some notable successes; for example, in Brazil, investments in forest conservation policies between 2000 and 2014 (averaging US$1 billion per year) dramatically lowered deforestation rates (de Souza Cunha, Börner, Wunder, Cosenza, & Lucena, 2016;see Brazil's Reference Levels submissions to UNFCCC). However, policy interventions have not yet proven widely effective in protecting remaining forests from the underlying driving forces (*sensu* Geist & Lambin, 2002) that contribute – sometimes synergistically – to the anthropogenic degradation of forests, at times leading to an unanticipated acceleration of losses (Busch & Engelmann, 2017).

Nevertheless, some areas of 'stable forests' remain free from evidence of human actions that cause physical changes to forests and lead to declines in ecological function (Thompson et al., 2013). Stable forests are those that are not already significantly disturbed nor facing predictable near-term risks of anthropogenic disturbance, and they represent a major global resource for carbon management, in addition to the value they provide through other ecosystem services. While conventionally such forests were thought to be in equilibrium in terms of carbon fluxes, recent science finds that these forests are, in fact, removing carbon from the atmosphere in far greater quantities than previously expected (Baccini et al., 2017; Lewis et al., 2009; Phillips & Brienen, 2017; Qie et al., 2017; Thompson et al., 2013), with removal estimates of up to 436.5 ± 31.0 Tg C yr^{-1} from forest growth (Baccini et al., 2017).

This paper aims to present a synthesis of the current understanding of risks to the integrity of stable forests, their contributions to climate change mitigation, policy gaps in protecting the integrity of stable forests,and potential solutions to fill those gaps. This synthesis emerged from a workshop carried out in Woking, UK, 6–7 September 2017among the group of authors.

The role of stable forests in the carbon cycle and climate change policy

Historically, climate policy considerations of the role of forests have tended to focus on forests as a source of emissions from deforestation and forest degradation, but recent science has highlighted the current or potential mitigation benefits from carbon sequestration (Griscom et al., 2017; Phillips & Brienen, 2017) and storage (Pan et al., 2011) capabilities.Policies aimed at forests are uniquely positioned to deliver large-scale potential to simultaneously reduce emissions, support a stable carbon reservoir, and provide a significant carbon sink (Seymour & Busch, 2016).

Stable forests play an important role as large, stable terrestrial reservoirs of carbon that have relatively slow turnover rates (c. 10^1–10^3yrs). Stable forests make up a significant portion of the approximately 861 ± 66PgC in aboveground biomass currently stored in global forests, with an additional 100 Pg C or more stored belowground in tropical peatlands alone (Dargie et al., 2017; Page, Rieley, & Banks, 2011) – equivalent to almost 100 years' worth of current fossil fuel emissions (Pan et al., 2011). These stocks are not at equilibrium, as conventionally assumed, but are actually growing, comprising a sink that is significant at regional and global scales (Mitchard, 2018; Pan et al., 2011; Stephens et al., 2007). For instance, stable Amazon rainforests may have offset all anthropogenic emissions from all sources in the region since the 1980s, outstripping the annual net sink in that region's regenerating forests (Phillips & Brienen, 2017). Overall, the tropical forestcarbon sink has remained 'large and persistent' over decades, in the range of 1 ± 0.5 Pg C (Pan et al., 2011), though estimates of the net tropical forest carbon flux have varied, as a result of, *inter alia*, interannual variability (Gatti et al., 2014), emissions from anthropogenic land-use change (Baccini et al., 2017), and differences in estimation methods(Harris, Brown, Hagen, Baccini, & Houghton, 2012).Approaches based on modelling, remote sensing, and ground monitoring data are consistent in reporting substantial sequestration in stable forests that is *additional* to the regrowth in disturbed forests (Baccini et al., 2017; Gatti et al., 2014; Pan et al., 2011; Phillips & Brienen, 2017; Qie et al., 2017; Schimel, Stephens, & Fisher, 2015).

Table 1. Types of anthropogenic disturbance and their effects on stable forests.

Category	Description	References
Direct activities that reduce stocks and stability	Direct, anthropogenic activities that degrade the ecological integrity of forests, such as the unsustainable harvest of wood products, overharvest of non-timber forest products (NTFPs), defaunation, alteration of hydrologic regimes (e.g. drainage), and edge effects associated with forest fragmentation.	Brandt, Nolte, and Agrawal (2016); Sasaki et al. (2016); Gauthier, Bernier, Kuuluvainen, Shvidenko, and Schepaschenko (2015); Peres, Emilio, Schietti, Desmoulière, and Levi (2016); Wohl, Hall, Lininger, Sutfin, and Walters (2017); Young, McCauley, Galetti, and Dirzo (2016); Chaplin-Kramer et al. (2015); Chaplin-Kramer et al. (2015); Pütz et al. (2014); Shapiro, Aguilar-Amuchastegui, Hostert, and Bastin (2016)
Direct activities that may increase stocks but reduce stability	Anthropogenic activities that may temporarily increase carbon stocks, but also increase the risks to forests or disrupt their ecological functions, such as fire suppression or the introduction of exotic tree species.	Abatzoglou and Williams (2016); Barbosa, Asner, Hughes, and Johnson (2017); Hantson, Pueyo, and Chuvieco (2015); Sokol, Kuebbing, and Bradford (2017); Williams, Gu, MacLean, Masek, and James Collatz (2016)
Indirect effects that reduce stocks and/or stability	Indirect anthropogenic effects, such as those resulting from global climate change (including changes in phenology, pest populations, fire intervals, etc.), and the effects of atmospheric transport and deposition of reactive nitrogen and other pollutants.	Doughty et al. (2015); Seidl, Schelhaas, Rammer, & Verkerk (2014a, 2014b)

However, the continuation of this important sink is not guaranteed. Some scholars warn that forests like those in the Amazon have already reached a tipping point due to negative feedbacks between deforestation, climate change, and the widespread occurrence of forest fires(e.g. Lovejoy & Nobre, 2018). Additionally, some types of anthropogenic disturbances may be undermining the stability of forests in ways that are difficult to detect (Table 1).

Beyond their contributions to climate mitigation, stable forests may also be a vital source of resilience in a changing climate, through qualities such as fire resistance, and to the potential for such foreststo serve as ecological source areas to support nearby restoration and recovery of damaged and degraded areas (Catterall, 2016; Chazdon & Uriarte, 2016; Lu, Zang, Ding, & Huang, 2016; Poorter et al., 2016). Forests can provide adaptation benefits byregulating local climate conditions, including local and regional cooling and the maintenance of moisture supply to critical agricultural lands (Lawrence & Vandecar, 2015; Spracklen, Arnold, & Taylor, 2012). Finally, stable forests are important reservoirs of genetic diversity that will be necessary to ensure that ecosystems and landscapes can continue to provide the ecological services that many communities and cultures depend on for their livelihoods, even as the changing climate and other factors cause changes in the phenology, location, composition, and character of these ecosystems (Watson et al., 2018).The future value of these important benefits can only be secured if the stability of today's stable forests is adequately protected from anthropogenic disturbance.

International climate policies have the scope to address such protections, but stable forests have received little attention in international action. For instance, the Parties to the Paris Agreement have reaffirmed their commitment to 'take action to conserve and enhance, as appropriate, sinks and reservoirs of greenhouse gases,'[1] which include stable forests, yet national and international activities have tended to focus on areas of recent forest loss and near-term threats of anthropogenic disturbance (e.g. Brazil, Mexico; de Souza Cunha et al., 2016). Without measures and financial mechanisms aimed at protecting the ecological integrity of stable forests, they remain vulnerable to the effects of underlying driving forces. Conversely, policies and near-term investments in protective measures for these forests – consistent with national commitments – could 'short circuit' long-term threats and prove cost-effective, avoiding high costs for protection and recovery in the future.

Methodological approach

To investigate these issues and explore their relevance for climate policy, we convened a diverse group of experts with relevant experience in nearly all stable forest geographies. Together, we undertook the task of characterizing the nature of policy approaches that might successfully incorporate and address the role of stable forests. We used facilitated joint fact finding and analysis to elicit collective insights, using a five-step, iterative process (Ehrman & Stinson, 1999; Lee, 1995; Mitchell et al., 2006):

(1) pre-workshop preparation of a set of thematic issues and questions, with experts assigned to provide inputs and relevant literature references, and global and country examples in their areas of expertise;
(2) at the workshop, presentations by the lead expert for each thematic issue, followed by discussion, clarification of points of agreement, disagreement (if any), contribution of additional information and references, and identification of needs for additional information/research;
(3) development of an agreed outline for the paper, and assignment of initial drafting responsibility to pairs of expert participants;
(4) development of a first draft with review by the full group, again to identify points of agreement and any disagreement, contribute information, and identify needs for additional information;
(5) agreement on follow up action to produce a full draft for submission, with lead and contributing authors.

The process yielded widespread consensus among the participants, and nearly all the expert participants elected to contribute to the authorship of this paper. The sections below present the findings from this process, starting with diagnosing the problem, then evaluating current policy frameworks, and finally developing a characterization of potential solutions.

Diagnosing the problem

A number offactors may have contributed to a relative lack of progress toward recognizing the role of stable forests. Among those is a perception that stable forest finance would compete for finance aimed towards areas at immediate danger,rather than complement and contribute to securing the effectiveness of forest finance as a whole.In our view, no such competition should exist; rather, securing stable forests should be part of holistic strategies that aim to manage and consolidate carbon fluxes across entire landscapes.

A related second factor has been the concept of additionality, which refers to measuring results in comparison to what would have occurred in the absence of new action.[2]At the project level, developing reliable means of projecting results and counterfactual scenarios has proven to be a technical challenge that has stymied innovation, contributed to cash flow difficulties for project developers, and ignored the value of historical efforts (World Bank, 2011). These problems have been exacerbated by the expectation that carbon removals from land-use activities would not be permanent (Federici, Lee, & Herold, 2017). Such requirements and expectations may no longer be as relevant under the Paris Agreement, in which protection of existing sinks and reservoirs of carbon can be recognized as a contribution (Article 5).

A third, related factorhas been that countries (or regions or projects) with large amounts of stable forests and historically low deforestation and degradation rates have, in some cases, elected to set their forest emission baselines (i.e. reference levels and reference emission levels) by using projections, upward adjustments (Guyana, Colombia, DRC, Congo, Vietnam)[3], or reference areas[4]that imply that higher levels of emissions are very likely in the future, in an effort to make such areas eligible for financeunder REDD+[5] mechanisms (FAO, 2017). This approach has been controversial because of concerns about the validity of the rationales used to justify the underlying assumptions and concerns about climate integrity, but the effect has been to set the expectation that emissions will increase, rather than focus on protecting the stability of forests and existing sinks.

A fourth factor has been the large uncertainties and data gaps that remain in the efforts aimed at reliably quantifyingcarbon dynamics of stable forests (Baccini et al., 2017; Grassi et al., 2018), presenting a challenge to linking specific policy actions with carbon outcomes. The combined result of all these factors has been that countries have lagged in developing policy instruments specifically designed to secure the ongoing climate benefits of stable forests, despite their collective acknowledgment of the importance of stable forests as carbon reservoirs in international climate policy.

Risks to the integrity and stability of forests

A lag in policy approaches means that risks from underlying driving forces may be ignored, or even exacerbated. Unanticipated risks can emerge directly or indirectly from ongoing or planned processes (e.g. economic development activities, population growth), or as the unintended consequence of actions aimed at reducing forest emissions elsewhere (e.g. conservation of high carbon stock areasunder active management). These risks can be difficult to estimate in advance, but empirical evidence suggests that their scale can be significant. For example, between 2000 and 2013, an estimated 7.2%of areas characterized as 'Intact Forests Landscapes' (IFLs, a subset of stable forests) showed evidence of new human disturbance (91.9 Mha of the estimated 1280 Mha extent of IFLs in 2000; Potapov et al., 2017). Another study over a similar time period (2000–2012) estimated that 2.5% of IFLs had beendeforested (Heino et al., 2015).Though protected area status seems to enhance stability of forests in some regions (Heino et al., 2015), recent studies show that protected statusdoes not eliminate risk entirely, necessitating additional and/or sustained support. In some cases, human disturbance soon follows after a process of protected area downgrading, downsizing, or degazettement[6] (known as PADDD; Mascia & Pailler, 2011). After degazettement, previously protected forest areas have experienced higher deforestation than areas that were never protected, and much higher rates than areas that remain under protection (Forrest et al., 2015), suggesting complex underlying dynamics driving these outcomes. The risk of PADDD is acute in areas where economic interests come into conflict with conservation efforts, leading to a shift in management interests. This has been the case in Brazil (Pack et al., 2016), as well as in Africa, Asia and Latin America and the Caribbean (Mascia et al., 2014). Of the approximately 2.2 Mha of IFLs that were lost annually between 2000 and 2012, over 20% took place inside protected areas (Heino et al., 2015).The documented loss of stable forests in protected areas around the world (Bowker, De Vos, Ament, & Cumming, 2017; Heino et al., 2015; Miranda, Corral, Blackman, Asner, & Lima, 2014; Pfaff, Robalino, Herrera, Sandoval, & Bawa, 2015; Pfaff, Robalino, Sandoval, & Herrera, 2015; Potapov et al., 2017) suggests that more robust solutions and/or capacities are needed for a wide range of jurisdictional contexts.

The gap in incentives and finance

A failure to extend adequate incentives for the protection of stable forests may lead to a distortion or mismatch in incentives (e.g. through REDD+) that could disadvantage countries or sub-national regions with large stable forests; whereas a holistic approach, in partnership with key resource managers (e.g. indigenous peoples and other forest communities, park systems, etc.),may lead to better outcomes (Grassi et al., 2017; Griscom et al., 2017; Law et al., 2018). As a proactive measure, adequateinterim support could have a significant, measurable impact on the future stability of such forests, similar to the way that a life insurance policy can be a sensible investment that provides a threshold of security for future generations.

We identifieda set of policy-relevant conditions that should be met, collectively, by policy approaches,in order to protect the durability and integrity of stable forests. When stable forests are viewed as a 'commons' that require governance to ensure their sustainability, then these conditions can be related to and informed by Ostrom's design principles for governing sustainable resources (Ostrom, 1990, 2005). Table 2 presents the conditions, their description, the corresponding design principles, and the identified gaps in current approaches.

Evaluating current policy frameworks

International climate agreements

The policy conditions identified in Table 2 served as a framework for assessing existing policy frameworks to address stable forests. The authors found significant shortcomings in meeting the needs for the long-term protection of stable forests (Table 3).

At the international policy level, the commitment to stable forests originates in the UN Framework Convention on Climate Change (UNFCCC), in which countries pledged to 'Promote sustainable management, and promote and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs of all greenhouse gases.'[7] That pledge was reaffirmed in the Paris Agreement.[8]However, such recognition has not materialized into actions directed at stable forests. The relevant supporting mechanisms have not explicitly addressed existing forest carbon reservoirs, and Parties have not articulated the actions they will take with regards to these reservoirs and sinks (FAO, 2017; Lee and Sanz-Sanchez, 2017).

Table 2. Attributes identified by participating experts for effective measures to preserve the climate benefits associated with stable forests.

Policy Attributes	Description	Corresponding Ostrom design principles	Identified gap
1) Anticipate risks	Activities to protect stable forests are developed in a forward-looking, anticipatory, and proactive way, rather than in backward-looking, historical, and reactive frames;	(Anticipation of risks establishes a basis for 6. Conflict-resolution mechanisms, and 5. Graduated sanctions.)	Incentives reward reductions in emissions, measured against historical levels, with no targeted incentives for forward-looking activities.
2) Incorporate broader value	Stable forests are identified, mapped, and incorporated within a wider sustainable landscape management plan designed to avoid and/or mitigate planned disturbance of and/or leakage to these forests as much as possible;	1. Clearly defined boundaries. 8. Nestled enterprises.	Preserving the integrity of stable forests is not often seen as a priority for planning, or it is addressed as a discrete protected area, rather than as an integral part of a larger landscape plan.
3) Allocate resources	Sufficient resources are allocated to establish and sustain protection efforts, including a sustained and sufficient stream of financial resources that is appropriately matched to the value of preserving forest services, and the cost (direct and opportunity) of doing so;	2. Proportional equivalence between benefits and costs.	Stable forests are typically considered ineligible for REDD+ finance or are designated as 'unmanaged lands' in developed countries, closing off potential resource allocation.
4) Sustain efforts	Protection efforts and/or management activities are undertaken in the context of sufficient legal authority to ensure they are sustained and enforced;	3. Collective-choice arrangements. 7. Minimal recognition of rights to organize.	Stakeholders in stable forest resources (including those with an interest in preserving their climate benefits) lack recognition or authority by government, or their tenure is not secure.
5) Monitor outcomes	Monitoring programmes exist or are established that can detect disturbances that could undermine the ecological stability of the forest on an ongoing basis.	4. Monitoring.	Tools and approaches to monitor some disturbances are expensive or unavailable.

Note: Each attribute relates to one or more aspects of Ostrom's design principles for governing sustainable resources (Ostrom, 2005, p. 259, 1990, p. 90). Experts identified gaps in existing policy approaches and incentive mechanisms.

Within the UNFCCC, there is also a policy framework for supporting developing countries in their efforts to reduce emissions from deforestation and degradation, and to conserve, sustainably manage, and enhance forest carbon stocks, collectively known as REDD+. Key decisions for REDD+, most notably the Warsaw Framework on REDD+, include the potential for developing countries to undertake activities that promote conservation of forest carbon stocks, sustainable management of forests, and the enhancement of forest carbon stocks[9] (known as the '+' activities), but so far these efforts have been mostly framed in terms of reducing emissions in areas at immediate risk.

Similarly, voluntary international policy initiatives like the Bonn ChallengeandLima Challenge emphasize expansion and restoration of forest areas, but do not address areas of stable forests.

Multilateral mechanisms like the Forest Carbon Partnership Facility (FCPF) have developed elaborate guidance, processes, mechanisms, and means of support for reducing emissions from deforestation and forest degradation, yet corresponding mechanisms for the preservation of forest carbon stocks are virtually non-existent. None of the international mechanisms to support REDD+ have complemented their objectives to reduce emissions from deforestation and forest degradation with the conservation of stable forests.

National climate policies

Countries have had the option to address stable forests through their own national policies. Historically, under the Kyoto Protocol, developed countries had various ways to account for fluxes from stable forests, but most opted to exclude 'unmanaged' areas of land from their accounting, meaning that the fluxes from such areas have no impact on the national targets, and thus do not warrant any climate-based justification for policy action. As a result, countries with Kyoto commitments have had little incentive to secure any climate-related benefits that could result from the protection or sustainable management of stable forests.

Under the Paris Agreement, we noted some evidence that stable forests are incorporated in national-level activities, but such efforts are typically not specified in national climate policies or commitments, which suggests

Table 3. Evaluation of how current policy frameworks and their adequacy in meeting the conditions to secure Stable Forest in the long term, based on Hein et al., 2018; Climate Focus, 2017; and Petersen & Varela, 2015, supplemented by the expert knowledge of the contributing authors.

Policy Attributes	International climate agreements	National climate policies	Donor-supported land management planning	Voluntary activities among non-state actors
1) Anticipate risks	**Missing**. Current policies are framed by historical emissions, with little incentive for forward-looking, holistic approaches.	**Mixed**. Some countries actively anticipate drivers and enforce protected areas, but these actions are insufficient or contentious in many places.	**Missing**. Donor-supported activities have been almost entirely in the context of emission reductions and have not recognized the climate value of stable forests.	**Mixed**. Some projects and activities have tackled underlying drivers (such as commodity supply chains) and recognized the value of existing stable forests, but these efforts have had little impact at the global scale so far.
2) Incorporate broader value	**Good**. The climate value of stable forests is emphasized in the UN Framework Convention on Climate Change and the Paris Agreement, and this value is linked to non-climate benefits.	**Mixed**. In some cases, stable forests are implicitly part of national climate policies, but they typically lack detail, coherence with other issues, and administrative support.	**Good**. Climate-related support has often been directed at holistic planning as part of 'readiness,' with non-climate benefits specifically targeted, and environmental and social safeguards enforced.	**Missing**. With a few notable exceptions, projects and activities have typically been designed to secure climate benefits alone, and they are not often integrated into a holistic land management strategy.
3) Allocate resources	**Mixed**. The Paris Agreement and the Warsaw Framework on REDD+ develop mechanisms that could direct resources toward the protection of stable forests, but these mechanisms are either incomplete or have focused on emission reductions.	**Mixed**. National policies have created and enforced protected areas, but such areas are often under-resourced, and PADDD activities are sometimes the result of inadequate resourcing in the face of development pressures.	**Mixed**. Donors have channelled significant resources into readiness and forest protection, but the overall scale of finance is still inadequate at a global level, and resources have tended to be directed at historical threats, rather than stable forests.	**Missing**. Voluntary activities have been funded at levels far below what would be required to adequately secure current areas of stable forests.
4) Sustain efforts	**Mixed**. The nature of commitments under the Paris Agreement prohibits backsliding on activities, but this has not yet been tested.	**Mixed**. Most countries engage in some sort of long-term land-use planning, but climate benefits have rarely been a priority in such efforts, and stable forests are often seen as untapped areas for future exploitation. The result is that enforcement can be inconsistent, or protection efforts can be removed (PADDD).	**Mixed**. While most donors require long-term planning as a condition of eligibility, these plans are not typically required to explicitly address current areas of stable forests.	**Missing**. Voluntary activities have proven to be ephemeral, with many projects or initiatives becoming abandoned when financial resources cannot be sustained.
5) Monitor outcomes	**Missing**. These agreements do not require ongoing monitoring of stable forests and they include the option to exclude such forests from monitoring activities.	**Mixed**. Many countries are equipped to comprehensively monitor forests, but unmanaged areas receive little attention, and monitoring is not always linked to enforcement.	**Good**. Donors generally require, and have supported, efforts to improve monitoring capacity, aimed at directing resources and enforcement.	**Mixed**. Most voluntary market activities require a significant monitoring effort, over long-time periods. However, this is typically limited to the project area or the specific commodity, resulting in piecemeal coverage and enforcement.

a failure to recognize the climate benefits of these forests and appropriately resource efforts to protect their integrity. For example, some developed countries, such as the US and Russia, implicitly include significant areas of stable forests in their (Intended) Nationally Determined Contributions(NDCs) – while also leaving some 'unmanaged' forests out of their accountable contributions (USA 2015[10]; Russia 2015[11]). The associated documentation fails to describe how particular policies, efforts, measures, or activities will achieve the protection and enhancement of carbon stocks in stable forests, despite widespread recognition of the value of these forests.[12]In many countries where sufficient resources exist, no description is available of how planning, monitoring, and ongoing financial investments have been established to protect stable forests in the future.

Among the developing countries participating in REDD+, as of October 2018, 34 countries had submitted reference emission levels, with only 3 including activities related to the conservation of forest carbon stocks or sustainable management of forests (Chile, Uganda, Vietnam). Ten included enhancement of carbon stocks in stable forests (Lee & Sanz-Sanchez, 2017).Some countries are making significant efforts to secure existing areas of stable forests by designating them as protected areas or assigning other forms of legal protection (e.g. Guyana and Colombia). In many cases, the submissions suggest that some countries are attempting to frame carbon stock or '+' activities as fitting within the context of reducing deforestation or forest degradation. For instance, Guyana intends to update its reference level with 'removals or carbon stock enhancements' at a later stage, reflecting the phased approach to REDD+ implementation in accordance with national circumstances. Interestingly, Guyana has framed its reference level as a reduction against a projected increase in emissions to be compared with global performance, rather than as the protection of existing forest reservoirs – again reflecting a backward-looking benchmark for performance, rather than a proactive, forward-looking approach. Other countries, like Mexico and Malaysia, intend to await the availability of more data.[13]

Donor-supported land management planning

Finance related to REDD+ is oriented toward demonstrated emissions reductions obtained through a comparison of historical reference emissions levels with actual emission rates (Hargita, Günter, & Köthke, 2016; Voigt & Ferreira, 2015; Wolosin, Breitfeller, & Schaap, 2016). For instance, the Green ClimateFund(GCF) and FCPF frame their support in terms of the three phases of REDD+ activities, culminating in payments for performance, as measured by emissions reductions. Similarly, we do not observe stock-based financial infrastructure in national REDD+ institutions. Like REDD+ methodology for the GCF, the Amazon Fund, for example, receives performance-based payments on the basis of demonstrated emissions reductions, recognizing substantial reductions relative to the baseline reference year (van der Hoff, Rajão, Leroy, & Boezeman, 2015). The same occurs with bilateral and multilateral agreements such as the Guyana-Norway Agreementand REDD Early Movers(REM) programmes. Donor organizations such as Norway's International Climate and Forest Initiative (NICFI) apply similar methodologies for Brazil, Guyana, Colombia and Peru, each of which have different realities in terms of forest dynamics (Wong et al., 2016). These institutions reward achievements related to reducing deforestation and addressing forest degradation, but we observe no financial compensation targets explicitly for the maintenance of stable forests.

Voluntary activities among non-state actors

Potentially, activities among non-state actors, such as those conducted through voluntary market mechanisms, could incentivize the generation of 'offsets' from stable forests. However, we found little supporting evidence that this is the case. In Brazil, for example, some voluntary REDD+ initiatives have adopted such an approach in parallel to the mainstream national programme that revolved around the Amazon Fund, but those efforts mostly occur as standalone projects of insufficient scale to offer protection to large forest areas(vvan der Hoff et al., 2015). Protocols for such projects require them to demonstrate their benefit in terms of *additional* emissions reductions (demonstrating that emissions reductions were the result of project activities (Valatin, 2011). As a consequence, we see that projects with significant forest stocks but low deforestation rates frame their contributions in terms of emissions reductions, sometimes based on disputable rationales, rather than the protection and enhancement of existing stocks (Seyller et al., 2016). The requirements for additionality in such projects, which makes them eligible for generating 'offsets,' generally fails to recognize their contribution to protecting current forest carbon stocks and the ongoing value of historical actions to safeguard these forests.

In theory, it could be possible that the aggregate effect of localized REDD+ projects could collectively cover large areas of stable forests and provide for their ongoing protection. Indeed, many such projects are deliberately aimed at creating biological 'corridors' that link together large areas of protected stable forests. Yet the ability to 'nest' (Pedroni, Dutschke, Streck, & Porrúa, 2009) these projects within national climate efforts remains elusive. In some cases, early action on these projects was completed before national climate strategies were developed, resulting in a mismatch between project carbon accounting and national carbon accounting frameworks. As a result, such projects are effectively ineligible for climate-related incentives.

More significantly, such projects are often piecemeal and uncoordinated, especially when pursued by competing interests without any overarching programme or policy framework to guide them. On their own, these projects have little incentive to pursue complete geographic coverage of stable forest areas or to align their parallel efforts by using similar methodologies and metrics. In current practice, projects lack access to international support mechanisms yet to be elaborated under the Paris Agreement, and most historical REDD+ projects are struggling to receive support (Silva-Chávez, Schaap, & Breitfeller, 2015; Wolosin et al., 2016).

Beyond international- or national-level policies, financial incentives, or voluntary carbon markets, the protection of stable forests could be addressed by international organizations that focus on stable forests as part of their mission, such as FAO and CGIAR; civil society organizations, such as IUCN or WWF; or through other commitments, such as subnational programmes or private sector commitments. In theory, stable forest preservation could be achievable if these actors were interested in such a role, were adequately supported, and had the means to secure areas of stable forests individually and/or collectively, even in the absence of national policy interventions and financial support. The Amazon Region Protected Areas Program (ARPA), which has contributed to increased management capacity in the protected areas network in Brazil (Leslie, 2017), could be one model of this kind of approach. These institutions and agents have made significant contributions, but they also lack the necessary resources and legal authority to execute a comprehensive strategy to protect stable forests and,thus, their efforts are always at risk of reversal from national planning processes, granting of concessions, and other risks (Tesfaw et al., 2018). As a result, the notable and worthwhile efforts of these entities still fall short of what is needed. In general, we did not identify processes underway that would lead to effective coordination of efforts among these entities, nor do we observe mechanisms that would equip them with sufficient resources and authority to carry out this task at the scale necessary. In theory and in practice, we find little evidence that such efforts would adequately address the conditions outlined above.

Characterizing solutions for conserving stable forests

In our assessment, addressing the long-term risks to stable forestsand effectively enhancing their conservation will require surmounting a few key challenges:

- First, the disturbances to stable forests are often difficult to detect or predict without *adequate identification, mapping, and monitoring* because they typically start very small. This suggests that existing mapping and monitoring systems need to be refined to detect and anticipate emerging threats to stable forests (Mitchard, 2018).
- Second, political institutions tend to strongly emphasize short-term threats (i.e. deforestation and forest degradation) rather than long-term conservation of stable forests, and financial institutions reinforce this tendency by remunerating demonstrated results (i.e. backward-looking), rather than incentivizing the forward-looking conservation of stable forests (Climate Focus, 2017; Hein, Guarin, Fromme, & Pauw, 2018; Petersen & Varela, 2015). This points to *a need for more efforts and resources aimed at the conservation of stable forests* that are additional to existing efforts and resources directed at reducing deforestation and forest degradation.
- Third, the efforts of international organizations and subnational actors aimed at forest conservation, currently uncoordinated and inadequately supported by philanthropy or voluntary carbon markets, are unlikely to adequately address the full extent of stable forests (Climate Focus, 2017; Wolosin et al., 2016). This challenge demonstrates *a need for broader sustainable landscape management plans designed to avoid planned disturbance of stable forests*.

We posit that these challenges can be addressed through a few key policy-related venues, as elaborated below.

Opportunities through the UNFCCC and REDD+

The UNFCCC could work to address the policy gap with regards to the '+' in REDD+ by clarifying and strengthening how stable forests fit within the REDD+ framework.The mismatch created by retrospective performance-based payments could be rectified by adding forward-looking, long-term protective measures (that also support sustainable low-carbon development), through the development of elements to support these measures and account for them adequately.

In many cases a decision to forego future conversion or exploitation of forests carries an economic cost that may not be fully recuperated through the provision of local goods and services from forests. In such cases, external climate finance could help make maintaining stable forests more economically viable. As discussed above, REDD+ funding has focused, to date, almost exclusively on reducing deforestation and forest degradation, but the REDD+ framework has the potential to support international payments for stable forests through the 'conservation of forest carbon stocks.' Simply shifting the focus toward the conservation of stable forests will not suffice, however, because deforestation and forest degradation remain pressing problems that need to be addressed. Instead, we propose the diversification of policy and finance mechanisms in which the conservation of stable forests becomes a parallel and complementary stream within the REDD+ framework (Figure 1).

Our rationale is similar to the case for a diversified investment portfolio, which balanceshigh-yield/high-risk investments with low-yield/low-risk investments. In this case, stable forests represent the low-yield/low-risk investments and, as such, would require some proportion of funding to be allocated for their continued protection. This will not only contribute to a more comprehensive REDD+ framework in which forest conservation plays a complementary role to efforts to reduce deforestation and forest degradation, but it would also complete the missing pieces of the current framework.

Early discussions of the concept that became REDD+ recognized the problem and began to develop examples of policy designs that focused more strongly on the conservation of stable forests. These policy designs attempted to address the difficulties of 'high-forest, low-deforestation'countries (HFLD; da Fonseca et al., 2007) in attracting sufficient resources and the reluctance of non-HFLD countries to allocate funding to prevent future threats to stable forest areas(Busch et al., 2009; Griscom, Shoch, Stanley, Cortez, & Virgilio,

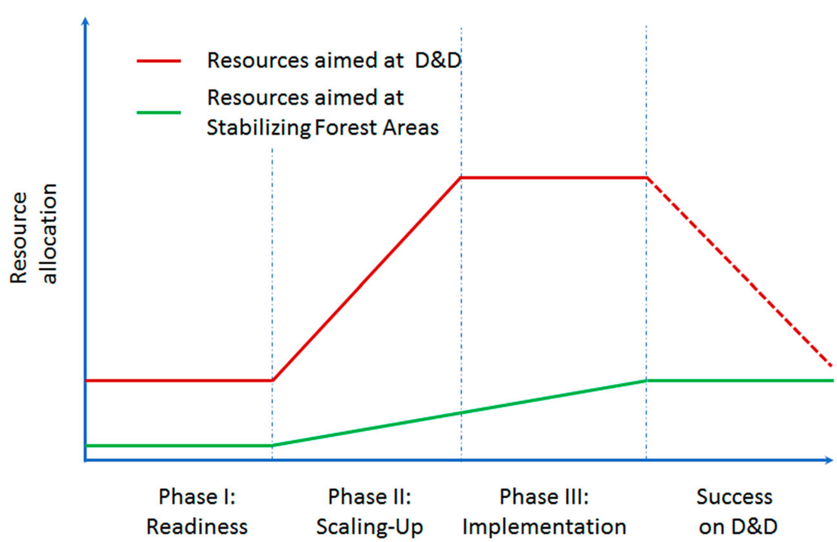

Figure 1. Stable forest resource allocation should gradually increase as REDD+ implementation is successful at stopping deforestation and forest degradation (D&D) and incorporating new forest areas into the stable forest condition, as defined here.

2009). These included adjusted reference levels for HFLD countries (Mollicone et al., 2007; Santilli et al., 2005) with explicit forest conservation components (as later used in the Guyana-Norway bilateral agreement) and dual payment streams for carbon stocks and for the reduction in emissions, as proposed by Cattaneoand others (2010). These early considerations seem to have been superseded by efforts to address the more urgent problems of deforestation and forest degradation, but we suggest that these considerations about how to diversify REDD+ policy and finance could be productively revisited, with the goal of developing a more forward-looking approach to the conservation of stable forests, which continues to be a gap in forest climate finance. While diversifying the international policy and finance structure may not immediately induce the conservation of stable forests, the presence of a durable incentive that explicitly supports and rewards such efforts could be an important signal for future national policymaking and planning.

Given the high biodiversity value of stable forests, the creation of a new framework under the Convention on Biological Diversity (CBD) in 2020 is an opportunity to signal the importance of stable forests for biodiversity and climate mitigation and strengthen the case for action under the UNFCCC.

Opportunities through national and subnational forest governance

Stable forests can be protected – and their benefits secured – by policies and processes at national and subnational levels. These efforts could build upon practices already underway in most countries, such as the following:

- Land-use planning and zoning to discourage deforestation and degradation in stable forests and to encourage development of economic activities in areas less sensitive to disturbance;
- Transportation and infrastructure planning to route development away from stable forests and toward less vulnerable areas;
- Prioritization, creation, and management of site-based forest management approaches, such as protected areas managed for conservation, indigenous territories, and other low-impact managed areas;
- Legal and administrative structures of land tenure and permitting, to enable land-use planning and forest management systems to be transparent, rational, and enforceable;
- Concession buybacks; restrictions on future concessions; enabling companies to set aside land on concessions; and removing the potential for renewal of existing concessions, where appropriate;
- Safeguards and regulation of finance and credit streams to disincentivize conversion of forests;
- Vision of long-term development based on intensification rather than extensification of economic activities;
- Establishment and enhancement of forest regeneration areas that direct development pressure and drivers of degradation away from stable forests.

None of these are completely new strategies. In fact, any programme design submitted to the FCPF is expected to include and combine several of these approaches, as they apply to specific programme areas within a comprehensive strategy, particularly as it pertains to controlling leakage and the risk of reversals (required aspects of the FCPF monitoring framework). Countries with limited resources face challenges when having to justify budget allocation towards stable forest areas while also dealing with active deforestation in other areas.

Opportunities through enhanced science and understanding

A better quantification of the contribution of stable forests to climate would enable a more informed accounting of the flows of carbon, providing a foundation for an improved set of incentives for conserving forest stocks and sinks. Recent findings demonstrate that specific areas of forest are still performing as sinks, even though yearly variability makes such performances fluctuate(Baccini et al., 2017; Phillips & Brienen, 2017). Long-term time series of estimations would elucidate the average quantity of carbon sequestered by these stable forests and provide the basis for providing appropriate recognition and support to maintain them. Within this framework, we believe that forest monitoring institutions should explore the following possibilities:

- Expand the coverage of carbon monitoring to include better ground sampling – more plots, in more forest types, over wider geographies and lengths of time – and explicitly integrate this with remote sensing efforts, including plot size, in order to calibrate and validate the increasing range of remote sensors and time-limited research missions. This high-priority issue has been discussed among major project proponents and managers like the National Air and Space Administration (NASA) Global Ecosystem Dynamics Investigation (GEDI), the jointNASA and Indian Space Research Organization's Synthetic Aperture Radar (NISAR) missions, and the European Space Agency'sBiomass mission and GlobBiomass project.
- Improve the scientific understanding of carbon and climate dynamics of stable forests.
- Build capacity to monitor and report with confidence on carbon stocks and fluxes in stable forests, and on trends in drivers and threats.
- Better understand the impact of climate change on the performance of stable forests beyond yearly fluctuations and in the longer term as some may and will be transitioning as they respond to the impacts of climate change.
- Include the quantitative contributions of stable forests as part of national forest inventories, and in UNFCCC national communications and NDCs

Conclusions

Stable forests are a necessary part of the climate solution. Until recently, due to the sense of urgency and focus on achieving emissions reductions immediately, these forests have fallen through the cracks of existing incentive mechanisms. The failure to recognize the potential contribution of these forests as part of the long-term climate solution may contribute to the loss oftheir integrity, in part due to the unforeseen consequences of mitigation actions primarily focused on the front lines of deforestation and forest degradation. Providing support to ensure the conservation of these forests into the future – without taking away from efforts to prevent deforestation and forest degradation – is necessary to secure their role as an important carbon sink into the later part of the century and beyond. This achievement will need to be sustained over time, particularly if deforestation and forest degradation are successfully attenuated.

To amend the current lack of support, stable forests should be consciously added to the portfolio of objectives in international mechanisms and national frameworks that drive resources and investment towards the long-term sustainability of forest resources. Relevant international institutions should recognize the relevance of efforts to conserve stable forests and support these efforts with adequate resources, while countries should work to safeguard and consolidate stable forests as part of holistic land-use plans and climate change strategies. Stable forests could gradually be incorporated into this broader portfolio over time, as REDD+ implementation progresses and as at-risk forests transition into the stable forest class.

Finally, scientific research can better characterize and quantify the potential contribution of stable forests to the climate solution. This could help to establish a common understanding among countries and donors, which would lead to their common inclusion in national inventories, UNFCCC communications and NDCs, and hence more successful efforts toconserve stable forests, in conjunction with efforts to check deforestation and forest degradation.

Notes

1. See Article 5 paragraph 1.
2. For example, under the Kyoto Protocol rulebook (Decision 3/CMP.1): 'A CDM [clean development mechanism] project activity is additional if anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity' (decision 3/CMP.1).
3. REDD+ Web Platform Submissions: https://redd.unfccc.int/submissions.html.
4. For example, projects using VCS VM0009 Methodology for Avoided Ecosystem Conversion (https://verra.org/methodology/vm0009-methodology-for-avoided-ecosystem-conversion-v3-0/).
5. 'REDD+' refers to a set of activities catalogued in paragraph 70 of UNFCCC Decision 1/CP.16

   ' (a) Reducing emissions from deforestation; (b) Reducing emissions from forest degradation; (c) Conservation of forest carbon stocks; (d) Sustainable management of forests; (e) Enhancement of forest carbon stocks … '

   where 'REDD' refers to 'Reducing Emissions from Deforestation and forest Degradation' and the '+' denotes activities (c) to (e).

6. 'Degazettement' refers to 'a loss of legal protection for an entire protected area' (Mascia & Pailler, 2011).
7. See Article 4 paragraph 1d.
8. See Article 5 paragraph1.
9. Decision 1/CP.16, para 70.
10. United States of America. 2015. U.S. First NDC. Retrieved at UNFCCC NDC Registry: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/UnitedStatesofAmericaFirst/U.S.A. First NDCSubmission.pdf.
11. Russia. 2015. Russian Submission INDC_eng_rev1.doc. Retrieved at UNFCCC INDC Submission portal: http://www4.unfccc.int/submissions/INDC/Submission%20Pages/submissions.aspx.
12. For example, Russian boreal forests are acknowledged to have global significance for mitigating climate change, protecting water resources, preventing soil erosion and conserving biodiversity on the planet. Russia alone accounts for 70% of boreal forests and 25% of the world's forest resources. Forest management is an important element of Russian domestic policy to reduce GHG emissions.
13. See UNFCCC submissions: http://redd.unfccc.int/submissions.html.

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References

Abatzoglou, J. T., & Williams, A. P. (2016). Impact of anthropogenic climate change on wildfire across Western US forests. *Proceedings of the National Academy of Sciences*, *113*(42), 11770–11775.

Armenteras, D., Espelta, J. M., Rodríguez, N., & Retana, J. (2017). Deforestation dynamics and drivers in different forest types in Latin America: Three decades of studies (1980–2010). *Global Environmental Change*, *46*, 139–147.

Baccini, A., Walker, W., Carvalho, L., Farina, M., Sulla-Menashe, D., & Houghton, R. A. (2017). Tropical forests are a net carbon source based on aboveground measurements of gain and loss. *Science*, *358*(6360), 230–234.

Barbosa, J. M., Asner, G. P., Hughes, R. F., & Johnson, M. T. (2017). Landscape-scale GPP and carbon density inform patterns and impacts of an invasive tree across wet forests of Hawaii. *Ecological Applications: A Publication of the Ecological Society of America*, *27*(2), 403–415.

Bowker, J. N., De Vos, A., Ament, J. M., & Cumming, G. S. (2017). Effectiveness of Africa's tropical protected areas for maintaining forest cover. *Conservation Biology: The Journal of the Society for Conservation Biology*, *31*(3), 559–569.

Brandt, J. S., Nolte, C., & Agrawal, A. (2016). Deforestation and timber production in Congo after implementation of sustainable forest management policy. *Land Use Policy*, *52*, 15–22.

Busch, J., & Engelmann, J. (2017). Cost-effectiveness of reducing emissions from tropical deforestation, 2016–2050. *Environmental Research Letters*, *13*(1), 015001.

Busch, J., Strassburg, B., Cattaneo, A., Lubowski, R., Bruner, A., Rice, R., … Boltz, F. (2009). Comparing climate and cost impacts of reference levels for reducing emissions from deforestation. *Environmental Research Letters*, *4*(4), 044006.

Cattaneo, A., Lubowski, R., Busch, J., Creed, A., Strassburg, B., Boltz, F., & Ashton, R. (2010). On international equity in reducing emissions from deforestation. *Environmental Science & Policy*, *13*(8), 742–753.

Catterall, C. P. (2016). Roles of non-native species in large-scale regeneration of moist tropical forests on anthropogenic grassland. *Biotropica*, *48*(6), 809–824. doi:10.1111/btp.12384

Chaplin-Kramer, R., Ramler, I., Sharp, R., Haddad, N. M., Gerber, J. S., West, P. C., … King, H. (2015). Degradation in carbon stocks near tropical forest edges. *Nature Communications*, *6*, 1–6.

Chaplin-Kramer, R., Sharp, R. P., Mandle, L., Sim, S., Johnson, J., Butnar, I., … Kareiva, P. M. (2015). Spatial patterns of agricultural expansion determine impacts on biodiversity and carbon storage. *Proceedings of the National Academy of Sciences*, *112*(24), 7402–7407.

Chazdon, R. L., & Uriarte, M. (2016). Natural regeneration in the context of large-scale forest and landscape restoration in the tropics. *Biotropica*, *48*(6), 709–715.

Climate Focus. (2017). *Progress on the New York declaration on forests: Finance for forests - goals 8 and 9 assessment report*. Prepared by Climate Focus in cooperation with the New York Declaration on Forest Assessment Partners.

da Fonseca, G. A. B., Rodriguez, C. M., Midgley, G., Busch, J., Hannah, L., & Mittermeier, R. A. (2007). No Forest Left Behind. *PLoS Biology*, *5*(8), e216.

Dargie, G. C., Lewis, S. L., Lawson, I. T., Mitchard, E. T. A., Page, S. E., Bocko, Y. E., & Ifo, S. A. (2017). Age, extent and carbon storage of the central Congo Basin peatland complex. *Nature*, *542*(7639), 86–90.

de Souza Cunha, F. A. F., Börner, J., Wunder, S., Cosenza, C. A. N., & Lucena, A. F. P. (2016). The implementation costs of forest conservation policies in Brazil. *Ecological Economics: The Journal of the International Society for Ecological Economics*, *130*, 209–220.

Doughty, C. E., Metcalfe, D. B., Girardin, C. A. J., Amézquita, F. F., Cabrera, D. G., Huasco, W. H., … Malhi, Y. (2015). Drought impact on forest carbon dynamics and fluxes in Amazonia. *Nature*, *519*(7541), 78–82.

Ehrman, J., & Stinson, B. (1999). Chapter 9, joint fact-finding and the use of technical experts. In L. Susskind, S. McKearnan, & J. Thomas-Larmer (Eds.), *The consensus building handbook* (pp. 375–399). Thousand Oaks, CA: Sage Publications.

FAO. (2017). *From reference levels to results reporting: REDD+ under the UNFCCC*. Rome: FAO. p. 36.

Federici, S., Lee, D., & Herold, M. (2017). *Forest mitigation: A permanent contribution to the paris agreement?* Working Paper, Climate and land Use Alliance (CLUA). p. 24.

Forrest, J. L., Mascia, M. B., Pailler, S., Abidin, S. Z., Araujo, M. D., Krithivasan, R., & Riveros, J. C. (2015). Tropical deforestation and carbon emissions from protected area downgrading, downsizing, and degazettement (PADDD). *Conservation Letters*, *8*(3), 153–161.

Gatti, L. V., Gloor, M., Miller, J. B., Doughty, C. E., Malhi, Y., Domingues, L. G., … Lloyd, J. (2014). Drought sensitivity of Amazonian carbon balance revealed by atmospheric measurements. *Nature*, *506*(7486), 76–80.

Gauthier, S., Bernier, P., Kuuluvainen, T., Shvidenko, A. Z., & Schepaschenko, D. G. (2015). Boreal forest health and global change. *Science*, *349*(6250), 819–822.

Geist, H. J., & Lambin, E. F. (2002). Proximate causes and underlying driving forces of tropical deforestation. *Bioscience*, *52*(2), 143–150.

Grassi, G., House, J., Dentener, F., Federicci, S., de Elzen, M., & Penman, J. (2017). The key role of forests in meeting climate targets requires science for credible mitigation. *Nature Climate Change*, *7*, 220–226.

Grassi, G., House, J., Kurz, W. A., Cescatti, A., Houghton, R. A., Peters, G. P., … Zaehle, S. (2018). Reconciling global-model estimates and country reporting of anthropogenic forest CO2 sinks. *Nature Climate Change*. doi:10.1038/s41558-018-0283-x

Griscom, B. W., Adams, J., Ellis, P. W., Houghton, R. A., Lomax, G., Miteva, D. A., … Fargione, J. (2017). Natural climate solutions. *Proceedings of the National Academy of Sciences*, *114*(44), 11645–11650.

Griscom, B., Shoch, D., Stanley, B., Cortez, R., & Virgilio, N. (2009). Sensitivity of amounts and distribution of tropical forest carbon credits depending on baseline rules. *Environmental Science & Policy*, *12*(7), 897–911.

Hantson, S., Pueyo, S., & Chuvieco, E. (2015). Global fire size distribution is driven by human impact and climate. *Global Ecology and Biogeography: A Journal of Macroecology*, *24*(1), 77–86.

Hargita, I., Günter, S., & Köthke, M. (2016). Brazil submitted the first REDD+ reference level to the UNFCCC—implications regarding climate effectiveness and cost-efficiency. *Land Use Policy*, *55*, 340–347.

Harris, N., Brown, S., Hagen, S. C., Baccini, A., & Houghton, R. (2012). *Progress toward a consensus on carbon emissions from tropical deforestation*. Woods Hole Research Center. ISBN: 978-0-615-72677-9. Retrieved from http://whrc.org/wp-content/uploads/2015/05/WI_WHRC_Policy_Brief_Forest_CarbonEmissions_finalreportReduced.pdf

Hein, J., Guarin, A., Fromme, E., & Pauw, P. (2018). Deforestation and the Paris agreement: An assessment of REDD+ in the national climate action plans. *Forest Policy and Economics*, *90*, 7–11.

Heino, M., Kummu, M., Makkonen, M., Mulligan, M., Verburg, P. H., Jalava, M., … Anand, M. (2015). Forest loss in protected areas and intact forest landscapes: A global analysis. *PloS One*, *10*(10), e0138918.

Hosonuma, N., Herold, M., De Sy, V., De Fries, R. S., Brockhaus, M., Verchot, L., … Romijn, E. (2012). An assessment of deforestation and forest degradation drivers in developing countries. *Environmental Research Letters*, *7*(4), 044009.

Kissinger, G., Herold, M., & De Sy, V. (2012). *Drivers of deforestation and forest degradation: A synthesis report for REDD+policymakers*.

Law, B. E., Hudiburg, T. W., Berner, L. T., Kent, J. J., Buotte, P. C., & Harmon, M. E. (2018). *Land use strategies to mitigate climate change in carbon dense temperate forests*. PNAS. doi:10.1073/pnas.1720064115

Lawrence, D., & Vandecar, K. (2015). Effects of tropical deforestation on climate and agriculture. *Nature Climate Change*, *5*, 27–36. doi:10.1038/nclimate2430

Lee, K. (1995). *Compass and gyroscope: Integrating science and politics for the environment*. Washington, DC: Island Press.

Lee, D., & Sanz-Sanchez, M. J. (2017). *UNFCCC accounting for forests: What's in and what's out of NDCs and REDD+*. Policy Brief, Climate and Land Use Alliance (CLUA). p. 16. Retrieved from *http://www.climateandlandusealliance.org/wp-content/uploads/2018/10/Policy-brief-NDCs-and-REDD-revised-Sep-6-2017.pdf*

Leslie, G. (2017). *RAPPAM scores & conservation outcomes in the Brazilian Amazon* (MSc). Stanford University.

Lewis, S. L., Lopez-Gonzalez, G., Sonké, B., Affum-Baffoe, K., Baker, T. R., Ojo, L. O., … Wöll, H. (2009). Increasing carbon storage in intact African tropical forests. *Nature*, *457*(7232), 1003–1006.

Lovejoy, T. E., & Nobre, C. (2018). Amazon tipping point. *Science Advances*, *4*(2), eaat2340.
Lu, X., Zang, R., Ding, Y., & Huang, J. (2016). Changes in biotic and abiotic drivers of seedling species composition during forest recovery following shifting cultivation on Hainan Island, China. *Biotropica*, *248*(6), 758–769. doi:10.1111/btp.1239
Mascia, M. B., & Pailler, S. (2011). Protected area downgrading, downsizing, and degazettement (PADDD) and its conservation implications. *Conservation Letters*, *4*(1), 9–20.
Mascia, M. B., Pailler, S., Krithivasan, R., Roshchanka, V., Burns, D., Mlotha, M. J., … Peng, N. (2014). Protected area downgrading, downsizing, and degazettement (PADDD) in Africa, Asia, and Latin America and the Caribbean, 1900–2010. *Biological Conservation*, *169*, 355–361.
Miranda, J. J., Corral, L., Blackman, A., Asner, G., & Lima, E. (2014). Effects of protected areas on forest cover change and local communities: Evidence from the Peruvian Amazon. *SSRN Electronic Journal*. doi:10.2139/ssrn.2537829
Mitchard, E. T. A. (2018). The tropical forest carbon cycle and climate change. *Nature*, *559*, 527–534.
Mitchell, R., Clark, W. C., Cash, D. W., & Dickson, N. M. (Eds.). (2006). *Global environmental assessments: Information and influence*. Cambridge, MA: MIT Press.
Mollicone, D., Achard, F., Federici, S., Eva, H. D., Grassi, G., Belward, A., … Schulze, E. D. (2007). An incentive mechanism for reducing emissions from conversion of intact and non-intact forests. *Climatic Change*, *83*(4), 477–493. doi:10.1007/s10584-006- 9231-2
Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. New York: Cambridge University Press.
Ostrom, E. (2005). *Understanding institutional diversity*. Princeton, NJ: Princeton University Press.
Pack, S. M., Ferreira, M. N., Krithivasan, R., Murrow, J., Bernard, E., & Mascia, M. B. (2016). Protected area downgrading, downsizing, and degazettement (PADDD) in the Amazon. *Biological Conservation*, *197*, 32–39.
Page, S. E., Rieley, J. O., & Banks, C. J. (2011). Global and regional importance of the tropical peatland carbon pool. *Global Change Biology*, *17*(2), 798–818.
Pan, Y., Birdsey, R. A., Fang, J., Houghton, R., Kauppi, P. E., Kurz, W. A., … Hayes, D. (2011). A large and persistent carbon sink in the world's forests. *Science*, *333*(6045), 988–993.
Pedroni, L., Dutschke, M., Streck, C., & Porrúa, M. E. (2009). Creating incentives for avoiding further deforestation: The nested approach. *Climate Policy*, *9*(2), 207–220.
Peres, C. A., Emilio, T., Schietti, J., Desmoulière, S. J. M., & Levi, T. (2016). Dispersal limitation induces long-term biomass collapse in overhunted Amazonian forests. *Proceedings of the National Academy of Sciences*, *113*(4), 892–897.
Petersen, K., & Varela, J. B. (2015). *INDC analysis: An overview of the forest sector*. WWF Policy Brief. Retrieved from http://d2ouvy59p0dg6k.cloudfront.net/downloads/r2_wwf_indc_brief.pdf
Pfaff, A., Robalino, J., Herrera, D., Sandoval, C., & Bawa, K. (2015). Protected areas' impacts on Brazilian Amazon deforestation: Examining conservation – development interactions to inform planning. *PLOS ONE*, *10*(7), e0129460.
Pfaff, A., Robalino, J., Sandoval, C., & Herrera, D. (2015). Protected area types, strategies and impacts in Brazil's Amazon: Public protected area strategies do not yield a consistent ranking of protected area types by impact. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *370*(1681), 1–12.
Phillips, O. L., & Brienen, R. J. W. (2017). Carbon uptake by mature Amazon forests has mitigated Amazon nations' carbon emissions. *Carbon Balance and Management*, *12*(1). doi:10.1186/s13021-016-0069-2
Poorter, L., Bongers, F., Aide, T. M., Almeyda Zambrano, A. M., Balvanera, P., Becknell, J. M., … Rozendaal, D. M. A. (2016). Biomass resilience of neotropical secondary forests. *Nature*, *530*, 211–214. doi:10.1038/nature16512
Potapov, P., Hansen, M. C., Laestadius, L., Turubanova, S., Yaroshenko, A., Thies, C., … Esipova, E. (2017). The last frontiers of wilderness: Tracking loss of intact forest landscapes from 2000 to 2013. *ScienceAdvances*, *3*(1), e1600821.
Pütz, S., Groeneveld, J., Henle, K., Knogge, C., Martensen, A. C., Metz, M., … Huth, A. (2014). Long-term carbon loss in fragmented Neotropical forests. *Nature Communications*, *5*, 1–8.
Qie, L., Lewis, S. L., Sullivan, M. J. P., Lopez-Gonzalez, G., Pickavance, G. C., Sunderland, T., … Phillips, O. L. (2017). Long-term carbon sink in Borneo's forests halted by drought and vulnerable to edge effects. *Nature Communications*, *8*(1). doi:10.1038/s41467-017-01997-0
Santilli, M., Moutinho, P., Schwartzman, S., Nepstad, D., Curran, L., & Nobre, C. (2005). Tropical deforestation and the kyoto protocol. *Climatic Change*, *71*(3), 267–276.
Sasaki, N., Asner, G. P., Pan, Y., Knorr, W., Durst, P. B., Ma, H. O., … Putz, F. E. (2016). Sustainable management of tropical forests can reduce carbon emissions and stabilize timber production. *Frontiers of Environmental Science & Engineering in China*, *4*. doi:10.3389/fenvs.2016.00050
Schimel, D., Stephens, B. B., & Fisher, J. B. (2015). Effect of increasing CO2 on the terrestrial carbon cycle. *Proceedings of the National Academy of Sciences*, *112*(2), 436–441.
Seidl, R., Schelhaas, M.-J., Rammer, W., & Verkerk, P. J. (2014a). Erratum: Corrigendum: Increasing forest disturbances in Europe and their impact on carbon storage. *Nature Climate Change*, *4*(10), 930–930.
Seidl, R., Schelhaas, M.-J., Rammer, W., & Verkerk, P. J. (2014b). Increasing forest disturbances in Europe and their impact on carbon storage. *Nature Climate Change*, *4*(9), 806–810.
Seyller, C., Desbureaux, S., Ongolo, S., Karsenty, A., Simonet, G., Faure, J., & Brimont, L. (2016). The "virtual economy" of REDD projects: Does private certification of REDD projects ensure their environmental integrity? *International Forestry Review*, *18*(2), 231–246.
Seymour, F., & Busch, J. (2016). *Why forests? Why now?: The science, economics, and politics of tropical forests and climate change*.
Shapiro, A. C., Aguilar-Amuchastegui, N., Hostert, P., & Bastin, J.-F. (2016). Using fragmentation to assess degradation of forest edges in Democratic Republic of Congo. *Carbon Balance and Management*, *11*(1), 11–26.

Silva-Chávez, G., Schaap, B., & Breitfeller, J. (2015). *REDD+ finance flows 2009–2014: Trends and lessons learned in REDDX countries*. Forest Trends. Retrieved from http://www.forest-trends.org/releases/p/reddx-2015

Sokol, N. W., Kuebbing, S. E., & Bradford, M. A. (2017). Impacts of an invasive plant are fundamentally altered by a co-occurring forest disturbance. *Ecology*, *98*(8), 2133–2144.

Spracklen, D. V., Arnold, S. R., & Taylor, C. M. (2012). Observations of increased tropical rainfall preceded by air passage over forests. *Nature*, *489*(7415), 282–285.

Stephens, B. B., Gurney, K. R., Tans, P. P., Sweeney, C., Peters, W., Bruhwiler, L., … Denning, A. S. (2007). Weak northern and strong tropical land carbon uptake from vertical profiles of atmospheric CO2. *Science*, *316*(5832), 1732–1735.

Tesfaw, A. T., Pfaff, A., Golden Kroner, R. E., Qin, S., Medeiros, R., & Mascia, M. B. (2018). Land-use and land-cover change shape the sustainability and impacts of protected areas. *Proceedings of the National Academy of Sciences*, *115*(9), 2084–2089.

Thompson, I. D., Guariguata, M. R., Okabe, K., Bahamondez, C., Nasi, R., Heymell, V., & Sabogal, C. (2013). An operational framework for defining and monitoring forest degradation. *Ecology and Society*, *18*(2). doi:10.5751/es-05443-180220

Valatin, G. (2011). *Forests and carbon: A review of additionality*. Research Report, Forestry Commission, Edinburgh.

van der Hoff, R., Rajão, R., Leroy, P., & Boezeman, D. (2015). The parallel materialization of REDD implementation discourses in Brazil. *Forest Policy and Economics*, *55*, 37–45.

Voigt, C., & Ferreira, F. (2015, August/September). *The warsaw framework for REDD: Implications for national implementation and access to results-based finance*. Carbon and Climate Law Review, Special issue on Implementing REDD+ in Context: Developing National and Sub-national Legal Frameworks, Forthcoming, University of Oslo Faculty of Law Research Paper No. 2015-28. Retrieved from SSRN https://ssrn.com/abstract=2637767

Watson, J. E. M., Evans, T., Venter, O., Williams, B., Tulloch, A., Stewart, C., … Lindenmayer, D. (2018). The exceptional value of intact forest ecosystems. *Nature Ecology & Evolution*, *1*, 599–610.

Williams, C. A., Gu, H., MacLean, R., Masek, J. G., & James Collatz, G. (2016). Disturbance and the carbon balance of US forests: A quantitative review of impacts from harvests, fires, insects, and droughts. *Global and Planetary Change*, *143*, 66–80.

Wohl, E., Hall, R. O., Lininger, K. B., Sutfin, N. A., & Walters, D. M. (2017). Carbon dynamics of river corridors and the effects of human alterations. *Ecological Monographs*, *87*(3), 379–409.

Wolosin, M., Breitfeller, J., & Schaap, B. (2016). *The geography of REDD+ finance*. Retrieved from http://www.forest-trends.org/releases/p/geography_redd_finance

Wong, G., Angelsen, A., Brockhaus, M., Carmenta, R., Duchelle, A., Leonard, S., … Wunder, S. (2016). *Results-based payments for REDD+: Lessons on finance, performance, and non-carbon benefits* (pp. 1–8). Bogor: CIFOR.

World Bank. (2011). *Biocarbon fund experience: Insights from afforestation and reforestation Clean Development Mechanism projects*. Washington, DC: Carbon Finance Unit of the World Bank.

Young, H. S., McCauley, D. J., Galetti, M., & Dirzo, R. (2016). Patterns, causes, and consequences of anthropocene defaunation. *Annual Review of Ecology, Evolution, and Systematics*, *47*(1), 333–358.