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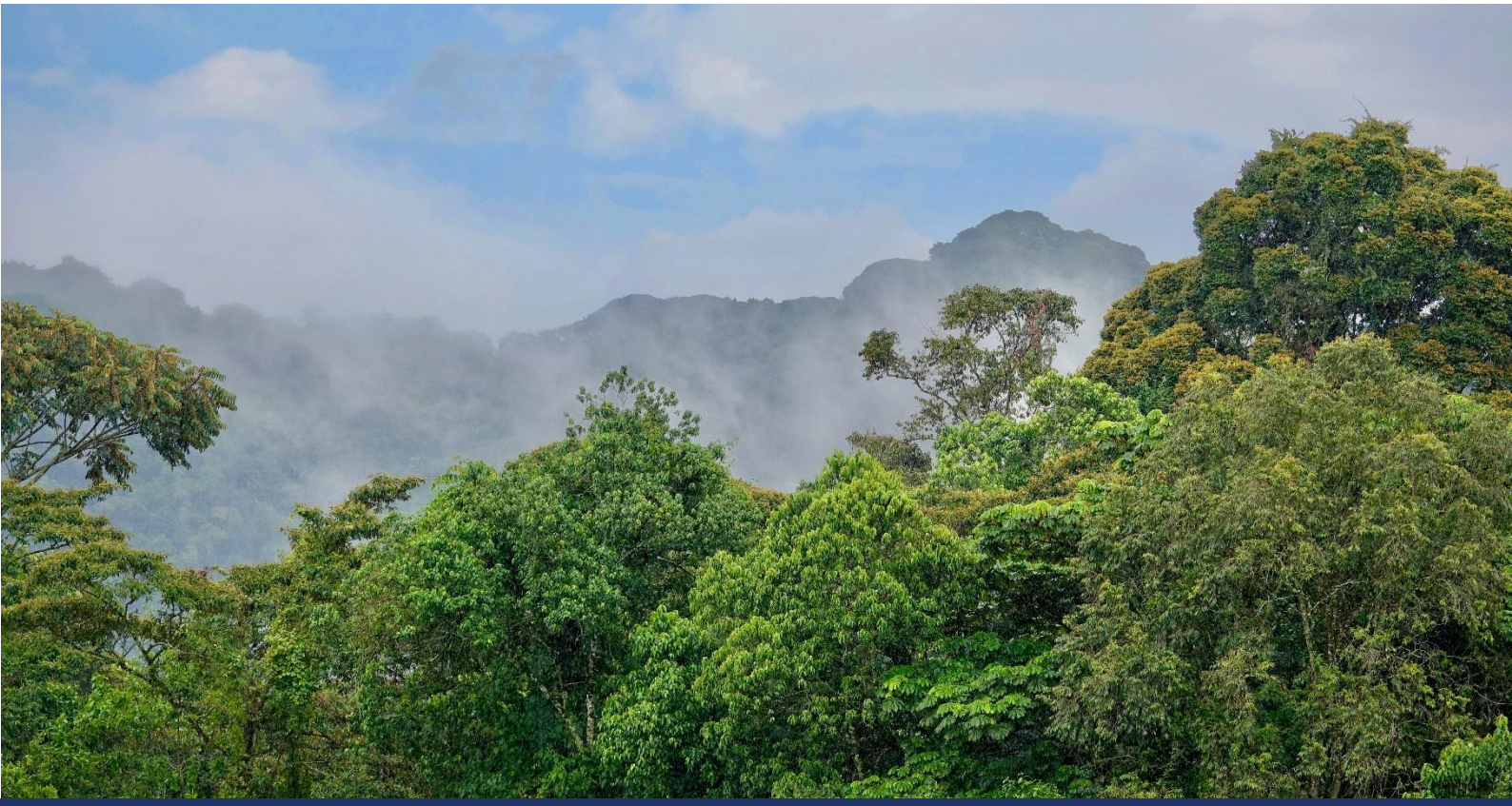

Opportunities to Reduce Tropical Forest Degradation and Mitigate Climate Change

15 October 2023

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Executive Summary

After COP26 in Glasgow (2021) and the announcement of the Forest and Climate Leaders Partnership at COP27, tropical forests received renewed attention for their potential contributions to climate change mitigation. Numerous studies of nature-based and natural climate solutions contend that improved tropical forest management can be an important and cost-effective pathway towards reductions of global CO2 emissions.

The impact of tropical forest degradation on climate mitigation goals and the gains that can be made by addressing degradation are often overlooked or ignored. The most recent estimates of the potential contributions of the 'Improved Forest Management Pathway' (IFM) for Natural Climate Solutions in the tropics is 537 $PgCO_{2e}$. Despite rates of forest degradation far exceeding those of deforestation, the former receives far less attention from environmentalists, scientists, and policy makers. Even fewer studies provide insights about how the necessary improvements can be implemented. Given that a major cause of tropical forest degradation is unsustainable and unnecessarily destructive timber harvesting, we focus here on ways to improve managed forests to reduce carbon emissions and increase carbon removals.

Along with poor timber harvesting practices, degradation is often caused by fires, illegal exploitation, and interactions among these factors. It is also important to recognize that values for one proxy of degradation - timber yield - decline with every harvest, even in forest management enterprises (FMEs) that follow government regulations and are certified as responsibly managed by the Forest Stewardship Council (FSC). We argue that timber yields from tropical forests can be sustained while the forests continue to deliver numerous co-benefits including decreased carbon emissions and increased carbon removals.

This report provides an overview and analysis of the current institutional, policy and technical landscapes, challenges, and opportunities to adopt and implement improved tropical forest management. The novel contribution of this report resides in its elaboration of options insufficiently considered in the forestry and carbon literature to realize improved carbon outcomes from managed forests. That is, we expand the mechanisms to achieve forest management improvements by replacing the timber harvesting approaches most commonly used with detailed ground-based options that enhance the contributions of managed and degraded tropical forests to achieve carbon-related and other goals. These options can address tropical forest degradation and are formulated through a theory-of-change (Figure 2) and related assumptions that determine the likelihood of change from poor to improved forestry practice (Table 1).

The report advances existing literature and analyses by outlining five pragmatic mechanisms through which tropical forest management can be improved, and suggests how, if substantial carbon funding is available and allocated appropriately, the transition from unsustainable forest exploitation for timber to improved forest management (IFM) can be realized.

The five recommended on-the-ground activities, if implemented, would improve the fate of tropical forests (Figure 3). Challenges and opportunities to their implementation are assessed through exploration of case studies in Loreto, Peru and Mato Grosso, Brazil. These case studies are used to take stock of the current situation and to explore the recommended paths towards IFM.

Current Forestry and Forest Degradation Landscapes

Forest degradation and the potential contributions of IFM to climate change mitigation continue to be disregarded for a variety of reasons, some technical and some cultural. For instance, the failure to apply silvicultural treatments to increase timber yields outside of experimental plots reflects the resilience of the timber mining or timber high-grading culture, particularly in the tropics. This resistance to change is exacerbated by governance failures, which are rife in forested areas, most of which are remote. There is also limited evidence that the goals of sustainability through certification and legality through verification are being achieved. Furthermore, the lack of explicit guidelines for IFM that reflect on-the-ground realities impede a more forceful inclusion of the *forest management pathway* in carbon markets and other trading systems.

Given that tropical countries are operationalizing their strategies to achieve their Nationally Determined Contributions (NDCs), the prominence of tropical forests and the role they can play in mitigating climate change, and the repeated call for Sustainable Forest Management (SFM), all point to a growing acceptance of and desire for improvements in the forestry sector. Realization of the sustained carbon benefits from IFM, which in the context of this report refers to climate change mitigation through reduced degradation, requires enabling policy environments and conditions across relevant sectors, including the willingness and incentives, to pilot and test different silvicultural interventions. We will now explore the five propositions in more detail: use of reduced-impact logging, increased wood utilization to reduce waste, reduce logging intensity and harvesting frequency, apply silvicultural treatments to achieve carbon-related outcomes, and plant trees in accessible degraded areas.

Five Mechanisms to Improve Tropical Forest Management

There are many opportunities for implementation of each mechanism but each also has its own limitations, all of which are surmountable given the current attention to tropical forests. This report applies to tropical forests where governance is sufficiently strong to render IFM possible. This IFM and its carbon benefits will require compliance with national legal frameworks, including payment of fees and taxes compatibility with nationally determined contribution (NDC) aspirations, respect of the terms of granted rights to harvest the resource according to national standards, and regulations and agreements between local communities and local governmental actors. Here we outline in brief each mechanism and its potential application:

Mechanism 1. Employ reduced-impact logging (RIL) practices

RIL is a well-known but seldom applied intervention that greatly reduces carbon emissions, and because timber yields can be maintained, suffers no risk of leakage. Although introduced for carbon offsetting 30 years ago, at which time it was demonstrated as effective in improving carbon outcomes across 5,000 hectares in Malaysia, no RIL-derived carbon credits have been marketed to date (Figure 4)

Development of a cost-effective and accurate method for measuring carbon emissions from logging, known as RIL-C, and its approval for carbon crediting means that RIL carbon emissions reductions can now be measured efficiently, and credits should be forthcoming. The major impediment to realization of the carbon benefits of RIL is lack of training of forest workers in RIL practices and of forest auditors in application RIL-C accounting protocols.

Mechanism 2. Increase utilization of wood from felled trees

Wasted wood is a major source of emissions from selective logging that can be reduced by supportive regulations and product market chain development linked to improved on-the-ground practices. This intervention can be incorporated into a broader silvicultural regime to promote regeneration of light-demanding tree species. Fortunately, there are already numerous examples of innovative ways to reduce wood waste and carbon emissions in selectively logged tropical forests (Table 4).

Mechanism 3. Reduce harvesting frequency or lower logging intensity

Retaining more carbon in selectively logged forests is possible by reducing the frequency of harvests or by decreasing logging intensity (Figure 6). Both would require policy changes, and both would reduce short-term profits from logging while increasing timber yield sustainability. The delayed-harvest intervention is already being marketed in the USA (NCX). Both changes risk leakage as they result in less wood entering markets and could have consequences well down the supply and value chain.

Mechanism 4. Apply silvicultural treatments to increase rates of carbon uptake in managed and degraded forests.

Liana infestations are a major impediment to tree growth in the tropics, especially in forests degraded by timber high-grading or other disturbances. Cutting lianas on infested future crop trees

(FCTs) is a cost-effective way to increase rates of timber volume increments and carbon removal (Figure 7). The cost of this treatment is extremely low, its benefits are entirely additional, it results in no leakage, creates jobs, and is straightforward and inexpensive to implement (Figure 9).

Limited recognition of the potential carbon benefits of liana cutting by carbon brokers and FMEs seems to impede the implementation of this carbon removal stimulating pathway. For most FMEs, adoption of liana cutting on FCTs would represent the first step from forest exploitation for timber to forest management.

Mechanism 5. Plant trees in accessible areas that are severely degraded

Carbon removal rates can be increased by tree planting in areas that lack natural regeneration, are otherwise severely degraded or deforested that are and will remain accessible, such as in overly wide road corridors. Adoption of this mechanism can result in co-benefits including jobs and increased environmental services (Figure 10).

Planted seedlings need to be tended for at least several years after planting for which continued accessibility is critical. This mechanism also requires abundant financial, technical, and logistic support. Carbon credits for this intervention should fit under the Verified Carbon Standard (VCS) approved VM0005 Methodology for Conversion of Low-productive Forest to High-productive Forest.

Deep Dive: Peru and Brazil Case Studies

The jurisdictions of Loreto, Peru and Mato Grosso, Brazil were selected as case studies because they are undergoing substantial but different institutional and other transformations that create opportunities for forestry-based economies, are also familiar to the authors who have on-the-ground experience in these areas, and because there seem to be conditions favorable for policy experimentation. Each case study examines the relevant forest sector, rights to timber extraction, carbon rights and carbon management initiatives, and opportunities for scale implementation of the five mechanisms proposed by this report.

Loreto (Peru)

Loreto, the largest department in Peru, covers 38.8 million hectares of which 13% is national forest; almost a third of Peru's granted timber harvesting rights are in Loreto (USAID 2019). Since 2010, Loreto's forest area declined from 36.8 million hectares to 34.4 million hectares. Of the remaining, 9.8 million hectares are production forests that yield about 39% of the timber harvested in Amazonian Peru (USAID 2019; SERFOR 2020). Peru's forest zoning process designated about 12.4 million hectares as of high conservation value, with protected areas and biodiversity special zones, which are not legally allowed to be logged.

Although Peruvian forests are mostly allocated for timber production, Gross Domestic Product (GDP) contributions from the forestry sector are small. Peru's forestry sector suffers from insufficient incentives that, added to limited skills and knowledge, reduce its contributions to regional development and to achievement of climate mitigation goals. Forest degradation due to illegal timber exploitation persists despite recent efforts to modernize and strengthen the institutional capacity of the forestry responsible agencies. Strides have been made to build skills for monitoring, management, and enforcement, including improved timber traceability. Despite these improvements, structural challenges remain to the creation and use of adequate forest management plans. Overall high operating costs, especially but not exclusively for transportation, and limited access to affordable capital to engage and maintain engagement in forestry business, are limitations to IFM.

Recommendations to improve forest management

- Model FMEs that implement and refine the proposed Mechanisms should be secured to promote changes in the culture of forestry. Research will be needed while these initiatives are tested. For instance, the issue of costs remains relevant across the Mechanisms, but are especially prominent for Mechanisms 1, 2, 3, and 5.

- Complement sanctions-based rationales with conditional incentive-based systems to foster cultural change and improve forest management. Incentives come in many forms and should be devised at different levels of the timber supply and value chains.
- Prioritize improved definitions/explanations of required practices, provide more precise guidelines, and close loopholes to anchor proper management and facilitate supervision.
- Generate a learning network that includes companies and other institutions that implement good practices. This network could be articulated with existing efforts through the Mochila Forestal and implemented by OSINFOR and others while creating opportunities for practical learning.
- Mechanisms should be formulated and launched by high-level interventions such as the Estrategia Regional de Desarrollo Rural Bajo en Emisiones (ERDRBE) (Table 10), through which IFM can be promoted for adoption by concessions, private areas, and bosques locales. Needed are strengthened forest operations capacities, as well as recognition of the rights of riverine populations who occupy the areas most suitable for forestry but lack rights, which inhibits development of legal and sustainable enterprises.

Mato Grosso (Brazil)

Mato Grosso is Brazil's third largest state and its largest livestock, soybean, and corn producer. Less well-known is Mato Grosso's leading role in native timber production. Commercial logging is the basis of the economy for 44 of the state's 141 municipalities and represents the fourth largest sector in the state's economy.

New and emerging regulatory frameworks coupled with funding sources in a range of state agendas are promising for IFM. In 2015, Mato Grosso launched the Produce, Conserve, Include Strategy (PCI), a multi-sector plan that established time-specific goals to increase agricultural, livestock, and timber production. The PCI also includes seven objectives for the conservation and re-establishment of forests and other native ecosystems.

Despite Mato Grosso's fairly robust and clear regulatory frameworks and the capacity for real-time and frequent monitoring of forests via satellites, weak forest governance remains a barrier to IFM. Especially lacking is a decision-support system that links information from remote sensing to immediate action as infractions occur. The State Environmental Secretariat (SEMA-MT) is keenly aware of this and is actively developing such a system.

Recommendations to improve forest management

- Upgraded and consistent surveillance is needed in municipalities where the forest frontier is quickly expanding (northwestern and northern parts of Mato Grosso), so that areas of legal and proper management are consolidated.
- Appropriate indicators need to be defined and linked to actions on the ground to achieve carbon goals and the complementary agendas of Mato Grosso's government. Among these agendas is the ambitious goal for sustainable forest management to contribute ~15% of the program's total reduction in emissions by 2035 (*PCI*: Table 11; *Carbono Neutro*: Table 12; *REM:* Table 13 and Table 14).
- There will be no changes in emission reductions or carbon removals by adding acreage to the State's statistics if there are no improvements in forest management practices.
- Voluntary carbon markets are not a silver-bullet to address all challenges (infrastructure, marketing, transport, exchange, availability of ports and bureaucracy) for the forestry sector but can contribute to IFM and carbon outcomes.
- At the FME level, a major impediment to IFM is lack of trained staff. Skilled workers will be in increasing demand as enforcement of regulations and carbon opportunities ramp up. Our strong recommendation is to support the *Instituto Floresta Tropical* (IFT), Brazil's highly successful forestry-

training institution that was formerly a world leader in forest management capacity-building but is now greatly diminished due to lack of funding (Table 17)

- Trained personnel can and should receive competitive salaries that will improve the quality of their work, build a professional path for those involved, and increase both worker safety and worker retention.
- Incentives for the private forest sector, including subsidies and tax benefits, can contribute to the public good. Their use will require a shift in mindset, as well as conditions, to overcome the reality of limited investment in the forest by FMEs.

Recommendations for both jurisdictions

The urgency of climate change requires new social contracts to form coalitions of change for the forestry sector. Initiatives can be undertaken by a range of actors including jurisdictions, private sector entities, carbon buyers, and donors. We point to coordinated actions to be taken by all actors involved (Table 8 and Table 9). More can and should be done to engage other actors whose mission it is to promote IFM and counter forest degradation.

Novel institutional and policy settings are needed to help companies achieve improved forestry and carbon targets. These should provide clear goals and meaningful indicators aided by independent verification, traceability, and clear business plans.

Knowledge gaps must be addressed to facilitate implementation of the proposed mechanisms (Table 16). Not all gaps relate to cost-benefit information, although this sort of analysis needs to figure prominently. Knowledge-gathering should include experimental studies on incentives for behavior and cultural change, from high-level managers to forest workers.

Implementation of pilot projects must follow the highest design standard to distill the added value of the intervention and facilitate learning. We propose steps to be considered when designing interventions that aim to improve both carbon outcomes from managed forests and ultimately lead to carbon credit sales (Figure 12).

Initiatives can be formulated following complementary approaches in which:

a. Individual relatively small-scale IFM-focused carbon projects or collections of such projects or collections of such projects, or

b. Jurisdictional forest carbon programs led by entire political-administrative units that encompass IFM (among other activities and sectors) and participate in emissions reductions plans.

In the second option, realized carbon benefits, in the form of revenues from the sale of carbon credits, can be allocated across sectors and as a function of activities according to a negotiated distribution scheme that provides incentives to actor groups who might not otherwise earn carbon revenues through stand-alone projects (Figure 13a and Figure 13b). For this jurisdictional approach to promote IFM and thereby counter forest degradation, this large-scale option led by governments need to assess effects on carbon emissions and removals through well-established protocols such as RIL-C. Currently, these effects are missed by the remote sensing methods utilized due to limited capacity to detect relatively small changes in standing forests.

The highly ambitious programs and plans in both focal regions call for urgent integration, in which USAID and USFS-IP can play key roles through their current initiatives to facilitate collaboration and integration. This coordination will optimize resource use and help assure that transparent carbon credit mechanisms lead to the realization of IFM's potential. Strategic and targeted dissemination of the results of this Report by USFS-IP and USAID will foster bringing together agencies and program and plan implementers towards a unified vision and action plan for the forestry sector in these countries (Table 15).

Conclusion

Tropical forests figure prominently in global agendas to tackle climate change. Members of the Conference of Parties of the UNFCCC, which include national governments within and beyond tropical forests, are committed to decisive actions to curb deforestation and forest degradation. Linking these high-level goals with suitable indicators and using these to assess the on-the-ground actions of a range of actors are priorities, as is integrating active forest management into already existing degradation-tackling agendas in each country.

The mechanisms proposed in this Report can be implemented through simple policy processes and gain support through innovative market- and non-market-based mechanisms and results- based financing to support IFM, while building long-term capacity to improve land-use planning and management.

One impediment to implementation of the recommended pathways is a lack of well-informed FMEs interested in broadening their business models to include a carbon income stream. Participating in carbon markets requires substantial business savvy, communication capacity, and transparency. Furthermore, confidence in carbon markets is unfortunately low due in part to the extravagant claims of many proponents. Finding FMEs that are willing participants in pilot projects, perhaps with substantial subsidies, should be a priority because working examples are desperately needed.

Lastly, implementation of all mechanisms require training: trained forest workers are needed to transform log mining and high grading into forest management. Again, the many co-benefits include professionalization of the workforce, better salaries, increased transparency that implies improved governance, and more resources for responsible agencies, such as royalties, that can be reinvested for continued improvement. For our proposed mechanisms to work, IFT should be rejuvenated and expanded to provide the needed worker training at least in Amazon Basin countries.

Training can also be expanded to foster a renewed understanding for decision-makers and other stakeholders, more broadly, about the climate and other benefits of IFM, and to support the consolidation of a cadre of qualified RIL-C and other auditors equipped with skills to verify and validate carbon credits from reduced emissions and increased removals.

Acronyms

ABC	*Plano de Agricultura de Baixo Carbono*
AFOLU	Agriculture, Forestry and Other Land Use
ART	Architecture for REDD+ Transactions
ART-TREES	REDD+ Environmental Excellence Standard
BPP	*Bosques de Producción Permanente* / Permanent Production Forests
BVRio	*Bolsa Verde do Rio de Janeiro* / Environmental Exchange of Rio de Janeiro
CAR	*Cadastro Ambiental Rural*
CDM	Clean Development Mechanism
CIPEM	*Centro das Indústrias Produtoras e Exportadoras de Madeira do Estado de Mato Grosso*
CI	Conservation International
COP	Conference of Parties
CRA	Tradeable credits/ environmental reserve quotas
CWI	Wetland conservation
CLUA	Climate Land Use Alliance
DBH	Stem diameter at breast height
EIA	Environmental Investigation Agency
EMBRAPA	*Empresa Brasileira de Pesquisa Agropecuária*
ERA	Extended rotation age
ERCC	*Estrategia Regional de Cambio Climático* / Regional Strategy on Climate Change
ERDB	*Estrategia Regional de Diversidad Biológica* / Regional Strategy on Diversity
ERDRBE	*Estrategia Regional de Desarrollo Rural Bajo en Emisiones* / Regional Strategy for Low Emissions Development
FCPF	Forests Carbon Partnership Facility
FMP	Forest Management Plan
FCT	Future Crop Trees / Future Carbon Trees
FLEGT	Forest Law Enforcement, Governance and Trade
FME	Forest management enterprises
FREL	Forest Reference Emissions Level
FSC	Forest Stewardship Council
GCF	Global Climate Fund REDD+ Pilot Programme
GCF-TF	Governors' Climate & Forests Task Force
GERFOR	*Gerencia Forestal Loreto*
GFW	Global Forest Watch
GIZ	German International Cooperation
GOMT	Government of Mato Grosso
GOREL	*Gobierno Regional de Loreto*
IBAMA	*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis*
IBGE	*Instituto Brasileiro de Geografia e Estadistica*
ICMBio	*Instituto Chico Mendes de Conservação da Biodiversidade*
ICMC	*Instituto de Ciências Matemáticas e de* Computação, *Universidade de São Paulo*
ICV	*Instituto Centro da Vida*

IDESAM	*Conservação e Desenvolvimento Sustentável*
IFM	Improved Forest Management
IFT	*Instituto Floresta Tropical*
IMAFLORA	*Instituto de Manejo e Certificação Florestal e Agrícola*
IMAZON	*Instituto do Homem e Meio Ambiente da Amazoˆnia*
INEI	National Statistics Institute - Peru
INPE	National Institute for Space Research-Brazil
IPAM	*Instituto de Psquisa Ambiental da Amazonia*
ITTO	International Tropical Timber Organization
JDI	Joint Declaration of Intent
JNR	Jurisdictional and Nested REDD+
J-REDD+	Jurisdictional REDD+
LEAF	Lowering Emissions by Accelerating Forest Finance Coalition
LoI	Letter of Intent
LtPF	Logged-to-protected forest
LtHP	Low-productive-to-high-productive forest
MCD	Minimum cutting diameter
MEL	Monitoring, Evaluation & Learning
MoU	Memorandum of Understanding
MRV	Monitoring reporting and verification
MT	Mato Grosso
NCS	Natural Climate Solutions
NDC	National Determined Contributions
NGO	Non-governmental organization
NTFP	Non-timber forest products
NFFD	National Fund for Forest Development
OCT	Oficinas Caboclos do Rio Tapajós
PAOF	*Plan anual de oferta forestal*
PDRC	*Plan Concertado de Desarrollo Regional* / Regional Concerted Development Plan
PES	Payment for environmental services
PMFS	*Planos de Manejo Florestal Sustentável* / Sustainable Forest Management Plan
PPCDAm	Action Plan for the Prevention and Control of Deforestation in the Legal Amazon
PRA	*Programa de Regularização Ambiental*
PRODEMFLOR	*Programa de Desenvolvimento do Bom Manejo Florestal no Estado de Mato Grosso*
RBD	Rio Branco Declaration
RBP	Results-based payments
RCT	Randomized Controlled Trials
REDD+	Reduced Emissions from Deforestation and forest Degradation Plus the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries
REM	REDD+ for early movers
REM-MT	REDD+ for early movers Mato Grosso
RIL	Reduced-impact logging
RIL-C	Reduced-impact logging + carbon

RL	Legal reserve
RRI	Rights & Resources Initiative
RWE	Wetland restoration
SAD	Deforestation alert system
SDGs	Sustainable Development Goals
SEMA-MT	*Secretaria de Estado de Meio Ambiente do Mato Grosso* / State Secretary for Environment in the State of Mato Grosso
SERFOR	*Servicio Nacional Forestal y de Fauna Silvestre*
SFB	*Servicio Florestal Brasileiro*
SFM	Sustainable Forest Management
SIMEX	Amazon System for Monitoring Timber Harvesting
SNIF	National Forest Information System
SPA	Science Panel for the Amazon
TICP	Transparency International Corruption Perceptions Index
TNC	The Nature Conservancy
TREES	REDD+ Environmental Excellence Standard
UDT	Unidades de Desarollo Territorial
UNFCC	United Nations Framework Convention on Climate Change
VCS	Verified Carbon Standard
Verra	Administers the Verified Carbon Standard
USAID	United States Agency for International Development
USFS	United States Forest Service
USFS-IP	United States Forest Service International Programs
USP	*Universidade de São Paulo*

Amazonian forest in Orellana, Loreto, Peru. USDA Forest Service photo by Diego Perez.

Introduction

"*The degradation in the Amazon is not solely an environmental problem: it is a symptom of economic and governance vulnerabilities, including high levels of poverty, human insecurity, weak governance, and inadequate infrastructure planning.*"[1]

Forest degradation, here defined as the loss of carbon from forests that remain forests, by selective logging is estimated to have affected 400 million hectares in the tropics and one billion hectares globally (Putz et al. 2022). Rates at which tropical forests are degraded by logging, fire, and fragmentation (not to mention defaunation by wildlife poaching) far exceed those of deforestation (Asner et al. 2006; Pearson et al. 2017). Yet, despite the prevalence of degradation, it receives far less attention from environmentalists, scientists, and policy makers than deforestation.

This report focuses on addressing forest degradation via selective logging and represents an effort to fill the gap between the many high-level analyses documenting change trajectories of tropical forests as seen using remote-sensing technologies, and specific outcomes in forests themselves. The mechanisms considered to address forest degradation in this report rely on improvements in forest management that can contribute substantially to climate mitigation, while also generating many co-benefits (Seddon et al. 2020; Walker et al. 2022). For example, Walker et al. (2022) estimated the potential total contributions of the Natural Climate Solutions' 'Improved Forest Management Pathway' in the tropics to be 537 $PgCO_2e$. Similarly, Griscom et al.

[1] Romina Bandura - Senior Fellow with the *Project on Prosperity and Development* on her presentation to the House Foreign Affairs Committee on the topic of "Forest Conservation in the Fight Against Climate Change" (May 12th, 2022).

(2020) estimated the cost-effective mitigation potential for this pathway (i.e., less than USD100/$MgCO_2e$) at about 500 $TgCO_2e$ per year.

Unfortunately, other than some consideration of national level enabling factors and constraints, few studies provide insights into how the improvements, which are often not specified, can feasibly be implemented. In this sense, we expand the traditional elements of improved forest management (IFM) more commonly formulated for boreal and temperate forestry (e.g., Kaaraka et al. 2021; Ontl et al. 2021) and more tailored to plantation forestry (i.e., relying on specific practices such as extending rotation, pruning, thinning, increasing stocking), to active improved forest management (e.g., Sasaki et al. 2016).

Before exploring the best opportunities to avoid further forest degradation by logging and to enhance carbon removals in already-degraded forests, two elements of current timber practices are important to highlight to provide context on opportunities for improvement:

1. Selective logging, at the intensities and minimum cutting cycle durations that governments of tropical countries allow, emits substantial quantities of carbon and does not sustain timber yields, almost without exception (Ruslandi et al. 2017; Sist et al. 2021; Putz et al. 2022).
2. Second and third harvests yield substantially less timber of lower quality and generate much lower profits than first harvests, while also degrading the forest further and reducing rates of carbon stock recovery (i.e., carbon removal; Putz et al. 2014; Rodrigues et al. 2022).

On the bright side, despite the failure of efforts over more than half a century to convert exploiters of tropical forests into forest managers, there is hope that if substantial carbon funding is forthcoming and allocated appropriately, this critical transition can be realized.

As countries across the globe embark on ambitious agendas for climate change mitigation and sustainable development (Nationally Determined Contributions and Sustainable Development Goals -NDCs and SDGs, respectively), it is important that proposed actions be formulated with a 'view from the ground', especially those intended to reduce forest degradation and to counter its widespread impacts. This report is intended to complement the continuing contributions of high-level studies on the potential to enhance forest carbon removals and reduce emissions (Houghton et al. 2015; Griscom et al. 2017, 2020, Walker et al. 2022) by focusing on ground-based paths towards improved forest management that, if adopted, would reduce carbon emissions and increase carbon removals. We provide analyses of the potential contributions of specific modifications of forestry activities to climate change mitigation and then operationalize ways to secure climate benefits from managed forests. We assume that logging will typically continue, hence our focus on reduced-impact logging and other changes in business-as-usual forest management practices. We also recognize that huge areas of tropical forest are already logged or otherwise degraded, hence our focus on silvicultural interventions that increase tree growth and carbon stocks.

Why forestry and forest degradation are often disregarded

Forest degradation and mechanisms to address it have been all but disregarded, while a large focus has been on acting to reduce deforestation. Typically, when carbon and forestry activities have been brought together, the dominant pathway to reduce logging-related degradation recognized by dominant carbon credit verifying standards (e.g., VCS) has been through elimination of the timber harvesting activity altogether (see Haya et al. 2023). Specifically, up to 2022, IFM has had a small share of the voluntary carbon market (11% of all offset credits to date; 6% in 2022 only) with 94% of IFM projects being located in the US and mostly based in reduction of carbon losses through elimination of timber harvesting. This Report expands on this limited vision for IFM's role in contributing to mitigate climate change to include practices pertinent to how forestry takes place in the tropics.

During the last few years an increased focus on the development of jurisdictional REDD+ programs, particularly the use of the Architecture for REDD+ Transactions-The REDD+ Environmental Excellence Standard (ART-TREES), has increased attention on tracking degradation as part of REDD+. Under ART-TREES, jurisdictions are required to develop baselines and targets for degradation and thus also need to

identify, monitor, and mitigate it with approaches that are transparent and clearly defined. To date, this is the focus of multiple active programs, initiatives, and workshops series since at least 2022.

On the forestry front, when the focus is on project-level REDD+ activities, degradation has been disregarded for a variety of reasons, some technical and some cultural. Although degradation is the second 'D' in REDD+ (reduced emissions from deforestation and forest degradation), it has received scant attention in climate change-mitigation initiatives - beyond mentions of forest fires and illegality as immediate threats. For example, in an important recent paper published in *Nature* on the potential for terrestrial carbon stores, Nolan et al. (2022) entirely neglect to consider the improved forest management pathway. To understand the disregard of efforts to decrease carbon emissions caused by forest degradation and to increase carbon removals through silvicultural treatments of already degraded forests, we suggest the following underlying reasons:

1. Many influential stakeholders including philanthropic groups, environmentalists, ecologists, and policymakers have highlighted concerns about logging tropical forests. Misleading and/or untested assumptions about forest management are widespread, and many stakeholders active in tropical forest conservation have been at least complacent in perpetuating the assumptions that selective logging invariably leads to deforestation and is generally associated with illegal activities and widespread crime. Several prominent forest researchers have disregarded the potential benefits of improved forest management and have argued instead for using carbon payments to stop logging through establishment of 'conservation concessions' (Rice et al. 2002; Schleicher 2018). Examples of this approach - retiring already inactive logging concessions has been supported by USAID, for forestry operations in Amazonian Peru. More recently, studies published in prominent scientific journals have argued for stopping all wood harvests (Peng et al. 2023; Roebroek et al. 2023).
2. Degradation is much harder to detect with passive remote sensing (e.g., LANDSAT) than deforestation (e.g., Read 2003; Réjou-Mechain et al. 2015; Beuchle et al. 2022; but see Gao et al. 2020). Improved image processing techniques (e.g., Dupuis et al. 2020) can improve our capacity to detect some forms of degradation remotely, but expensive ground-based monitoring is still required other than for mapping major logging roads. Unmanned aerial vehicle remote sensing (UAV-RS) (i.e., drones equipped with GPS and digital cameras) may eventually provide a viable way of monitoring forest degradation with high accuracy over large areas; their advantages include flexibility, relatively low costs, and the possibility to fly below cloud cover. They have been in use to collect a variety of parameters for forest management at small scales (Dainelli et al. 2021) and are increasingly being deployed to monitor forest health (Ecke et al. 2022). However, substantial technical (e.g., integration with LiDAR and other sensors; flight length/distance, etc.) and bureaucratic challenges (e.g., restrictions on flight paths) remain before UAV-RS is broadly applicable over areas larger than several forest stands (Dainelli et al. 2021; Ecke et al. 2022). When wall-to-wall data from canopy penetrating satellite-based sensors [e.g., light detection and ranging techniques (LiDAR)] become available, detection costs will decrease.
3. The forests in which much degradation occurs due to unnecessarily destructive and illegal logging are often remote, which increases the costs of supervision and renders enforcement challenging. Given that illegal loggers avoid the costs of abiding by regulations and avoid paying royalties and many other fees, they can sell logs for lower prices which serves to depress already low market prices of tropical timber. Successful application of new technologies for log tracing, strengthening the capacities of judiciaries to enforce forest laws, and other efforts to stem the tide of illegal logging will thus have both development and climate change mitigation benefits.
4. The norms of many forest management enterprises (FMEs) in the tropics still do not include adequate consideration of long-term sustainability, ecosystem services, social welfare, biodiversity, or transparency of business practices. One consequence of the lack of commitment to transparency is that access to active logging areas is a perennial problem.
5. Few people are sufficiently trained to recognize logging practices that should be improved; fewer still can recommend cost-effective improvements in harvesting practices.

The importance of improved remote-sensing techniques should not be diminished but stopping and reversing tropical forest degradation requires that informed observers have ready access to areas being degraded, those in a degraded state, and those undergoing restoration. Despite the global importance of forest degradation caused by poor logging, the number of observers trained to recognize its causes and to devise viable recovery options is diminishing. We deal with this problem later, but here point out as an example that *Instituto Floresta Tropical* (IFT) in Brazil, once the premier training center for reduced-impact logging (RIL), now trains 100 times fewer people annually than it did at its peak due to lack of funding. Meanwhile in Brazil, the area subjected to selective logging has increased due to unabated illegal logging and the creation of new forest concessions (Sist et al. 2021). Globally, while much high-level attention is paid to the potential benefits of improved forest management, university-level forestry graduates with training in forest engineering and silviculture are becoming increasingly scarce due in part to the closure and transformation of so many forestry programs around the world (O'Hara and Salwasser 2015).

Using carbon payments to address forest degradation

Although improved forest management could achieve reduced emissions over standard forestry practices and insufficient forest management expertise could compromise climate change mitigation funding. Limited knowledge among forestry practitioners and responsible agencies of what is needed to improve harvest operations has led to many false claims that RIL practices are being implemented, when in fact they have not been implemented or implemented incorrectly (Ellis et al. 2019). Lack of reliable data on the financial costs of most recommended RIL practices is also a constraint to greater uptake. Moreover, embarking on carbon projects requires technical knowledge and market insights that are not common among most potential participants and beneficiaries in the forest management sector.

The result of these limitations is that unnecessarily destructive conventional logging practices continue to be used, often with the approval of governmental and certification body auditors. Additionally, the high hopes for carbon markets to change the *status quo* remain elusive as carbon funds for improved forest management are scarce and carbon prices are often too low to leverage change. These challenges grow as confidence in carbon markets suffers from reports that question claims of additionality, the overall integrity of approaches used by REDD+ projects, and the standards on which they are based (West et al. 2023).

In this report we will:

- Provide a broad assessment of the carbon-related aspects of tropical forestry, drawing information and examples from the literature, interviews with a variety of stakeholders, and personal experience.
- Use high-level theories-of-change (ToCs) to map the conditions necessary to achieve improved carbon outcomes in managed and degraded forests.
- Demonstrate the major bottlenecks to implementing improved practices, showing assumptions that undermine the likelihood of achievement of desired results, pointing out assumptions from our ToCs that are not met, and propose ways to overcome limiting factors.
- Explore the potential for scaling up to broader geographies and scaling-out to a broad range of partner organizations the benefits of improvements in forestry carbon management.
- Document the perceptions of key actors, as well as research already available and needed to safeguard the integrity of proposed activities as they are implemented.
- Use nested ToCs to explore propositions to improve carbon outcomes for managed forests in the Department of Loreto (Peru) and the State of Mato Grosso (Brazil) as case-studies.
- Provide an overview of options for monetizing carbon savings and removals achieved through improved forestry management, via independent forestry carbon projects and/or jurisdictional REDD+ programs, including a discussion of the challenges and potential benefits.

Throughout, we use the von Thünen approach (von Thünen 1826) that considers that distance to markets, travel time, or transport costs determine the fates and profitability of different land uses (Figure 1). We also

consider the carbon fates, that is the time to achieve full carbon potential, of degraded areas, managed, and secondary forests, as a function of their accessibility (high or low). Through this lens, we highlight the prospects for each type of area to deliver carbon benefits relative to other practices such as improved logging, use of silviculture treatments to increase tree growth and timber yields, restoration, or being left alone to naturally recover as in conservation concessions (see Figure 1).

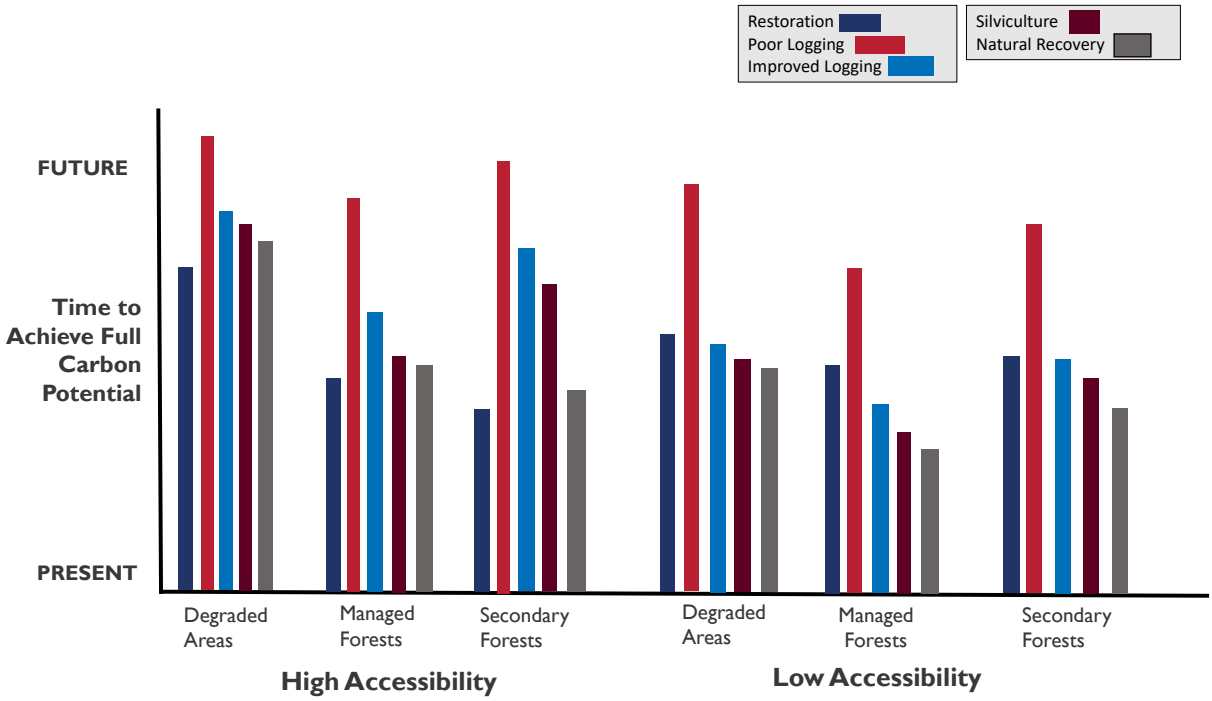


Figure 1. Carbon fates: the likely trajectories and carbon accumulation potential of existing types of forested landscapes, resulting from types of management practices and accessibility.

As Figure 1 depicts, in accessible highly degraded areas, restoration activities cost less than in more remote areas and may therefore be an attractive option. Similarly, due to high operating costs in remote areas, unassisted natural recovery may be a more suitable option than active silvicultural interventions. The point we stress is that for all forest types, irrespective of accessibility and with other conditions remaining the same (*ceteris paribus*), improved forest management can help realize carbon potentials sooner than most other practices, and at even at faster rates when silvicultural treatments are adopted.

Improved governance[2] and a strengthened policy environment[3] are required to realize the potential of improved forest management. Better targeting and coordination of support for climate change mitigation from national governments, donors, foundations, and the private sector are needed to link to actions on the ground to realize the potential of managed forests.

[2] Achieved through increased clarity about rights and responsibilities; suitable adaptive regulations that shift goals as compliance improves; efficient and cost-effective enforcement and monitoring.

[3] Achieved, for instance, through incentive systems; transparency; accountability; negotiated partnerships.

Part I. A Model of Change for Reducing Carbon Emissions and Increasing Carbon Removals from Degraded Forests

Our general model of change to deliver sustained carbon benefits from degraded forests is contingent on the realization of several intermediate steps. In the context of this short-term study, emphasis is on the environmental, socio-economic, and policy impediments to carbon management improvements and related tradeoffs and synergies. We do not provide detailed calculations of carbon benefits specific to each activity, but instead use existing information from the literature to provide ballpark estimates, as needed, to support our arguments and choices.

The steps along the process of change from business-as-usual forestry practices to improved management, represent the necessary ingredients to secure a range of carbon benefits from managed forests. Specifically, long-term desired outcomes include the reduction of carbon emissions via avoiding continued degradation in already exploited but still productive forests, along with greater wood utilization to minimize waste, and enhanced carbon stocks resulting from silvicultural treatments applied in areas degraded by timber harvests and fire.

Specific activities will be formulated as propositions that should be disseminated to and discussed with forestry stakeholders to assess socio-political and economic feasibility. For exploited and recovering forests that will be logged again and as part of the propositions to be considered, we examine the tradeoffs associated with lengthened cutting cycles, increased minimum-cutting diameters, increased utilization of timber now deemed unsuitable or that is otherwise wasted, and other management factors. In all cases, we highlight the likely socio-economic and environmental compromises that emerge from improved forestry carbon management (Figure 2).

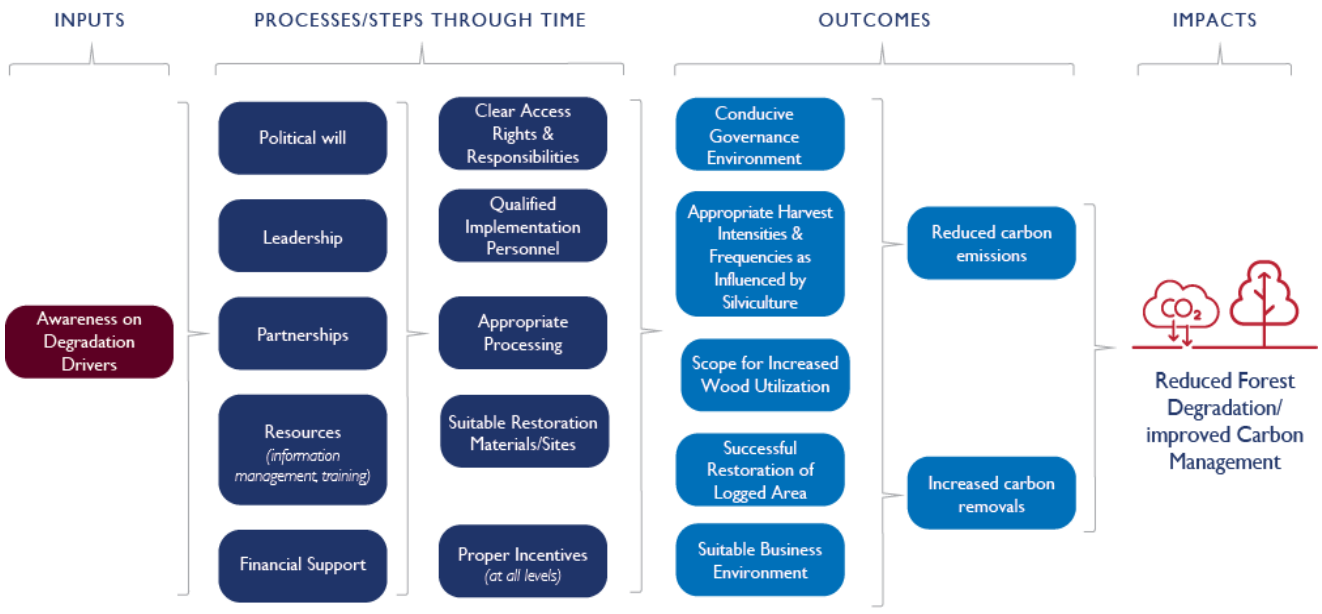


Figure 2. General model of change from business-as-usual to improved forestry practices: activities and processes needed to deliver the long-term goal of improved carbon management in degraded forests that would result in reduced forest degradation and improved forestry carbon management.

Based on the model in Figure 2, benefits from reduced degradation are achieved when there are conducive governance environments, appropriate harvest intensities and silvicultural treatments, proper RIL implementation, successful restoration (i.e., either within the concessions harvested and disturbed areas), and suitable business environments. More importantly, a cultural change among those working in the forestry sector is needed to support a sustained transition from timber mining to improved forest management. For such a change to happen, governments, non-governmental organizations, researchers, and forest industries need to start working towards the goals they do share and use the tools at their disposal (e.g., incentives, participation). The likelihood that environmentalists will recognize the potential benefits of working with rather than against forest industries will increase if abuses by the latter are curtailed and if environmentalists have more opportunities to learn about the wide range of benefits from improved forest management such as through ready access to well-managed forests (e.g., Ribeiro et al. 2020). It would also help if some attention shifted from reforestation and restoration to the avoidance of degradation through improved forest management.

The likelihood of improvements in forestry carbon management being adopted will increase as knowledge of their costs and benefits is generated and shared. Too often, these costs represent an invisible burden for forest managers so that they assume these costs without questioning whether they could be minimized with improved performance, due to the absence of systematic monitoring. Access to information about operating costs requires changes in attitudes and perceptions among industrial forestry sector managers. They must also be willing to share financial information. Agreeing to a high level of transparency about these matters should be a prerequisite for support from USAID or other agencies.

The necessary conditions to improve forestry carbon management can be formulated as assumptions at every point in time. The level of confidence that can be assigned to each assumption needs to be assessed to gain insights about whether the expected improvements along the transformation of poor to good forestry practices will occur. For instance, the existence of a *Conducive Governance Environment* is one short-term result that can be possible through the existence of *Clear Access Rights and Responsibilities* (Table 1, Figure 2). But this previous result is not a sufficient condition to achieve a conducive governance environment: the underlying assumption in this case is that there are ways through which these rights are realized, that all involved are fully informed about the rights and responsibilities, and that there are ways through which conflicts over rights can be resolved. Checking the terms under which legal frameworks deal in theory and practice with forest resources and carbon rights and responsibilities would provide information to qualify the governance environment and subsequently to test whether stakeholders would be motivated to invest in improving forestry practices.

In some cases, the level of confidence in an assumption (also known as assumption strength) is low. In these situations, safeguards are warranted at the project design stage to increase the likelihood of progress towards improved management. These provisions could also help to track any negative consequences or unsurmountable barriers during project implementation; this information can be used to inform mitigation measures.

We first discuss the assumptions in a general manner and expand on the characteristics of each enabling condition. Later in the report, we include specific considerations when we introduce each of the proposed mechanisms to achieve improved carbon outcomes from managed forests.

Table 1. Assumptions about FMEs and other actors that underpin efforts to promote improved forestry carbon management. Strength refers to the extent to which the assumption currently seems to be supported by literature or other information.

Assumption	Strength	Justification
FMEs seek to broaden their business model by marketing carbon and/ or expand to non-timber forest products (NTFPs).	Variable	Awareness of and faith in carbon markets varies substantially but reduced profits from reentry logging should motivate diversification of income streams.

Assumption	Strength	Justification
FMEs commit to improve forestry practices.	Low/Moderate	Many tropical countries require RIL as does the Forest Stewardship Council (FSC), but field data indicate that RIL practices are rarely employed. This implementation failure is likely due to vagueness in the regulations coupled with weak monitoring and enforcement. Fundamentally, uncertainty often remains regarding the legality and quality of forest management implementation.
Subcontractors also agree to improve forestry practices.	Unknown	Information about subcontracting is scarce (except perhaps for local communities in Peru) and the ability of FMEs to control the quality of work done by their subcontractors is not known, although required for FSC operations.
Managers have the information, trained personnel, and management systems needed to improve carbon outcomes.	Low/Moderate	Despite compelling evidence of carbon and timber benefits from RIL, training efforts have dwindled and there are few if any incentives for RIL practice adoption. Costs for training may deter managers especially if trained workers demand higher wages and better working conditions.
Carbon and other benefits can effectively be measured and communicated.	High	The VM0035 protocol is available to document carbon outcomes from RIL adoption. Monitoring may remain limited due to scarcity of auditors trained to use the RIL-C protocol and costs associated with the time needed in the field. Protocols for other practices may still be required (see also VM 0005 on liberation thinning practices; Table Annex 2).
Costs of changes in forestry practices are known and sufficiently low to be covered by carbon sales.	Low	Reliable estimates of the costs of carbon enhancing improvements in forestry are poorly known. Improved worker safety resulting from better practice implementation represents a big incentive for companies to adopt RIL if it reduces their insurance payouts; but represents the opposite if trained workers demand higher wages. There are few opportunities for FMEs to benefit from the hydrological and biodiversity outcomes.
Honest carbon project developers and carbon brokers available.	Moderate	It is not clear which institutions would be most appropriate for development of forestry-carbon enhancement projects. Several, including FORM International, seem to work at too high a level to be useful. The Nature Conservancy (TNC) and Conservation International (CI) play this role in their project areas. Jurisdictions may embark on managed forests carbon programs and attempt to deal with this issue on a case-by-case basis. Meanwhile, dishonest brokers abound.
Markets for forestry-based carbon available.	Low/Variable	Forestry-based carbon projects are a hard-sell because of environmental opposition to any form of timber harvesting. Other interventions might find more marketing opportunities. Jurisdictional REDD+ programs could provide incentives and other support for embedded improved forest management initiatives through the ART-TREES standard.

Proposed Mechanisms for Improved Forest Carbon Management

Here we discuss five non-exclusive options for reducing carbon emissions from logging and increasing carbon removals in degraded forests, as elicited from our ToC: Goal 1. *Reduced Carbon Emissions* and Goal 2. *Increased Carbon Removals* (Figure 2). We formulate these options as propositions through which goals are to be achieved and are linked to the ToC formulated earlier, all of which rely on specific mechanisms. These are:

1. Use reduced-impact logging (RIL) practices.
2. Improve wood utilization to reduce waste.
3. Log less frequently (in Brazil, it would mean for instance, to increase the minimum cutting cycle from 25-35 years to 50-60 years) or log less intensively (again in Brazil, for instance, to reduce maximum harvest intensities from 30 to 15 m^3/ha; elsewhere it would entail to increase minimum-cutting diameters (MCD): examples in Njdondo et al. 2014; Rossi et al. 2017).
4. Apply silvicultural treatments to increase carbon stocks and timber yields.
5. Plant and tend trees in degraded areas that are and will remain accessible for at least a few years.

Below, we expand on the necessary conditions to achieve desired results as laid out when introducing our ToCs, which seem relevant for all our proposed mechanisms. Then for each mechanism, we present a justification and further explore implementation in the context of specific case-study regions, their logging histories, and current capacities (see *Part II*; Figure 3).

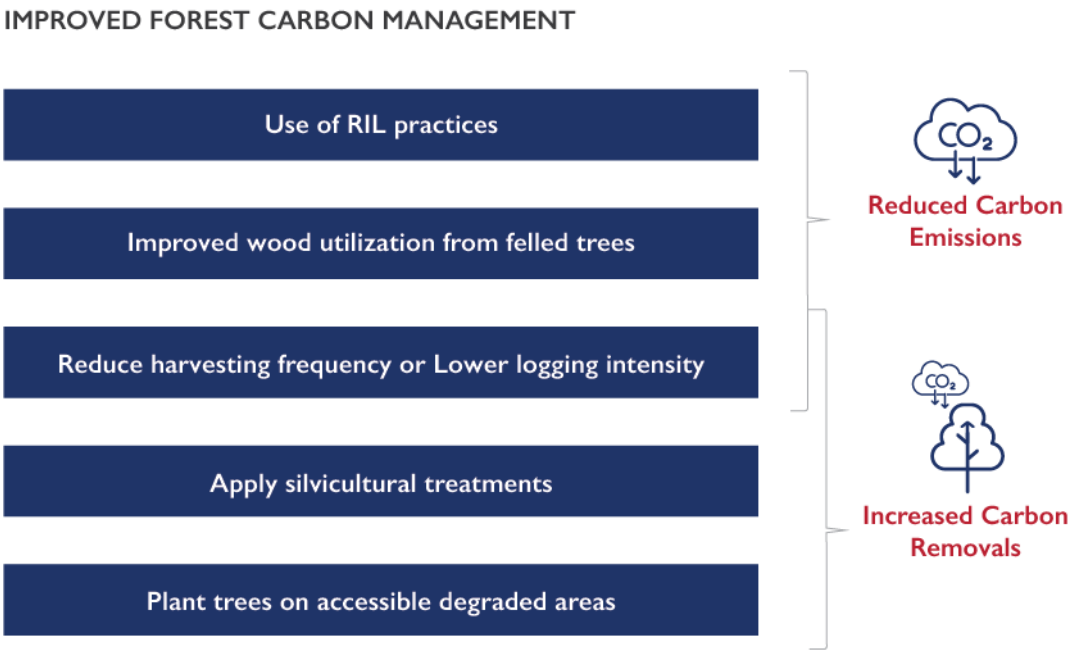


Figure 3. Main mechanisms to deliver improved carbon outcomes from managed natural forests (*Reduced Carbon Emissions* and *Increased Carbon Removals*).

Necessary Conditions for Achieving Desired Outcomes

As mentioned above, achieving carbon management benefits relies on the existence of a *Conducive Governance Environment*. This entails compliance with national legal frameworks, including payment of fees and taxes, overall advancement to meet NDC aspirations and commitments, respect of both the terms of

granted rights to harvest according to national standards, as well as of regulations and agreements between local communities and local and national governments. It is possible, for instance, that other government agencies in other sectors such as those focused on mining or infrastructure development, may have other intentions for the forest lands. We consider, for example, whether uncertainty over forest tenure and carbon ownership, by governments or project implementers, are likely to impede private sector forestry carbon initiatives (Table 2).

Table 2. Carbon rights for selected tropical countries, adapted from Rights and Resources Initiative (RRI) (2021).

Country	Rights and Mechanisms	Notes
Ethiopia, Peru, Republic of Congo	Explicitly recognize community rights to carbon on lands owned by/designated for communities	Small area under community regimes in Ethiopia and Republic of Congo
Brazil, Colombia, Costa Rica, Peru	Carbon rights can be tied to land/ forest ownership including public, private, and collective	In some of these countries the existence of regulations does not imply full observance and compliance.
Bhutan, Fiji, Nepal, Nicaragua, Tanzania, Vietnam, Zambia	Ambiguous legal frameworks that can be interpreted to recognize community carbon rights	
Costa Rica, Indonesia, Mexico, Philippines and Vietnam	Benefit-sharing mechanism designed	Mechanism only operational in Vietnam
Costa Rica and Mexico	Operational grievance/ feedback mechanisms	15 other countries with mechanisms designed but not yet operational
None	Rights to sell carbon	13 countries with inconclusive frameworks. Bolivia explicitly prohibits carbon credit sales
Democratic Republic of Congo	State ownership	Vietnam, Nepal, and Zambia: possible transfer of rights to communities

The key to improve forestry carbon management is likely to be identification of conditions that lead to a *Suitable Business Environment*, within which carbon and financial benefits can be realized and communicated transparently. Appropriate *Harvest Intensities/ Silvicultural* aspects imply that regulatory frameworks favor the maintenance of commercial forestry as a land use. In all cases, proper incentive systems should be available to motivate desired practice changes when used in a targeted manner; managers should also be compensated for undue losses.

Beyond the forest itself and focusing on the likely buyers or investors in carbon management initiatives, which could be private sector actors, a suitable business environment for investment will entice their engagement and support. The terms of engagement should have clear guidelines so that the integrity of the degradation-related carbon credits and safeguards against leakage and non-permanence[4] (COICA et al., 2022) can be demonstrated.

[4] Examples include the Voluntary Carbon Market Integrity Initiative (VCMI), which launched in June 2022 and is currently under consultation, https://vcmintegrity.org/, and the Tropical Forest Credit Integrity Guide (TCFG; https://tfciguide.org).

More broadly, incentives can take the form of compensation payments (more commonly *ex-post* or conditional-to-performance) to landowners when they are induced to:

1. adopt practices that require them to forego or postpone benefits. These could include reduced volumes resulting from increased set asides on steep slopes or in riparian areas, increased minimum cutting diameters, and longer cutting cycles to achieve improved carbon management outcomes; and/or
2. reduce unnecessary environmental damage and apply silvicultural treatments that result in demonstrable carbon benefits.

Incentives can take the form of increased opportunities for training workers and others in the forestry sector, so their skills remain current to the challenges of evolving management conditions and their practices remain of high quality. Training is needed for both on-the-ground activities and business practices, in ways to increase carbon-finance literacy. Incentives can also take the form of tax and fee reductions and other creative policy tools to motivate and reward changes that result in carbon benefits. Reduced import taxes as well as good-term credit programs for the forestry sector should be considered as conditional rewards to help FMEs acquire more modern equipment and overall, improve current technological shortcomings.

Capable personnel are also needed to achieve successful restoration of degraded forest, as are proper incentives and as discussed above, clarity about rights (for instance, tenure, availability, and access to degraded but restorable lands), responsibilities, and expectations regarding potential future benefits and their distribution. Issues of permanence and leakage also require examination.

More generally, qualified implementation personnel are vital to all activities aimed to improve forestry carbon management. Improved skills will be required for forest management design, implementation, and monitoring, as well as for engaging in business arrangements.

Key factors that can set improved carbon management plans in motion rely on *Political Will* at the highest level to foster proper regulatory environments and coordinated action, promote informed FMEs willing to invest in often risky changes in management, emerging leadership to coordinate innovative action, and creative partnerships with a suite of actors from the private sector and civil society. Strong leadership is also key to catalyzing existing and potential funding to implement activities. This backing will need to increase substantially to support the required training, improvements in information quality and its management, monitoring, and overall management practices. All these inputs can take strategic advantage of the abundant available information on drivers of deforestation and forest degradation and the existing opportunities to support carbon management agendas.

Mechanism 1. Use of RIL-Practices

Reduced-impact logging (RIL) was introduced 30 years ago (Putz and Pinard 1993) as a set of practices designed to reduce the stand and soil damage caused by selective logging to minimize carbon emissions. Other than the carbon connection, there was nothing new about RIL at that time; all the recommended practices had been well known for decades, were frequently recommended, and then, as now, seldom applied. In any case, the topic of RIL has received abundant attention from researchers and policy makers. Here we provide estimates of the potential short and long-term carbon benefits of applying RIL overall and broken down by practice; we discuss why RIL benefits are seldom realized and explore options for increased carbon benefits. We offer these suggestions because although RIL's potential for carbon emissions reductions has been explicitly recognized for 30 years, no carbon credits derived from RIL have been marketed to date. To respect US Government restrictions on primary forest logging, we focus on re-logging, which is increasingly common, less well studied, and likely to yield fewer carbon benefits.

We focus on the main RIL practices of harvest planning, improved felling, road width reduction, and winching logs as examples of the recommended practices (Figure 4). We briefly describe the requirements for each practice, the carbon benefits when properly employed, and apparent limits on adoption.

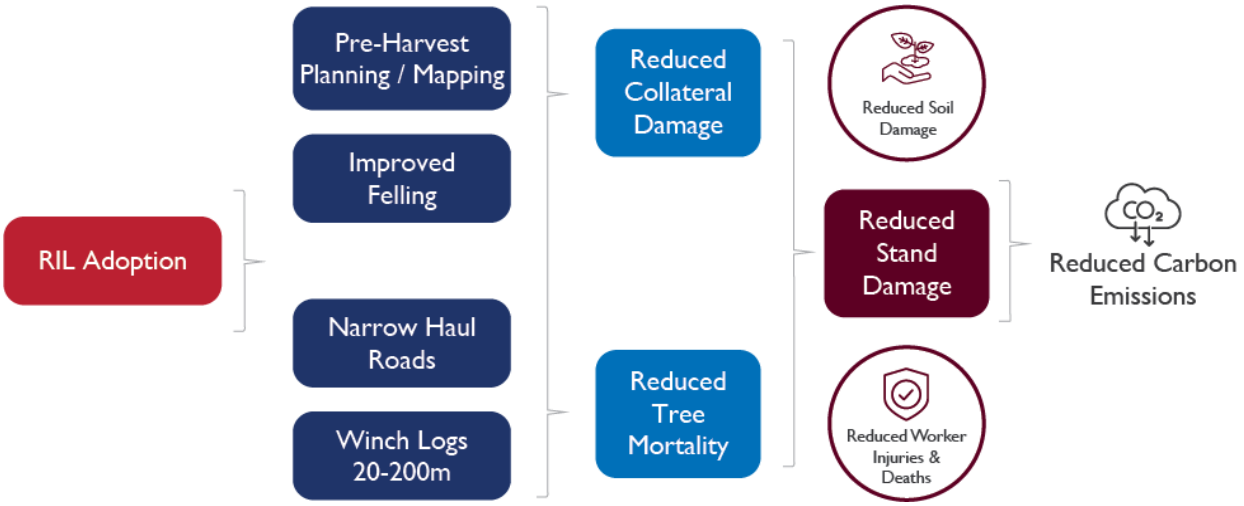


Figure 4. Reduced carbon emissions resulting from adopting RIL practices. Fewer worker injuries and less soil damage are co-benefits of RIL adoption that are not often assessed in financial terms but that do have long-term carbon benefits.

Harvest Planning

The preparation and use of detailed harvest plans superimposed on small scale topographic maps (1:5,000) can increase the efficiency of logging operations and reduce carbon emissions. While the benefits of harvest planning are substantial, they are also diverse and difficult to quantify. Resistance to both proper plan preparation as well as reluctance to utilization of plans already prepared are substantial. The first is presumably due to its expense, the second due to lack of training of field staff. Unfortunately, it is common for logging crews supplied with detailed stand maps to not use them. Where labor costs are low, tree finders can locate and mark on the ground paths to harvestable trees, a system with low costs and little need for university-trained foresters. That said, while few RIL practices have been adopted voluntarily in forestry concession in the tropics, some loggers do rely on stand maps, reportedly to reduce the number of lost logs, a problem highlighted in a thorough study twenty years ago in Brazil by Holmes et al. (2002).

Road Width Reduction

Reduction in the widths of road clearings will here serve as an example of the need for open interactions between company representatives and outside experts. Road width reduction is the RIL practice with the largest possible carbon benefits: 35% of total emissions from selectively logged tropical forests or 2.0 MgC/m^3 of timber harvested (Ellis et al. 2019). Clearings on both sides of the working logging road surface are often opened to distances of up to 40 m. There are many well-known engineering alternatives to this forest carbon emitting practice with new ones introduced frequently (e.g., geotextile road fabrics), but the costs of each alternative need to be estimated in a transparent manner and in ways that are accepted by FMEs in terms of benefits to be received. For example, trafficability can be increased by surfacing roads with gravel, but the costs of that option vary with distance to hard rock (or laterite) sources and availability of rock crushing machines. Similarly, roads can be designed and constructed so that road corridors need not be so wide (e.g., with proper drainage), but such improvements require forest engineering expertise, which comes at a cost. The important consideration here is that willing loggers need to participate fully in assessments of the potential carbon savings and operational costs.

Given that FMEs differ in their access to heavy equipment and that every road segment is different in terms of its slope, aspect, distance to surfacing materials, and so on, the solutions are going to be spatially specific. Furthermore, after road widths are reduced, loggers will need a continual assessment of the effects on trafficability and maintenance, including shutdowns due to trees falling across the narrowed roads. One benefit for monitoring, reporting and verification (MRV) is that this is virtually the only aspect of RIL that can currently be monitored remotely, which reduces costs and increases reliability of the data.

Improved Felling

Anyone who can start a chainsaw can cut down a tree and felled trees invariably fall in one direction or another, which is why we avoid use of the term 'directional felling.' That said, proper felling is a sophisticated skill that needs to be learned and that has substantial financial, carbon, and worker safety related benefits (Peters 1991, Putz and Romero 2012, Garland 2018). Application of proper felling techniques increases wood yield from felled trees due to lower stumps, less log splitting (e.g., the barber chair phenomenon), and less collateral damage from felling and timber yarding. Carbon emissions from felling are substantial at 17% of overall emissions, 0.3 MgC/m^3, (Ellis et al. 2019) but can be substantially reduced by formal worker training. Unfortunately, forest worker training opportunities have dwindled over the past decade and felling practices have suffered. Support for IFT or other organizations like it would be a cost-effective, albeit indirect, way to reduce carbon emissions while reducing the risk of injury for forest workers.

Cable Winching of Logs

Wherever logs are pulled along the ground with cables, the soil and stand damage caused by movements of heavy machinery (i.e., tractors, skidders, or bulldozers, hereafter skidders) is avoided. Although most skidders are equipped with cable winches sufficiently strong enough for this purpose, cables are rarely extended longer than needed to wrap around the log. That means that skidders are driven right up to the log, whereas they should stay on pre-marked skid trails with the final 20-30 meters of log movement by cable winching. The carbon benefits from this change in business-as-usual practice would be substantial. Failure to follow the recommended practice is reportedly due to concerns about cable breakage, especially if the tractor driver is held fiscally responsible or owns the cable. Workarounds should be designed to address these concerns, but use of higher quality steel cables would be one simple remedy worth testing. This is one specific example of research that could produce results to inform suitable incentives for FMEs to adopt the most appropriate technology.

With logging increasingly relegated to steep terrain and swamps, alternatives to ground-based yarding with skidders are needed, such as mobile cable yarding devices. Such devices are used around the world, but in the tropics they are more common in Malaysia where excavators were modified into movable yarding machines and marketed under the trade names of Logfisher or Rimbaka. These mobile yarding devices with 100-200 m pullback distances and 5-10 Mg capacities move along ridgetop roads and pull logs up the slopes. Quality research on cost efficiency and stand damage is needed, but the results available seem promising (Azian et al. 2019). Reportedly, many of these machines now sit idle in Malaysia due to exhaustion of timber supplies but few of them have been exported even to nearby Indonesia for reasons that deserve to be explored but that probably include extremely high import duties. TNC is reportedly planning to acquire a LogFisher to use in the concession in Kalimantan that it recently acquired.

Other Considerations

The amounts by which carbon emissions are reduced through RIL practices vary with the effectiveness with which those practices are implemented, the logging intensity, and whether stands have been logged before. With the recent development of sampling and data-handling protocols for measuring emissions from logging, for instance RIL-C, it is now possible to determine by how much emissions have declined. For the use of RIL-C sampling methods to become widespread, field crews need to be trained but this training requires only a few days and would be a worthwhile investment. Both TNC and CI provide this training in their project areas (Table 3). CI currently seeks workers in Amazonian Peru to train and then to establish a regional baseline for carbon emissions due to logging (Anand Roopsind, pers. comm).

Table 3. Increased carbon retention in tropical forests with adoption of Reduced-Impact Logging – RIL practices.

Modified Practices	Potential Carbon Retained	Impediments	Solutions
Narrower road corridors	4-20 Mg CO_{2e}/ha	Costs TBD but vary with terrain, engineering, and distance to gravel	Research needed
Improved felling and bucking	3-14 Mg CO_{2e}/ha	Lack of trained staff; royalties need to be differentiated	Training; royalties that reward wood utilization
Cable winching of logs	2-3 Mg CO_{2e}/ha	Import duties on cable yarder; better cables	Incentives and enforcement

To promote widespread use of RIL, and to secure its carbon benefits, a few motivated companies need to demonstrate the cost effectiveness of improvement in harvesting practices. Company representatives need to participate in these assessments to increase their acceptance of the cost estimates associated with each recommended carbon-saving modification relative to business-as-usual harvesting practices. Company representatives are also best equipped to develop effective incentive programs (e.g., what bonuses should be provided to whom and how), for which examples should be supplied from other companies or even from other sectors. We encourage jurisdictions that want to employ this or any other improvements in forest management practices to consider conducting randomized controlled trials or other experimental approaches to assess their cost-effectiveness and efficiency.

Even within the same country, FMEs vary substantially in their emissions per cubic meter of timber harvested, per Mg of carbon in the harvested logs, or per hectare harvested (Ellis et al. 2019). Exploration of this variation should be a research priority. In particular, what is it about forest operations in the well-performing FMEs that fosters employment of RIL practices? If worker bonuses are involved, to whom are they paid, for what, and how much? Rather than being overly prescriptive, we recommend that FMEs endeavor to reduce their carbon emissions however they choose, ideally tracking their costs to assess efficiency and cost effectiveness, knowing that those emissions will be measured with accurate protocols like RIL-C.

Co-Benefits & Tradeoffs

Biodiversity

The deleterious biodiversity impacts of RIL are much less than those from conventional logging, but nevertheless vary with logging intensity. Several studies have suggested that RIL carbon benefits, and perhaps the biodiversity benefits as well, disappear when logging intensities exceed 8 trees/ha or 60 m^3/ha (Sist et al. 1998, Roopsind et al. 2018). Fortunately, logging intensities that high are now rare even in places where they were formerly common due to previous over-harvests of the best stands.

Social

A major benefit of RIL training and application are reductions in worker injuries and fatalities. That logging is the most dangerous occupation in the world (Peters 1991; ILO 1998; Garland 2018) is far too often overlooked; improvements in forest worker welfare should be of paramount importance. Although the links between RIL and worker safety are not yet supported by data, the connections are clear and should be documented through well-designed research.

FMEs that receive credible payments for RIL-derived carbon emissions reductions, as measured by the RIL-C protocol or its equivalent, need well-trained and supervised workers. For example, RIL training emphasizes

how to fell trees in manners that maximize the harvested volumes while minimizing risk. For selection of the intended felling direction, the first criterion is worker safety. Overall, the goal is to develop a 'safety culture' that includes proper use of personal protective equipment.

Economic

Unfortunately, despite the solid foundation for financial assessments of RIL provided by Holmes et al. (2002) more than two decades ago and the RILSIM accounting tool that Dennis Dykstra developed soon after using the same data (www.blueoxforestry.com/rilsim/), the financial costs of each of the many recommended RIL practices remain unknown, or at least not publicly available. A literature review of studies on the financial aspects of RIL published a decade ago (Medjibe and Putz 2012) revealed few studies with interpretable, reliable, and comparable data; the intervening decade has witnessed little improvements to this deplorable situation. Clearly, external support for implementation of carbon-enhancing forestry practices should always be linked to financial analyses including time-motion studies and the like.

Garnering the carbon-benefits of RIL requires a professionalized workforce, but trained workers can demand higher wages and better working conditions. To the extent that use of RIL increases the efficiency of logging operations and increases worker retention, FMEs should recognize that these costs could at least be partially defrayed. Properly designed policy experiments to try out incentive systems could help motivate sustained positive change in the sector.

Policy

To know whether a policy that requires RIL is delivering the intended benefits, a quantitative assessment tool like RIL-C needs to be applied and the results reported. Quantitative data are needed because the results of evaluations vary with the experience and standards of the evaluators.

Permanence and Risk

Forests subjected to RIL retain more growing stocks of timber, which might increase their susceptibility to illegal logging relative to otherwise similar but degraded forests. On the other hand, application of RIL, especially if linked to carbon payments, probably increases the vigilance of forest protection efforts. It should also be noted that the focus on committed emissions from RIL disregards the increased rates of post-harvest carbon accrual (Vidal et al. 2016; but see Bedrij et al. 2022).

RIL-Related Carbon Verification Protocols

A lack of clarity remains about how effectively RIL practices are applied, but we now have an accurate, field-based monitoring protocol that has been tested across several RIL-C (Ellis et al. 2019). This approach was developed by forest scientists affiliated with The Nature Conservancy (Griscom et al. 2014; Ellis et al. 2019). It is affirming that a very similar approach was developed independently by researchers affiliated with Winrock (Pearson et al. 2014). RIL-C seems on the verge of being adopted by the FSC for carbon auditing. It is also supported by a VCS-approved protocol [VM0035 RIL-C IFM[5] Methodology (Reduced Impact Logging Practices to Reduce Carbon Emissions) and VM0047 RIL-C North and East Kalimantan Performance Method Module; Table Annex 2]. Modifying these protocols for use in other geographies requires time (estimated at one year) and money (USD50,000-USD100,000), but the costs are likely to decline as experience accumulates.

While interest in RIL seems to be increasing, the measurement protocol is still not widely used. For example, forestry authorities in Brazil and Indonesia now require RIL, for which they provide their auditors with checklists that are detailed but nevertheless allow many avoidable emissions to be overlooked. One impediment to RIL-C protocol usage is that trained auditors are needed. With a lead auditor and three local

[5] IFM is defined as: Forest management activities which result in increased carbon stocks within forests and/or reduced GHG emissions from forestry activities when compared to business-as-usual forestry practices (UN-REDD Programme Glossary, n.d.)

assistants, the carbon emissions from felling, yarding, and hauling (i.e., log roads and landings) can be assessed in a logging area usually in 3-4 days.

Mechanism 2. Improved Wood Utilization from Harvested Trees

RIL practices, when properly implemented, substantially reduce the amount of collateral damage and increase the recovery of wood from trees purposefully felled. Nevertheless, potentially useful wood left in the forest is a major source of carbon emissions stemming from selective logging. Inefficiencies in the conversion of roundwood (i.e., logs) into saw timber, finger-jointed boards, or veneer, deserve scrutiny by milling experts given that the average efficiencies of conversion of logs into saw timber are typically 30-40% in the tropics (Abebe and Holm 2003). Here we focus on avoidable emissions from wood waste in the forest (Figure 5).

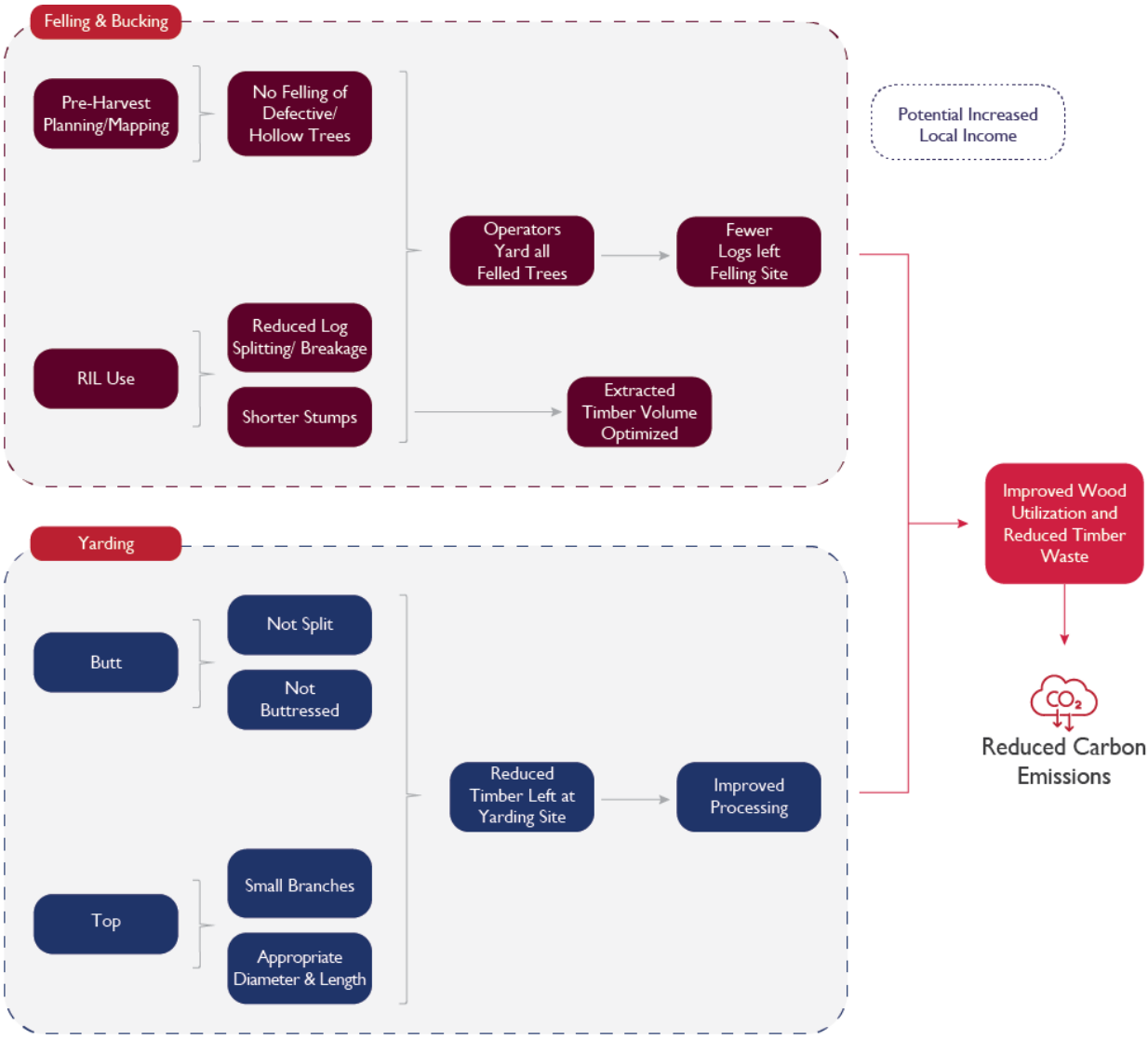


Figure 5. Ways through which reduced felled tree waste and increased wood utilization can reduce carbon emission in managed forests. Likely co-benefits include additional income from transformation of formerly wasted wood into handcrafts and furniture.

The solid wood that is typically abandoned in the forest or on log landings is derived from the remainders of felled trees (33% of total emissions, 0.59 MgC/m^3) and collateral damage from felling and skidding (17% of total emissions, 0.3 MgC/m^3), as documented in several tropical countries (Ellis et al. 2019). Utilization of

what would otherwise be wasted has received intermittent attention from project developers (Table 4), with little consideration to the carbon consequences and only occasional efforts to combine the added wood harvests with silviculture.

Table 4. Innovative ways to reduce wood waste and carbon emissions in selectively logged tropical forests.

Approach	Location	Notes
Precious hardwoods used to make jewelry	Costa Rica	Even long-abandoned wood can be used to make high-quality jewelry. Requires technical and marketing abilities.
Permits to harvest buttresses from felled trees sold to woodworkers	Queensland, Australia	Requires willing artisans and markets. Apparently ceased in 1988 with closure of logging operations after the forests were included in the World Heritage List.
Turnery using sawmill offcuts	Quintana Roo, Mexico	A women's cooperative formed, lathes were provided, and high-quality bowls and other artisanal products were produced and marketed in the nearby resort of Cancun. Reputedly more lucrative than logging, which caused some gender-related social friction and may have promoted the use of more than just waste wood.
Otherwise wasted wood manually hauled from felling gaps used to make charcoal in portable kilns	Quintana Roo, Mexico	Reduces the cost of gap clearing for enrichment planting with the 'bosquetes' system (Navarro-Martínez et al. 2017).
Otherwise wasted wood used for furniture manufacture	Belize	Local farmers permitted to enter recently logged areas with farm tractors to extract large branches used as raw material for fashioning furniture.
Short sections of logs processed with portable mills	West Kalimantan, Indonesia	Breakdown sawing carried out on landings in logging concession. Stopped apparently due to governmental concerns about royalty capture.
Large branches and other waste wood harvested and used in the steel industry	Mato Grosso, Brazil	Apparently not part of a silvicultural treatment. Not sure how extensive, nor the carbon consequences. Wood trucked to Pará.
Parts of felled hardwood logs from swidden clearing and other fallen trees are used to make furniture, small sculptures, and other decorative items. The initial intention was to use logging waste.	Pará, Brazil	*Oficinas Caboclos do Rio Tapajós* (OCT) wrote forest management plans for communities which were never approved because the *Instituto Chico Mendes de Conservação da Biodiversidade* (ICMBio) required a reserve-wide forest management plan first, which was not finished until years later. Another major obstacle was product transport and marketing due to the small volumes that the group of artisans could produce. Finally, identifying and developing sufficient business management capacity among the participant communities proved difficult.

The waste wood problem increases if smaller trees of lower quality are harvested, which is common for reentry logging. Given the slow rates of timber volume recovery, second and third harvests are mostly from residuals, not ingrowth (i.e., newly recruited trees), so a higher proportion of trees have defects and consequently more wood from felled trees is left in the forest. Also, product yields increase with log size, so there will be more mill waste from smaller trees unless compensated for by improvements in processing technology.

Interventions designed to reduce wood waste could be promoted with carbon payments, but we expect that the direct carbon benefits would be small. Even if minor, carbon payments could render job-generating waste-reducing efforts more financially attractive.

The silvicultural and carbon consequences of these sorts of increased wood utilization should be determined. By further opening the canopy and increasing disturbance to the soil and remnant vegetation, harvesting waste wood could promote regeneration and growth of light-demanding tree species. Alternatively, the same effects could promote infestations by lianas and other light-demanding weeds.

Branch wood harvesting can be a step towards felling gap preparation for enrichment planting of seedlings of light-demanding tree species (see Mechanism 5 below). This is an increasingly common stand improvement treatment in *ejidos* in the Yucatan of Mexico (Navarro-Martínez et al. 2017). Some of what formerly was waste wood is marketed for popsicle sticks and other uses, but the majority is converted into charcoal in portable kilns on log landings and on roadsides. Locating the gap treatments near roads facilitates the follow-up treatments needed to assure survival and continued growth of planted seedlings. The carbon consequences of this approach to forest management deserve to be assessed, but they are likely positive over the long-term; carbon-based incentives, even if small, might accelerate adoption of this sustainability-enhancing silvicultural intervention.

For waste-reducing interventions to expand, like the ones described in Table 4, several impediments need to be overcome. First, justifiable governmental concerns about the proliferation of portable sawmills that can hamper their employment need to be considered. Market development for whatever products emerge is another challenge. The required access to logged-over areas also has potential unwanted indirect consequences such as increased poaching, but harvests of previously wasted wood can purposefully contribute to a silvicultural system.

Finally, the beneficial carbon consequences of these innovations might not warrant the costs of capacity building, marketing, monitoring, reporting, and verification. Willingness to convert what is now waste wood into marketed products is often hampered by governmental royalty collection policies. Given that conversion efficiencies of waste wood are lower than those of prime logs and given that the profitability of the former is substantially lower, the royalty rates per cubic meter of raw logs should be lower but seldom are. This is an issue that deserves more consideration.

Mechanism 3. Reduce Harvest Frequency or Reduce Logging Intensity

Reduction of logging related carbon emissions can be achieved through decreasing the allowed intensity of harvesting (see sections *Reduce Allowable Harvest Volumes per Unit Area* and *Reduce Harvest Frequency*) or through lengthening cutting cycles. These two options, as well as their combination, have received some attention from researchers as interventions to reduce carbon emissions (e.g., one of the Natural Climate Solutions - NCS pathways in Griscom et al. 2017) and in the context of REDD+ incentives (Njdondo et al. 2014; Rossi et al. 2017). Their potential for transformational change of the forestry sector has also been highlighted (Chia et al. 2019), but neither has been adopted and trends are in the opposite direction (Figure 6).

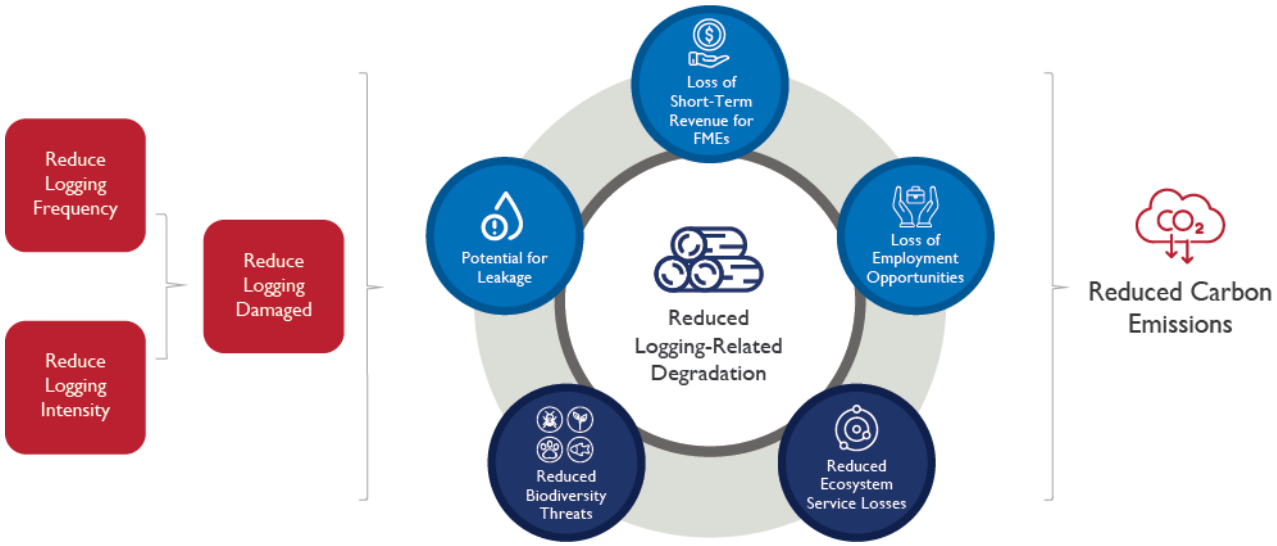


Figure 6. Retention of more carbon in selectively logged forests by reducing the frequency of harvests or by decreasing logging intensity. Co-benefits are indicated in dark blue while negative consequences are shown in light blue.

Reduce Allowable Harvest Volumes per Unit Area

Reducing the volumes of timber allowed to be harvested per unit area to reduce carbon emissions from selectively logged forests might be accomplished in several ways including by increasing the minimum cutting diameter (MCD) or increasing the number of harvestable trees that need to be retained as seed trees. The benefits of this policy change are reduced stand damage and thereby decreased time needed for overall timber volumes and carbon stocks to recover while reducing impacts on biodiversity. Given that current government mandated minimum cutting cycles are typically 25-35 years and at least twice that time is needed for timber stocks to recover at current logging intensities (Sist et al. 2021), sustained timber yields would be favored by this reduction in logging intensity.

Forest owners and FMEs expecting timber revenues would both object strenuously to mandated reductions in logging intensity. Faced with this policy change their choices would be to accept lower incomes, log more extensively, or close their operations. If the extensification (i.e., expansion of timber harvesting activities to larger areas) course is followed, which would represent a clear example of activity-shifting leakage, then many of the benefits of reduced-logging intensity could be lost. Furthermore, given that road construction is the biggest operational cost in selective logging operations, profits per tree, per cubic meter, and of course per hectare would also be reduced. Carbon payments sufficient to compensate for these losses would need to be very large.

Across-the-board reductions in harvest intensity would also not favor regeneration and growth of the high-value light-demanding species that dominate tropical timber markets, which are already at a disadvantage after selective logging practices (Fredericksen and Putz 2003). Enforcement of intensity reducing regulations is complex due to the tremendous spatial heterogeneity in logging intensities, which renders intensity calculations extremely scale dependent. Given that 50% of the average logged block remains untouched (Putz et al. 2019), calculated logging intensities decrease with the area over which they are averaged.

Reduce Harvest Frequency

A much more feasible way to promote carbon retention in logged forests is by reducing the frequency of logging through extension of the minimum cutting cycle. Currently, firms in the US are paying landowners an annual fee to postpone their timber harvests on carbon-benefits grounds. Through one program, carbon is credited for every year that cutting of harvestable timber is delayed (NCX: https://ncx.com/). Given that many landowners would willingly delay access to timber rents for the right price, the break-even price of carbon is critical, which NCX estimates as USD12 per $MgCO_2e$. This amount might be sufficient to compensate forest owners with a positive margin. However, losers in this mechanism would be workers and

other actors down the supply and value chains who would not have access to the income related to the harvesting of that timber derived from transportation and processing activities (Pirard et al. 2023).[6]

Given that all minimum cutting cycle durations set by tropical countries (typically 25-35 years) substantially underestimate the time needed for stand recovery, payments to extend cutting cycles would have both carbon and sustainability benefits. Finally, a protocol is already available for this intervention (VM0003, Methodology for Improved Forest Management through Extension of Rotation Age; Table Annex 2); modifications might be needed for application in selectively logged tropical forest, but at least some of the protocol development work is already done.

Mechanism 4. Application of Silvicultural Treatments to Enhance Tree Growth

Many silvicultural treatments are available to increase seedling recruitment, rates of tree growth, and forest carbon accumulation, but few are applied outside of experimental areas due primarily to their up-front costs and insecurities about long-term forest access. These interventions may have simultaneous positive (i.e., increased commercial value of the timber stand) or negative (i.e., reduced biodiversity) effects (Figure 7). Here we explore two common stand improvement treatments applied to increase growth of future crop trees, liana cutting, and liberation thinning (i.e., elimination of arboreal competition).

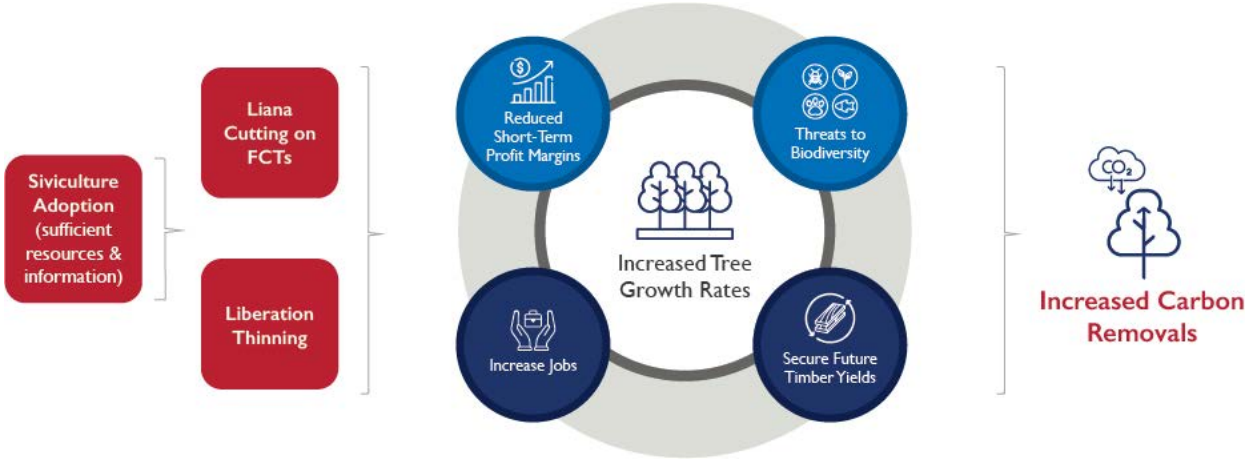


Figure 7. Simplified model for the adoption of silvicultural practices that lead to enhancement of carbon stocks with positive (indicated in dark blue boxes) and negative (indicated in light blue boxes) effects.

When appropriate payments are available to decrease carbon emissions and increase rates of carbon uptake, stand improvement treatments could become more common. These treatments range in financial costs, logistical challenges, biodiversity impacts, and carbon benefits. One possible impediment is that, unlike the RIL option, positive carbon benefits are delayed. Therefore, FMEs that choose to implement these interactions would have to secure funding for the initial treatments. Furthermore, protocols will need to be developed or modified (e.g., VM0005 -Methodology for Conversion of Low-productive Forest to High-productive Forest; Table Annex 2).

[6] Note that the mention of NCX in no way indicates our endorsement; we are concerned that due to inattention to additionality, some of the carbon credits marketed by NCX may be 'hot air'. One knowledgeable forester who was curious about this program admitted to receiving carbon money for acreage that he had no intention of ever harvesting; he said that he expected "NCX to suffer the fate of Elizabeth Homes and *Theranos*." (Interviewee).

Enhanced Carbon Removal by Future Crop Trees by Liberation from Lianas

Based on traditional ecological knowledge reinforced by more than half a century of scientific research (e.g., Featherly 1941, recently reviewed by Estrada-Villegas and Schnitzer 2018, Finlayson et al. 2022), freeing trees of encumbering lianas (i.e., climbers or woody vines) is recognized as a cost-effective silvicultural intervention to increase tree growth and enhance rates of forest carbon sequestration. We note that although lianas are not common in all forests and, even in liana-rich forests, do not infest all trees, they are particularly abundant in tropical forests formerly subjected to selective logging, especially if that logging was intensive and uncontrolled. Numerous studies also indicate that lianas are increasing in abundance even in tropical forests that are not subjected to logging due to some combination of increased natural disturbances, climate change, and carbon fertilization (Phillips et al. 2002, Schnitzer et al. 2021).

Here we describe how tree liberation from lianas can enhance carbon removals by FCTs, which we here define as:

- trees expected to be harvested in the next cut: 'future crop trees;' or
- trees treated solely for the purpose of carbon removal: 'future carbon trees.'

This dual definition of FCTs is warranted by the carbon-enhancing potential of this intervention in forests that will be logged as well as degraded forests that will henceforth be protected. We develop a specific example, but the rationale can be generalized to other forested landscapes. We discuss the financial implications of mechanism adoption as well as issues related to leakage, co-benefits and tradeoffs, permanence and risk, and layout suggested protocols for monitoring outcomes of mechanism adoption. In doing so, we revisit some of the more general assumptions underlying the feasibility of this mechanism to deliver desired results and potential linkages with other interventions (e.g., reduced-impact logging; Mechanism 1).

It is important to note that we focus on liberating FCTs from lianas because we strongly disagree with blanket liana cutting for biodiversity-impact and financial reasons (see section on *Co-benefits and Tradeoffs below*). Our estimates of the carbon benefits of this treatment are conservative insofar as they only account for increased growth of liberated trees and disregard the carbon benefits accrued by neighbors.

Based on two recent meta-analyses of dozens of liana cutting studies, trees freed of their liana burden typically almost double in growth rate, an impact that endures for at least two decades (Estrada-Villegas and Schnitzer 2018; Finlayson et al. 2022). Similarly, studies based on blanket liana cutting report strongly positive forest-wide rates of carbon sequestration (Heijden et al. 2019; Reis et al. 2020; Estrada-Villegas et al. 2022).

The idea for this carbon removal pathway, which emerged during preparation of this report, was pursued at a field workshop in Belize (May 2022), the output of which is now a manuscript in press in Forest Ecology and Management (Putz et al. 2023)[7]. In that paper we illustrate the carbon benefits of tree liberation from lianas over a 20-year period using data from Mills et al. (2019) for *Swietenia macrophylla* trees (big leaf mahogany) in Belize liberated from their load of lianas with stem diameters of two-centimeter, three-centimeter, and four-centimeter diameter. We assumed that the liana-laden tree continues to grow at 0.4-centimeter diameter at breast height - DBH (measured at 1.3 meters or 50 centimeters above buttresses) per year. In contrast, the liberated tree grows at 0.45 centimeters and 0.70 centimeters per year for post-treatment years one and two, respectively, before reaching 0.8 centimeter per year for years 3-10 after which growth decreases asymptotically to 0.40 centimeter per year at year 20 (note that these are very conservative assumptions; Finlayson et al. 2022).

Results over the first 20 years after liberation for the released tree are plotted against those of a control tree that remained liana laden (Figure 8). We concluded that by liberating from lianas five FCTs per hectare would provide 3.21 $MgCO_{2\text{-}e}ha^{-1}$ by 20 years after the treatment.

[7] Figure 8 and the summary here about this Mechanism were drawn from this publication.

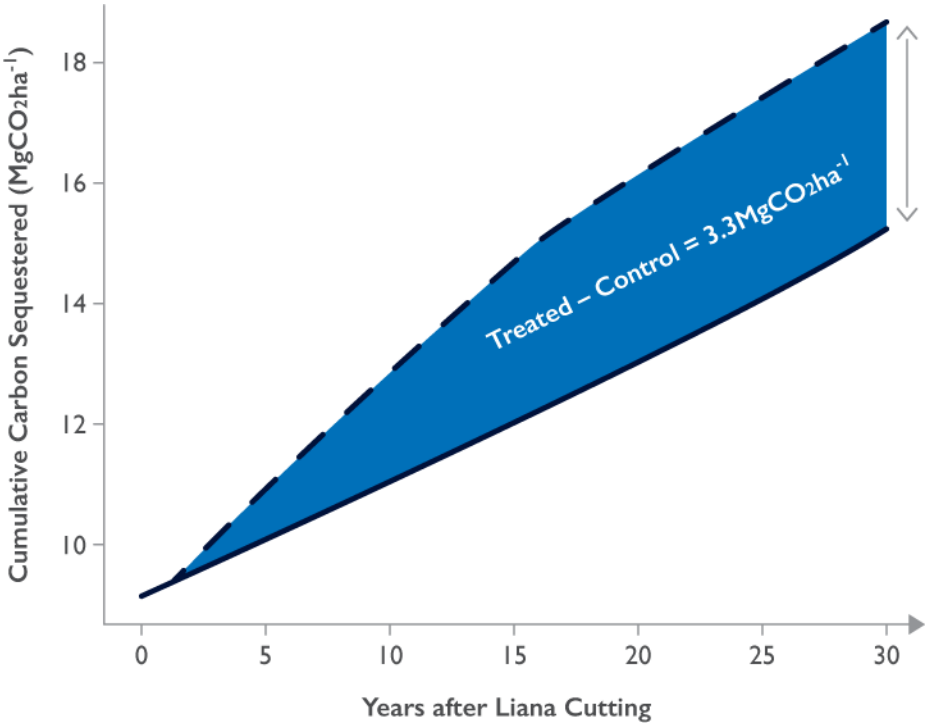


Figure 8. Projected above- and below-ground arboreal carbon benefits per hectare from liana liberation of 5 liana-infested future crop trees (FCTs; dashed line), compared to baseline growth of 5 FCTs which are liana infested and remain so (solid line; from Putz et al. 2023). We assume all trees are initially 40 cm in diameter, 25 m tall, with a wood density of 0.5 g cm^{-3}, and an annual untreated stem diameter increment of 0.4 cm. To estimate biomass, we use the pantropical allometric equation for trees (Chave et al. 2014), a root:shoot biomass ratio of 0.235 (Mokany et al. 2016), and biomass-to-carbon ratios of 0.47 (IPCC 2006).

Another important consideration for this natural climate solutions (NCS) pathway is incorporation of new technologies to ensure it remains competitive in the carbon market. In particular, remote sensing of lianas with unmanned aerial vehicles (i.e., drones; Waite et al. 2019) is already feasible and measurements from satellite-mounted sensors should soon be operational (van der Heijden et al. 2022). These methods can be employed to assess the thoroughness of liana removal treatments and to monitor liana re-infestation. Improvements in remotely sensed tree crown measurements, if coupled with ground-based allometric data, could allow measurement of tree growth responses. Thus, for a treatment that is already low cost compared to other NCS practices, there are likely to be additional cost-savings that could be realized by incorporating remote sensing techniques into project monitoring.

Financial Aspects of Tree Liberation from Lianas to Enhance Carbon Removal

The main goal of this mechanism is to make visible, in an accountable and transparent manner, the contributions of liana cutting on FCTs to carbon removal by the liberated trees. The carbon seller needs to guarantee product delivery in a cost-effective manner, making efficient use of either the firm's resources or those supplied by interested investors. Providers of carbon benefits through liana removal from FCTs should also be able to gauge the costs of this treatment vis à vis other investments they could make in improved forest management. Important considerations for the carbon seller include the timing of benefit accrual and the time-value of their investment.

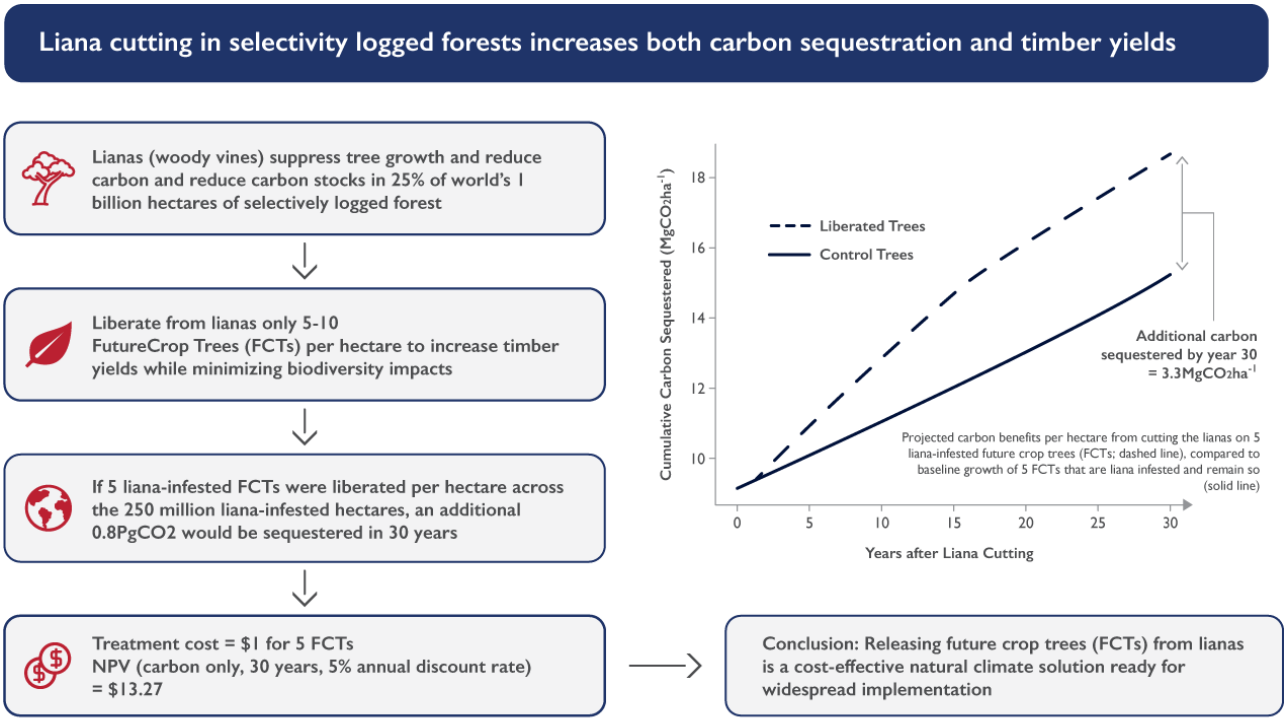
Purchasers of additional carbon removed from the atmosphere by trees freed of their lianas need to make sure they are not purchasing 'hot air' but rather a legitimate product that they will in turn be able to position competitively and safely in carbon markets. This consideration is important for buyers given the recent widespread emergence of seemingly fraudulent or at least questionable forest-based carbon removal initiatives (West et al. 2022; Canham 2021; Badgley et al. 2022). Rapid proliferation of these dubious forest-based carbon projects risk undermining the credibility of legitimate interventions.

As with all activities implemented by business actors, cost-effectiveness of the liana cutting treatment needs to be evaluated. Factors to include in cost estimates will vary among forests and from the perspectives of different stakeholders. For example, liana cutting can sometimes be combined with other forest management activities such as inventory work, which would reduce its costs. Costs would likewise be reduced if the workers involved would otherwise be idle due to wet weather shutdowns of harvest operations or while managers await governmental approval of their harvest plans. Wise application of this treatment will be promoted by assembly of comparable data on its implementation costs in different places (i.e., forest types, countries) and for different types of managers (e.g., private sector firms or communities; Table 5).

Table 5. Proposed template to record and track the costs of FCT liberation from lianas.

Location:								Date	
Activity	Duration (hours)	Labor Costs (per tree)	Total Labor Costs	Materials Type	#	Cost/Unit (USD/ea)	Materials Cost (USD)	Transportation Costs (per tree)	Total Transportation Costs

The financial costs of liana cutting on FCTs in the Belize study reportedly range from USD0.11-0.20 per tree and USD1.50-2.00 per hectare (Mills et al. 2019); similar costs for this treatment were reported in Brazil (Vidal et al. 1997). Based on the additional timber increments, net present values (NPVs) from each liana-liberated mahogany tree in Belize reportedly increase by USD161 when harvested after 40 years. The direct costs (i.e., just treatment application) of the 0.32 $MgCO_2e$ per hectare gained from this treatment are well less than USD1.00.



Adapted from Forest Ecology and Management, Putz et al. 2023

Figure 9. The carbon benefits of cutting lianas on a five future crop trees that were initially 40 cm DBH (from Putz et al., 2023; see text for details).

Forest regulations in many tropical countries specify that lianas should be cut on trees to be harvested but few require they be cut on FCTs. When the latter is required (e.g., Belize; P. Cho, personal communication), the regulations do not clearly define the population of FCTs from which lianas are to be cut. Nevertheless, even if the quality of implementation of this silvicultural treatment could be improved, there is a risk that their adoption may not be considered additional insofar as the intervention is required by law. This is to be established, as different crediting systems vary in their requirements.[8] For instance, whereas Verra's Jurisdictional and Nested REDD+ standard requires new legislation to be created for a J-REDD+ program to receive credits reduced emissions, the REDD+ Environmental Excellence standard ART-TREES is less onerous (See section *How does it work? Improved Forest Management under Project vs. Jurisdictional Approaches* below).

Leakage

There is no reason to expect any leakage from this treatment. By this, we mean that there will be no carbon-associated losses beyond the project area due to application of the liana removal treatment. In fact, insofar as the treatment increases timber yields, it might result in negative leakage.

Permanence

If the treated stands are not logged, the carbon benefits of this treatment are more assured because liana-free trees, especially those that have benefited from this condition for several years, are more wind-firm than those that remain liana-infested. In rare instances, trees lashed together in the canopy by woody vines may collectively be less prone to wind damage. Much more often though, liana-laden trees are rendered more susceptible to branch and stem breakage as well as uprooting for several reasons. Firstly, the mass of lianas is concentrated on the tops of trees, far from their fulcrum or pivot point. Secondly, liana-laden trees are less robust than those that are free-growing. As a consequence, if one tree in a connected cluster falls, all the rest are in jeopardy (Putz 1984).

In stands from which the liberated FCTs will eventually be harvested, robust quantification of GHG emissions requires that our framework account for carbon lost in harvests (Parisa et al. 2022; Verra 2021). With recent advances in accounting methods for temporary carbon storage (Parisa et al. 2022; Verra 2021; Ruseva et al 2020; Wise et al. 2019), lack of permanence is not likely to constitute an insurmountable barrier to robust accounting of liana removal treatments.

Co-Benefits and Tradeoffs

Biodiversity

While lianas contribute to forest biodiversity, the deleterious effects of liana removal from 10-20 FCTs per hectare (i.e., less than 25% of canopy trees) are not likely to be detectable. On the other hand, non-volant canopy animals, like sloths and monkeys, will be inconvenienced by decreased access to the newly liana-free trees while some species may be deprived of specific flowers and fruits on which their diets depend (Putz et al. 2001). In contrast to the benign effects of very selective tree liberation from lianas, as explained above, focused on FCTs of a subset of the most valuable commercial species, cutting all lianas in a forest should be avoided because it is expensive and likely to have serious impacts on biodiversity (briefly reviewed by Estrada-Villegas et al. 2022).

Social

In forests being managed for timber in which tree inventories are mandated by law, adding liana cutting on future crop trees (FCTs) to inventory crew duties will require that additional crew members be employed. In some cases, liana cutting might gainfully employ workers who would otherwise be idle due to conditions unsuitable for logging (e.g., wet roads). In other cases, new employment opportunities will be created where

[8] "*If it can be shown that these activities result from laws, statutes, regulatory frameworks or policies implemented since 11 November 2001 that give comparative advantage to less emissions-intensive technologies or activities relative to more emissions-intensive technologies or activities they need not be taken into account and the baseline scenario could refer to a hypothetical baseline rate of avoided emissions or sequestration without the national and/or sectoral laws, statutes, regulatory frameworks or policies being in place.*" https://verra.org/wp-content/uploads/2017/11/VT0001v3.0.pdf

the treatment is applied in degraded forests not otherwise under active management. These new jobs will represent strong counter-arguments to the complaint that forest protection results in lost employment opportunities (Kniivilä and Saastamoinen 2002; Poudyal et al. 2018).

Practical application of liana removal treatments is facilitated by the fact that freeing FCTs from lianas makes sense to forest workers and can be implemented with the machetes they already employ. Workers will need to be trained to complete more intensive searches for lianas, which may be rooted far from the stem of an infested FCT.

Economic

The value of managed timber stands will increase in response to liberation of FCTs from lianas. In the short-term, forest managers will be able to capitalize on carbon benefits provided by proactive adoption of enhanced silvicultural management that in the immediate term may come at a cost. In the future, they will see increased timber yields compared with counterfactual areas.

Policy

Improved forest management that is transparent and open to scrutiny, as required when actors are aiming to derive carbon-based financial benefits, will help strengthen forest governance. Needed activities of these schemes relate to enhanced monitoring and accountability. Better forestry will also incrementally solidify gains made through enhanced forest management and boost overall contributions of the forestry sector to achieve national goals on several global agendas, including the SDGs and NDCs.

Protocols for Setting Sample Plots, Estimating, and Monitoring Outcomes from Liana Removal Projects

Project design requires that developers (e.g., forest concessionaires) clearly describe how the treatment will be implemented and the methods to be used to measure carbon removal benefits. That is, they must specify their sampling approach (e.g., belt-transects), tree marking, and other procedures, as well as what data are to be collected, their frequency of collection, and how they will be analyzed and stored. We offer the following suggested approach.

Given that the effects of liberation from lianas on tree growth rates likely vary among stands, forests, species, tree sizes, and liana infestations, estimations of the carbon benefits of the treatment need to be stratified by these factors through the establishment of a reference-setting study in each project area. In the example developed here, individuals from five tree species within a project area of 100 hectares are divided into two stem diameter classes: 10-20 centimeter and 20–40-centimeter DBH, and two liana infestation categories: less than 50% of crown covered by lianas and more than 50% crown cover. To secure sample sizes adequate for statistical analyses, we suggest the sampling of 15 trees in each of the four classes for both treated (= lianas removed) and control trees for each of the five species; by these criteria 600 trees are needed for baseline establishment - 60 treated and 60 control trees of each species.

Treated and control trees should be intermixed in the same area, selected at random, and separated by greater than 20 meters. To capture variation within the project area, trees should be sampled in 40-meter-wide belt transects separated by more than 500 meters; each of these strips should include 100 trees which would require strips to be less than 2 kilometers long. Each tree included in the reference-setting study should be numbered consecutively with an aluminum tag nailed on the north side of the tree 30 centimeter below the DBH measurement height, which should be indicated with a painted line 10-20 centimeters long also on the north side. Liberated trees in the project area outside of the baseline-establishment area should be painted and mapped to facilitate relocation but need not be tagged.

Liana-free trees should be disregarded as should trees that host strangler figs (*Ficus* spp.). Liana stems should be cut as close to where they emerge from the ground and as high up as possible. After cutting and measuring the stem diameters of all climbing lianas less than 5 meters from the target tree bole regardless of whether they infest the focal tree, all other lianas climbing on the focal tree should be cut (Table 6 presents a template for reference-setting data collection).

Table 6. Template for a field data sheet to record information about liana-liberation of future crop trees (FCTs) to determine tree growth reference-levels for a specific project (details in text).

Location:					Date:	
Crew Members:				Data recorder:		
Tree #	Treated Y/N	Species	DBH (cm)	Crown Liana Cover		Notes
				High	Low	
1	Y	Mahogany	40.1	√		
2	Y	Cedro	31.5		√	
3	N	Palo Maria	27.3		√	
...	...	...	...	...	...	...

Notes on Suggested Monitoring Protocols

Treated and control trees on the reference-setting area should be re-measured annually by trained crews of the project implementer (e.g., staff of the forest concessionaire) for the first two years and then at 2-year intervals (Table 7). These repeated measures will allow adjustments in estimates of carbon accrual rates and therefore payments for carbon accrual in the project area. It is anticipated that treatment benefits will diminish in 10-20 years, but re-treatments are possible. Until data from the growth response study are available, which will require 1-2 years, the carbon benefits of liana cutting should be estimated from growth rates of liana-infested and liana-free trees of the same species and size classes in the closest available permanent sample plots.

Table 7. Proposed template for annual tree growth monitoring in reference-setting area. DBH measurements from previous year should always be included.

Location:					Date:	
Crew Members:				Data recorder:		
Tree #	Treated Y/N	Species	Previous DBH (cm)	Current DBH (cm)	Liana Removal Efficiency (%)	Notes
1	Y	Mahogany	40.1	40.3	80	Remaining lianas removed
2	Y	Cedro	31.5	31.7	100	
3	N	Palo Maria	27.3	27.9	0	
...	...	...	...			...

Monitoring activities should be streamlined and require collection of the minimum amount of information needed to account for changes in carbon stocks due to treatment implementation. Indicator monitoring serves two purposes. First, data are necessary to evaluate implementation quality of the liana removal treatment and to take timely remedial measures, to effectively address whether workers are following guidelines for liana removal and tree marking and measuring. Second, monitoring serves as a means for

forest managers to estimate carbon removal trajectories on both the reference-setting study and project areas where lianas will be cut. In these two types of areas, activities include assessment of whether the treatment was applied correctly, and in the reference-setting study area, tree stem diameters should also be measured.

Independent third-party carbon credit validation will be required for carbon removals to be recognized and traded by project sponsors (i.e., government organizations, NGOs, private and public sectors). Specific protocols will have to be developed for the liana elimination from FCT carbon removal enhancement treatment and duly approved by VERRA and other institutions but in the meantime, activities could be covered under VM0005.

Liberation Thinning

In managed natural forests in the tropics, perhaps the most recommended thinning operation is the release of selected future crop trees (FCTs) from competition from adjacent arboreal neighbors (Wadsworth and Zweede 2006). This treatment, often referred to as liberation thinning, has many silvicultural, financial, and environmental advantages in the poorly stocked stands in which tropical foresters generally work. By restricting thinning operations to the near vicinities of FCTs large enough to be harvestable at the end of the current cutting cycle, portions of most stands remain untreated, which often makes silvicultural sense, saves money, and avoids needless environmental disruption.

Liberation thinning prescriptions generally call for cutting, frill-girdling, or killing trees with crowns above or within some lateral distance (2 or 4 meters) of the crowns of FCTs. While this treatment is well known among foresters and has repeatedly been found efficient in stimulating timber volume increments (Hu et al. 2020), it is seldom applied outside of research and project areas, probably for financial reasons. A recent study in Belize, Guyana, Suriname, and Trinidad and Tobago documented the high financial cost of this treatment and clearly showed that it is not an effective way to increase forestry carbon stocks; the carbon pay-back period based on 30% increased growth of liberated FCTs was 130 years (Gräfe and Köhl 2020). For this reason, this silvicultural treatment will not receive further attention in this Report.

Mechanism 5. Plant Trees in Accessible Degraded Areas

The widespread enthusiasm for tree planting for climate change mitigation is fueled by a lack of information coupled with misinformation about the requirements, impacts, costs, and benefits of this intervention. Even with the best of intentions, most planted trees in the tropics die well before reaching maturity. To the financial, carbon, and biodiversity costs of tree planting should be added the indirect social, political and psychological costs of management failures. Common reasons why planted trees die, or grow slowly include:

1. Inappropriate matching of species and provenances to site conditions, including those due to climate change
2. Unsuitability of planting sites due to site and/ or socio-economic conditions
3. Poor quality seedlings (e.g., root-bound in bags or pots)
4. Poor planting techniques (e.g., small planting holes)
5. Too much shade (either initially or before the planted trees reach the canopy)
6. Compaction of soil adjacent to the planting hole
7. Herbivores and diseases to which nursery stock is particularly susceptible
8. Post-planting droughts
9. Inadequate tending post-planting (recommended: two times per year for year one, one time per year for years 2-5)

Because of the frequent failure of planted trees to thrive, resource waste associated with reforestation programs is often huge (Rana et al. 2022). Successful tree planting operations are possible, but require expertise and come at substantial costs, many of which remain unaccounted for in estimates of the potential for reforestation as a nature-based solution to climate change (Figure 10).

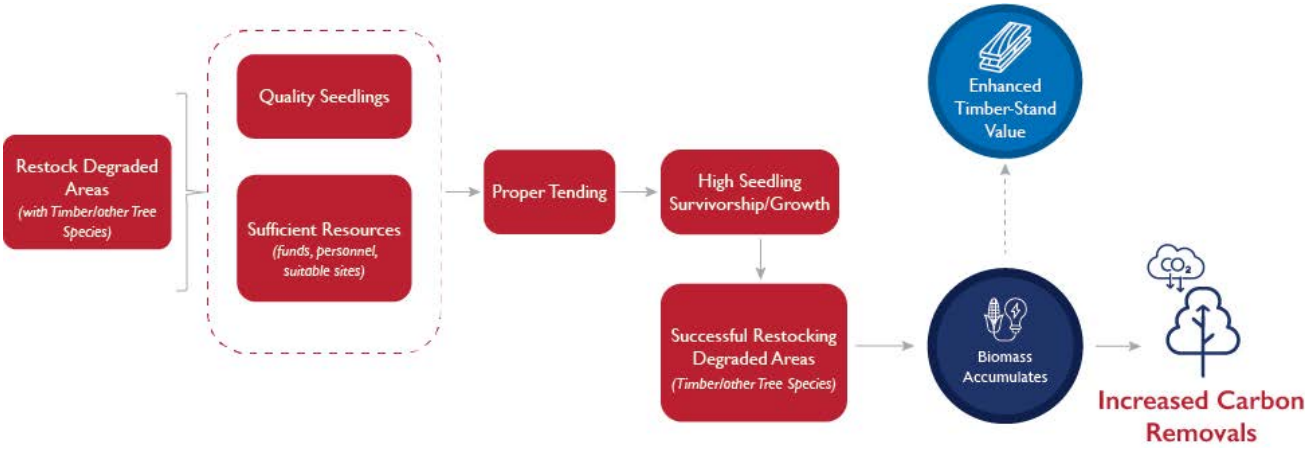


Figure 10. Carbon benefits from increased stocking by tree planting in degraded areas that are accessible. Co-benefits are indicated in light blue.

Necessary ingredients for successful planting include proper design of planting interventions including appropriate conditions for tree establishment and growth. Seedling quality can be improved through proper nursery practices for which training, continuing education, and supervision are required, not to mention adequate resources. For many native species, research is needed to develop best management practices. For example, incorporation into the potting mixture of forest soil from nearby large trees of the planted species could help assure development of critical mycorrhizal and microbial associations. Also, if seedlings transplanted from the forest (wildlings) are used, most species benefit from being tended in a nursery until they reestablish a suitable root: shoot ratio. Finally, 'hardening up' nursery stock before out-planting by withholding irrigation and fertilizer can reduce transplant shock but requires species-specific research.

Here we consider situations in which previous episodes of over-harvesting, fires, or other factors resulted in stands under-stocked with trees with the highest capacity to store carbon and produce marketable timber. Different planting treatments are required for different sorts of areas, with different financial costs and carbon benefits. Badly compacted and eroded log- landings, for example, will likely yield only modest amounts of carbon and are costly to restore. Wherever trees need to be planted, the costs are high, but if planting and follow-up treatments are conducted correctly (which is the exception), the benefits can be substantial. It should be noted that the carbon benefits will not be permanent, at least if commercial timber species are planted and later harvested. This means that assigned carbon credits need to be discounted (B. Sohngen, pers. comm.). Despite the long history of expensive and extensive failures of enrichment planting, several noteworthy recent large-scale successes coupled with timber scarcities and emerging carbon markets are breathing new life into this well-known silvicultural intervention.

Enrichment planting is being applied in some places both with (Moura-Costa et al. 1994) and without carbon payments (Navarro-Martínez et al. 2017). Even if there are also reported financially favorable results of trials with *Swietenia macrophylla* in Brazil (Costa Pinto et al. 2021), we failed to elicit any interest in this intervention in the interviews.

Main Opportunities and Barriers for Implementation of Proposed Mechanisms

A first step to advance implementation of the proposed mechanisms would be to explicitly integrate improved management practices and active forestry as an element of tropical countries' and subnational

jurisdictions' agendas (e.g., Loreto in Peru and Mato Gross in Brazil) to address forest degradation. Then, the role each mechanism could take would need to be examined in more detail to maximize potential.

There are a range of opportunities to advance implementation of the mechanisms proposed, some of which are common to all (Table 8). The virtues of increased transparency associated with participation in forestry-carbon markets cannot be under-estimated, as they also reflect achievement of goals well-beyond carbon itself and imply consistent regulatory regimes and their enforcement. We also note that these common issues across mechanisms are also shared by different tropical forests, irrespective of the country where they are located.

Actions are to be taken by a range of actors, primarily through national and local governments in many of their sectors, including finance, justice, education, and technical training. There are also ample roles for donors, FMEs, NGOs, grassroots organizations, forestry associations, timber-exporter associations, and others in the private sector to take the lead and become champions of any of the propositions developed. Alliances with universities and technical schools could be beneficial for all involved (see section *Further Considerations for Forestry-Carbon Projects*).

Table 8. Common opportunities and impediments to adoption of the carbon-enhancing mechanisms proposed.

Issues Common to All Mechanisms		
Opportunities	**Impediments**	**Actions**
Tropical countries are advancing to operationalize strategies that would support their path to achieve their NDCs.	Proposed mechanisms require integration into national degradation-tackling agendas. Several high-level initiatives with unclear strategies for on-the-ground implementation, including MRV.	Disseminate work presented in this report, particularly as it pertains to feasibility of mechanisms 1 and 4 and create specific conditions for trials. Need to dive into each specific initiative (e.g., *Estrategia Regional de Desarrollo Rural Bajo en Emisiones* (ERDRBE) in Loreto; PCI, REM and Carbono Neutro in MT) and find opportunities to test the mechanisms through well designed policy experiments so that implementation is integrated with their goals.
Participation in carbon projects lends legitimacy to land tenure or usufruct rights.	Many FMEs resist investing in forestry practices that yield benefits only after decadal delays.	Fortify or create systems of incentives to support experimentation. Clarify and strengthen rights to carbon regimes and processes to realize these rights.
Participation in carbon projects attracts participants for different reasons (e.g., enhanced security	Confusion, lack of trust.	Consolidated approach to link grand goals to on-the-ground actions that can demonstrably lead

Issues Common to All Mechanisms		
Opportunities	**Impediments**	**Actions**
derived from international contractual agreements).	Lack of information, knowledge, skills. Abundant proliferation of carbon-trading actors and proposals with risks of abundant 'hot air'. Reluctance to try risky things	to the desired carbon outcomes from managed forests. Establish jurisdictional programs to provide support, including funding and streamlining bureaucracy.
Confluence of interests and intentions by global community and national governments/ actors.	Too many plans/ projects are not coordinated or integrated, which causes confusion. Process of formulation of specific on-the-ground actions by high-level initiatives is slow and commonly absent.	Governments (at all levels) consolidate their leadership to clearly communicate agendas. Need to experiment with policies and learn to improve practice (moving from pilot to broader levels) through quality-designed experiments (e.g., randomized controlled trials (RCTs)).
Prominence of tropical forests and repeated call for SFM need to make room for improvements in on-the-ground practices.	Unpopularity of any sort of logging, often taken as representing illegality or at least involving corruption and other crimes.	Successful trials of policy and practice, properly designed, implemented and communicated, can help demonstrate forestry's virtues
Professionalize forestry work and thereby boost local/ regional prosperity.	Lack of trained personnel and training opportunities.	Invest in building human and social capital.
Carbon credits already fit into VCS approved VM0035 and should fit under VM0005 verification methodologies. They will also fit into the ART-TREES Standard.	Proposed mechanisms require integration into national degradation-tackling agendas and into programs with active forest management goals.	Promotion of Mechanism 4a could be started right away among standard bodies to assess potential adoption and refine it.
	Requires trained auditors.	Collaborate to increase these skills (e.g., NGOs: CI, TNC).
Functional system of alerts of deforestation and degradation.	Systematic actionable information system to speedily link alerts to actions.	Invest in building human and social capital.

There are also opportunities and limitations specific to each mechanism (Table 9). We provide some initial thinking and note that at this level, it is important to consider issues more specific to each country (e.g.,

regulatory frameworks, characteristics of the forestry sector, markets dynamics) when tailoring mechanism implementation for each locale, as done for each case-study (see Part II).

Table 9. Analysis of general factors that may enable or hamper adoption of proposed mechanisms to consolidate carbon outcomes from managed forests.

Mechanism	Opportunities	Impediments	Actions
Mechanism 1 Employ reduced-impact logging (RIL) practices.	Global, national and private sector initiatives need to be used to promote new rules of engagement.	Reluctance of FMEs to meet the needed increased transparency of their operations.	Instill and support a culture of collective experimentation and learning to achieve shared goals.
	National forestry institutions can create the need and encourage better accounting to support decision-making.	Lack of reliable data on the financial costs of the recommended practices. Lack of cost information may deter investment and inform design of most suitable incentive system.	Leave it to managers to decide how they want to reduce their emissions, but then measure them carefully using the RIL-C protocol and tracking costs.
	Existing successful experiences –IFT Brazil (with activities all over the tropics).	Lack of training opportunities for forest workers is impeding effective application of RIL practices.	Support IFT, Brazil, so they continue to provide their world leading capacity building.
Mechanism 2 Increase utilization of wood from felled trees.	No risk of leakage and the carbon saved is entirely additional.	Inadequate regulatory environment.	Revise regulations and adapt as needed.
	Can generate benefits for local communities.	Lack of technology/ equipment.	Develop trials to generate information on how and where to promote the adoption of this mechanism and related cost/benefit ratios; product and market development.
Mechanism 3 Reduce harvesting frequency or logging intensity.	Implementation amenable to easy monitoring with remote sensing to target field verification efforts.	Potential negative consequences affecting forested areas that share supply and value chains: risks of leakage.	Develop complementary modes of verification and conditionality.
	Can generate co-benefits (reduced loss of ecosystem services).	Decreased local prosperity (reduced jobs), including	Articulate incentives all along the supply and value chains (i.e.,

Mechanism	Opportunities	Impediments	Actions
		rents for timber companies.	opportunity costs beyond specific FMEs).
	Can favor maintenance of tropical forest assets and increase stand values leaving time for trees to recover commercial value.	Requires funding and proper monitoring to avoid leakage. Establishing additionality is challenging . Baseline establishment is costly.	Requires careful design and proper funding under the highest conditionality bar.
Mechanism 4 Apply silvicultural treatments to increase rates of carbon uptake in managed and degraded forests.	Liana cutting in FCTs is simple and can be done at low cost.	Requires promotion and demonstration, generating more data on cost-benefit ratios.	Potential participants (e.g., donors, funders, managers) need to be educated of this feasible option.
	Results in ~ 3 years.	Requires initial support.	Promote mechanism feasibility broadly to secure champions.
	Could generate jobs.	Requires support.	Source funding.
Mechanism 5 Plant trees in accessible areas that are degraded.	Increased stocking is feasible by tree planting in accessible badly degraded areas in managed forests.	Accessibility is critical. Requires funding, suitable sites, quality seedlings, and tending.	Can be promoted and demonstrated in pilot initiatives.
	Generates ecosystem services.	Requires baseline information.	
	Generates jobs.	Need skills.	

Further Considerations for Forestry-Carbon Projects

Here we introduce some basic ideas regarding processes that will lead to effective implementation of forestry-carbon projects. We discuss the limitations different actors may face (e.g., costs as a function of actor type) and the sorts of institutions that might sponsor such initiatives. We also highlight potential ways around barriers and provide design recommendations for project development (Figure 11).

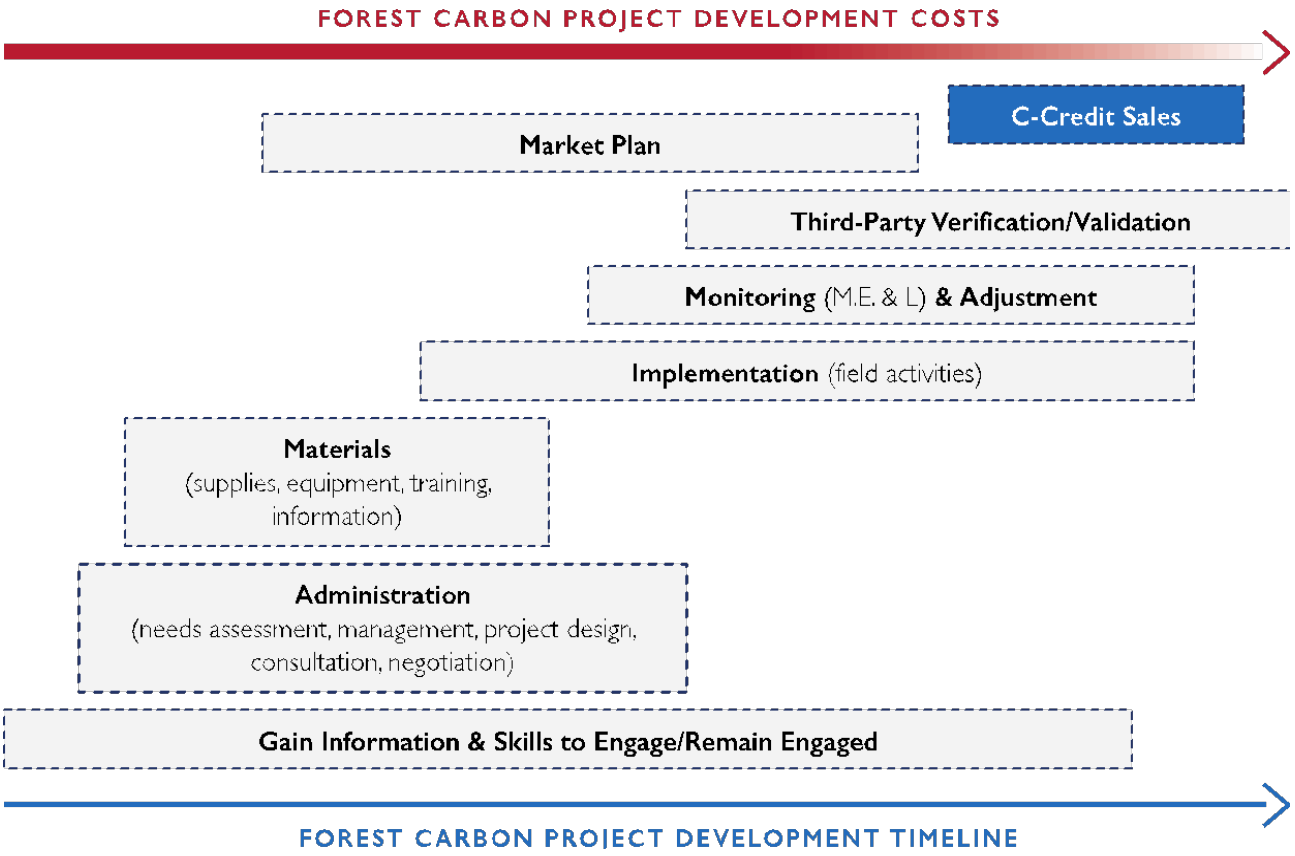


Figure 11. Timeline of activities and costs of forestry-carbon projects once a FME manager decides to develop a new initiative or join an existing one. Costs vary throughout and are higher (darker red) or lower (lighter red) as a function of the project cycle and the type of actor (see text). Design of the marketing plan can start at any time along project development. MEL: Monitoring, Evaluation & Learning.

A range of impediments need to be overcome by FMEs before they can derive any benefits from a forestry-based carbon project, even if the REDD+ mechanism recognizes this potential given that the '+' in REDD stands for additional forest-related activities that protect the climate, namely sustainable management of forests and the conservation and enhancement of forest carbon stocks. Some of the issues we describe below could be addressed through use of a jurisdictional approach (see section *How can Improved Forest Management earn Carbon Credits? Jurisdictional Level*). First, many FMEs of various sizes are unaware of the potential use of carbon financing to improve their forest management practices. Others have heard about the possibility but were soured on carbon forestry by previous exposure to overblown claims that inflated expectations. Most are naturally suspicious, incredulous, or perceive these initiatives as too complex for serious consideration. The first step they might take would be to search on the internet for 'carbon revenue and forestry.'

Just as an illustration, one search with those terms produced the following text (our emphasis bolded):

> "The **idea behind a forest carbon project: Pay people to not cut down their forests through the sale of 'carbon credits.'** Governments, companies, industries and individuals dedicated to taking climate action can buy and trade credits to supplement their emission-reduction actions, with the **revenue being paid** to local communities as **an incentive to leave their forests standing or increase their forest cover through restoration**. The result: Buyers neutralize a portion of their emissions; market forces reduce further emissions as prices for credits rise over time; **and forests stay standing**, absorbing more climate-warming carbon from the atmosphere while supporting local livelihoods."[9]

For managers involved in active forest management, this commonly promoted approach, which seems favored by USAID for logging concessions in Peru, would squelch their interest and keep them from diving deeper into learning how carbon projects could become potential sources of support for improved management. Unless these stakeholders reach out to governmental agencies or other trusted institutions (e.g., local government/ agency; university researchers; NGOs) that can describe other models, they might assume that carbon financing is not available to firms that continue practicing forestry. For others, the stop-logging model may be attractive if they feel forestry is a risk- and problem-laden commercial activity, uncertain at best due to market fluctuations and climate change, and often not very profitable. FMEs with mostly logged-over forest that are faced with declining volumes and steeply declining profits (Rodrigues et al. 2022) might also find the not-logging option attractive (which casts doubts on additionality).

FMEs that access reliable sources of information about options for participation in carbon-based interventions for forestry are then faced with the need to decide on the multitude of options available (NCX, Pachama, Carbonext). [10] But, as psychologists have long been aware, overloading people with choices can lead to inaction. There is also the risk that if they move quickly to take advantage of nascent opportunities, managers may simply choose the best-advertised or packaged option, which may not be the most credible or efficacious outcome. Fast-talking and unscrupulous carbon project promoters, known in the sector as 'carbon cowboys,' who do not understand local conditions and often show insufficient concern about additionality are the bane of carbon forestry.

A common impediment to the initiation of forest-carbon projects, or any type of payment for environmental services (PES) scheme for that matter based on *ex post* payments, is that the costs of treatments are immediate whereas payments for accrued carbon are at least, somewhat delayed. FME managers that persist in the pursuit of carbon financing may be especially attracted to initiatives that provide initial support. This is even a concern even for wealthy FMEs that are unwilling to take on risks or assume costs that threaten their profit margins.

Costs

Costs of carbon-forestry projects vary through time and as a function of the type of actors and the quality of their business-as-usual practices. Initial costs may relate to gaining information and becoming savvy at regarding the workings of the range of carbon programs and options, including implications of settling on any one in particular. Investments will often be required to reform administrative practices or hire additional staff to engage in negotiations during project development. In many cases, novel benefit-distribution mechanisms will need to be negotiated, which will come with their share of transaction costs. Other costs relate to material expenses like supplies and equipment, GPS and information handling devices, and to training for managers and others so that they can effectively participate in development of the intervention. This training would increase carbon policy literacy carbon, improvability to negotiate with carbon brokers, provide skills to develop a competitive forestry-carbon portfolio and to stay on top of the game. Once

[9] Google search (https://www.conservation.org/projects/what-are-carbon-credits)

[10] Pachama: https://pachama.com/; Carbonext: https://carbonext.com.br/en-US

projects are underway, costs will relate to monitoring (i.e., design and setting up data management systems) and development of verification and validation protocols, if these are not already available, along with payment to the auditors who carry out the verifications.

The costs of carbon forestry are not all monetary. Most prominently, managers may be obliged to open their operations to scrutiny (i.e., allow visits to the forests, open accounting books) by trained auditors to validate reduced emissions and increased removals. Other entities that will expect access include those who will scrutinize the legitimacy of the carbon enhancing interventions, and importantly, those critical of active forest management, which continues to be perceived by some as destructive and associated with all sorts of illegal activity and crime (i.e., reputational costs). There might also be increased scrutiny by government officials, who as a function of the carbon-rights regime particular to each place, may need to verify the carbon accounting to include the credits in their NDCs.

To explore the challenges related to information access, carbon-forestry literacy, costs, and other impediments, we consider the diversity of actors involved in implementation of forestry carbon projects and their different roles and expectations. These considerations may be useful to promote improved forest management practices and structure realistic portfolios of climate-based solutions.

Types of actors

Forest managers seeking to participate in carbon markets can be concessionaires who acquired rights to forest resources from the government, local communities and Indigenous groups who may or may not own the land where forestry is practiced, industrial and non-industrial private landowners, and governments at all levels that directly manage areas. In some cases, carbon rights are owned by the manager of private or public lands, and this tenure regime can be an incentive to participation for some, or a barrier for others (Table 2). Carbon rights aside, the capacities of actors to adopt the forestry carbon-enhancing mechanisms will vary with their carbon-project literacy, financial solvency, and the nature of their business, as well as with the availability of external financial support when they cannot change practices using their own resources (e.g., information such as quality FMPs, technical skills, and personnel).

Initiatives to promote widespread adoption of improved forest management for carbon can be led by a variety of actors with different motives. Included in this group are external agents, mostly from the private sector, who wish to offset some of the emissions of their own operations. For instance, the rationale for jurisdictions to employ these carbon-capturing mechanisms may derive from purely economic aspirations (e.g., job creation in the forestry sector to increase local and regional market dynamism and prosperity) and/ or desire to make visible their contributions to achievement of nationally defined goals (e.g., NDCs, SDGs).

Municipalities, departments, and states under a jurisdictional REDD+ approach may become front-runners in supporting improved management of forests within their jurisdictions. Depending on the land and carbon rights regimes particular to each area, negotiations for accountable and equitable carbon benefit distribution should take place so that there are no losers from intervention adoption. These politico-administrative entities may have enough funding to promote desired initial adoption of practices from their own budgets or be able to leverage resources from central governments. Jurisdictions could engage towards this end, either directly on their own managed lands, or through developing credit systems to support forestry practitioners. Alternatively, jurisdictions may seek backing from donors, the private sector, or generate revenues targeted to investment in the mechanism. For example, small tax increments on goods and services, related or not to the forestry sector can be effective (. See section *How can Improved Forest Management earn Carbon Credits? Jurisdictional Level* for more detail on how individual jurisdictions might support IFM through carbon credit sales).

Types of Forest Carbon Project Sponsors

Besides public actors, other sponsors of the initial phase of forestry carbon mechanism implementation may belong to the private sector, as well as NGOs who are interested in realizing carbon benefits from managed

forests either for philanthropic or self-interest reasons. They may support a whole jurisdiction (e.g., a municipality) to adopt practices through novel public-private partnerships or engage directly with either concessionaires and/ or local and Indigenous communities. To avoid double-counting of carbon emissions and removals, strict observance of third-party protocols are needed (e.g., Voluntary Carbon Standard) with transparent negotiations as well as agreements regarding benefit distribution.

Stipulations underlying the *modus operandi* mentioned above should consider the timeframes over which both costs and benefits are realized, which in turn will vary with the type of actor. For instance, less wealthy forest managers with high discount rates would be motivated to defer costs and earn benefits quickly. All five forestry carbon enhancing pathways discussed in this Report involve up-front investments in training, market development, and administrative adjustments (see Tables 9 and 10 above), but they differ in the duration of delays in carbon accrual. For example, research has shown that the carbon benefits of tree liberation from lianas (Mechanism 4a) may not start to accrue until after year two due to carbon released from the cut stems (Finlayson et al. 2022). In contrast, the RIL-Use (Mechanism 1) and increased wood utilization pathways (Mechanism 2) suffer no such delays in carbon benefits, if the 'committed emissions' assumption is accepted: carbon is released instantaneously when biomass is converted into necromass by, for example, logging damage. Time-lags in enjoyment of carbon benefits from tree planting (Mechanism 5) vary with the amount of carbon released from site preparation and carbon accrual rates of the planted trees.

How to Make Things Happen

Irrespective of the type of mechanism(s) adopted (see previous section: *Proposed Mechanisms for Improved Forestry Carbon Management*), and implementation modality (see next subsection: *How can forest management earn carbon credits?*), parties interested in advancing the forestry-based improved carbon outcomes agenda should work together in transparent and accountable ways. Activities to be developed are complex and entail making sure that forest managers come to the table with open eyes and realistic expectations about the costs and benefits of forestry carbon projects. This apparently straightforward requirement is laden with difficulties starting with ensuring that managers receive quality information about the variety of credible options available and their terms of implementation. All involved need to be clear about their rights and responsibilities from the highest-level of management (i.e., shareholders) to the chainsaw operators. Other field personnel and members of surrounding communities, including those along the value chain (i.e., consumers), need to play roles in changing the prevailing forestry culture of business-as-usual timber mining to implementing improved practices.

We propose some general steps that link what happens on the ground at the level of the forest management operation to the development of high integrity carbon credits. The first step is to identify actions to be taken and practices to be adopted to reduce carbon emissions and increase carbon removals. Farther along the path to participation in carbon markets, in Figure 12 we examine some of the common unquestioned assumptions and assess their risks. We hope this general action map is useful to guide initial conception and further thinking about articulation of the mechanisms proposed.

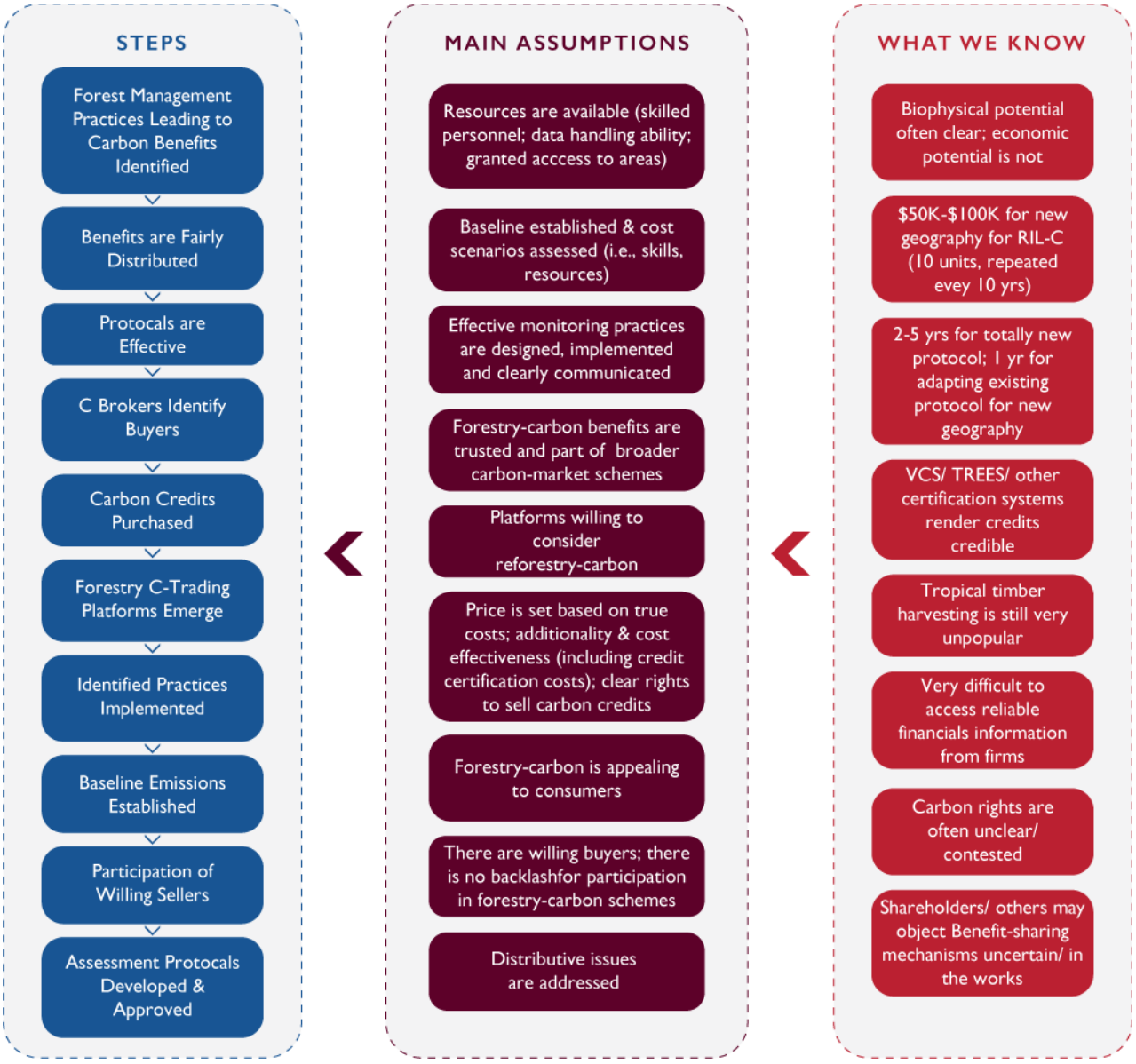


Figure 12. Steps to be considered when designing interventions that aim to improve carbon outcomes from managed forests (i.e., reduced emissions and increased removals) and ultimately lead to carbon credit sales. Note that some steps can be taken simultaneously.

The answer to who should run which activities is context dependent. In some cases, as discussed above, those in charge of promoting carbon deals could be either internal (i.e., governments, jurisdictions, private sector) or external actors (i.e., carbon brokers, investment funds). The extent to which each of these parties prevails in setting project agendas and the *modus operandi* (i.e., project development) that include benefits and costs-sharing, will be determined by power struggles on uneven playing fields because negotiators differ in information access, resources, exposure to risk.

That said, politics and power asymmetries are not insurmountable obstacles to addressing the current vacuum and confusion regarding rules, roles, responsibilities, and rights. Our concern is that carbon markets are not regulated, and in the absence of effective safeguards, unscrupulous actors who are well informed will take advantage and disenfranchise others, leaving just 'hot air'. Stories abound of carbon cowboys pushing unrealistic deals on uninformed forest owners.[11] These abuses will undermine PES-like schemes for active

[11] Listen to this podcast for examples: https://news.mongabay.com/2022/02/podcast-carbon-cowboys-and-illegal-logging/, Mike DiGirolamo, 1 February 2022.

quality forest management that deliver carbon outcomes and other benefits, and the abandonment of managed forests for forested landscapes that do not contribute to regional economies and do not generate local prosperity.

Rather than being normative about which actors should lead in developing forestry-carbon portfolios, we emphasize the importance of considering the voices of those most directly affected by participation in such schemes. Participation must be supported by quality information that is well-disseminated through open channels, inclusive processes (i.e., meaningful and transparent participation of *all* stakeholders), and robust project monitoring, evaluation and learning systems with adjustments made along the way. This type of practice will lead to collective and informed decisions about whether carbon projects are worth the investment and the risk.

How can improved forest management earn carbon credits?

Project-level

Existing forest carbon projects operate largely independently of governments and have boundaries defined by forest management units or concessions. IFM projects make up only a small proportion of projects in the tropics registered with the principle voluntary carbon verification standards. Among the nearly 1800 projects in Verra's VCS Project Registry, the largest certifier of voluntary greenhouse gas projects of any type globally, only eight are IFM projects in the tropics (another 32 IFM projects are in China and Russia). Among five other carbon standards surveyed,[12] 23 projects containing REDD+ and/or IFM elements were identified in the tropics under the Plan Vivo Standard (Table Annex 1). Of the combined 31 projects in the tropics, only two specifically cite RIL and sustainable forest management as focal activities. The remainder were focused on converting logged forest to protected forest, afforestation, reforestation, and agroforestry.

To date, forest management has had to contend with several challenges with respect to establishing viable carbon projects. Generally, forest carbon projects that require cessation of timber harvests (e.g., conservation concessions) have a high potential for activity-shifting and market leakage, because loggers will be motivated to harvest timber outside the project area (Table Annex 2). Where harvests continue but are reduced by lengthening cutting cycles or reducing harvest intensities, the threat of leakage remains but is diminished. In contrast, the approved VCS RIL-C methodology[3] eliminates the risk of leakage because it requires no reduction in harvest levels (VCS 2016 VM0035; Table Annex 2). Similarly, no leakage is expected from the carbon enhancing interventions of improved wood utilization, silvicultural treatments to increase carbon removals, or tree planting in degraded areas.

Perhaps most challenging for forest-based carbon projects is the requirement to demonstrate additionality. This challenge is fundamental where the improved management practices that lead to reduced emissions proposed by the project are legally required (Table Annex 2). In many cases, the relevant regulations are vague and open to multiple interpretations. For example, where RIL is a regulatory requirement such as in Indonesia and Brazil, quantitative assessment protocols are not specified. Consequently, it is not clear whether project's changes in business-as-usual practices are additional or simply represent legal compliance. Furthermore, use of RIL practices is not binary but instead represents a sliding scale that can be accurately quantified with the RIL-C protocol. Several other VCS IFM methodologies also address aspects of forest management, including increased harvesting cycles (VM0003), halting logging in previously logged areas (VM0011), and halting logging in areas where logging is planned (VM0010). Of these VM0011 and VM0010 are most widely applied as additionality can often be readily demonstrated (Table Annex 2; Box 1).

[12] No IFM projects outside USA in American Carbon Registry (https://acr2.apx.com/myModule/rpt/myrpt.asp?r=111); Gold Standard Land Use & Forests Framework – so far, A/R only (IFM to be included) (https://globalgoals.goldstandard.org/203-ar-luf-activity-requirements/); Natural Forest Standard – no IFM projects (https://www.naturalforeststandard.com/nfs-registry/); Plan Vivo Standard (2 tropical IFM projects: 1 project in Solomon Islands, 1 in Fiji) (https://www.planvivo.org/Pages/Category/projects?Take=28; https://mer.markit.com/br-reg/public/index.jsp?entity=retirement&sort=account_name&dir=ASC&start=0&acronym=PV&limit=15&additionalCertificationId=&categoryId=100000000000001&name=&standardId=100000000000004&unitClass=); Rainforest Standard – unclear if the standard still exists (2008-2018) (https://www.nytimes.com/2015/01/20/opinion/a-carbon-offset-market-for-trees.html); VCS – 8 IFM projects (2 Brazil, 1 Colombia, 1 Peru, 1 Malaysia, 1 Congo, 1 Bolivia, 1 Cameroon; also 31 in China, 1 in Russia) (https://registry.verra.org/app/search/VCS/All%20Projects)

Box 1

MAJOR CONCEPTS AND ISSUES THAT PERTAIN TO PAYMENTS FOR FORESTRY CARBON BENEFITS IN THE CONTEXT OF RIL

Diverse self-imposed rules and norms have proliferated due to a lack of regulation of carbon markets. Many are not evaluated, formalized or ratified by appropriate statutory bodies. Here we try to clarify the major requirements for legitimate forestry-carbon interventions but admit that many of these issues remain in flux. We base some of the ideas presented below on the VCS 'Additionality Tool' (Verra 2012) in full recognition that Verra should not be entrusted with policy formulation. Some of these concepts are more of a concern for independent forestry carbon projects than for initiatives within jurisdictional forestry carbon programs (see section *How can Improved Forest Management earn Carbon Credits? Jurisdictional Level).*

Additionality: Satisfying the 'but for' the intervention criterion is more challenging for some of our proposed forestry-based carbon pathways than others. Claims of additionality are often difficult to justify for the 'not logging' approach (i.e., 'conservation concessions'), for which a VCS protocol is available (VM0010 Methodology for Improved Forest Management: Conversion from Logged to Protected Forest; Table Annex 2). This is due to the likelihood of carbon loss by illegal logging (see below for leakage concerns). In contrast, the carbon benefits from liana cutting on future crop trees are clearly additional. Where a carbon-benefiting activity is legally required, some people wrongly question whether legal compliance is additional, in other words, whether projects should be credited for complying with the law [See footnote #3].

Baseline: Carbon credits are calculated relative to a baseline that represents the expected trajectory for carbon in the absence of the intervention. Baselines can be historic or based on either actual or synthesized areas that resemble the project area without the intervention to which carbon credits are ascribed. Due to changing conditions over time, baselines are typically updated at specified intervals (e.g., 10 years for the regional baselines for RIL-C). What is important is that there is clarity about baseline establishment.

Permanence: The carbon benefits of many forestry interventions are not permanent (i.e., in perpetuity, durable, or to last more than 100 years) due to planned harvests and risks (see below). Calculations of the per ton value of short-term carbon storage need to account for the time-value of money by discounting to avoid over-estimates that are prejudicial against forestry carbon (B. Sohngen pers. com.; Groom and Venmans 2022).

Leakage: Interventions that slow or stop timber harvests risk losses of the carbon benefits when loggers go elsewhere for raw materials. Given that use of RIL entails no reductions in timber yields, it is not susceptible to leakage. In contrast, where carbon credits are derived from the cessation of logging (i.e., conservation concessions or the 'logged forest to protected forest' pathway), extended cutting cycles or reduced harvest intensities, proponents will need to account for the risk of leakage. Interventions that stimulate carbon removal (i.e., liana cutting and tree planting) are not leakage prone.

Risk: To account for the chance of losses due to fire, storms, illegal logging, or other unanticipated forces, forestry carbon providers are typically required to carry insurance or hold some credits that cannot be sold in a 'buffer pool.' Given that active forest concessions reportedly suffer lower deforestation rates than elsewhere (Burivalova et al. 2020), the "Conversion from Logged to Protected Forest" pathway seems very risky unless substantial efforts are invested in protection. Similarly, while it is recommended that tree planting be done in accessible areas to facilitate follow-up treatments, access can endanger forest carbon.

Jurisdictional Level

There are many potential advantages of embedding improved forest management for carbon credit projects within jurisdictional approaches (Nepstad et al. 2013; Boyd et al. 2018). In this approach, landscapes are defined by policy-relevant boundaries, with significant governmental involvement. The goal is to protect forests, reduce emissions and improve livelihoods across entire governmental territories: national level, states, provinces, districts, counties, and other political administrative units. Under a jurisdictional approach, entire jurisdictions (national or subnational) are rewarded for reducing emissions from deforestation, degradation and removals. While progress in measuring deforestation accurately over large areas is advanced, detection and measurement protocols to monitor degradation and removals over the same expanses with low uncertainty are becoming operational. One benefit of developing forestry carbon management projects within jurisdictions is that funds could be allocated for this purpose from those received by the jurisdictional body. Jurisdictions can decide how to allocate the benefits of credits earned, whether on a one-to-one basis based on measured emissions reductions or according to some other allocation scheme that seeks to increase positive impacts.

Two main types of carbon-centered compensation systems, which are currently operational, have emerged since the jurisdictional approach was first proposed a decade ago (Nepstad et al. 2013):

a) results-based payment (RBP) contracts, in which there is no transfer of carbon credits from a public jurisdictional provider to public or private sponsor (e.g., REDD+ for Early Movers -REM; the Forest Carbon Partnership Facility -FCPF- Carbon Fund, the Global Climate Fund -GCF- REDD+ Pilot Programme; Nepstad et al. 2022); and

b) jurisdictional REDD+ (J-REDD+) credit sales from a (public) jurisdictional seller to a public or private buyer (e.g., Guyana's sale of TREES-verified credits).

Under RBP mechanisms, 'donor' countries or firms can make a contribution to a 'host' country or sub-national jurisdiction, to reward success in slowing emissions from deforestation or some forms of forest degradation. The donor pays for the emission reductions already achieved, as monitored with remote sensing. This transaction is recognized in a UN-linked registry. Emissions reductions are measured, validated, verified, and registered through a UNFCCC-defined process. Once the payment is received, the emissions reductions are retired. Emission reductions are not transferred; they remain with the host jurisdiction where they occurred and can be used towards the nation's NDCs. RBPs have been the principal mechanism through which developed nations have provided support to developing nations and subnational governments to implement their jurisdictional programs to date. Since 2008, a total of USD4.2 billion in commitments and USD2.05 billion in disbursements have been made to 28 individual jurisdictions including two subnational jurisdictions, Acre and Mato Grosso States in Brazil (Nepstad et al. 2022). Among these examples, several include sustainable forest management goals into the jurisdictional emissions reduction program.

In contrast to RBP contracts, in J-REDD+ credit sales, the first of which was transacted by Guyana in December 2022 transferable carbon credits are generated. Several dialogues currently taking place focus on whether the sale of credits in the voluntary carbon market should carry corresponding adjustments—that is, whether the nation in which the credits were created must reduce its own mitigation claim towards its NDC upon transfer of those credits.

The recent decisions on Article 6 of the Paris Agreement at COP26, growing demand for forest carbon credits in the voluntary market (FTEM 2021), and the emergence of J-REDD+ as the most promising source of large volumes of high-quality forest carbon credits are all contributing to a great deal of dynamism in the forest carbon market. Coalitions of offset-seeking companies and governments (see Box 2; Slavin 2022) and individual companies seeking volumes of forest carbon credits that could soon be worth billions of USD each year are focused on J-REDD+ program credits (D. Nepstad pers. com.; Box 2).

Box 2

LOWERING EMISSIONS BY ACCELERATING FOREST FINANCE (LEAF) COALITION AND THE REDD+ ENVIRONMENTAL EXCELLENCE STANDARD (TREES STANDARD)

Currently, two entities are proposing to buy credits from jurisdictions that become certified under one or both of the standards. One is the Lowering Emissions by Accelerating Forest finance (LEAF) Coalition, which represents a group of private companies, public and private donors, and NGOs that propose to act as brokers for jurisdictions (nations and sub-nationals) wanting to sell forestry carbon credits. Participating jurisdictions must become verified under The REDD+ Environmental Excellence Standard -TREES once LEAF has signed a non-legally binding Letter of Intent (LoI) with jurisdictions whose proposals are selected. It offers a minimum floor price of USD10/tCO_2e.

To date, LEAF has opened three calls for proposals. The first two concluded in 2021 and 2022, respectively; the third will conclude in May 2024. To date, twenty-six proposals have been selected to be eligible for either an MoU or a LoI with LEAF as a result of the first call. Of these, three (Ecuador, Costa Rica, Nepal) have signed Memoranda of Agreement with LEAF, which set out next steps and a timetable for the signing of binding Emissions Reduction Purchase Agreements (ERPAs. The LEAF Coalition provides no upfront finance to jurisdictions to develop their programs to a standard that can be certified under ART-TREES.

As of December 2021, Mercuria Energy Trading S. A., a commodity trading company active in a wide spectrum of global energy markets, is offering to provide upfront finance to subnational jurisdictions to pursue either ART-TREES or Jurisdictional and Nested REDD+ (JNR) certification, despite not being able to secure any guarantee that those same jurisdictions will sell their credits to Mercuria once they are certified. To date, seven subnational jurisdictions in Argentina, Brazil and Peru have signed MoUs to explore certification options. In October 2022, the Brazilian state of Tocantins selected Mercuria for the sale of up to 200 million tons of jurisdictional carbon credits generated and expected from 2016 to 2032. In June 2023, Tocantins and Mercuria signed a ten-year ERPA, the first such agreement established between a company and a subnational government.

The two operational standards for J-REDD+ crediting both include mechanisms for measuring and rewarding emissions reductions associated with avoided forest degradation. The REDD+ Environmental Excellence Standard (ART-TREES; Box 3) requires qualifying jurisdictions to establish and monitor progress against a forest degradation baseline, that is, a composite of activities contributing to degradation, for the whole jurisdiction (ART Secretariat 2021). In doing so, an opportunity is created for improved forest management to become an important component of the overall J-REDD+ program.

Box 3

ARCHITECTURE FOR REDD+ TRANSACTIONS (ART) AND **THE REDD+ ENVIRONMENTAL EXCELLENCE STANDARD (TREES)**

Architecture for REDD+ Transactions (ART), established in 2018, and **The REDD+ Environmental Excellence Standard (TREES**), launched in 2020, were designed to help accelerate progress toward national-scale accounting and implementation to achieve emissions reductions at scale and to achieve Paris Agreement goals (ART Secretariat 2021). The TREES standard permits subnational jurisdiction participation with restrictions. Under TREES, countries and eligible subnational jurisdictions can generate verified emissions reduction credits by reducing their deforestation and degradation emissions and meeting precise and comprehensive requirements under the TREES standard for:

- accounting and crediting;
- monitoring, reporting and independent verification;
- mitigation of leakage and reversal risks;
- avoidance of double counting;
- assurance of robust environmental and social safeguards; and
- transparent issuance of serialized units on a public registry.

For jurisdictions that want to include forest management, Verra's Jurisdictional and Nested REDD+ (JNR) framework requires the jurisdictional forest reference emissions level (FREL) to include GHG emissions from forest degradation above a threshold derived from the program's GHG benefit. The benefit threshold amounts to less than five percent of the total GHG benefit generated by the project (VCS-Methodology-Requirements (v 4.1 Section 3.3.6) and if the activities involved align with Verra's definition of IFM (Verra 2021; Box 4).

Box 4. VERRA'S JURISDICTIONAL AND NESTED REDD+ (JNR) FRAMEWORK

This framework serves as a comprehensive carbon accounting and crediting platform for governments to guide development of their REDD+ programs and help nest REDD+ projects and subnational jurisdictions within these programs (Verra 2021). JNR was specifically designed to facilitate private investment in REDD+ at multiple scales and is therefore aligned with the Paris Agreement's objectives of engaging the private sector, while linking to national efforts, as well as providing emission reductions to emerging compliance and voluntary markets.

Verra includes the following categories in its definition of IFM (Verra 2021):

1. Reduced-Impact Logging (RIL);
2. Logged to Protected Forest (LtPF);
3. Extended Rotation Age (ERA);
4. Improved forest management plus wetland restoration (IFM + RWE);
5. Improved forest management and wetland conservation (IFM + CIW); and
6. Low productive to high-productive forest (LtHP).

Clearly, measurement of carbon emissions reductions or increases in carbon removals stemming from the improved forest management practices recommended in this Report will require project-level monitoring embedded in a broader jurisdictional context. The wall-to-wall remote sensing coverage used to monitor deforestation across the jurisdiction can be used to measure the benefits of, for example, future crop tree liberation from lianas, although not yet fully operational for a range of actors. Remote sensing can more commonly be used for detection of new logging roads, at least those built by industrial FMEs. Unfortunately, clandestine logging operations, especially those that extract logs or rough-sawn lumber with farm tractors, oxen, motorcycles, or manually, open few large roads or skid trails, which makes them difficult to detect from space with passive remote sensing. Increased availability and use of high resolution, high frequency imagery (e.g., PlanetLabs), active sensors (e.g., LiDAR) and combined sensor approaches (e.g., Chloris Geospatial) is leading to rapid advances in monitoring of forest degradation.

In December 2022, ART issued Guyana the world's first jurisdictional forest carbon credits the TREES standard (ART 2022). Guyana was issued 33.47 million TREES credits for the 2016-2020 crediting period. Hess Corporation committed to purchasing approximately one-third of these historical credits as well as current and future credits (12.5 million of 2016-2020 credits, and 2.5 million per year for the 2021-2030 crediting periods) at a minimum total value of US$750 million (GoG DPI 2022). In an interview, a representative of the Guyana Forest Commission, the proponent of the Guyana jurisdictional program under TREES, reports that the submission and review process of TREES has generally been time-efficient, but that the novelty of the program appears to be slowing some aspects of the verification and validation process. At the time that Guyana was approved to move to registration, only one validation/verification body had been certified by Architecture for REDD+ Transactions (ART) to review the documents (P. Bholanath pers. comm.). Guyana was able to adapt much of the policy, governance, monitoring, and reporting infrastructure developed in support of its LoI with Norway and its FCPF program, obviating the need to start from the beginning (P. Bholanath, pers. comm.).

Currently, sixteen other national and sub-national jurisdictions are pursuing TREES certification (Table Annex 3). Twelve other countries and four subnational jurisdictions have submitted concept notes; many of these jurisdictions are likely to be developing their registration documents. Costa Rica is currently undergoing validation and verification of its registration documents for the 2017-2021 period.

In contrast to ART, the VCS registry lists no (JNR) programs as yet, despite being an approved methodology since 2012 (JNR Registry, n.d.). This is likely to have multiple causes, including the relatively complicated presentation of the JNR requirements, as well as the requirements and restrictions themselves.

Furthermore, although the jurisdictional approach to forest carbon has been under development and discussion for the last decade, the concept has only slowly gained traction among political and economic actors around the tropics and globally, reflected by the recent creation of the TREES Standard.

How does it work? Improved Forest Management under Project vs. Jurisdictional Approaches

For carbon-revenue benefit distribution and climate change mitigation, the project-based approach presents important challenges. Typically, only a few forest units across a landscape participate in the scheme and emissions reductions are modest (Figure 13a).

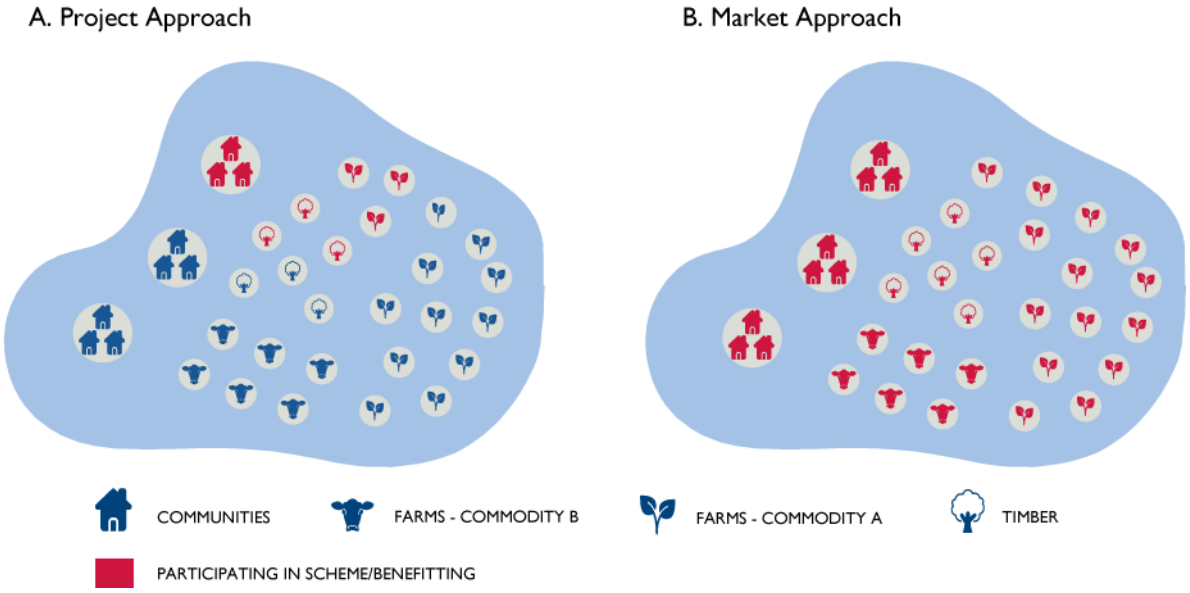


Figure 13. (a) Under a project approach, a small number of forest units across a landscape participate in the voluntary carbon market so emissions reductions and removals are typically modest. (b) Under a jurisdictional approach, an entire administrative/political landscape participates in the scheme, with the prospect of increasing emissions reductions. Benefits can be allocated according to a negotiated distribution scheme that provides incentives and compensation to key sectors and actors who might not otherwise earn carbon revenues as stand-alone projects.

Individual REDD+ projects typically quantify emissions reductions based on a historical baseline or forest reference level and therefore might penalize land-users that have a history of low emissions (DiGiano et al. 2016, Stickler et al 2018). In contrast, under J-REDD+ (Figure 13b), emissions reductions achieved across all of a region's land-based sectors (e.g., active forest management, protected areas, Indigenous territories and local community lands, agriculture) provide the basis for potentially substantial flows of finance that can be allocated among sectors and programs to achieve the jurisdiction's goals. Therefore, jurisdictional programs deliver more benefits to historically non- and low-deforestation and degradation-associated actors than allowed by emissions reduction accounting applied to forest units alone. The JNR standard requires that a benefit-sharing mechanism be included as part of the program application. TREES does not have specific requirements for benefit-sharing plans, but J-REDD+ proponents are required to conform to the Cancun Safeguards, including free, prior and informed consent, consultations, transparent allocation of resources, and adherence to national and international policy regarding the rights of indigenous and other traditional peoples and local communities, among others.

Typically, allocation of funds from sales of jurisdictional credits is determined via a benefits-sharing agreement negotiated by a multi-stakeholder body or process. As a result, distribution of benefits within J-REDD+ programs are defined via a negotiated process, such that the historically high deforesting and degrading actors also receive incentives to reduce emissions, but forest conserving actors receive compensation and incentives to continue and improve their practices or as otherwise defined by the program. For example, where traditional and local communities are the owners of carbon (as defined by

individual nations' laws and arrangements), the jurisdictional proponent must have a pre-arranged agreement with these groups regarding the monitoring, reporting, and distribution of the proceeds from the sale of credits. Alternatively, credits owned by and/or generated by traditional and local communities could be separated from the jurisdictional program, the program would not be permitted to count them towards its own credits and the owners could decide if and when to participate in carbon markets. Guyana's recently certified J-REDD+ credits and experiences with RBP programs, including Mato Grosso and Acre REDD+ for Early Movers -REM programs, serve as a direct model and precursor for negotiated allocation schemes. Forest conserving actors receive incentives and support in a manner consistent with what each group has requested and negotiated under the agreement.

Both TREES and JNR permit stand-alone projects within the proponent jurisdiction; generated credits can be sold by the projects. The jurisdiction must present a plan for accounting for these projects, such that the credits they generate and sell are not also sold by the jurisdiction. Depending on the jurisdiction's preference, projects may be integrated into the jurisdictional strategy to varying extents.

Until recently, the principal obstacle to including forest degradation and removals in jurisdictional programs was insufficient data linking degrees of land cover changes with carbon stocks and emissions. These data are required to adequately reduce uncertainty in estimates at the scale of the jurisdiction. As with forestry carbon projects, a key component of jurisdictional crediting programs is the baseline, in this case the FREL. Both types of reference level are typically calculated using linear projections of past deforestation (and degradation) trends and adjusted in light of current information. In the case of projects, flawed assumptions about the 'business-as-usual' scenario vs. the 'forest carbon project' scenario can ultimately lead to inflated emissions reductions (West et al. 2023, Guizar-Coutiño et al. 2022). Jurisdictional FRELs, by definition, include the entire jurisdictional area, except where areas are omitted to account for projects that will not be included in the jurisdictional program, and thus eliminate various assumptions regarding spatial area and other factors that often influence smaller-scale projects.

The jurisdictional baseline is generally produced using wall-to-wall remotely sensed data combined with emissions factors. These are typically derived from field data and specified in the national GHG emissions inventory methodologies, as per UNFCCC requirements. Depending on the resolution of the imagery and biomass sampling, this approach is likely to miss many of the carbon benefits of IFM due to sensor saturation and the relatively finer scale of carbon emissions differences offered by the proposed interventions.

To date, most national and subnational FRELs have been developed for primary forest clearing. Across the tropics, both national and sub-national level jurisdictions are now working to develop FRELs for clearing of secondary forests and for forest degradation. To receive TREES certification, jurisdictions are required to present degradation reference levels. Estimating carbon removals FRELs for reforestation or regeneration following clear-cutting of either primary or secondary forest are relatively straightforward, particularly as more and better data and data processing become available. In contrast, data collection and monitoring are more complicated for carbon removals in degraded forest in response to carbon-promoting treatments (but see proposal to monitor removals from liana removal within Mechanism 4 - *Apply Silvicultural Treatments to Enhance Growth* above).

Currently, the jurisdiction lowers emissions, measured against this jurisdictional baseline, by whatever means most appropriate. The distribution of incentives and benefits to sectors and activities is not necessarily proportional to the source of emissions reductions. Instead, this distribution is negotiated to allocate incentives to sectors based on the jurisdiction's full set of negotiated priorities (government plus society) for promoting particular sectors and actions, in particular places. These incentives could be used to initiate and support improved forestry carbon management interventions, like those recommended in this Report, aimed at project, concession, or private forest owner levels within the jurisdiction.

In the case of forest management, reductions that can be achieved from the sector may be small relative to those that can be achieved by reducing forest conversion for agriculture. So rather than distributing the funds earned in proportion to the amount of each sector's own direct emissions reductions, the jurisdiction/multi-stakeholder negotiation process may determine that the natural forest management sector should receive a much larger proportion of the benefits, to reflect, for example, an agreed-upon collective goal. Members of the multi-stakeholder group may have decided that responsible forestry is an important

sector or activity to promote in the context of the jurisdiction's longer-term plans and in light of co-benefits this land use provides (e.g., jobs, biodiversity, economic).

J-REDD+ programs also resolve some of the other challenges posed by projects. The additionality issues faced by projects largely disappear, at least under the TREES standard (see Box 3 above) because emissions reductions are measured against historical baselines from deforestation and degradation established for the entire jurisdiction. This decouples forest management from carbon accounting via the jurisdictional program (i.e., actual emissions and funds allocation do not align), as described above.

In J-REDD+ programs, credit transactions are a step removed from forest management and logging operations. Thus, forest management can be recognized and incentivized through finance received because of credits generated from forestry, agriculture, and other land-based sectors, provided that forest management has been identified by the multi-stakeholder platform as a desired activity. The program delivers finance that can be optimized to favor improved forest management. That finance can then be distributed according to the jurisdiction's priorities, as opposed to the actual emissions reductions earned by each activity or sector.

Credit: USFS/USAID / Liliana Lizárraga

Part II. Country level case studies

Case-Study Loreto – Peru

Forest sector characteristics and trends

Peru is among the tropical countries with substantial forest cover (~53%), most of which is in the Amazon Basin. Forested areas have been allocated for different uses, mainly timber production (~60%) and preservation (25%). Despite its extensive forest cover, contributions from the forestry sector to GDP are small. The proportion of the national GDP from forest rents[13] were 0.813% in 2020 (highest: 0.81% in 1982; World Bank 2021[14]). While small at the national level, these rents are substantial at the Amazon region level (33%; USAID-ProBosques 2019).

Cross-sectoral actions have launched programs to develop Policy Guidelines for Public Investment in Forestry Development. Their goal is to consolidate State efforts to increase the productivity and competitiveness of the forest sector, within a framework of sustainable development, generating processes of social inclusion through articulation of forestry activities to markets. Although emphasis has been on plantations, some attention is also paid to natural forest sustainability (SERFOR 2020).

[13] Calculated as round wood harvest times the product of average prices and a region-specific rental rate.

[14] World Bank Forest Rents (% GDP). Available here: https://data.worldbank.org/indicator/NY.GDP.FRST.RT.ZS?locations=PE

Peru's forestry sector suffers from insufficient incentives that, added to limited skills and knowledge, reduce its contributions to regional development and achievement of climate mitigation goals. Other contributing factors relate to high personnel turnover in government forestry offices due to a lack of job security, low skills, and inadequate institutional information management infrastructure. For example, incongruent information between forest management plans, volumes and species extracted and traded (USAID-ProBosques 2019). These failures make it difficult to monitor management activities and to assess compliance with existing regulations like timber extraction, shipping and commercialization.

Forest degradation in Peru persists due to illegal timber exploitation despite recent efforts to modernize and strengthen the institutional capacity of the forestry sector. Strides have been made in building skills for monitoring, management and enforcement, including improved timber traceability. Nevertheless, structural challenges remain for the creation and use of adequate forest management plans for which there are insufficient data from permanent plots to set minimum cutting diameters and minimum cutting cycles; lacking these data, the minimum cutting cycle is set at 30 years (SERFOR 2020). At the forest operation level, limitations pertain to a failure to use RIL practices and not applying silvicultural treatments to increase growth and yield.

Peru has gone through several waves of institutional reform trying to achieve changes in the sector, which is widely recognized as corrupt and mostly dysfunctional. To that end and particularly since signing of the free-trade agreement with the USA in 2007, Peru continues to attempt institutional innovations to capture the benefits of sound management. Recent reductions in illegal logging are commendable, but that 37-40% of locally harvested timber remains illegal (Rodríguez 2020; *Consejo de Ministros* 2021) jeopardizes efforts to promote sustainable forest management.

Against this backdrop, the goal of this section is to highlight opportunities and limitations to improve carbon outcomes of managed forests in Peru using the Department of Loreto as a case-study. To that end, we briefly introduce existing initiatives related to carbon-related agendas. Then, based on the results of interviews with a range of actors in the forestry sector in Loreto, *Gerencia Forestal Loreto* (GERFOR) (see Annex 1) and others at the national level, OSINFOR, we discuss the potential for the five mechanisms proposed in this Report to deliver carbon benefits and the conditions under which they may do so.

Obtaining rights to timber extraction

Forestlands in Peru can be owned by the government (public forests; ~ 70%) or private entities, which includes local communities that hold legal tenure rights to ~34% of the national territory (RRI 2020). Ownership categories determine the types of management arrangements. Concessions to publicly owned forests can be granted for up to 40 years for timber exploitation of areas of 4,000-50,000 hectares. This category encompasses 48.5% of authorized forest exploitation. Managers of forest concessions can benefit not only from the revenue from timber sales but also from those associated with the provision of environmental services associated with management.[15]

On private lands, the terms for granting permits (*permiso forestal*) are similar to those for concessions. Timber harvesting permits for community lands account for 34.4% and those for private lands for 8.4% (PCM 2021b). Private and community forest owners can also benefit from sales of ecosystem services (e.g., carbon), as established for concessions.

For both concessions and private lands, timber is allowed to move along the value chain only with an official transportation guide (*guía de transporte forestal*) that details the volume and species of timber harvested (*oferta efectiva*) based on the specific volumes and characteristics (*oferta potencial*; SERFOR, 2015). Harvestable volumes and species' information, including provenance, are to be specified in an operation plan that describes proposed activities for 1-3 years in blocks of 400-500 hectares but up to 1000 hectares. The overall management operation and its long-term sustainability goals are described in much detail in the forest management plan (FMP) outlining all activities for the whole management unit to facilitate implementation,

[15] i.e., "así como derecho *a los beneficios procedentes de los servicios de los ecosistemas que se desprendan de su manejo", OSINFOR 2018.*

Checking the health of trees in forest concessions, Loreto, Peru. USDA Forest Service photo by Liliana Lizárraga

monitoring and control. Based on the FMPs to which we had access, much of the information included is simply copied from one plan to the next and little of direct relevance to forest harvest operations or other aspects of management are included. Although liberation thinning, liana cutting, and enrichment planting are all mentioned as silvicultural interventions, no specifics are provided about the actual application of these treatments (e.g., how many trees, of what sizes, or etc.; Kometter and Reynel 2006).

Obtaining carbon rights

Peru is one of the few countries that ties carbon rights to land rights, including community rights to carbon based on activities on their lands. The country also established a regulatory foundation with specific definitions regarding carbon credits and processes for credit validation, registration, and trading (RRI 2021). Although safeguards for grievance resolution were designed, they are not yet operational and there is still a need to design benefit-sharing mechanisms. This ongoing set of processes around REDD+ guidelines include broad public consultations and is led by the Ministry of the Environment. It has six main elements that are expected to be finalized by November 2022: emissions registration and contribution to NDC, conflicts and dispute resolution, activity implementation and institutional arrangements, nesting protocols, safeguards, and benefits-sharing (*Ministerio del Ambiente* 2022).

Forests in Loreto

Loreto, the largest department in the country, covers 29% (38.8 million hectares) of the national territory with 13% of national forest cover. Of the close to 36.8 million hectares of natural forest in 2010 (~98% of Loreto's area), 34.4 million hectares remain. Of the remaining, 9.8 million hectares correspond to production forests that yield about 39% of Amazon timber production (i.e., 657,000 m^3; USAID 2019;

SERFOR 2020). Almost a third of granted timber harvesting rights are in Loreto (28.5%; USAID 2019). In 2021, the department lost 41,000 hectares of natural forest (i.e., 29 Mt of CO_2 emissions; GFW 2022[16]).

As a result of a forest zoning process, about 12.4 million hectares in Loreto are designated as 'of high conservation value, with protected areas and biodiversity special zones. They are not legally allowed to be logged. There are about 110 logging permits in private lands (~21,000 hectares) and ~ 44 active concessions (231 granted; Vergara 2019; ~1.1 million hectares) out of 827 at the national level, which cover ~11.1 million hectares (SERFOR 2020). More updated figures show 80 operations active in Loreto versus 361 inactive ones (~3.6 million hectares; FOREST 2022). 56% of authorized operations are not active nationwide (SERFOR 2020), leaving almost 60% of the commercial volume that could legally be harvested, unharvested. This is reportedly due to high operation costs, of which 36% correspond to transportation, and low timber prices (SERFOR 2020). One concessionaire we interviewed mentioned that logging operations were rendered impossible for an increasing portion of the year due to increased frequencies of rains during what was historically the dry season. Even a small amount of rain can render dirt hauling roads inoperable for several days. As a hypothesized local effect of global climate change, this phenomenon deserves careful evaluation.

One complaint mentioned by our interviewees is based on the claim that only operations greater than 40,000 hectares can be profitable for reasonably well capitalized FMEs, for example those that own at least one skidder, bulldozer, excavator, and road grader. This is especially true if they operate legally, but these large operations represent only 6% of all granted concessions. At the other end of the continuum of capitalization of forestry operations, a few workers with a functional chainsaw or even a two-person ripping manual saw, can profitably operate in much smaller areas. Similarly, small-scale agroforestry actors can profitably manage small areas of forest and forest plantations if allowed to do so (Putzel et al. 2012; Mejía et al. 2015; Sears et al., 2018). This means that when the large operators cease logging, others with less overhead will likely step into the breach unless actively prevented from doing so with credible threats of detection, capture, fines, loss of equipment, or incarceration.

Illegal timber harvesting is a lingering problem in the forestry sector. Although the extent of illegality has been reduced from ~80% to 37-40% (EIA 2012; Rodríguez 2020; Consejo de Ministros 2021), governance failures[17] and weak traceability remain structural problems for the sector. These systemic failures reflect overall governance limitations as Peru ranks 105th on the Transparency International Corruption Perceptions Index (TICP 2021). Sadly, the forestry sector in the Peruvian Amazon has hardly changed in the years since Smith et al. (2006) wrote:

> "In Peru, governance failures that have promoted norms inconsistent with good management are government's perceived lack of interest in long-term timber management, inconsistent forestry laws, perceived discrimination against the timber sector, and ineffective law enforcement. As a result of decades of these governance failures, loggers developed a short-term perspective on timber extraction and felt entitled to violate government's laws. Poor logging practices continued under the new law because of governance failures. The Peruvian experience shows that changing laws radically is often easier than avoiding governance failures in implementation."

Although the focus of this Report is on carbon-related aspects of forest degradation, it seems relevant to mention a more insidious and widespread type of degradation: defaunation by wildlife poachers whose access to the forest interior is facilitated by logging roads. Defaunation is so widespread in the Peruvian Amazon that it could indirectly affect forest carbon stores because some of the extirpated species are critical for dispersal of the large seeds of trees that grow to be large and store great quantities of carbon (Peres et al. 2016). Fortunately, when hunting is controlled wildlife populations can recover quickly. The authors of this Report observed this recovery in a concession in Amazonian Bolivia (La Chonta Forest Concession) and in the Los Amigos Biological Station in Madre de Dios, Peru in which strict controls on hunting were implemented.

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[16] Global Forest Watch (GFW) available here: https://www.globalforestwatch.org/

[17] This includes monitoring and enforcement of regulatory frameworks, corruption, slow transition from centralized to regional control; Sears and Pinedo-Vásquez 2011.

State of Carbon Management Initiatives in Productive Forests

Ongoing national/ regional/ local strategies

The Peruvian government signed the Paris Agreement in April 2016 with commitments to reduce emissions in all sectors by 20% by 2030. These emissions derive from the energy, industry, waste, land use and agricultural sectors, with agendas that include adoption of adaptation and mitigation measures. Peru subsequently formulated its NDCs and increased these determined contributions by 10% in 2020 to achieve reductions of up to 30% by 2030. This is the equivalent to 208.8 Mt CO_2e by 2030 (non-conditional goal), however without financial support, that commitment declines to 179 MtCO_2e (*Ley Marco sobre Cambio Climático del Perú -2018*, Gobierno de Perú 2020).

Along with specification of sectoral goals, several mechanisms have been created to enable participation of civil society in the design of strategies to adapt to and mitigate climate change. These actors and processes were formalized through the 2018 *Ley Marco sobre Cambio Climático* that lays out the principles and general concepts needed to design, coordinate, implement, monitor, report, and communicate public policies in a transparent manner. Sectoral contributions are to be recorded through the national registry (*Registro Nacional de Medidas de Mitigación -RENAMIRE*) as a basis for proper assessment of carbon markets.

The Peruvian national government is endeavoring to consolidate policies that link initiatives and articulate legal frameworks that address climate change. These included the approval of the *Estrategia Nacional sobre Bosques y Cambio Climático (ERCC) 2019*, which aims to reduce forest loss and degradation, improve landscape resilience, and reduce vulnerability of local and Indigenous communities. Efforts are currently underway to include enhanced carbon removal in the country's carbon policy. The Climate Change 2018 Law was later refined in 2021 with specific definitions of roles, responsibilities, and typology of activities and legal frameworks in the context of REDD+ (*Lineamiento para la Identificación y Clasificación de las Acciones REDD+*). One recognized activity is sustainable forest management.

More recent moves by the Peruvian government have framed climate change strategies within larger national agendas to reduce climate risks and strengthen disaster management capabilities. As such, and to enhance coordination among agencies, actors and different sectors of national, regional, and local governments, and country leaders recognized the need to develop specific actions towards carbon neutrality so that global increases in temperature can be maintained below 2°C.

Acknowledgement of the urgency to act implied both the formalization of the climate emergency as a matter of national interest and a strategy to accelerate cross-sectoral action. This important decision obliges regional and local governments to design and implement local mitigation and adaptation plans. This call was extended to all representatives of civil society so they would assume more active roles. Activities include improving climate change literacy and strengthening of information management systems (e.g., monitoring, early detection) that include biophysical, environmental, socio-economic (inclusive of public health) aspects, as well as expected climate change impacts on financial flows. The Ministry of Economy and Finance is specifically tasked with setting a carbon price and expanding on land titling to local communities to achieve the target of 55% of the national territory titled to Indigenous and Afro-Peruvian communities (RRI 2021).

Development of Loreto's Low-Emission Rural Development Strategy

In response to consistently increasing regional deforestation, the Government of Loreto included goals to reduce deforestation in a variety of its regional public policies. The 2015 *Plan Concertado de Desarrollo Regional (PDRC)* for the department included a target goal of no more than 1.5 million hectares of forest clearing by 2021 (GOREL 2015). The *Estrategia Regional de Diversidad Biológica (ERDB)* and the Regional Strategy for the Management of Regional Conservation Areas included goals to increase the land area designated as protected areas or other conservation units. Finally, the regional government proposed an ERCC that identifies measures for the minimization of climate risks in addition to general actions for mitigation and adaptation to climate change. However, no strategy to coordinate economic development and

environmental protection existed until Loreto received a small grant to develop its jurisdictional low-emissions development strategy ERDRBE in 2018.

As a member of the Governors' Climate & Forests Task Force (GCF-TF) and a signatory of the *Rio Branco Declaration (RBD)*[18], Loreto was eligible for approximately USD400,000 in support from the Norwegian government via the United Nations Development Programme (UNDP) to develop a regional business plan, along with the broader jurisdictional strategy (Stickler et al. 2020). The ERDRBE strategy was developed over the course of approximately 18 months via a participatory process that engaged stakeholders throughout the department in a series of assessments and discussions. Topics included a complete analysis of causes, actors, and processes associated with deforestation and forest degradation, an analysis of the actions necessary to address these problems, as well as of the costs to implement those changes.

The *ERDRBE* development process assessed challenges for the timber sector in Loreto. The following barriers and limitations were identified (GOREL 2021):

1. Lack of data about the timber potential of Permanent Production Forests (*Bosques de Producción Permanente* (BPP));
2. Lack of a seed bank and modern nurseries for reforestation;
3. Difficulties in accessing timber resources;
4. High cost and excessive paperwork to obtain licenses and permits for logging;
5. Limited availability of human and technological resources for adding value to final products;
6. Weak penetration of the financial sector;
7. Limited energy supply with low quality and high cost; and
8. The absence of ships that collect international cargo from the Port of Iquitos.

Additionally, the assessment identified difficulties in forest governance and in the public perception of the forestry sector as informal. This increases its risks and limits access to financing with conditions that encourage sustainability. Of note, quality of forest management was not cited as a problem in this analysis.

ERDRBE Loreto has four strategic objectives that can be broadly classified as addressing protection, production, inclusion, and governance (GOREL 2021). Within these objectives, the strategy identifies 32 performance targets for the region, to be reached by 2030. The strategy defines a medium and long-term vision of 10 years or more, establishing and prioritizing objectives, goals, and interventions. The ERDRBE document notes that it is not designed to replace the regional agreed-upon development plan (PDRC), but instead provides a mechanism for stakeholder participation in the identification of interventions in support of the broader regional development strategy. The ERDRBE explicitly ties its own time-bound, measurable goals to those of Peru's NDC, national climate change strategy, and the Joint Declaration of Intent.

To achieve its targets, ERDRBE divides the region into six territorial development units, *unidades de desarrollo territorial* (UDT), defined by their common biogeographic and socio-economic characteristics. Each UDT is further sub-divided into a total of 49 socio-environmental units, *unidades socioambientales*. These sub-divisions are delimited by the actors and spaces occupied or controlled by the UDTs, such as Indigenous community forestlands, permanent production forests, protected areas, or small family agricultural zones. Within each of these units, a set of interventions is tailored to achieve the specific socio-economic and environmental outcomes. In total, ERDRBE defines 236 specific interventions and another 45 cross-cutting, jurisdiction-wide, interventions among 12 broad groups of interventions. The cross-cutting interventions are designed to advance enabling conditions needed to drive transformational change in the region (but see *Loreto Case-Study Conclusions* subsection).

Main Organizations/ Projects that Support Peruvian Forests

[18] The *Rio Branco Declaration* (2014) reaffirms the commitments of members of the Governors' Climate & Forests Task Force to reduce tropical deforestation, protect the global climate system, improve rural livelihoods, and reduce poverty in their jurisdictions.

Recently, several programs have been part of a larger plan consolidated for tropical forests worldwide (including Brazil, see next case-study), in which different US organizations have a role to play. These include United States Forest Service (USFS), and the Plan to Conserve Global Forests – Critical Carbon Sinks: White House 2021[19] (see Box 5; Annex 3).

BOX 5: PLAN TO CONSERVE GLOBAL FORESTS - WHITE HOUSE 2021

1. **Incentivize forest and ecosystem conservation and forest landscape restoration** through innovative market- and non-market-based mechanisms and results- based financing, to mobilize investment in conservation and enhancements of carbon stocks, sustainable forest management, critical ecosystem restoration, and improved land and forest management actions.
2. **Catalyze private sector investment, finance, and action to conserve critical carbon sinks** by increasing sustainable production and sourcing of climate-smart commodities and services, developing complementary economic development models, and promoting accountability.
3. **Build long-term capacity** to enhance sustainable land use planning, management, and resource governance by deploying technical assistance and new tools; improving enforcement and prosecutorial capacity; and strengthening data, transparency, monitoring and verification.
4. **Increase the ambition of governments and other stakeholders** to set and achieve strong climate and conservation targets, including through diplomatic engagement, policy dialogues, and multilateral fora and institutions.

Implementing Proposed Mechanisms to Improve Carbon Outcomes from Managed Forests in Peru

Overall challenges to improved forest management in Peru relate to high operating costs, especially but not exclusively for transportation. Limited access to affordable capital to engage and maintain engagement in forestry business is also frequently cited as a limitation. More fundamental barriers relate to the *modus operandi* of managers who continue to resist adopting a culture of sustainable forest management. They instead wish to maintain their business-as-usual approach to timber harvesting, without much planning or outside interference. It is distressing that this situation has changed little over the past decades, the descriptions of the problem in Smith et al. (2006) and other early studies still pertain today.

This culture persists despite the new institutional frameworks and sustainability-oriented national goals. According to one study participant, sustainability-concerned professionals working in the sector struggle to convince concessionaires that they should invest in even the timber stock censuses that provide the solid foundation for FMPs and annual operating plans. These expenses are considered unnecessary by many managers who even object to receiving technical assistance for conducting quality inventories. This

[19] Available here: https://www.whitehouse.gov/wp-content/uploads/2021/11/Plan_to_Conserve_Global_Forests_final.pdf

resistance led to the expiration of concession rights of some operations, but after some of these forests reverted to the State, they were subject to land rights' claims, allocated to non-forestry land uses or invaded.

As outlined above, although several organizations invested considerable resources and time to supporting FSC certification adoption, convincing FMEs of the benefits of certification remains a challenge in Amazonian Peru. The main resistance hinges on the problem that certified wood enjoys few price premiums and does not have guaranteed markets. That said, some companies that chose not to pursue FSC certification had their authorizations expired. This is one way that, in addition to sanctions, the government can incentivize improved forest management. Unfortunately, certification, like state-sponsored interventions, involve cumbersome, lengthy, and expensive processes. The door should remain open to incentives-based approaches that support some of the mechanisms below.

Difficulties in obtaining authorizations to harvest timber due to both insufficient personnel in responsible agencies and cumbersome procedures contributes to illegality (Mejia et al. 2015). These conditions are not conducive to management as an ineffective governance environment contributes to more than half of assigned concessions not being active, keeping the overall forestry sector, including transformation and processing processes, from reaching its potential.

Challenges related to climate change, particularly unusual rains during what was historically a dry season, have made matters worse for forest managers. Some concessionaires have decided to drastically reduce their logging operations and diversify their income stream to other forest services, including Green Gold Forestry with carbon payments for not logging and from sales of NTFPs. As mentioned earlier, forest managers can capitalize on benefits associated with environmental services that derive from the management practices they adopt. But, in the case of not logging and the associated lack of management, especially when it occurs in public lands granted as concessions, it has not yet been established how ownership of carbon benefits would be decided and what proportion will be allocated to governmental agencies at all levels (see discussion below of *bonos de carbono*).

Some concessionaires are aware that current harvesting cycles are not sustainable even following the strictest standards from FSC, and they have tried to reduce volumes to keep investments low. This observation matches information provided by a relatively recent assessment of timber harvesting which determined that certified companies were planning to harvest only trees greater than the government-mandated minimum cutting diameter, although this practice does not seem reflected in their annual operation plans (Kometter 2019; SERFOR 2020). The low-quality FMPs continues to be a problem, as does the extremely low implementation of practices established within them ("*No hay manejo forestal*"). This is made worse given some legality gaps, as we discuss below.

Respondents also reported challenges faced by Indigenous communities trying to manage their forests. Timber harvesting is carried out by subcontractors, who fund, run, and profit from the operations. As they are not legally responsible, they often do not follow best practices. This situation has led to several Indigenous communities receiving hefty fines that limited the extent to which they contributed to timber supply chains. More generally and as stated by one of our interviewees, there are not enough trained personnel to carry quality forest management operations.

Roles for IFM in Loreto's Low-Emission Rural Development Strategy

The ERDRBE Loreto includes six performance targets associated with forest management classified as *protection and production objectives* (Table 10). One of these objectives specifically focuses on non-timber forest management, but the others are to be achieved through a mix of native timber management, non-timber forest products, and afforestation/reforestation.

Table 10. The Loreto ERDRBE includes six targets associated with forest management under two of their principle strategic objectives.

Strategic Objective	Target by 2030
Protection Conserve Loreto's forests by adopting measures to confront climate change.	Increase the area of forest under forest management units to 35 million hectares.
	Increase to 5.8 million hectares the area of forest with rights granted for the use of forest resources under effective management.
	Increase to 50,000 hectares the area of forest under sustainable management for non-timber forest products.
	Increase by 3.5 million hectares the area of forest lands on which Indigenous communities sustainably manage forest resources.
Production Achieve productive development of the rural area to generate jobs and well-being in harmony with nature.	Increase forest product exports by USD30 million.
	Increase sustainable rosewood product exports by USD2.8 million.

The ERDRBE includes interventions to encourage what it refers to as 'sustainable forest management' as well as management of forest plantations with native species. Sustainable forest management will be carried out in alignment with the national guidelines approved by the National Forest and Wildlife Service prior to the strategy. The strategy explicitly requires that primary forests not be converted into forest plantations.

More specifically, one of the strategy's 12 broad groups of interventions targets permanent production forests and timber concessions. The BPP category has a total of 29 zones totaling ~9.4 million hectares. The 260 forest concessions located within the BPPs cover a total of ~2.4 million hectares and are distributed in three UDPs: Ucayali, Mariscal Ramón Castilla, and Maynas-Loreto-Requena.

The Regional Conservation Areas, *Areas de Conservación Regional* (ACR) also cites forest management for both timber and non-timber products as a focus. Specifically, sustainable forest management for timber is to be established in one of the four ACRs, the Ampiyacu Apayacu (434,129 hectares), which straddles the Mariscal Ramón Castilla, Maynas-Loreto-Requena, and Putumayo UDTs.

Within the Natural Protected Areas (*Areas Protegidas Naturales*) intervention group, both *National Reserves* and *Communal Reserves* are slated to include forest management for timber, among other activities. The National Reserves are contained in the Maynas-Loreto-Requena, Mariscal Ramón Castilla, and Ucayali UDTs and cover a total area of ~3.2 million hectares. The Communal Reserves occupy an area of 389,115 hectares, distributed in the Maynas-Loreto-Requena and Putumayo UDTs.

Finally, two cross-cutting interventions explicitly target forest management. First, the *Forest and Land Use Planning* intervention focuses on ensuring the appropriate allocation of land and forest rights. The intervention prioritizes finalizing the forest zoning process to continue the forest management planning process. Each portion of the forest estate is assigned to the corresponding management unit and rights are granted to provide legal certainty to all users of the forest while limiting activities to those that are sustainable. The ERDRBE notes that this includes resizing of BPP areas that overlap with lands of Indigenous or local communities, to enable titling processes and inclusion in public registries. This also requires the creation of local forests for small producers, the declaration of protected forests and the granting of concession contracts for agroforestry in special treatment areas. An additional priority under this

intervention is to recognize the rights of riverine populations, which occupy areas suitable for sustainable forest production but lack rights. This prevents development of legal and sustainable enterprises.

Another key transversal intervention is focused on *Boosting Forestry Development*. In part, the intervention focuses on strengthening governance, monitoring and enforcement related to forests and wildlife. This is achieved via the creation of Forest and Wildlife Management Units, the improvement of operational capacity in the field, as well as legal recognition of the corresponding Forest Management and Wildlife Committees. The latter complements the support for and strengthening of forest custodians for forest monitoring to prevent illegal activities of extraction and deforestation. Indigenous communities are key actors in forest production due to the large area of forests they occupy and are slated to receive assistance for improving their technical and financial capacity to manage for timber and non-timber products.

The forestry sector also requires support to promote timber and non-timber forest products and wildlife in different national and international markets. The following factors are important to achieving this: product development and added value processing, provision of information on potential markets, and strengthening of human and technological capacities to write and apply forest management plans. The intervention will also seek financial support for forest product producers through banks and a forestry fund associated with sustainability and legality commitments. Administrative procedures and regulations will be reviewed and simplified to reduce demands that do not contribute to conservation and hinder the legal production of forest products. Finally, the intervention will also focus on improving quality control to ensure legality and sustainability.

Potential for Carbon Payments to Support SFM in Loreto

Peru lacks a formal policy allowing subnational regions to sell jurisdictional credits. In December 2021, Ucayali Region signed an agreement with Mercuria Energy S.A to transact jurisdictional credits (GOREU 2021). However, the national government, represented by the Ministry of the Environment, *Ministerio del Ambiente* (MINAM), cancelled the contract because there is no legal arrangement that permits regional governments to purchase and/or sell credits independently (MINAM-PP 2022).

It is not yet clear whether Peru will have a national program to sell credits despite Norway's provision that it become certified under REDD+ Environmental Excellence Standard (ART-TREES) to continue receiving funding under the Joint Declaration of Intent (JDI). This results-based payment program is intended to contribute to Peru's efforts to reduce deforestation and to develop a verified carbon emission reductions payment program with support from the Governments of Norway, Germany, UK, and USA (Addendum 2021). The first phase of the JDI was initiated in 2014 with support only from Norway and Germany (JDI 2014).

Currently, independent carbon projects are permitted in Peru, although if and to what extent they will continue to be permitted may change as Peru further develops its national climate change strategy. At the time of writing, the International Database on REDD+ projects, IDRECCO, (Simonet et al. 2016) lists two on-going ARR projects that include timber production as one of their objectives. One focuses on shade-grown coffee and cacao, the other focuses on conversion of pastures to plantations of exotic trees. The VCS registry lists one IFM project (Green Gold), whose objective is to cease logging operations and manage the portion of its concession in the project area as protected forest (VCS 2022; Table Annex 2).

Mechanism 1. Use of RIL practices

Interactions with several different types of actors in the forestry sector revealed the lack of systematic adoption of RIL practices or an adequate understanding of what is involved. Moreover, although RIL adoption is recommended in legal frameworks, it is not required. Despite Verra's efforts at defining additionality to avoid this problem, making RIL practices mandatory could reduce prospects for additionality. For example, whether paying to obey the law may dis-incentivize proper management through rewarding 'poor' performers.

Formal training of logging crews was common in the early 2000s. These courses have all but stopped. For example, IFT trainers from Brazil ran several courses in Peruvian concessions. Other training was provided

early on by CATIE (*Centro Agronómico Tropical de Investigación y Enseñanza*), and some of the trainees replicated this training in other concessions. Later, the World Wildlife Fund (WWF) worked with a small service company that provided RIL training and monitoring services. As part of REDD+ initiatives supporting timber concessions, several RIL-focused training sessions were run for operators in 2011-2013 (CCB 2014). Some certified companies then continued the training with their own trained personnel but overall, RIL training was not provided as part of a systematic capacity-building strategy. Unfortunately, the prevailing concept of what constitutes RIL has deteriorated to only directional felling.

Technical capacity also needs to be built at the forest manager level (*regentes*, as designated by law in Peru) but high turnover is a disincentive for FMEs to support this activity. One respondent suggested that RIL training could be incorporated into the local technological institutes as part of the forestry experts' curriculum. Unfortunately, not all Peruvian staff have formal technician training in forestry. Hopefully the training planned for Peruvian forestry technicians in RIL-C by Conservation International will at least temporarily and locally overcome an important bottleneck for quality monitoring. Nevertheless, the training service they provide needs to be adopted by a Peruvian governmental or non-governmental organization for structural improvement.

As stated by one study participant, RIL adoption was motivated by the desire for forest certification, but the focus was more on environmental impacts than on productivity and performance. There have not been quality assessments by FSC auditors of RIL implementation in certified firms. This is unfortunately typical of certification audits everywhere (Romero and Putz 2018; Ellis et al. 2019). The availability of the RIL-C protocol to assess carbon emission consequences of RIL-adoption should guide surveillance activities and measurement of C-outcomes (Goodman et al. 2019).

The study by Goodman et al. (2019) used the RIL-C protocol to measure carbon emissions from selective logging in nine concessions in Madre de Dios Province, five of which were FSC certified. The study reported that carbon emissions could be reduced by 54% through the application of RIL practices by properly trained workers. Carbon emissions were not lower in the FSC certified concessions and were dominated by decomposition of the portions of felled trees that remained in the forest. This finding coupled with comments from several interviewees' points to the relevance of the reduce wood waste pathway discussed below (Mechanism 2).

As noted by several interviewees, working in forestry in Peru is not an attractive career path. They advised that the provision of staff training in improved forest management might promote worker retention and attract new workers to the field.

Recently, in support of conservation concessions, or the stop logging pathway, USAID-sponsored project staff reached out to regentes and concessionaires with inactive operations to promote abandoning the prospect of logging in order to become eligible for carbon credits payments. According to one Peruvian professional we interviewed, logging concessions granted by public auction assign to the concessionaires the responsibility to perform activities related to timber management. Concessionaires pay royalties to the government based on their harvests, i.e., per cubic meter harvested, and an annual harvesting fee determined by a proportion of the tax unit to be paid irrespective of whether concessions are active or not.[20] Respondents stressed that the timber management activities undertaken provide jobs and support local economies as the timber they harvest enters market chains, along which more jobs and more revenue is generated. Concessionaires who seek carbon payments for not logging would still presumably pay the annual fee, but otherwise would not contribute to the economy.

Conservation concessionaires are required to comply with current regulatory frameworks and would require governmental confirmation via credit registration in *El Registro Nacional de Medidas de Mitigación* (RENAMI). The same rationale applies for Indigenous communities who have valid timber harvesting permits: they can also receive compensations from the environmental service benefits provided and need to follow credit registration. Depending on the size of the carbon payments, this not logging option would be financially attractive particularly to concessionaires with poorly stocked concessions due to previous harvests or other factors, extremely high operating costs, or other impediments to making profits from

[20] For example, 0.01% per hectare; the tax unit is currently PEN 4,600.

timber. Of course, for such concessionaires, any claims of additionality of not logging would be seriously suspect.

Conservation concessions supported by carbon payments for avoided emissions suffer from several problems. First, if a forest would not have been logged anyway for a variety of reasons (lack of infrastructure, poor stocking, labor shortages), then the intervention lacks additionality and should not be eligible for carbon payments. For forests that would have been otherwise logged, both activity-shifting and market leakage would be likely. Although the area might not be profitably harvested by a highly capitalized firm with high operating costs, smaller operators might log profitably, which increases the risks of illegal logging and jeopardizes the expected permanence of protection. Finally, this intervention seems like a classic case of a private benefit taking priority over a public benefit, considering that the benefits of active forestry include royalty payments as well as benefits along the value and supply chains (e.g., jobs). It is unclear whether regional agencies, which should support decisions that are in the regional interest, and other affected actors have been part of negotiations towards not logging forest logging concessions, thereby missing all the above-mentioned benefits.

Several interviewees were adamant that forestry, with proper support and clear guidelines, generates incomes for numerous actors at local, regional, and national levels (*activa la economía*). Interviewees opined that conservation concessions, in contrast, remove any hopes for forestry-related socio-economic benefits in areas where other sources of income are scant. As mentioned earlier, benefit distribution seems unclear in these cases. For instance, as revealed by one interviewee, some permit holders claimed REDD+ related benefits linked to land use, but there are several elements with which compliance is required for this to be possible or at least legitimate (e.g., FPIC, registration of credits in national registry, demonstration of safeguards and benefit-sharing distribution with stakeholders). Likewise, it needs to be determined how the carbon credits generated by privately registered-emissions activities which relate to deforestation/ degradation, figure into satisfaction of the government-established NDCs. One interviewee mentioned that 30% of the credits from private projects are to be retained by the government to satisfy its NDC. However, we failed to find confirmation of this claim and one expert interviewee clarified that discussions about benefit-sharing processes are ongoing and the policy may vary with the type of market (e.g., voluntary). In contrast, a recent publication from the Brazilian REDD+ Alliance (Moura Costa et al. 2020) states quite clearly that Article 6.4 of the Paris Agreement allows that private sector use of carbon credits to meet their corporate environmental responsibility goals does not affect the use of the same credits to satisfy the NDCs in the host country.

Mechanism 2. Improved wood utilization from felled trees and reduced waste

One general impediment to efforts to reduce wood waste in Peru is the prevailing culture of forest management that starts at the highest level all the way to ground operators. This informal system of norms is resistant to change and not incentivized to overcome problems, particularly when change is not legally required.

In the case of reducing waste and improving wood utilization, which are major problems in Peruvian FMEs, lack of appropriate equipment may render use of branches and small log sections difficult, particularly given the long distances that need to be traversed to access these materials. Not many species will be of value for this type of investment. This impediment notwithstanding, we note that chainsaw lumber is commonly produced from such materials in Peru and other geographies.

One study participant described the results of an unpublished cost-benefit assessment in Madre de Dios on large branch wood utilization for sawn-timber using machinery already owned by the concessionaire. The analysis revealed a negative financial outcome due to the high costs of moving and sawing branches, coupled with the low sale price for the wood. The interviewee suggested that use of other processing technology (e.g., portable sawmills) could have led to different outcomes. The costs of working in the field are so high that technological innovations might not make a major difference. For a while, one company ran a band sawmill in the middle of the forest, but that operation was abandoned due to the high cost of transporting both workers and sawn wood. Another recent study in Ucayali demonstrated that for every felled tree of tornillo (*Cedrelinga cateniformis*) one meter^3 of wood was wasted in branches less than 30 centimeters in diameter and less than 90 centimeters long (Zamudio, unpublished document). These losses, which were

also reported by Goodman et al. (2019), translate into governments receiving lower royalty payments than possible from trees already felled, because those royalties are assessed based on timber volumes transported out of the forest (*guia de transporte forestal*). Furthermore, waste of usable wood represents losses for the concessionaires who, along with neighboring communities, could be earning additional income if the operating cost problems can be overcome with new technology and marketing. We also suspect that the financial feasibility of waste wood utilization is better for the higher valued woods such as mahogany, but this remains to be investigated.

Another example worth mentioning is not felling trees that have poor form or that are hollow. One interviewee stated that it would seem "Peruvian forests have no hollow trees," as all trees marked for harvesting seem to be successfully transported and commercialized. Apparently, there is a common practice of utilizing felled hollow trees that yield no commercial timber to launder timber harvested without authorization. For example, timber from the felled hollow trees is replaced by timber from trees from outside the designated logging compartments within the same concession/ permit, or worse, beyond its boundaries.

Mechanism 3. Reduce Harvest Frequency or Reduce Logging Intensity

Harvesting cycle extension is something that some respondents suggested could be tested but more information would be needed to understand the consequences, economic and otherwise, of this modification of management. Previous assessment determined that cutting cycles of less than 30 years did not allow the full recovery of the species with respect to the volume harvested within the first cycle (Kometter 2019). The reality is that following the current rules concerning cutting cycle duration will remove any potential scope for technical and economic sustainability of timber harvests from concessions.

Mechanism 4. Apply silvicultural treatments to enhance growth

Forest management plans currently lack details about silvicultural treatments such as how many trees should be liberated from lianas. More fundamentally, information from the forest inventory is rarely used to promote stand development and the sustainability of future harvests (Kometter and Reynel 2006). This situation was confirmed by one of our interviewees, who stated that forest agencies require certain silvicultural practices, but they do not provide specific guidance. For example, managers are required to retain ~20% of inventoried individuals as seed trees, but it is not clear whether this proportion is based on science.

A respondent reported that lianas are cut on trees destined to be harvested, on seed trees, and sometimes on FCTs during census data collection about six months prior to harvesting in some certified operations, but the sizes and numbers of treated FCTs are not clear. There are no other silvicultural treatments applied and forest managers are reluctant to do anything not demanded by law. When silvicultural treatments are mentioned in forest management plans, the specifics are not clear and the costs are not estimated, which leaves forest managers with no clear signals about what, beyond timber harvesting, they should be doing to improve timber stocks (Kometter and Reynel 2006).

During interviews with 15 different people involved in the forestry sector, some interest was expressed in the carbon enhancing pathway FCT Liberation from Lianas in logged-over forests. Representatives of Indigenous groups that recently regained control over their traditional forests were particularly interested. The forests they now own are fairly small (3000-5000 hectares) and liana-laden trees are common due in part to previous episodes of logging. Nevertheless, small-scale logging continues. We provided background information that included suggested costs and carbon benefits, but the people with whom we interacted were new to carbon markets and did not seem to recognize the potential. Given what we learned through these interviews, one of these forests might be an excellent setting for a demonstration project. We note that Conservation International plans to pursue this option with Indigenous communities in the region but has yet to settle on a demonstration site.

Mechanism 5. Tree-planting in accessible degraded areas

This activity is apparently not implemented in forest concessions, but one interviewee suggested light-demanding species (e.g., mahogany) could be planted in harvesting gaps. One impediment to this intervention is the regulation that logging areas be closed once harvest operations have concluded. Given the need to tend planted seedlings for up to five years, this regulation would preclude successful enrichment planting. Another participant suggested this option would be desirable in burned areas such as the Tahuamanu Province, Department of Madre de Dios.

In contrast to logging concessions, some smallholders in Peru do plant and tend timber tree crops, but the scales of these operations are not known. Interestingly, both fast-growing low-value timbers, like *Guazuma crinita* (*bolaina*; Putzel et al. 2013) and slow-growing high-value timbers, like *Dipteryx* spp. (*shihuahuaco*; Putzel et al. 2012) are planted in stands degraded by logging as well as in agricultural fallows. Follow-up studies on these smallholder forest management systems seem warranted. Regulatory restrictions on small-scale forestry were reportedly severe a decade ago when the studies were published, but perhaps work-arounds have developed, or the regulations have been changed or are not enforced.

Recommendations

As an element of the required cultural change of the Peruvian forestry sector, it is important to complement the sanctions-based rationale with a conditional incentive-based system to improve management. As demonstrated for the Peruvian Amazon, a punitive approach that is inadequately implemented or not sufficiently stringent will not eliminate illegal behavior (Smith et al. 2006, Anderson et al. 2019). Incentives can come in many forms and should be employed at different levels of the timber supply and value chains, from the FME managerial level to forest operators, sub-contractors, and others. Better definitions of the required practices and more precise guidelines are needed to reduce room for interpretation and close loopholes, as well as to promote improvements in forest management and to facilitate supervision of forest workers up to the level of FME managers. Improvements would include promoting rights to carbon benefits under different forest management regimes and contributions to NDCs from different actors in the sector. Governmental action can indeed reduce illegal resource use and land use change, as demonstrated for deforestation in Madre de Dios (Montoya-Zumaeta et al. 2022). Clarity and incentives may also help push local governments to organize the management of their municipal forests.

One commonly reported bottleneck for improved forest management practices is a lack of trained staff. One respondent suggested that RIL training could be incorporated into the local technological institutes as part of the forestry curricula. It would help if free courses on different aspects of RIL, including improved felling and bucking, skid trail planning, were offered within the framework of the technological training. This could include Indigenous communities through their forest supervisory offices. Some trainees can become future trainers.

One participant shared a checklist used to evaluate the capacity of chainsaw operators to fell trees and buck logs for yarding in ways that minimize waste. This draft standard (*Estandar de Competencia Laboral de Operaciones de Tala / Corte de Árboles Aprovechables*) contains several indicators of the expected behaviors and knowledge, and includes proper use of personal protective equipment (CITEForestal, and *Ministerio del Trabajo y Ministerio de la Producción* 2022). It is not clear how and by whom this checklist is meant to be used, but that the Ministry of Production provided these guidelines suggests that integration and coordination between trainers, governmental agencies, and sponsors of capacity-building activities is ongoing. Generating a learning network that includes companies and other institutions that implement and uphold good practice standards seems worthwhile and could be articulated with existing efforts through the *Mochila Forestal* implemented by OSINFOR and others. Production of short training and demonstration videos, if properly framed, could be a worthwhile investment.

In terms of specific mechanisms, RIL could be made mandatory, as were inventories and management plans a few years ago. This additional requirement would undoubtedly be resisted by many forest managers. One

regulatory mechanism would be to link continuation of logging permits to satisfying the requirements for RIL, as determined by the RIL-C protocol. One interviewee suggested that OSINFOR could oversee this mechanism, thereby taking over from researchers and NGOs. If permitted, FMEs could adopt RIL through participation in carbon markets on their own or as nested projects within jurisdictions.

A quantitative assessment of the economics of wood waste reduction by utilization is needed to assess the viability of this pathway towards improved forest management and to inform any regulatory frameworks needed for its application. One interviewee suggested that this practice could be monitored by SERFOR. This seems to be a potential area of future work that could contribute to improved forest management and carbon outcomes.

Organizations with forestry-related programs should provide additional opportunities for practitioners to learn about the different realities of the forestry sector within Peru and abroad. These initiatives include USAID-USFS (Forest Project), ProBosques, Forest Law Enforcement, Governance and Trade (FLEGT) and Lacey Act, and GIZ. Other projects run through NGOs, including Conservation International, could sponsor these opportunities for practical learning and experience exchange.

The ERDRBE described above includes interventions to encourage sustainable forest management and the management of plantations of native species. But processes to define a common vision at the regional level on the use of territory with green growth or low carbon approaches, agreed by the key actors, are still unfinished. Although Loreto has a deforestation reduction goal in the PDRC, the proposed indicator is not compatible with the Rio Branco Declaration--now restated within the Manaus Action Plan (GCF-TF 2022)- or the indicator used for future result payment systems (Stickler et al. 2020). Furthermore, the PDRC does not consider specific goals for addressing the main causes of deforestation or forest degradation (Stickler et al. 2020). In this sense, it has been determined that although there are good steps towards building a planning instrument that guides fulfillment of the goal of the Manaus Action Plan in the Loreto region, these advances must be strengthened to reduce deforestation and forest degradation in this jurisdiction.

The ERDRBE should formulate and launch sufficiently detailed mechanisms through which SFM can become a reality in concessions, private areas and bosques locales. This could be achieved through increasing capacities to carry out forestry management, including agroforestry and other integrated land use management systems that consider timber harvesting. Appropriate indicators are needed that will link program goals with actions taken on the ground. In that sense, increasing the area under forest management, promoting monitoring and enforcement, and improving access to markets as proposed in this overarching plan are commendable goals. Nevertheless, they risk being aspirations that will fall short of achieving results if major investments are not made to improve forestry practices through training and planning, an effective system of incentives, and if monitoring systems through meaningful indicators cannot reveal progress made and limitations found along the way.

Finally, Projects that are about to start should consider information in this Report, for instance *S* from GIZ in Peru. Even if specific recommendations are not followed, at least putting this new synthesis of carbon enhanced outcomes through IFM could steer activities in more strategic and productive manners.

Case Study Mato Grosso, Brazil

Forest Sector Characteristics and Trends

Brazil holds about one-third of the world's remaining primary tropical forests, around 60% of the Amazonian forests, with close to 400 million hectares lost since the 1970s. Deforestation accelerated when the Brazilian government advanced aggressive plans for colonization and development of the region, for example through infrastructure development - which continues to this day.[21] In the 1970s, estimates of forest cover were at 88% of the national territory, or 851 million hectares of which only 456 million hectares remained in 2017 (IBGE 2019).

Almost three quarters of forests are public (70%-75%) and the remaining are private. Indigenous lands account for 23% of the Brazilian Legal Amazon and 2.3% more of this area awaits legal recognition (RRI 2021). The great majority of the forest in Brazil (98%) is in the Amazon (ISA 2021). There are major risks associated with ill-defined property boundaries or ambiguity when these registers show major overlaps with already designated or still undesignated lands (Azevedo-Ramos et al. 2020). These authors established that undesignated public forests, which covered roughly 65 million hectares in 2019, overlapped by about 10% with other already designated land categories. Of the remaining ~50 million hectares, 2.5 million hectares was deforested between 1997-2018. This deforestation led to about 1.2 Gt CO_2e in emissions (Azevedo-Ramos et al. 2020).

Brazil's National Institute for Space Research (INPE) carries out a monitoring program for deforestation and degradation in the Amazon. The program uses two operating systems, PRODES and DETER, which have complementary goals. Since 1988, PRODES has provided a continuous record of annual deforestation (forest clearing) of areas greater than 6.25 hectares, using satellite imagery and a combination of automated and manual geo-processing. DETER tracks both deforestation (DETER-A, since 2008) and degradation (DETER-B, since 2015) at a monthly frequency (Assunção et al. 2019). Originally using lower resolution imagery and mapping areas of clearing 25 ha or greater, it now detects clearing and degradation of 1-3 ha and above. Brazil is the first tropical nation to reliably and credibly document and make this information publicly accessible. Several other non-governmental initiatives also provide carry out monitoring and mapping, including MapBiomas (annual deforestation, degradation, and regrowth at 30x30 m resolution) and the Deforestation Alert System (SAD), operated by the *Instituto do Homem e Meio Ambiente da Amazônia* (IMAZON) (monthly reports of deforestation and degradation of areas greater than 1 ha) (Imazon 2022).

The principal drivers of deforestation in Brazil include forest conversion, often in the context of land grabbing, for pasture, farmland, and plantations, as well as surface mining, infrastructure development that could include increased access, and intense fires. Insecure land tenure, corruption and policies that prioritize conversion over conservation, and poor law enforcement all favor the land grabbing and speculation that leads to extensive forest clearing. Land grabbing continues; the BBC recently revealed that Amazonian forests on indigenous lands were being sold through Facebook (Fellet and Pamment 2021).

Brazil witnessed several waves of deforestation, with low rates observed during periods of increased enforcement and strong regulatory frameworks. Among the most relevant efforts to reduce deforestation were the Action Plan for the Prevention and Control of Deforestation in the Legal Amazon (PPCDAm), launched in 2004, reformulation of credit allocation policies, and cadastral updates. The combined action of these innovative instruments led to a decline in deforestation rates by almost 80% between 2005 and 2012 (Barreto and Muggah 2019).

Nepstad et al. (2014) suggested that 2004 marked the commencement of a period of improved law enforcement due to establishment of initiatives such as DETER, PPCDAm, the expansion of protected areas in the Amazon, as well as the Amazon Soy Moratorium proposed and championed by Greenpeace. These initiatives contributed to reduced deforestation by increasing risk faced by those failing to comply with legislation. In addition, to gain access to credit, landowners were required to register their property

[21] At the time of report revision, IBAMA gave the preliminary licensing to continue the paving project of BR 319, increasing the prospects of new projects arriving to the regions.

boundaries with the state environmental agency, which facilitated monitoring for compliance (Nepstad et al. 2014, West and Fearnside 2021 provide more comprehensive analyses). However, the effectiveness of command-and-control policies and law enforcement depend on the government's sustained political will, which is affected by the state of the national economy as well as by political cycles (Ruggiero et al. 2021).

Technological innovations helped implement the PPCDAm and related instruments, including the above mentioned Amazon Soy Moratorium launched in 2006. Improved forest monitoring using satellite-based tools helped to target field operations to enforce regulations. This can be seen with *Operação Curupira* in Mato Grosso for the years 2005-2006 and more recently *Operação Verde Brasil* between 2021- 2022, which resulted in the collection of BRL142 million in fines and tackled 1,835 forest fires.[22]

Other proposals for addressing forest loss articulated during 2006 provided incentives to utilize highly degraded lands, expand protected areas and indigenous reserves, and allocate logging rights through a concession system. Early that year, the Brazilian Congress approved the Law of Public Forests Management (LPFM) (Law. 11284/2006), which regulates management of public forests and aims to stimulate long-term investment in sustainable forest management. Public forests are under the management of the *Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis* (IBAMA) and ICMBio. The *Serviço Florestal Brasileiro* (SFB) prepares an annual plan for granting concessions specifying goals and target areas for concession establishment (PAOF 2021; 2022). With 1.26 million hectares currently in federal forest concessions, the goal of the *Plan anual de oferta forestal* (PAOF) 2023 is to include an additional 4.15 million hectares, mostly in the states of Amazonas, Pará, and northern Rondônia.

Between 2013 and 2018, deforestation rose by ~70%, with many land users emboldened by the regulatory changes (Barreto and Muggah 2019). The "new" Forest Code gave amnesty to landowners who had cleared forest/native vegetation beyond that permitted by legal reserve criteria (e.g., 80% legal reserve in Amazon forest biome, 35% legal reserve in Cerrado, etc.) prior to 2012. It also reduced the area under strict protection by re-gazetting some protected areas. In the amnesty process, fines could be negotiated and were typically reduced. In unsettled public lands, about 20% of all recorded forest losses in the Brazilian Amazon occurred between 2019 and 2020 (IPAM, 2021). Deforestation in the nine Amazon states increased by 9.5%, while prosecutions fell by 42%.

Unfortunately, the shifting policy landscape that responds to various visions for the region led recently to substantial increases in forest loss. The trend continues as deforestation in the Brazilian Amazon grew by 29% in 2021, the highest rate reported in the last 14 years. This equates to more than one million hectares, of which 47% was in Federal public protected areas.[23] In May 2022 alone, 147,000 hectares were deforested, while degradation affected 6,500 hectares (IMAZON 2022). Over half of the deforestation (60%) occurred on private lands, with 16% in conservation areas. Purposeful budget reductions for land monitoring have limited the government's ability to enforce its policies. In 2020, for instance, the budgets of responsible agencies were reduced by close to 10%, then by another 27% in 2021 (*Observatório do Clima* 2021). Moreover, inconsistencies were identified in the information provided for 21% of the authorizations for verified logging, affecting an area of 30,000 hectares (Silgueiro et al. 2021).

The fine amnesty process (*conciliação*) has been disappointing. Only five of the seven thousand hearings that were supposed to be held have happened. In 2020, of the BRL1.79 billion in fines, equating to around USD370 million at the time, only three were effectively paid (*Observatório do Clima* 2021; Coelho et al. 2022).

Forest degradation

The area of Amazonian forest degraded annually is about the same as the area deforested (SPA 2021). The threat of fires to forest management and associated economic losses have been estimated to affect 2% of the designated management area for timber production, mostly in areas close to the agricultural frontier (de Oliveira et al. 2018). A recent study revealed that degradation caused both by human and natural causes, and their interactions, released three times as much carbon as deforestation between 2010-2019 (Qin et al.

[22] https://www.gov.br/pt-br/noticias/meio-ambiente-e-clima/2019/10/operacao-verde-brasil-aplica-cerca-de-r-142-milhoes-em-multas-e-combate-1-835-focos-de-incendio [Accessed May 2022].

[23] IMAZON. https://imazon.org.br/en/imprensa/deforestation-in-the-brazilian-amazon-grows-29-in-2021-and-is-the-highest-in-the-last-14-years/ [Accessed May 2022].

2021). For instance, this combined degradation might look like damaged trees and leftover branches, caused by poor selective logging, serving as fire fuels under drought conditions. These results confirm those from a previous assessment, which established that from 1992 until 2014, the area of Amazonian Forest in Brazil that was degraded, approximately 33.7 million hectares, surpassed the 30.8 million hectares that were deforested (Matricardi et al. 2020).

The Forest Code

The Brazilian Forest Code (FC), (formally known as the *Native Vegetation Protection Act*) is the principal instrument for protecting forests on private rural landholdings (Stickler et al. 2013). It requires landowners to maintain a percentage of their land—known as the *Reserva Legal* (RL)—in native vegetation according to the biome in which the property is located; in the Amazon forest biome, this percentage is 80%. Economic activities are permitted in the RL once a management plan has been approved. Producers may include exotic species within RLs when recovery actions are needed to achieve the minimum threshold. Allowed activities include selective timber harvesting and the collection of NTFPs, including fruits, lianas and seeds, in limited and defined quantities. The use of the RL for commercial purposes requires authorization, cannot reduce forest cover, or change land use, and should not threaten the conservation of native vegetation in any way. Non-commercial uses are permitted but must be reported to the environmental agency. Finally, the FC establishes the need for the maintenance and recovery of native vegetation in *Areas de Preservacao Permanente* (APPs - Permanent Preservation Areas). These include riparian and steep-sloped areas, and wetlands.

The FC also requires landowners to register their properties in the *Cadastro Ambiental Rural* (CAR)—Rural Environmental Registry—which records geographic boundaries, environmental characteristics, land uses and legal sub-divisions, among other information, for each property. The CAR comprises a database to support environmental and economic planning, monitoring and enforcement, including combating deforestation and forest degradation.

Alongside the CAR, the *Programa de Regularização Ambiental* (PRA) -Environmental Compliance Program, assesses legal compliance and indicates actions that must be fulfilled to meet the FC. The PRA considers the CAR and specifies terms of commitment and plans for the recovery of degraded areas under a gradual environmental plan. Brazilian states establish their own PRAs in ways that are compatible with the rules defined by the Federal Government. This process considers the regional, territorial, climatic, historical, cultural, economic and social peculiarities of each state; implementation is the responsibility of the state governments.

In states like Mato Grosso and Acre, with few Federal or state-managed forestlands that have formulated goals for avoided degradation and associated emissions reduction, the RLs on private lands present important challenges and opportunities. In the past, compliance with the FC has been challenging, in part due to monitoring and enforcement difficulties, but primarily due to the generally outsized opportunity cost of keeping forests standing (Stickler et al. 2013). Income from forest management is typically substantially less than the potential income from converting the forest to croplands, particularly for soybeans, or even pastures for cattle; clearing forest also increases land values substantially (Stickler et al. 2013).

A recent assessment of the effectiveness of the FC demonstrates that compliance with the law remains incomplete; only six of 26 states have advanced their PRAs and most have only taken small steps (*Coalizão* 2022a). Three have not even begun this process at all. Full adoption of the FC will help consolidate benefits for the productive sectors with added transparency and traceability to value chains, but some states still face major challenges to compliance.

Some states have proposed modifications to the FC because they consider the 80% forest retention goal out of reach. For instance, a recent proposal called for Mato Grosso to be removed from the country's Legal Amazon region, which would reduce the RL from 80% and 35% to 20% for both forests and *Cerrado*, respectively, thus permitting more forest clearing and less restoration of forests to expand land available for industrial agriculture, around 10 million hectares (InfoAmazonia 2022). Such initiatives have been met with substantial resistance from other sectors, including environmentalists, civil society, and academia.

Obtaining Rights to Timber Extraction

To exploit natural forests on private lands, the Brazilian legislation specifies that an environmental license must be obtained; the latter requires development of an approved Sustainable Forest Management Plan (PMFS) (*Plano de Manejo Florestal Sustentável*). On public lands, timber concessions are granted through a public-bidding process; the land remains public throughout the concession period.

The first step in the forest concession process on Federal lands is the selection of forests by the SFB to be allocated to this category, which are then included in the PAOF. This plan contains descriptions of the forests to be offered. The official announcement of the bidding process elaborates upon this information and includes the details of the area under offer including products, the size and location of the FME, and the criteria to be used in the preparation of the concession PMFS. This document estimates that existing stocks of timber made from sample inventories. Forest census, which is the 100% inventory of commercial trees, is only conducted by the concessionaire for each annual harvesting unit. Forest management plans should meet sustainability criteria such as maintaining acceptable levels of logging intensity and cutting cycles. The third step is the bidding process between interested enterprises, communities, and cooperatives.

The allowed logging intensity in the PMFS should consider three main factors:

1. an estimate of annual productivity, formulated as m^3/hectare/year, based on studies of commercial species in the region and estimates of the productive capacity of the forest;
2. a cutting cycle of at least 25 years and a maximum of 35 years; and
3. concession rights granted for 40 years.[24]

The legislation also defines MCD, which must be established for each harvested species through studies that consider the diameter distributions of trees and other ecological characteristics relevant to their natural regeneration. In cases where no specific MCD has been set, the legal default value is 50 centimeters.

Periodic technical inspections to monitor management operations are developed by the responsible state-level agency, for example SEMA in Mato Grosso, to which the permit holder must submit annual reports. Forest inventories, topographic maps that show slopes, water bodies and flood-prone areas, and logging impacts that show opening patios, roads and skid trails, are required; so too is monitoring forest recovery after forest management interventions (PAOF 2021).

Fees paid by concessionaires are made available to the municipalities and states where the forest concessions are located. For Federal forests, some portion is transferred to the National Forest Development Fund (FNDF) and to the Chico Mendes Institute for Biodiversity Conservation (ICMBio), as established in the 2006 Law.

Timber harvesting in the Brazilian Amazon is characterized by poor management and corruption, for example false documentation, logging beyond allowed areas and volumes, and FMPs that over-estimate conversion efficiency (Brancalion et al. 2018). Much logging in the Brazilian Amazon is illegal with a chronic institutional inability to respond to deforestation alerts. As one interviewee stated, "it is very easy to be illegal." Fines are too seldom assessed and too low to deter illegality. These failures represent a major barrier to transforming actors in the sector from timber exploiters to forest managers (de Lima et al. 2018).

One Brazilian expert explained that illegal Amazon timber can be sold for half the price of equal quality legal timber because illegal harvest costs do not include the same labor fees, taxes, royalties, or other costs that authorized producers are expected to pay. When management plans authorize felling more trees than exist in an area, it allows illegal loggers to conceal a tree's true origin, which allows for a common form of timber laundering. Licenses can be faked easily and appear as legal, and rates can be overestimated to convert logs into sawn wood by timber industries.

[24] One interviewee clarified this ideal process never occurs, and rather: "Companies simply use during the first seasons the regulation regime imposed by legislation [Resolução Conama 406/200], stating an average of 0.86 m^3/hectare/year, while local studies are not conducted based on the continuous inventory system. That would imply, for example, 20 m^3 for 25 year cycle or 30 m^3 for a 35 year cutting cycle."

> "What we are sure of is that 10% of the production comes from concessions and/or certified areas. The other 90% is gray…How can we influence Brazilians to ask for proof of legal production? I think that's probably the greatest challenge that we have in the timber market."
> M. Lentini, Imaflora, 2021[25]

Obtaining Carbon Rights

The Brazilian Federal Government has not yet settled on a full regulatory framework to define carbon credit ownership, responsibility for credit registration and validation, and mechanisms to allow their trading. In principle, and in contrast with those cases under either public, private, or collective ownership for which carbon rights are tied to land and forest ownership, concessionaires are not given the rights to commercialize carbon credits, or exploit water, genetic or mineral resources, or wildlife (reviewed in Rodrigues de Lima and Munk 2012; RRI 2021).[26] But because states and the Federal Government have concurrent jurisdiction to legislate with respect to forests, there is a risk that rights may not be recognized in practice, thus the need to fill that regulatory gap (see below: *Ongoing Forest-Related Debates*).

A legal mechanism was created in 2020 to consolidate payment for environmental services initiatives, *Floresta+*: Forest and Carbon, and its implementation will define the extent to which issues of leakage, additionality, and permanence will be addressed. Given that those willing to invest in PES schemes need to demonstrate the credibility of the expected results, it is possible that sponsors who adopt the highest-level standards for demonstrating performance (e.g., VCS and CCB, but see discussion of challenges for different certification schemes in Section *How does it work? Improved Forest Management under Project vs. Jurisdictional Approache*), could in turn contribute most to guarantee that goals are achieved (Moura-Costa et al. 2020).

Mato Grosso

Mato Grosso, the focus of our analyses, is Brazil's third largest state by area at 903,358 km^2, equivalent to France and Germany combined, and twice the size of California. It is home to 3.6 million people, comprising 1.7% of the Brazilian population (IBGE 2021). Its GDP-per-capita is the seventh highest among Brazilian states at USD10,930 (IBGE 2019). The state is also Brazil's largest livestock producer, with an estimated to 32.7 million head in 2021 (IMEA 2022). In agriculture, Mato Grosso also leads the ranking in soybean and corn production with 32.24 megaton and 31.24 megaton, respectively.

Less well-recognized is Mato Grosso's leading role in native timber production. Commercial logging is the basis of the economy for 44 of the state's 141 municipalities and represents the fourth largest sector in the state's economy.

In contrast to other states, Mato Grosso has no public forest concessions; all logging is carried-out on privately owned land. Close to 90% of the timber produced is consumed domestically (M. Lentini, pers comm). Currently, the state claims 3.8 million hectares of forests under legal forest management, with a production volume of about 4.1million m^3, estimated at BRL313 million (CIPEM 2021; 2017). Nationwide, and as point of comparison, concessions generated about BRL28 million in 2020 (Gazeta 2022).[27]

Forests in Mato Grosso

In 2010, Mato Grosso had 50.7 million hectares of natural forest, extending over 56% of its land area. In 2021 alone, it lost 527,000 hectares of natural forest, equivalent to 286 megatons of CO_2 emissions. Although the technical solutions for real-time and frequent monitoring via satellites already exist, the

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[25] M. Lentini (IMAZON). Available: https://qz.com/2075846/brazil-is-failing-to-stop-illegal-logging-of-the-amazon {accessed April 2022].

[26] One interviewee clarified there is a bill proposal aiming to change that – PL 5518/2020.

[27] *Ações para o desenvolvimento sustentável da cobertura florestal marcam o Dia Internacional das Florestas*. 2021 (available here: https://agazetanews-com-br.translate.goog/noticia/rural/162030/acoes-para-o-desenvolvimento-sustentavel-da-cobertura-florestal-marcam-o-dia-internacional-das-florestas?_x_tr_sl=pt&_x_tr_tl=en&_x_tr_hl=en&_x_tr_pto=op,sc)

problem, second to lack of map-power and equipment, is lack of a decision-support system that can link this information to immediate action as infractions occur. SEMA-MT is already beginning to consolidate and equip teams and individuals in the field with devices so that they can upload and receive information directly, rather than having to be in the capital or large towns. However, lack of cell-phone signal in remote areas remains a challenge.

During 2019-2020, 234,300 hectares of forest were logged in Mato Grosso (Silgueiro et al. 2021), representing nearly 51% of all logging detected in the Brazilian Amazon (SIMEX Amazonia 2022).[28] In the 2022 calendar year, 60% of forest degradation in the Legal Amazon took place in Mato Grosso, 10,988 km^2, more than double the next highest degradation volume (Pará: 5182 km^2) (DETER 2022). In the same time period, Mato Grosso clear cut 2023 km^2, behind Pará (3509 km^2) and Amazonas (2570 km^2); Mato Grosso's clearing represented 20 percent of all deforestation in that year. [29]

In 2016, *Instituto Centro da Vida* (ICV) assessed the fates of logged forests after logging and reported a low correlation between logging and subsequent clearing: 8-9% conversion rate for illegally logged forests; 2-3% conversion rate for legally cleared forests. They also reported that 90% of the forest structure remains intact post-logging. This analysis should be repeated given the spike in deforestation over the last three years in these areas. Specifically, in Mato Grosso deforestation was concentrated in recent years in municipalities where logging preceded it. The active logging frontier has thus been shifting from where it was historically located in the Arc of Deforestation to the northwest and north, at the center of the Brazilian Amazon (Lentini et al. 2021).

According to one interviewee, there are two basic modes of timber exploitation in Mato Grosso, which vary with the age of the frontier. Owners of property close to older forest frontiers, where there are already areas of soy or cattle, have capital to contract third parties to manage their LR, i.e., to design and implement PMFS including the removal of logs. If logging is subcontracted, it is unlikely to be low impact. The owners do not specify sub-contractors' practices provided they get some revenue. This is typically only a minor portion of their well-established portfolios. In contrast, near the active forest frontier, in the northwestern and northern regions of Mato Grosso, the model is different. Here, landowners stated that they "intend to continue timber harvesting for generations," so they are more likely to invest in lower impact methods, which at the end, will not materialize unless there is a conducive environment that supports them to follow suit with those intentions. For instance, trained workers, incentives, enforcement and markets boosted. Land-use decisions continue to be significantly affected by the prospects for soy establishment and active land-speculation, which have led to the recent spike in deforestation.

State of Carbon Management Initiatives in Productive Forests

Ongoing national/regional/local strategies

In 2009, Mato Grosso launched the Program for the Prevention and Control of Deforestation and Fire (PPCDQ) (SEMA-MT 2013), a command-and-control strategy for curtailing illegal forest clearing and forest degradation that was harmonized with the national PPCDAm (Nepstad et al. 2014). The PPCDQ is now in its fourth phase (2021-2024) and is called the Program for the Prevention and Control of Deforestation and Forest Fires (PPCDIF) (GoMT 2021).

Mato Grosso has greatly improved its ability to monitor and enforce compliance with the FC through PPCDQ and PPCDIF policies as well as through work related to its REDD+ for Early Movers (REM) contract (see below). However, the vast revenues to be gained from converting forests remain a major disincentive to legal adherence even when accounting for any possible fines due to non-compliance with the FC. Recent increases in the fines by the Federal Government may deter forest-related infractions,[30] which still require better enforcement and follow-up with legal processes.

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[28] Fifty-one per cent is around 4.8 million m^3.

[29] http://terrabrasilis.dpi.inpe.br/app/dashboard/alerts/legal/amazon/aggregated

[30] https://www.reuters.com/business/healthcare-pharmaceuticals/exclusive-brazils-bolsonaro-may-backtrack-boost-environmental-fines-protect-2022-05-24/

Produce, Conserve, Include Strategy

In 2015, Mato Grosso launched the Produce, Conserve, Include Strategy (PCI) 2015, a multi-sector plan that established time-specific goals to increase agricultural, livestock, and timber production. Additional objectives were to conserve and re-establish forests and other native ecosystems, and to increase social inclusion (PCI 2021). Seven of the 24 goals of PCI are focused on forest management (Table 11).

Table 11. Original and updated PCI goals referring to forest management, tree plantations, afforestation, and reforestation. Goals specifically relevant to native forest management are highlighted in gray. The PCI goals were revised in 2021.

Theme	Mato Grosso PCI Strategy Goals (Updated 2021)
PRODUCE	Increase planted forest over deforested area to 800,000 hectares by 2030*
	Increase timber production from planted forests to 11.75 million m^3 by 2030†
	Increase native forest under sustainable management to 6 million hectares by 2030*
CONSERVE	Keep 60% of state area covered by native vegetation (primary and secondary)†
	Eliminate illegal logging by 2030†
	Preserve one million hectares of forest legally able to be deforested under any kind of compensation*
	Register 90% of rural properties in the CAR by 2022†
	Validate 100% of submitted CAR by 2018
	Regularize 5.8 million hectares (100%) of Legal Reserve; 1.9 million hectares through restoration, by 2030*
	Regularize on million hectares (100%) of degraded Permanent Preservation areas by 2030*

**Original PCI Goals; †Updated PCI Goals (Sampaio et al. 2022)*

REDD+ for Early Movers (REM)

In 2017, Mato Grosso entered into its first formal agreement for direct forest carbon finance, signing contracts with Germany and the UK through their REDD+ for Early Movers (REM) program for roughly USD 50 million in results-based-payments over three years (REM-MT 2019). Mato Grosso was Germany's and the UK's second subnational recipient of a REM contract, after Acre State. This was prompted by the state's progress in establishing the legal framework for jurisdictional REDD+, i.e., the REDD+ System law of 2013, and the multi-sector PCI strategy (Stickler et al. 2020).

Through the REM contract, approximately 15 million tons of historical CO_2e emissions reductions are being retired from the state's allocation of one billion from the National REDD+ Council (CONAREDD). This contract was implemented within the framework of Brazil's National REDD+ Strategy, which allocates to the states of the Brazilian Amazon emissions reductions that can be used in results-based-payment contracts. Through this mechanism, recognized under Article 5 of the Paris Agreement and fully operational in Brazil, there is no transfer of credits to the donor parties. Rather, the amount of finance and the corresponding volume of retired emissions reductions are noted on a forest carbon Diploma, now called a Certificate, issued by the Ministry of Environment.

Payment of REM funds to date is based on reduction of emissions from deforestation only. At the time the program was initiated, there was not sufficient systematic monitoring data for degradation available. The program baseline and payment threshold, which is the measured area of deforestation below which payment may be authorized, are dependent on historical and current measurements of forest conversion to non-forest lands. The program is intentionally designed to distribute the revenues from the emissions reductions to the range of programs and actor groups.

It is in the context of Mato Grosso's REM program that the state's governance structure for determining climate finance benefit-sharing was implemented (REM-MT 2019). Also, state-wide, sector-specific programs were developed. The benefit-sharing strategy was designed through a participatory process and consultation of the State Climate Change Forum (*Forum de Mudanças Climáticas do Estado de Mato Grosso*) and the Mato Grosso REDD+ Management Council (*Conselho Gestor de REDD+ de Mato Grosso*). These bodies include representatives from numerous sectors: civil society, state, Federal, and municipal governments, producers, industry and commerce, judiciary and legislative bodies, academia, family agriculture, Indigenous peoples, the forest sector, and public ministries (Nepstad et al. in prep.). The goal of the benefit-sharing strategy is to quantify the contribution of different stakeholders or beneficiaries to emissions reductions. This is relevant for both those who kept the forests conserved and those who reduced their deforestation rates, using the stock-flow approach (Moutinho et al. 2011). The result of this benefit-sharing process was the recognition of four beneficiary groups, each with their own sub-programs:

1. Family agriculture, traditional peoples and communities;
2. Indigenous peoples;
3. Sustainable production, innovation and markets; and
4. Institutional strengthening, with a focus on law enforcement.

Development of Mato Grosso's Low Emissions Rural Development Strategy

Carbono Neutro Mato Grosso

In the lead up to the 2021 UN Climate Summit, COP26 in Glasgow, Mato Grosso's government formalized its goal to reach economy-wide carbon neutrality by 2035 via the *Carbono Neutro* program. The definition of this target, which included an interim target of 80% reduction in emissions by 2030, was based on progress already made in addressing the main source of carbon dioxide emissions, deforestation, and inspired by the results of a two-year dialogue and analysis of the state's decarbonization pathways (The Climate Pathway Project -TCG 2022). This program identified 12 priority actions for reducing emissions and increasing carbon removals from the atmosphere through changes in land-use systems (GoMT 2021). Three of these priority actions explicitly focus on forest management, while four others are relevant to it (Table 12).

Table 12. Priority actions indicated by the *Carbono Neutro* Mato Grosso (MT) program. Indicated are actions directly (**) and indirectly (*) relevant to forest management

Priority Action	Goal
1	Maintenance of the state's forest assets, with socioeconomic incentives for conservation**
2	Sustainable forest management**
3	Land tenure regularization and consolidation of legal land rights*
4	Implementation and improvement of the management of public and private protected areas**
5	Commercial reforestation*
6	Restoration of the forest landscape*

Priority Action	Goal
7	Reduction of forest fire*
8	Increase in the productivity of agricultural activity in areas already converted, applying good agricultural management practices
9	Protection of secondary vegetation
10	Recovery of degraded pastures
11	Crop-livestock-forest integration
12	Production and consumption of biofuels

Improved forest management, generally referred to as sustainable forest management in Brazil, is expected to contribute approximately 15% of the *Carbono Neutro* programs' total reduction in emissions by 2035. It aims to expand the area under SFM from 4.7 million hectares in 2021 to 6 million hectares by 2030, and to 8.3 million hectares by 2050. Exactly what is meant by 'sustainable' in this context is never stated, but management details are typically scant.

The program certifies participants under one of four *Carbono Neutro* MT seals, depending on the role of the recipient, which could be funder, supporter, committed, or actor pledging to meet the carbon neutral target.[31] The program explicitly cites PPCDIF-MT, PCI, and the development and implementation of REDD+ mechanisms as essential tools for achieving the overall *Carbono Neutro* goal (GoMT 2021).

The *Carbono Neutro* program builds on a two-decade long history of public policy innovation to manage land-use activities and enforce the Brazilian Forest Code. Specifically, Mato Grosso was the first state to implement a property-level environmental licensing program the *Sistema de Licenciamento Ambiental de Propriedades Rurais* (Environmental Licensing System for Rural Properties) in 2000 (Stickler et al. 2013, Rajão et al. 2012). Within this system, the *Licença Ambiental Única* (LAU) (Single Environmental License) was created to track and enforce compliance with the FC and other regulations. Implementation and efficacy of the License was impeded by the complexities of reviewing and approving applications.

Legal Framework and Antecedents

To fast-track FC enforcement, the MT Legal program was launched in 2009, establishing deadlines by which farmers had to submit maps of their landholdings and plans for coming into compliance. This program was renamed the *Cadastro Ambiental Rural* (Rural Environmental Registry) and was brought into national legislation through the new FC in 2012 (Stickler et al. 2013).

With forest conversion to soy and pasture dominating the state's land cover change patterns from 1996 to 2005 (Nepstad et al. 2006, Macedo et al. 2012), Mato Grosso's principal focus was on reducing deforestation. Nevertheless, with respect to forest management, the MT Legal program aimed to improve timber traceability and increase production from sustainable forest management.

Mato Grosso also took an important step towards establishing a formal legal framework for its emerging low-emission rural development agenda with the final approval in 2013 of the State System for Reducing Emissions from Deforestation and Forest Degradation, Conservation, Sustainable Forest Management and Increase in Forest Carbon Stocks (SisREDD+) (Law no. 9.878 AL-MT 2013). SisREDD+ is designed to capture revenues as compensation for its success in reducing emissions from deforestation and forest degradation, via REDD+, across the entire state. This was only the second state law in Brazil, after Acre's, to

[31] CIPEM received a Certificate from *Carbono Neutro* on June 6, 2022.

establish a legal framework for jurisdictional REDD+, in which performance is measured against state-wide reference levels of each biome (Amazon, *Cerrado*; Stickler et al. 2018, 2020).

Ongoing Forest-Related Debates

- **Updating the national policy on climate change**, which aims to align the policy in the context of the Paris Agreement and the new challenges related to climate change, including the proposal to reduce 100% of greenhouse gas emissions by 2050.
- **Regulation of carbon markets in Brazil** is the objective of a proposed bill (PL 412/2022) which is essential to the evolution of the country's climatic maturity in the opinion of many national experts. Credits will include those from the agroforestry sector.
- **Design and put in practice enabling regulatory frameworks for setting carbon market prices**. On May 19, 2022, the Brazilian government published a new decree in the Federal Official Gazette as part of a move toward reducing the country's carbon emissions. The Decree No. 11,075/2022 establishes procedures for the elaboration of sectoral climate change mitigation plans and creates the National System for Reduction of Greenhouse Gas Emissions. This instrument defines significant concepts linked to the carbon market; for example, carbon credits, methane credits, carbon stock units, and certified emission reduction credits.
- **Greater speed for forest concessions**, process that aims to streamline steps along the current regulatory process and make concessions more attractive.

Main Organizations/ Projects that Support Brazilian Forests

As in the Peru case study, several programs have been part of a larger plan recently consolidated to work for tropical forests worldwide in which different US organizations play roles (see Box 5 above and Annex 4).

Implementing Proposed Mechanisms to Improve Carbon Outcomes from Managed Forests in Brazil

Incentives for improved forest management, a combination of financial, technical, and other assistance, derived from a jurisdictional program may help make SFM a viable alternative to forest-converting activities. Such incentives could help overcome the barriers that now prevent broader adoption of improved forest management practices. This in turn could help overcome barriers to compliance with the FC and help the state achieve its emissions reduction goals. Nepstad et al. (2022) estimate that avoided degradation could constitute a larger source of emissions reductions than avoided deforestation, largely through reduction of forest fires. In all cases of the use of incentives or other strategies to support mechanisms' adoption, one interviewee believed that it is important to register potential carbon payment projects together with the registration of the property, to ensure that the area will not be deforested in the future.

As stated by several of our respondents and in keeping with other results of our analyses, incentives are needed to avoid land use conversion in Mato Grosso. This is critical as interviewees told us up to now, "incentives come and go and are not sufficient to sustain change." Instability also translates into "risky environments for investors," and "uncertain regulatory autonomy regarding who gets to determine ownership of carbon benefits, price and distribution." (Interviewee). Another interviewee suggested there may be lines of credit that could be used for improved forest management, for instance *Plano de Agricultura de Baixo Carbono* (ABC). This is a sectoral plan linked to the guidelines of the National Climate Change Policy and related to commitments made by Brazil at COP15 in 2015 in Paris (see section *Ongoing forest debates* above). It is not clear whether it would be feasible to include forestry activities in this plan.

According to our interviewees, besides insufficient incentives to improve management practices, there is a major limitation due to the absence of "additional payment for SFM timber versus other timber." The

question remains "how do you get the market to recognize these investments?" This is particularly important as 90% of timber produced is consumed domestically. One interviewee said that "no one wants to buy certified timber" given "the relatively high cost of investments to do reduced-impact logging" and then cited the example of the Modeflora system.[32] Overall, respondents lamented the high cost of capital for investments that yield few benefits.

There are also structural system failures, as recognized by our interviewees. For instance, SISFLORA could present a loophole that allows illegal timber to be hidden via credits that are central to the system. An interviewee highlighted the following example of a loophole:

> An "authorized management unit that is allowed to remove a certain volume of different sets of tree species, being assigned credits for the volume of each set. This means that the volume of any one species is not precise and timber from that set of species can be added from an illegally logged area at some stage in the removal /processing."

The *TimberFlow* system, in contrast, allows the visualization of the timber flows by species common names.[33]

Overcoming cultural resistance within the forestry sector to learning new things and adopting new methods remains a challenge, as stressed by one interviewee: "People are resistant to new techniques." But, alongside investment in training to overcome cultural barriers to change, there are other obstacles. For instance, one interviewee said that "some governmental procurement policies can be hurting the private sector as it is not possible for them to use native woods in public constructions."

Funding options to assist in the adoption of mechanisms are outlined below. Ideally, authorities and influencing institutions, including SEMA, state authorities, NGOs, timber producers, unions and workers, will begin to articulate in more detail how the programs described below can transfer support to those committed to improved and maintained quality forestry in a performance-based system.

Roles for Improved Forest Management in Mato Grosso's Low Emission Rural Development Strategy

Mato Grosso signed a Letter of Intent with the LEAF Coalition in December 2022, signaling its intent to pursue certification under ART-TREES , but is still evaluating to what extent it will include nested projects (D. Nepstad pers. comm.). The state-wide program will include avoided degradation of mature forests, which is the current basis of the REM contract, and of secondary forest (Nepstad et al. in prep.). One current priority under the REM program is to improve the state's ability to effectively monitor forest degradation to strengthen policy implementation and reduce carbon emissions from these sources. This is in line with Brazil's updated national FREL, which now includes a separate degradation reference level (GoB 2022). Here, we provide more details on the REM program, and how it is likely to support and determine the inclusion of improved forest management in Mato Grosso's jurisdictional strategy as it goes forward.

REM Sub-program 3: Production, Innovation & Markets

The Sustainable Production, Innovation and Markets Sub-program focuses on the production chains that have historically had the greatest impact on Mato Grosso's natural areas. These production chains include extensive cattle raising, soybean cultivation, and timber extraction. With 10% of the REM-MT budget allocated, the sub-program's central strategy is to reduce or eliminate deforestation and forest degradation from the beef, soy, and timber production chains, increase reforestation or afforestation, and to connect sustainable production to regional and international market demands. These sectors have a combined gross domestic product of around BRL 51 billion and include diverse producers, scales, and regions, with a corresponding variety of problems, which presents the sub-program with some challenges (Nepstad et al. in prep.).

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[32] Modeflora is a process of forest planning that employs different digital technologies [(Global Positioning System (GPS), Geographic Information System (SIG) and Remote Sensing (RS])to map the forest and facilitate planning, high-precision monitoring of forest management activities (https://www.embrapa.br/en/busca-de-solucoes-tecnologicas/-/produto-servico/1315/modelo-digital-de-exploracao-florestal--modeflora).

[33] www.timberflow.org.br

The principal objectives of the sub-program are to:

1. Support compliance with existing socio-environmental legislation to reduce sourcing risks and to promote forest restoration;
2. Support technically and financially feasible beef breeding and production practices that promote the efficient use of resources and reduce deforestation pressure and ensure certification under the Mato Grosso state 'seal of origin;
3. Connect beef, soy and timber producers to markets that recognize the value of sustainable production; and
4. Support technological innovation through activities that allow the diffusion of new technologies in target regions, improve production efficiency, and reduce pressure leading to deforestation and other environmental damage.

The sub-program's geographic focus is mainly on deforestation and forest-degradation frontier areas: in the northwest of the state for livestock, which is the state's main cattle breeding areas and forest management concentrated in the northwest, and in the central north-south corridor for soy. To target interventions for each sector, the program design takes advantage of extensive analyses of deforestation and degradation hotspots, suitability analyses, and diverse socio-economic and environmental analyses.

Subprogram 3 has four axes, two of which include specific actions focused on sustainable forest management (Table 13). The *Sustainable Forest Management* axis (Axis 3) aims to increase the volume of legally harvested timber to 80% of all wood from natural forests in the state.

Table 13. REM program activities focused on forest management under the Production, Innovation & Sustainable Markets Sub-program (Sub-program 3); and key targets and activities under the Sustainable Forest Management axis (Axis 3)

M&E Element	**Description**	
Result	Best forest management practices disseminated and implemented	
Objective	Increased volume of wood from legal timber extraction in the market	
Indicator	Indicator: % of legal timber extraction in Mato Grosso	
Baseline	61%	
Target	80%	
Action Line	**Activities**	**Tasks**
Support sustainable timber forest management	1. Modernize and improve technical procedures for monitoring timber management.	1. Create a structure to implement a training plan for operation and compliance in forest management. The current lack of compliance is partly due to the lack of training and qualification in the state forest management structure and system.
	2. Support the organization and modernization of the forestry sector.	2. Establish a critical mass of premium producers of 'risk-free wood for export.' This strategy will establish rules, processes and procedures to guarantee to the market that compliant producers are risk-free. This would be a pilot and basis for expansion.

M&E Element	Description	
	3. Consolidate a sustainable market.	3.1 Create a working group to apply Brazilian Forest Management rules as a standard for the Amazon biome, based on the ITTO International Framework on SFM.
		3.2 Create an integrated working group to increase SISFLORA's credibility with various stakeholders and the participation of relevant actors to ensure continuous improvement of the SISFLORA system, keeping SISFLORA synchronized with the EU Timber Regulation (EUTR) or the Regulation on Deforestation-free Products as well as with zero fraud.
	4. Record, geo-reference, and systematize results achieved.	4. Update forest management and deforestation data.

The program was designed to focus on various technical and regulatory aspects of implementing management standards to meet the ITTO International Framework on SFM and EUTR requirements, among others. Activities focus on technical capacity building among producers and regulators, establishing rules, processes, and procedures to support risk-free timber production, improving the credibility and adoption of the SISFLORA system.

Under the *Supply Chain Innovation* axis (Axis 4; Table 14), activities focus specifically on improving chain of custody monitoring of timber products to provide and expand the use of sourcing guarantees for timber originating in the state.

Table 14. Key targets and activities under REM's Supply Chain Innovation axis (Axis 4).

M&E Element	Description	
Result	Commodity assurance tools developed and implemented, and/or expanded use.	
Objective	Increase the volume of commodities using socio-environmental assurance and origin guarantees by 20% from the existing baseline.	
Indicator	Volume of timber (m^3) from forest management under SISFLORA monitoring.	
Baseline	154,800 m^3 (average annual authorized volume from 2017 to 2019).	
Target	185,800 m^3 from forest management regulated by SISFLORA by 2023.	
Action Line	**Activities**	**Tasks**
Develop and implement tools to provide sourcing guarantees, and/or expand their use.	Support improvement of chain of custody monitoring of timber products in Mato Grosso.	Prepare SISFLORA to be audited and to support the audit cycle.

As reports from and evaluations of the implementation of the sub-program become available, it will be useful to understand specifically how the REM program affected forest management and which actions were most effective in expanding SFM in the state.

Opportunities for Nested REDD+ projects in Mato Grosso

The development of a system for nesting REDD+ projects within the state's broader REDD+ program presents several potential advantages for Mato Grosso and project proponents (Nepstad et al. in prep.). Nested projects are less likely to overstate their impacts since they are constrained by the jurisdiction-wide baseline or FREL.[34] The sum of emissions reductions and removals claimed by the jurisdictional program and all nested projects cannot exceed the total number of emissions reductions and removals as defined by the state-wide FREL.

Nested projects may be more attractive to some buyers of REDD+ credits because of the clear link to a particular type of intervention, for example avoided deforestation as well as any of the five mechanisms highlighted in this report; or because of preferences regarding social or environmental co-benefits. Some investors may seek REDD+ credits that deliver benefits to indigenous peoples or smallholders, while others may wish to see their purchase of credits contribute to the protection of a nature reserve or to the promotion of SFM. Potential REDD+ beneficiaries may prefer to engage in a nested REDD+ project to gain some independence from the state-wide program.

Both ART-TREES and JNR include opportunities to integrate nested private projects or lower-level jurisdictional projects in broader jurisdictional programs. Requirements for nested projects include rigorous accounting and management to avoid double counting emissions reductions at the jurisdictional or project scales. These requirements also help ensure project integrity and compliance with leakage, permanence, additionality criteria and risk buffer pools, where a portion of verified credits are allocated to the buffer pools according to risk assessments and retired if reversals occur.

Nested REDD+ projects can be beneficial because they allow for the monetization of Agriculture, Forestry and Other Land Use (AFOLU) categories that may not necessarily be included in the jurisdictional program at a scale that provides sufficient incentives to relevant actors (Nepstad et al. 2022). The options for nesting projects within JNR or ART-TREEs programs range from complete dependence on the jurisdictional program, where carbon transactions and benefit distribution are mediated through a central program or institution, to complete independence from the broader jurisdictional program, where projects generate and sell carbon credits directly (Nepstad et al. 2022). Designing a jurisdictional program that coordinates all project level REDD+ activities could help reduce transaction costs for individual nested projects (Nepstad et al. 2022). Another advantage of nested projects is that success and associated benefits do not need to rely on performance at the jurisdictional scale (Nepstad et al. 2022).

A disadvantage of nested projects, on the other hand, is that they are costly to establish and monitor, and the benefits flowing to actors on the ground, for instance forest managers, can be greatly reduced as project revenues are also allocated to investors and project developers through benefit-sharing agreements (Nepstad et al. 2022). Independent nested projects may also have higher exposure to leakage and permanence risks (See Box 1).

Potential for Carbon Payments in Support of Sustainable Forest Management in Mato Grosso

Mechanism 1. Use of RIL practices

> "*There are no economic incentives to invest in forest management.*" Interviewee.

As transportation costs increase, several interviewees mentioned that the high cost of capital represents an insurmountable barrier to upgrading management. For smaller operations, the lingering barrier remains the lack of capital as well as the scarcity of trained field personnel. Some participants suggested that they already

[34] Overstating impact is an important criticism of independent REDD+ projects in the Brazilian Amazon (West et al. 2020).

implement RIL and that "in their operations, 3-4 years after harvesting it is hard to see evidence of harvesting." This might be true in some cases given the assessment of performance guidelines that SEMA follows in the field[35] and the most recent normative for SFM,[36] or at least for well-established low-intensity logging operations, under the strong assumption that there is full enforcement of regulations.

Mechanism 2. Improve wood utilization from felled trees

In Mato Grosso loggers can use residues, such as branches and buttresses, from exploited trees as long as these activities are specified and included in the PMFS. In the state, waste cannot exceed 1m^3 per tree felled; this volume limit will soon be based on the dendrometric relationship developed for the management area or on a residue inventory (Decreto 1313 2022). The volume of residues from authorized forest exploitation will not be added to the projected timber volumes in the PMFS or POA.

In operations with well-trained personnel, best practices determine that hollow trees will not be harvested. For instance, one interviewee said that "there is no incentive to harvest hollow trees as there is no economic benefit associated with doing so. People are well trained to do their jobs." But use of branches, tops and other tree residuals seems problematic as interviewees said that the use of portable sawmills are not efficient.

In some areas, waste is used to make energy for industrial processes (e.g., large diameter branches from harvested trees; (Roque Lima et al. 2021). More recently, there have been assessments of the potential for using residues from mill operation to power industrial processes elsewhere (Lentini M, pers. com.). But, at the logging operation level, some interviewees stated that, "waste is low because fees are paid for standing tree volume, which would deter waste production."

One example of implementation of this mechanism in the state of Pará's Tapajós National Forest is the *Oficinas Caboclos do Rio Tapajós* (OCT). This initiative started in 1988 under the sponsorship of *Instituto de Pesquisa Ambiental da Amazonia* and others who supported communities to develop a small-scale industry based on the use of wood from dead trees and logging residues. The goal was to manufacture high-quality traditional furniture and to provide raw materials from the forest to neighboring communities (McGrath et al. 2009). While the intervention was successful for a while, it eventually was terminated. This was reportedly due to lack of governmental acceptance, lack of capacity, scarcity of industrial connections, and disputes within the community (T. McGrath, pers. com.). Some of the groups originally participating in the OCT continue producing pieces and selling them locally, using fallen and felled trees from swidden agriculture plots.

Mechanism 3: Reduce harvesting frequency or lower logging intensity

These options seemed unpopular to most interviewees even if legislation allowed modification of other parameters associated with forest management. Specific studies with robust field information are needed to evaluate the consequences of these choices. Studies conducted by EMBRAPA (2020) show, for example, that adapting logging intensity by adjusting minimum-cutting diameters and cutting cycles to match each species characteristics, guarantees a faster economic return and maintains relative species' balance and overall biodiversity of the forest. Despite substantial evidence to the contrary, cutting cycles assume timber volume accumulation of around 30 m^3 per hectare every 35 years. Logging is then based on the total recovery of the timber volume removed, for instance, annual average volumetric increase of commercial timber of 0.86 m^3 per hectare per year).

Several researchers have demonstrated that harvesting cycles must be longer than those defined in legislation, currently 25-35 years, and/or minimum cutting diameters need to be larger than the current DBH, set at 50 cm, to sustain timber yields (Ferreira et al. 2020; Sist et al. 2021). But, as stressed by interviewees, it is not likely that forest managers will agree to voluntarily adopt higher cutting diameters or longer logging cycles given low timber prices (Barreto et al. 2009). Studies like those of Njdondo et al.

[35] *INSTRUÇÃO NORMATIVA nº 02, de 05 de julho de 2018.*

[36] see https://www.legisweb.com.br/legislacao/?id=429880.

(2014) in Gabon and Rossi et al. (2017) in Cameroon, which assessed the break-even carbon payment to compensate for these options, would be warranted for Mato Grosso.

Mechanism 4. Apply silvicultural treatments to enhance carbon removals

"*Industry can add value to the forest and bring benefits if it is incentivized.*" Interviewee.

Interviewees recognized that forest managers given proper incentives can be motivated to invest in the forest. Some interviewees saw opportunities to reduce waste by improving technology, again if affordable capital, via incentives and subsidized credit lines, was available to allow them to buy new equipment. Some of them noted the investment already made, which suggests that well-established large operations may be interested in trying out this mechanism. One interviewee noted an investment of BRL1.5 million, equivalent to USD 285,000.

Participants recognized the potential for liberation thinning to increase FCT growth rates but questioned its legality unless previously included in their approved forest management plan. They also recognized the slippery slope as it "may be used inappropriately to remove more trees than needed, causing more damage and hurting the forest". We failed to elicit explicit responses to the proposed future crop tree liberation from lianas treatment, which may reflect a lack of silvicultural perspectives among people we interviewed.

Mechanism 5. Plant trees on accessible degraded areas

This option did not receive much support by interviewees, even if it was recognized by some that planting and establishing light-demanding species could be successful in small logging gaps. One interviewee objected to planting trees on log landings, arguing that this action would threaten investments already made in managed forests given that landings are considered permanent infrastructure and should be kept open. This is sensible given that planting trees in the compacted soils of log landings is generally futile. Overall, it appears that experimenting with tree planting in degraded areas may only be of interest to large operations.

Recommendations

In general, weak forest governance constitutes a considerable barrier to improved forest management in Mato Grosso. The state does have fairly robust and clear regulatory frameworks that establish actions needed to manage forests to secure reduced impacts, including specification of practices to use and sufficient detail to orient enforcement and monitoring activities. Furthermore, the state also adopted ambitious goals such as the *Carbono Neutro* program that aims for sustainable forest management to contribute approximately 15% of the program's total reduction in emissions by 2035. However, along with PCI, the goal is to expand the forest management area to six million hectares by 2030. Utilizing 'area under forest management' is an inadequate and flawed indicator because we know that what matters for carbon and forestry is whether the best practices are adopted. Adding acreage will not result in emission reductions or carbon removals if there are no changes in practices. Where managers are already asserting that they are managing properly, their practices must be audited carefully to assess their claims.

Improved scrutiny of field operations must be a priority for responsible agencies. That said, more support from the government for improved forest management would go a long way to increase the trust that forest managers have in the government and thus their awareness of the importance of and willingness to be completely transparent, so that managers are willing to open their forests for this added examination. This condition will create the required transparency under which any of the mechanisms proposed can improve carbon outcomes from managed forests. Upgraded surveillance includes expansion of inspections of processing industries in critical municipalities where the forest frontier is quickly retreating, notably northwestern and northern parts of Mato Grosso, so that this effort results in the consolidation of areas of legal and proper management.

Remaining forests on the frontier where there is an uncontrolled advance of agricultural activities is where land grabbing, speculation and losses of rights are common. This is one of the reasons why timber harvesting continues to have its low standing as a land use, and why it is viewed as a likely precursor to land

conversion. It will be very hard to expect FMEs to adopt RIL and other improvements in their practices if timber markets remain distorted due to availability of illegally sourced wood coming mostly from these active frontier areas.

For some of our interviewees, "the challenge is far beyond management…there are problems with infrastructure, marketing, transport, exchange, availability of ports and bureaucracy throughout the process." The availability of *TimberFlow*, soon to be fully linked to SIMEX, should boost traceability, and assist enforcement and sanctioning. It will help to have centralized, integrated, and accessible information, as an essential tool to ensure the traceability of timber through the entire chain of custody. This innovation will also indirectly help consolidate market networks.

At the level of each FME, a major obstacle is the lack of trained staff. As discussed, the near demise of IFT leaves a profound lack of institutional power dedicated to addressing this need. One interviewee stated:

> "…about five years ago, near Santarém, Pará wanted to establish an 'academy' in the FLONA Tapajós for this kind of training, but so far nothing has happened. At some point, there were at least seven initiatives for establishing training centers in different states." These included Mato Grosso, Acre, and Amapá, but none have moved ahead.

A key issue that reduced IFT's capacity was the sale of *Fazenda Cauaxi* where they historically operated. There are creative ways through which this lack of locale could be solved. One interviewee mentioned that many universities and EMBRAPA have forest areas where this type of training could take place. In the case of universities, training in RIL and other improved management practices, including setting of permanent plots and data management so that these plots serve the purpose of informing decisions regarding harvesting intensities and frequencies, can greatly contribute to the formation of forest engineers at these and other institutions. Once enforcement of the new regulatory tools increases, managers will demand these skills from their operators, which should highlight the need for IFT or an institution like it. Partnerships could also be established with the private sector to establish demonstration sites.

Our strong recommendation is to renew support of the IFT, a highly successful forestry-training institution that was formerly a world leader in improved forest management but has since lost that status due to lack of funding and lack of a training site (see section *Moving the IFT Training Agenda Ahead* below). Investments in training by companies should be matched by workers receiving competitive salaries that will attract people to this unpopular job but will also improve the quality of work and build a professional path for those involved.

Based on the information presented above, there seems to be renewed attention to the roles managed forests can play in contributing to climate change mitigation while improving rural prosperity. Several initiatives explicitly prioritize sustainable forest management, as illustrated by the *Carbono Neutro* and PCI example and critique above. As part of Mato Grosso's jurisdictional strategy, there is support available to improve forestry practices through the REM program, sub-program 3, specifically to build forest management capacities and assist the process of modernization of the forestry sector. All these good intentions in support of improved forest management need to be coordinated and integrated. When pilots are developed, they should not favor the same municipalities or types of actors. They should be implemented strategically to increase impact and improve coverage. Moreover, integration and coordination during field implementation activities will not saturate the bandwidths of local actors and will create an image of working toward a shared goal, contributing to experience exchange and mutual learning. This is of utmost importance not only for participants directly engaged in activities on the ground, but also for the sponsoring programs and agencies that can optimize and magnify the scope of funding.

Another necessary change relates to a shift in perspective about the ways through which incentives from public sources should be used. This is important insofar as it is sometimes perceived that incentives to the private sector, including subsidies and tax benefits, only generate private benefits and in some cases reduced rents for governments. Instead, quality job generation and contributions to local and regional market dynamism are mechanisms through which these 'private benefits' can generate and contribute to the public good. Additionally, this boost through incentives may also shift private sector interests to invest in tropical forest management.

Combined Recommendations for Loreto (Peru) and Mato Grosso (Brazil)

This final section is intended to serve as a summary of the main actions that can be taken by both USFS-IP and USAID to progress the agenda of improved forestry with prospects of carbon benefits and reduced degradation. The two regions selected are very different in their forestry sectors but nevertheless share many limitations and offer many of the same opportunities for using improved forest management to reduce carbon emissions and increase carbon removals. Furthermore, both Loreto and Mato Grosso are undergoing great transformations, institutional and otherwise, that open opportunities for forestry carbon policy experimentation (Table 15). The contrasts between Mato Grosso, where forest management happens on private land, and Loreto, with its more traditionally structured concession-based forestry sector, are revealing. Regardless, both need informed efforts to improve the fates of forests through strengthening the forestry sector.

Table 15. Analysis of impediments, opportunities, and suggested actions for USFS-IP and USAID.

Impediments	Opportunities	Actions
Integration and coordination of initiatives		
Lack of integration and coordination of high-level initiatives that address climate change and forestry, at all levels of government. Perception of the forestry sector as plagued by illegality and corruption, and of logging leading to deforestation.	IFM related initiatives can serve as umbrellas and vehicles for adoption of mechanisms. There is urgency to advance towards results based on COP26 outcomes, specifically for forestry. All IFM-related opportunities can be used to stimulate cultural changes among forestry stakeholders including FMEs, regulatory agencies, and consumers to promote improved forest management.	USAID and USFS-IP to: 1. share results of this report with: • Authorities and agencies at the national, state, and department levels; • Other international donors and NGOs working in forestry and climate change mitigation and adaptation; • Timber and producer associations to motivate learning and to promote experimentation. 2. In Loreto (Peru): USAID and USFS-IP to link more effectively with ERDRBE, to support improved training, investment, incentives, and enforcement. 3. In Mato Grosso (Brazil): USAID and USFS-IP to increase visibility of IFM goals and operations across all initiatives to increase synergies and decrease redundancies. For instance, for PCI, *Carbono Neutro*, REM, and ABC.
Stakeholder IFM buy in		

Impediments	Opportunities	Actions
Limited stakeholder recognition and understanding that IFM is needed and that IFM is not yet a reality, despite claims made by some stakeholders.	There are actions in several domains related to forest management and forestry more generally - for instance, the USAID, GIZ and NGO agendas. However, these actions only tangentially address prioritization and investment to directly improve forest management.	USAID and USFS-IP to: 1. promote investment in forestry training and on-the-ground practice implementation, together with quality and timely monitoring by responsible agencies. 2. Integrate capacity-building that also benefit sub-contractors to professionalize the forestry work force. 3. Require that claims made by FMEs and producer associations be open to scrutiny to facilitate needed improvements. 4. In Mato Grosso (Brazil): push for corporate commitments to IFM, with clear time-bound goals and meaningful indicators (KPI and SMART); specify steps to be taken for independent verification and traceability.
Strengthening objectives		
Goals are insufficiently clear to promote improvements on the ground that are needed to improve the fates of forests.	Governments formulate ambitious goals to conserve tropical forests that need support.	USAID and USFS-IP to: Develop meaningful, cost-effective indicators for all interventions designed to improve forestry. These metrics should reflect realities on-the-ground, rather than relying on acreages under management plans of certification.
Volatile timber markets entail financial risks. Available capital is insufficient or only accessible at large costs.	There are several initiatives that can help articulate a more trustful environment for investment by FME managers.	USAID and USFS-IP to: Continue assisting national Ministries of Finance, Environment, and others, to trial incentives and support the adoption of IFM; keep close track of costs and benefits to support scaling up and out.
Unresolved legal frameworks and loopholes.[37]	Clarity in guidelines and expectations benefits all government and forest managers.	USAID and USFS-IP to: 1. Support agencies to develop clearer forest management guidelines. For

[37] The Brazilian government has taken, in early June 2023, an important step that could enable implementation of RIL and adoption of RIL-C protocols for liana removal and other silvicultural practices in concessions, addressing legality and benefits sharing with the government (see: https://carboncredits.com/brazils-bill-will-allow-loggers-to-earn-24m-from-carbon-credits/).

Impediments	Opportunities	Actions
		example, SEMA in Mato Grosso has a unique set of monitoring guidelines to assess forest management quality. 2. Promote exchanges across project participants in different countries, creating a learning environment to share experiences and promote reflection on successes or failures. 3. Incentivize activities to improve enforcement, following prime quality guidelines, and sharing results of performance to foster adaptation and mutual learning.

We heard several times during our work that timber unions in Mato Grosso claim they can maintain a stable forest base with long-term timber sustainability. Given plans from PCI to expand land allocation for forestry activities to six million hectares, new social contracts will be required based on corporate commitments to operate in transparent manners so that there is actual progress towards SFM. As suggested by one interviewee, this social contract requires the formation of coalitions through novel institutional and policy settings, with "*clear goals and key performance indicators, independent verification, traceability and a clear business plan on how to companies will achieve goals*" (Interviewee). Whether participation in this novel arrangement will be restricted to companies and government agencies, or whether other actors can play more fundamental roles through recognized and credible certification and verification systems, carbon credit transparent mechanisms might help close the gaps in both Mato Grosso and Loreto. This gap closing is critical right now, when opportunity costs for the land at frontiers continue to increase, putting remaining forests at risk.

One interviewee referred to this arrangement as a 'Prodemflor 2.0' type of intervention in the case of Brazil, supported by combined and coordinated efforts from all existing programs that include improved forest management as a goal. If companies continue to claim they implement quality management, they will need to prove it with mechanisms more explicit than FSC certification if they expect to participate in carbon credits markets. Companies need to avoid reputational damage, which will nudge legitimate practice changes. This transparency could help attract investors and support from cooperation agencies and lead to concrete benefits for firms, workers, their communities, and local governments. Lessons learned from the private sector can inform the ambitious plans for forest concessions elsewhere.

Finally, we identified knowledge gaps related to implementation of the proposed mechanisms but argue that the gaps can be filled as the mechanisms are tested with robustly designed research (Table 16). These proposed studies could be developed along with key local and regional universities, technical school, NGOS, and broad participation of stakeholders.

Table 16. Identified knowledge gaps and research suggestions to improve implementation of the five proposed mechanisms for improved forest carbon management

Knowledge Gap	Justification	Suggestions
Mechanism 1		
RIL costs	Cost estimates that are reliable and accepted by FMEs are not yet available but perceived costs are nevertheless the main impediment to implementation.	Update and use the RILSIM protocol based on the Holmes et al. (2002) study in Brazil.
Cable winching	Emissions could be avoided if logs were cable winched at least 10-20m from the stump, but this is almost never done.	Census FMEs to identify the impediment and then devise solutions, such incentives with well-designed policy experiments. For example, RCTs.
Incentive for workers	Changes in behavior and performance can be incentivized to motivate improved practice adoption by workers. This activity will require a boost in supervision and will be linked to training.	Incentives: • Experiment with payments to workers, for instance reduced waste through Mechanism 2 leading to reduced emissions linked to Mechanism 1. • Create Excellence Awards at the FME level. • Take the best workers on tours to demonstrate skills where needed. • Provide support so that FME or timber producer associations launch awards for best-performing workers. • Promote FME successes in safety and reduced worker accidents. • Timber associations can create credentials for high-performing FMEs with reduced worker accidents and RIL performance.
Mechanism 2		
Utilize wood waste Safeguards for wood waste use	Different elements: best technology adapted to the situation, explore and help develop products and markets as a function of products, costs/ benefits of each option.	• Set up subsidized pilot projects with different FMEs. • Experiment with payment to workers, including bonuses for efficient timber recovery and penalties for wasted wood (linked to Mechanism 1).

Knowledge Gap	Justification	Suggestions
Potential negative effects of wood waste use	Measures to avoid illegal hunting or illicit timber extraction will be required if implementation results in more people in the forest.	Experiment with different measures to assess their feasibility of implementation. For instance, only allow waste wood to be collected within one week after harvesting, while forest managers are still on site.
	Studies needed on the impacts of waste wood harvesting on soil and regeneration, especially if skidders or farm tractors are used.	• Pilot projects in forests where the principal commercial species are light-demanding and not regenerating adequately. • Combine waste wood utilization with enrichment planting or assisted natural regeneration.
Mechanism 3		
Reduce harvest frequency; lower logging intensity.	Either option, or both acting in tandem, can reduce carbon emissions and increase carbon removals. Data is needed on the timber-carbon tradeoffs of each option including foregone benefits down the supply and value chain, including what leakage is likely and how it can be avoided.	Work with FME managers to assess the economics of these options so that they accept the results.
Mechanism 4		
Liana cutting on future crop trees.	There is plenty of available research supporting this treatment. Each project will develop its own baseline, for instance treatment effect, having both treated and control trees. There is no need for research grade data on stem diameter increments.	The commercial and carbon viability of this option should be promoted and publicized to secure funders and investors.
Mechanism 5		
Tree planting in roadside clearings.	Additional research on species selection, planting techniques, and follow-up treatments would be helpful, although this is already a well-known option.	Some well-publicized demonstration projects would help promote this intervention. Special attention is needed on costs along the tree-planting implementation chain.

Trials of the mechanisms require the highest quality designs through policy experiments that allow assessment and attribution of intervention impacts. Results obtained and insights gained through implementation can facilitate learning by all involved, which will ultimately benefit forestry and carbon outcomes.

Moving the *Instituto Floresta Tropical* Training Agenda Ahead

Based on discussions with current and former IFT staff, we compiled a list of the types of training relevant to this Report that IFT could offer (Table 17). The courses could be run in Brazil or elsewhere but require a forest in which logging has occurred within 3-6 months, is underway, or can be carried out for educational purposes. For illustrative purposes we here use the example of 18 courses per year that would reach 250 participants and cost approximately USD226,000, without IFT's institutional overhead.[38] The costs per student, estimated at USD655-USD1,100, vary with the course offered and do not include travel expenses for students or instructors. An additional course to train auditors on the RIL-C protocol is also described.

Table 17. Courses, description, number of students, and costs that IFT has capacity to offer on improved forest management delivering carbon outcomes.

Course	Course Description	Number of days	Number of trainers	Number of students	Cost USD	Cost per student	Courses per year
Techniques for Improved Tree Cutting and Worker Safety	Safety and operational techniques for directional tree felling to decrease wood waste, including equipment maintenance. Course designed for team leaders, chainsaw operators and felling operation field assistants.	4	2	10	6,564	656	8
Forest Management: **RIL for Decision Makers**	All key aspects of sound management of natural forests, including pre-harvest, RIL and post-harvest silviculture. Designed for government agents, community leaders, forestry investors and entrepreneurs, journalists, and other	5	6	15	14,232	949	3

[38] IFT overhead costs may include acquisition of equipment, instruments and contracting of support services such as vehicle rental, one-off consultants, among others.

Course	Course Description	Number of days	Number of trainers	Number of students	Cost USD	Cost per student	Courses per year
	key strategic audiences.						
Forest Management: RIL for Forest Managers and Technicians	Covers all stages of forest management. Targets those responsible for coordinating and executing forestry operations, technicians and operational and field forestry managers, forest engineers and students.	6	6	20	USD 22,041	USD 1102	4
Training on the RIL-C Protocol for Auditors	It addresses all stages of sustainable forest management using the RIL-C protocol. Directed to auditors from independent verification bodies, government workers, and independent professionals.	4	6	15	USD 14,232	USD 949	3

Techniques for Improved Tree Cutting and Worker Safety. This course encompasses the best safety and operational techniques for directional felling, as well the techniques to decrease wood waste, and include equipment maintenance. Training is focused on the minimization of impacts and damage during felling and bucking operations. Minimum course content involves felling techniques for different types of trees and operational conditions, safety protocols, chain sharpening, carburetor adjustment, fuel mixtures, material and equipment used, daily maintenance routines, chainsaw engines, among others. This course is for team leaders, chainsaw operators and felling operation field assistants.

Forest Management/RIL for Decision Makers. The course encompasses key aspects of sound natural forest management including pre-harvest operations, RIL and post-harvest silviculture. It is directed to government agents, community leaders, forestry investors and entrepreneurs, journalists, and other key strategic audiences. It addresses all stages of sustainable forest management through practical field-based activities: demonstrations, hands-on experience, technical presentations, and evaluative activities. It stimulates critical thinking for decision making with an analytical and practical view of IFM.

Forest Management/RIL for Forest Managers and Technicians. This course covers all stages of forest management so that participants understand that forest management can be economically viable and is technically possible. The course offers participant the opportunity to observe and discuss all activities carried out during the development and execution of reduced-impact logging, including pre-harvest activities,

harvesting, and post-exploratory activities. The course delivers both lectures on IFM and practical demonstration of activities in the field. This course is intended for those responsible for coordinating and executing forestry operations, technicians, forest managers, forest engineers, and forestry students.

Training on the RIL-C Protocol for Auditors. After IFT staff complete the 3-4 day training in the field delivered by researcher Peter Ellis from TNC or Anand Roopsind from CI, they will offer the course to forest auditors from certification bodies, government agencies, and others. If needed, topics such as additionality, baselines, and leakage will be covered, but emphasis will be on field-based measurement protocols, data management, calculations, and reporting. Trainees would spend four half-days in a recently logged, within 3 months, forest measuring roads and skid trails, establishing biomass plots, and measuring collateral damage. Afternoons will be dedicated to data management, calculations, and reporting. This course can be combined with the existing **RIL damage assessment** training that IFT already offers .

Besides support to deliver the courses described, IFT would require some funding (USD30,000) to update the Strategic Plan 2020 developed with CLUA funding in 2019.

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Annexes

Annex 1. Methods

The report included five stages that started with literature review, summaries of forest-based carbon management activities underway and planned, and syntheses of related information based on interactions with a range of people in different institutions, in the target countries and elsewhere. We planned to integrate with information regarding USAID's work in these countries as much as possible.

For each country, the stages of preparation for this report were:

(i) Identify agents driving degradation in production forestry, their management approaches, activities, and carbon management outcomes (literature review);

(ii) Characterize the relevant aspects of their contexts, for instance, legal and economic;

(iii) Identify suites of interventions underway, or possible, that could enhance forest carbon outcomes with attention to underlying assumptions and risks;

(iv) Propose safeguards to address risks and strategies to overcome barriers; and

(v) Propose articulation and integration into larger carbon mitigation and management agendas.

Interview Guide

An Interview guide was prepared and available in English, Portuguese, and Spanish (below).

USFS-IP/USAID SL Proyecto Degradacion En Bosques Manejados

Meta del trabajo: identificar conjuntos de intervenciones en curso, en consideración y potencialmente útiles que podrían mejorar los resultados de carbono en bosques manejados.

Las principales vías consideradas son: (i) reducir la degradación: mediante prácticas adecuadas de aprovechamiento; reducir los daños colaterales relacionados con la tala; mejorar la utilización de la madera; y (ii) aumentar las reservas de C mediante la restauración de bosques degradados.

Los mecanismos que se están explorando que pueden mantener y aumentar las reservas de carbono en los bosques degradados por la tala incluyen:

(i) Uso de aprovechamiento de impacto reducido (AIR o RIL en inglés) en bosques que se están talando por segunda o tercera vez (p. ej., reutilización de caminos, construcción de caminos más angostos, cambio de extracción terrestre a uso de cable en lugares con pendientes pronunciadas y en pantanos, uso de mecanismos de incentivos para adoptar AIR prácticas, auditoría/supervisión de prácticas de tala);

(ii) Mejora de la utilización de la madera de árboles talados y árboles dañados por la tala (p. ej., mediante la diversificación de productos, el aserrado en los sitios de tala y en los desembarcaderos de troncos);

(iii) Restauración de bosques degradados mediante la aplicación de tratamientos silvícolas para mejorar el crecimiento de los árboles (p. ej., liberación de árboles de lianas, plantación de árboles donde los desmontes de caminos son amplios y en otras áreas de compartimentos madereros); y

(iv) Reservas basadas en una planificación sensata del uso de la tierra (por ejemplo, áreas ribereñas y empinadas);

Temas a investigar con los **manejadores de operaciones forestales**:

1. ¿Uso de la silvicultura? ¿Uso de AIR?
2. Qué impidementos existen para que lleve a cabo AIR de manera más consistente/efectiva/en la práctica?

3. ¿Se están cosechando ramas grandes? ¿Para qué? ¿Cómo se hace? ¿Bajo un contrato separado? Tipo de producto y destino?
4. ¿Existen operaciones madereras con márgenes de beneficio reducidos? ¿O porciones de operaciones de tala?
5. ¿Se están talando áreas comercialmente por primera vez? ¿O hay registro de reingreso?
6. ¿Qué arreglos se hacen para detener los incendios? ¿Es la falta de personal capacitado un problema?
7. ¿Se necesita más equipo? Si es así, ¿qué tipo? ¿Existe un sistema funcional de detección temprana de incendios?

Mano de obra:

8. Uso de contratistas (S/N y ¿por qué?).
9. Para implementar AIR, se necesitan trabajadores capacitados y supervisados. ¿Es la falta de trabajadores capacitados un problema? ¿Existen problemas con la supervisión, como demandas conflictivas sobre rendimientos y calidad del trabajo?

Aspectos económicos:

10. *Modus operandi*: madera vendida en la puerta del aserradero, o en el patio, o en pie (todas tienen implicaciones para los desechos y el volumen extraído y posibles acciones a proponer para abordar los desperdicios)
11. Está en marcha la tala comercial de madera?
12. Describir por favor la cadena de suministro y de valor de la madera de su operación.
13. Qué haría que los operadores decidieran cambiar de manejo forestal a una actividad diferente? ¿Cuándo es demasiado alto el costo de continuar con la extracción de madera en comparación con otras actividades? ¿Con qué aspectos está más relacionado esta decisión? Por ejemplo, precios de la tierra, costos de transporte, requisitos legales, etc.

Certificación:

14. ¿Hay auditores de adopción de AIR? Si es así, requieren demasiadas mejoras de los madereros en términos de calidad del trabajo?

PSA/ carbono del bosque:

15. Si los pagos de servicios ambientales (PSA; carbono por ejemplo) estuvieran disponibles, ¿quién podría estar interesado en la restauración de áreas degradadas para carbono o para madera y carbono, o interesado en realizar otras actividades? Cuáles?
16. En el caso de esquemas basados en reducir emisiones de carbono, ¿quién hace el registro real? ¿Empleados o contratistas de la empresa?

General:

17. Qué tipo(s) de "acción(es)" falta(n) a nivel de intervención; es decir, quién no está haciendo qué o qué no está sucediendo (p. ej., nuevo ángulo/enfoque, tipo de intervención, actor, temas específicos que deben abordarse, lugares, recursos incluyendo habilidades/ capacidades así como financieros, dónde, cuándo, etc.), mecanismos de integración en agendas más amplias y carbono potencial (y otros beneficios) y costos.

Temas a investigar con los **administradores de operaciones forestales** (ejemplo: SERFOR, GERFOR):

1. Tipos de actores que realizan el aprovechamiento: privados, concesionarios, comunidades, otros? Cuáles son prevalentes? Continúan actividades en la actualidad?
2. Regiones donde se realiza el aprovechamiento en el momento.
3. Proporción de concesiones activas (#)

4. Proporción de permisos activos (#)
5. Número de permisos/ Concesiones en trámite
6. Mecanismos de monitoreo: ¿Existe un sistema funcional de detección temprana de actividades ilegales?
7. Principales barreras
8. Oportunidades presentes
9. Contexto legal: definido? En evolución?
10. Contexto operativo para acceder a mercados de C: Existen programas o se trata de una alternativa/oportunidad realista con posibles ingresos complementarios o alternativos?

Temas a investigar con los **administradores de aserraderos**:

1. Mecanismos de operación: verticalmente integrado o no?
2. Tipo de productos?
3. Describir cadena de valor/ suministro?
4. Tipo y destino de productos?
5. Dificultades?

Interviewee List

Peru case study:

Interviewee/s	Organization
David Blas	OSINFOR
Jorge Solignac, Henry Lagunas, Silvia Meléndez, Sixto Luna	GERFOR –Loreto
José Luis Capella	SPDA
William Pariona	GIZ
Kerry Reeves, Victor Merino, Alvaro Gaillour	USAID
Andrea van der Ohe, Rebecca Ciciretti, Craig Wayson, Priyanka Jagtap, Rosa Zamora	USFS-IP
Claudio Schneider, Percy Summers, Anand Roopsind, Bronson Griscom	Conservation International
Mariolidy Sánchez, Percy Recavarren	AIDER
Peter Cronkleton, Manuel Guariguata	Center for International Forestry Research and World Agroforestry (ICRAF-CIFOR)
Gustavo Suárez de Freitas	Earth Innovation Institute
Concessionaires	Green Gold Forestry
Ing. Guiomar Seijas	Regente

Interviewee/s	Organization
Javier Montoya-Zumaeta; Javier Arce; Margarita Céspedes; Jorge Rodríguez; César Sabogal	

Brazil case study:

Interviewee/s	Organization
Marco Lentini	IMAFLORA
Renato Farias, Vinicius Silgueiro	ICV
Jayleen Vera, Kirsten Silvius	USFS-IP
Sergio Safe, Alexandre Brasil	EVERGREEN Investimentos Florestáis
NN and NA (preferred not to be identified)	Concessionaires
Frank Rogieri	Fórum Nacional das Atividades de Base Florestal do Mato Grosso (FNFB)
Valdinei Bento dos Santos	CIPEM
Iran Pires Peres	IFT
Daniel Bentes	Associacão Brasileira de Empresas Concessionárias Florestais –CONFLORESTA (States of Pará and Rondônia)
Eric Holst, Mark Moroge[39]	Environmental Defense Fund (EDF)
Dan Nepstad, David McGrath	Earth Innovation Institute

[39] Interactions with EDF were mostly for the benefit of informing them of the work of this report but they did not provide answers to the survey.

Annex 2. Tables

Table Annex 1. Carbon projects in the tropics classified as improved forest management and registered under recognized voluntary carbon standards

Project Name	Standard	AFOLU Activities	Status	Country	Estimated Annual Emission Reductions (tCO_2e)	Crediting Period Start/End	Natural Forest Management	Activities
Forest Conservation in Boumba-et-Ngoko	VCS	IFM	Under development	Cameroon	191,321	2018-2037	No	LtPF
Improved forest management through logged-to-protected forests and reduced impact logging in UFA Ngombé, Republic of Congo	VCS	IFM	Under development	Congo	413,560	2015-2024	Yes	RIL-C; LtPF
Kuamut Rainforest Conservation Project	VCS	IFM	Under development	Malaysia	729,030	2015-2045	No	LtPF
Serra do Sudeste Landscape Restoration and Reforestation Project	VCS	IFM; REDD+	Under validation	Brazil	8,152	2021-2051	No	ARR/ANR
Green Gold Loreto I	VCS	IFM	Registered	Peru	486,931	2020-2040	No	LtPF
INFAPRO Rehabilitation of logged-over dipterocarp forest in Sabah, Malaysia	VCS	IFM	Registered	Malaysia	138,013	2017-2026	No	LtPF
Grouped Project for restoration of degraded lands in Jaguar Corridors, Colombia	VCS	IFM; REDD+	Registered	Colombia	6,835	2015-2055	No	ARR/ANR
Amazon Rio REDD+ IFM	VCS	IFM; REDD+	Registered	Brazil	61,238	2013-2049	No	APD; LtPF
April Salumei REDD Project	VCS	IFM; REDD+	Registered	Papua New Guinea	1,032,650	2009-2047	No	LtPF

Project Name	Standard	AFOLU Activities	Status	Country	Estimated Annual Emission Reductions (tCO_2e)	Crediting Period Start/End	Natural Forest Management	Activities
Conversion to Protection of the Amazon Rain Forest	VCS	IFM	Under validation	Bolivia	9,900	2008-2038	No	LtPF
Babatana Rainforest Conservation Project	Plan Vivo	IFM	Registered	Solomon Islands	16,990	2015-2044	No	LtPF
Drawa Rainforest	Plan Vivo	IFM	Registered	Fiji	18,800	2012-2043	No	LtPF
Gula Gula Food Forest program	Plan Vivo	IFM	Under development	Indonesia	Not available	2019	No	ANR
Bujang Raba Community PES project	Plan Vivo	REDD+	Registered	Indonesia	40,000		No	ARR/ANR
Halo Verde Timor Community Forest Carbon	Plan Vivo	IFM	Registered	Timor Verde	Not available	2011-2041	No	ARR/ANR
Rehabilitation and sustainable management of degraded pastures in the Sahel region of Burkina Faso	Plan Vivo	ARR; IFM	Registered	Burkina Faso	Not available	2014-2044	No	ARR/ANR
Scolel'te	Plan Vivo	ARR; IFM	Registered	Mexico	Not available	1997-2037	Yes	ARR/ANR
Trees for Global Benefits	Plan Vivo	ARR; IFM; ANR	Registered	Uganda	Not available	2003-2033	No	ARR/ANR
CommuniTree Carbon Program	Plan Vivo	ARR; IFM	Registered	Nicaragua	Not available	2010-2060	No	ARR/AF
Trees of Hope	Plan Vivo	ARR; IFM	Registered	Malawi	Not available	2007-2057	No	AR/AF
Ethiotrees	Plan Vivo	ANR	Registered	Ethiopia	Not available	2016-2036	No	ANR
Nugum Lunang Lelum Tano' (Punan Long Adiu)	Plan Vivo	REDD	Registered	Indonesia	Not available	2018-	No	AD; LtPF

Project Name	Standard	AFOLU Activities	Status	Country	Estimated Annual Emission Reductions (tCO_2e)	Crediting Period Start/End	Natural Forest Management	Activities
Hiniduma Bio-Link Project	Plan Vivo	ARR; REDD+	Registered	Sri Lanka	Not available	2011-2031	No	ARR/AF
Loru Forest (Ser-Thiac)	Plan Vivo	REDD	Registered	Vanuatu	2,442	2016-2046	No	AF; AD-DtPF
Khasi Hills Community REDD+ Project	Plan Vivo	REDD+	Registered	India	Not available	2012-2042	No	AD; ANR
Vanga Blue Carbon	Plan Vivo	REDD+; ARR	Registered	Kenya	Not available	2019-2039	No	AD; ARR
Hieu Commune REDD+ project	Plan Vivo	REDD+; IFM	Registered	Vietnam	Not available	2019-2048	No	ANR; AD; AF
Durian Rambun	Plan Vivo	REDD+	Registered	Indonesia	6,618	2013-2043	No	AD; ANR; ARR
Mikoko Pamoja	Plan Vivo	REDD+; ARR	Registered	Kenya	2500	2012-2032	No	ARR; AD
Yaeda-Eyasi Landscape REDD project	Plan Vivo	REDD+	Registered	Tanzania	Not available	2021-2040	No	AD
Tahiry Honko	Plan Vivo	REDD+	Registered	Madagascar	Not available	2018-2037	No	AD; ARR; IFM
Rimbak Pakai Pengidup (Nanga Lauk)	Plan Vivo	REDD+	Registered	Indonesia	Not available	2018-2022	No	AD

AD: Avoided Deforestation; AD-DtPF: Avoided Deforestation – Deforestation to Protected Forest; AF: Agroforestry; IFM: Improved Forest Management; ANR: Assisted Natural Regeneration; LtPF: Logged to Protected Forest; ARR: Afforestation/Reforestation/Regeneration; RIL-C: Reduced-impact logging for climate; REDD+: Reduced Emissions from Deforestation and Forest Degradation; VCS: Voluntary Carbon Standard

Table Annex 2. Description of how approved methodologies for improved forest management address leakage (market- and activity-shifting) and additionality

Standard	Methodology Name	Description	Leakage	Additionality
VCS	Methodology for Improved Forest Management through Targeted, Short-Term Harvest Deferral	This methodology applies to project activities that reduce net greenhouse gas (GHG) emissions in managed forests for a specified time through harvest deferrals to extend cutting cycles. Projects using the methodology are considered under the improved forest management (IFM) subclass of extended rotation age (ERA) projects. The methodology is applicable to projects in all types of forests, including plantation forests.	Activity shifting leakage is assumed to be zero given the applicability conditions of the methodology, as owners and managers must enroll the entirety of holdings within the project area. Market shifting leakage must be calculated.	This methodology uses a dynamic performance method for the demonstration of additionality: Step 1: Regulatory Surplus--Project proponents must demonstrate regulatory surplus in accordance with the rules and requirements regarding regulatory surplus set out in the latest version of the *VCS Methodology Requirements*. Step 2: Performance Benchmark--The procedure described in the methodology provides a dynamic performance benchmark in the form of carbon at risk of removal due to harvesting that would occur, in the absence of carbon finance, during the activity period. This performance benchmark forms the baseline scenario for the activity period. Deferral of harvests that would occur under the project scenario are deemed additional.
VCS	VM0003 Methodology for Improved Forest Management through	Quantifies the GHG emission reductions and removals generated from improving forest management practices to increase the carbon stock on land by extending	The type of leakage emissions to be calculated are GHG emissions due to market effects resulting from a shift in harvest through time. Leakage due to activity shifting is not permitted. If the project decreases wood product	The project proponent must test the additionality of the project using the current *UNFCCC CDM Tool for the demonstration and assessment of*

Standard	Methodology Name	Description	Leakage	Additionality
	Extension of Rotation Age, v1.2	the rotation age of a forest or patch of forest before harvesting.	production by more than 5% relative to the baseline then the project proponent and all associated landowners must demonstrate that there is no leakage within their operations – i.e., on other lands they manage or operate outside the bounds of the IFM project.	*additionality*. If a financial analysis or a demonstration of barriers does not lead to the preclusion of the project scenario then the project must be considered non-additional. The Clean Development Mechanism (CDM) Additionality Tool provides a step-wise approach to demonstrate and assess additionality: • Identification of alternatives to the project activity; • Investment analysis to determine whether the proposed project activity is either: 1) not the most economically or financially attractive; or 2) not economically or financially feasible; • Barriers analysis; and • Common practice analysis. Based on the information about activities similar to the proposed project activity, the common practice analysis is to complement and reinforce the investment and/or barriers analysis.
VCS	VM0005 Methodology for Conversion of Low-productive Forest to	Quantifies the GHG emission reductions and removals generated by avoiding re-logging or the rehabilitation of previously logged forest. Rehabilitation is achieved by implementing silvicultural techniques	This methodology only provides for the determination of leakage due to market effects. Project Action: Substantially reduce harvest levels permanently where there	The project proponent must demonstrate that the project is additional through the use of the latest version of the *VCS Tool for the Demonstration and Assessment of Additionality in IFM Project Activities*. This

Standard	Methodology Name	Description	Leakage	Additionality
	High-productive Forest, v1.2	to increase tree density and growth rates, such as cutting climbers and vines, liberation thinning, or enrichment planting.	is moderate to high risk of leakage. For example, RIL activity that reduces timber harvest by 25% or more across the project area; or a forest protection or no logging project.	tool provides for a step-wise approach to demonstrate additionality in IFM project activities: STEP 0. Preliminary screening based on the starting date of the IFM project activity; STEP 1. Identification of alternative land use scenarios to the IFM project activity; STEP 2. Investment analysis to determine that the proposed project activity is not the most economically or financially attractive of the identified land use scenarios; or STEP 3. Barriers analysis; and STEP 4. Common practice analysis.
VCS	VM0006 Methodology for Carbon Accounting for Mosaic and Landscape-scale REDD+ Projects, v2.2	Quantifies the GHG emission reductions and removals generated in mosaic and landscape scale REDD+ projects by allowing such project activities to be combined with improved forest management, afforestation, reforestation and re-vegetation activities, as well as clean cookstoves initiatives. This methodology is applicable to forest that would be deforested in the absence of the project activity. Deforestation and degradation in the baseline would be caused by: 1) conversion of forest to	Leakage does not only occur on forest land outside of the project area, but also on non-forest land, such as woodlands or grassland. The market leakage assessment need only be included when illegal logging activities that supply timber to national or international markets are an identified driver. Stopping illegal logging to supply timber products to local communities is going to shift pressures to forested areas close to the project area. As a consequence, emissions due to market-effect leakage	The project proponent must demonstrate the additionality of the project using the most recent version of *VCS Tool for the Demonstration and Assessment of Additionality in AFOLU Project Activities* (VT0001). (see Box 1 for further detail)

Standard	Methodology Name	Description	Leakage	Additionality
		crop-land or grazing land for small-scale farming; 2) conversion of forest land to settlements; 3) logging of timber for commercial sale; 4) logging of timber for local and domestic use; 5) fuel-wood collection of charcoal production; or 6) forest fires.	will be detected by the monitoring for activity shifting leakage. However, if the illegal logging activities supply timber products to regional, national or global markets, there is high likelihood of market leakage beyond the detection boundaries of the activity-shifting leakage.	
VCS	VM0010 Methodology for Improved Forest Management: Conversion from Logged to Protected Forest, v1.3	Quantifies the GHG removals generated from preventing logging of forests that would have been logged in the absence of carbon finance. This methodology is applicable where the baseline scenario includes planned timber harvest, and under the project scenario, forest use is limited to activities that do not result in commercial timber harvest or forest degradation.	Leakage due to activity shifting is not permitted. Where the project proponent controls multiple parcels of land within the country the project proponent must demonstrate that the management plans and/or land-use designations of other lands they control have not materially changed as a result of the planned project (designating new lands as timber concessions or increasing harvest rates in lands already managed for timber) because such changes could lead to reductions in carbon stocks or increases in GHG emissions. Leakage due to market effects is equal to the net emissions from planned timber harvest activities in the baseline scenario multiplied by an appropriate leakage factor.	The project proponent must demonstrate the additionality of the project using the most recent version of *VCS Tool for the Demonstration and Assessment of Additionality in AFOLU Project Activities* (VT0001). (See Box 1 for further detail)
VCS	VM0011 Methodology for Calculating GHG	This methodology quantifies the GHG emission reductions generated from improving forest management and	There are two sources of leakage that need to be considered and addressed in this methodology:	For the specific case of demonstration and assessing additionality, the project proponent must use the latest version of

Standard	Methodology Name	Description	Leakage	Additionality
	Benefits from Preventing Planned Degradation, v1.0	preventing the planned degradation of a forest by stopping selective logging. This methodology accounts for a reduction in GHG emissions by stopping logging as well as an increase in carbon stock growth. This methodology is applicable to previously logged or intact tropical forests where selective logging would have occurred in the absence of carbon finance.	1) Carbon from degradation due to the baseline activity shifting. For example, removal of harvested wood products including sawlog, pulplog and commercially harvested fuel wood and emissions from the associated activities outside the project area; and 2) Carbon from market leakage, due to shifts in supply and demand of the products and services affected by the project activity, which in this case is the supply and demand of timber.	the *VCS Tool for the Demonstration and Assessment of Additionality in AFOLU Project Activities* (VT0001). (See Box 1 for further detail)
VCS	VM0035 Methodology for Improved Forest Management through Reduced Impact Logging v1.0	Applicable to projects which implement reduced impact logging practices to reduce greenhouse gas (GHG) emissions (RIL-C practices) in one or more of three GHG emission source categories: timber felling, skidding and hauling.	Since the applicability conditions do not allow for changes in harvest levels, it can be conservatively assumed that leakage is zero because there is no difference in harvest levels between the baseline and project scenarios.	This methodology uses a performance method for the demonstration of additionality: Step 1: Regulatory Surplus--The project proponent must demonstrate regulatory surplus in accordance with the rules and requirements regarding regulatory surplus set out in the latest version of the VCS Standard. Step 2: Performance Benchmark--The Projects must exceed the region-specific performance benchmark for each impact parameter (i.e., proxy factor), as provided in the applicable RIL-C performance method module. One or more impact parameters are defined in the applicable RIL-C performance method module for

Standard	Methodology Name	Description	Leakage	Additionality
				each of three categories: felling impacts, skidding impacts and hauling impacts. A project is deemed additional for one or more impact parameters if the impact parameter is below the additionality benchmark assigned for that impact parameter.
Plan Vivo	PM001 Agriculture and Forestry Carbon Benefit Assessment Methodology	This methodology provides details of carbon accounting procedures that can be used in smallholder agriculture and community forestry projects that generate Plan Vivo Certificates (PVCs).	If there is potential for significant GHG emissions from activity shifting leakage, activity shifting leakage emissions must either be estimated, or a conservative leakage discount factor must be applied. If project interventions result in a reduction in the production of wood, animals, or agricultural products by agents other than those engaged in subsistence and small-scale production, market leakage must also be assessed. Since Plan Vivo projects can only take place in project areas where the project participants are involved in subsistence and small-scale production, market leakage from changes to the activities of project participants does not need to be included in the carbon accounting.	No mention of additionality.

Table Annex 3. Jurisdictions applying for registration under the TREES and JNR standards. Although the jurisdictions listed as applying under JNR have not yet advanced to being listed in the VCS registry, we include them here as we have had confirmation that they are advancing with their applications.

Jurisdiction			Standard	Status*
Country	Name	Submitting entity		
Brazil	Amapá	Subnational	TREES	Listed; Concept Note submitted Dec 2020
	Maranhão	Subnational	TREES	Listed; Concept Note submitted Dec 2020
	Tocantins	Subnational	TREES	Listed; Concept Note submitted Dec 2020
Colombia	Amazon Region (Amazonas, Caquetá, Guainía, Guaviare, Putumayo and Vaupés)	National	TREES	Listed; Concept Note submitted Oct 2021
Costa Rica	Costa Rica	National	TREES	Listed; Concept Note submitted Dec 2020
DRC	Thsuapa	National	TREES	Listed; Concept Note submitted Aug 2021
Ecuador	Ecuador	National	TREES	Listed; Concept Note submitted Aug 2021
Ethiopia	Ethiopia	National	TREES	Listed; Concept Note submitted Jan 2023
Gabon	Gabon	National	TREES	Listed; Concept Note submitted Apr 2022
Ghana	10 southwestern regions	National	TREES	Listed; Concept Note submitted Aug 2021
Guyana	Guyana	National	TREES	Registered; Credits for 2016-2020 period issued Dec 2022
Mexico	Quintana Roo	Subnational	TREES	Listed; Concept Note submitted Sep 2022
Nepal	Bagmati, Gandaki and Lumbini	National	TREES	Listed; Concept Note submitted Feb 2022
Papua New Guinea	Papua New Guinea	National	TREES	Listed; Concept Note submitted Dec 2021

Jurisdiction			Standard	Status*
Country	Name	Submitting entity		
Uganda	Uganda	National	TREES	Listed; Concept Note submitted Jan 2023
Vietnam	11 provinces	National	TREES	Listed; Concept Note submitted Aug 2021
Peru	Peru	National	TREES	Listed; Concept Note submitted Feb 2022
	Ucayali	Subnational	JNR	Application for registration in progress*
Argentina	Misiones	Subnational	JNR	Application for registration is in progress

*National government may not approve of certification for subnational jurisdiction

Annex 3. Organizations in the Forestry Sector in Loreto-Peru

Governmental Organizations

- ***Organismo de Supervisión de los Recursos Forestales y de Fauna Silvestre* (OSINFOR)** oversees the performance of forestry operations. This agency issues field-based score cards to forestry operations that qualitatively indicate management quality; developed the digital applications SIGO and SIADO (information management systems) to follow up and store enforcement reports along with information on FMP; provides workshops for regional governments, prosecutors, and users to illustrate the use of these tools; developed, with USAID support, a series of training materials on different aspects of forest management (e.g., forest values, regulations and access to resources, conflict resolution, fire prevention), which has been broadly disseminated.
- ***Forest and Wildlife Service Peru (SERFOR)*** is the technical and regulatory agency responsible for implementing the Peruvian Forest and Wildlife Law. Certifies forest regents.
- ***Loreto Gerente Regional de Desarrollo Forestal y de Fauna Silvestre (GERFOR – LORETO)*** is the agency responsible for enforcing forest regulatory frameworks in coordination with SERFOR, based at the Loreto Regional Government. It develops natural resources surveillance and control systems, deploys field inspections, and grants forest rights and management plan licenses.
- **The Peruvian Ministry of Economy and Finance** authorized in 2021 the transfer of USD4.4 million to be used to reactivate and finance activities aimed at strengthening the competitiveness and sustainable use of forest resources and wildlife in Ucayali, Loreto and Madre de Dios. Most resources are designated to support control and surveillance, with less focus on improving practices on the ground, including FMP preparation, timber harvesting and processing.

In 2020, SERFOR and the National Statistics Institute (INEI) Peru, along with Costa Rica and Germany, began to develop the *System of Environmental and Economic Accounts (SCAE)* that will demonstrate the contributions of the forest and wildlife sector in the national economy.

Other Organizations/ Projects

- **USAID** has supported SERFOR in the development of an online information management system for forest and wildlife, also known as the System Control Module National Forest and Wildlife Information System (MC-SNIFFS). Despite the expressed desire of many Peruvians in government and the private sector to maintain an active forestry sector in the Amazon, USAID-Peru supports the allocation of carbon incentives for not logging.
- **SilvaCarbon**, together with USFS, helps to build government capacity to produce and use improved information related to forest and terrestrial carbon stores and land use change and degradation.
- ***Forest Oversight and Resource Strengthening Program (FOREST)***, with the USFS, provides capacity-building for agency workers at SERFOR, OSINFOR, and regional governments. It provides overall support to strengthen institutional capacity for forest governance, including as public administration, capacity building programs, information management and implementation of the regulations. Training activities also target local communities to build their negotiation skills and achieve better deals with logging subcontractors.
- ***ProBosques*** seeks to strengthen forest sector activities through the design and adoption of dynamic management tools, including legality and source tracking and traceability of timber products. For example, a tool for legality verification. To support a diversified forestry agenda, ProBosques also supports both small actors from the private sector to improve management performance and rents, as well as Indigenous communities to strengthen their lobbying . This supports development plans for diversity of commodities. ProBosques also provides territorial management including monitoring and surveillance with sustainability considerations to develop and strengthen market linkages including harvesting palm fruits, forest enrichment, fishing management, but less in wood.

- ***Prevenir*** supports the Peruvian government and civil society to improve conditions to prevent and combat environmental crimes. It developed the app *MiBosque* to record and share timely information regarding management and infractions alerts.
- ***Forest Alliance*** consolidates a comprehensive forest management model for Indigenous lands through firming of community-based forest management with AIDER. It focuses on creating enabling conditions (e.g., monitoring protocols, clarifying tenure), sustainable business models for several products (but not yet carbon), and facilitates learning and experience sharing, by identifying partnerships and consolidating communities' organizations.
- *The* ***Catalyze initiative*** will create a platform of services in biodiversity-rich regions through a blended finance approach to facilitate new investments at scale in the Amazon region. This will include further job creation, sustainable licit market development, and inclusive growth. The initiative engages with domestic and international finance providers to mobilize financing across varied sectors. In the Amazon, the initiative will pilot scalable approaches for businesses to grow in three ways: by structuring new investments through private partnerships; strengthening the depth, breadth, and availability of financial services for entrepreneurs; and supporting the development of digital ecosystems to sustain new business.
- The **German Cooperation Agency (GIZ)** supports environmental policy and the protection and sustainable use of natural resources, including sustainable use of forests, the establishment of protected areas, climate risk insurance and steps to mitigate the impact of extreme weather events. GIZ is housed with the *ProAmbiente* program. This program seeks to increase the competitiveness of products derived from the forest, especially timber-derived, and has additionally been co-financed by the Tropical Wood Program of the Sustainable Trade Initiative of the Netherlands (IDH), within the framework of the *ProMadera* project[40] (*The Amazon Alternative)*. This last project aimed to support FSC certification adoption and maintenance (i.e., forest management, chain of custody, and control-wood certification) by covering 50% of training and other associated costs including FSC audits, high conservation value forest assessments, as well as links to international markets, which was also cosponsored by IDH. The recently approved phase for the *ProAmbiente* program *Promotion and Sustainable Management of Forest Production in Peru* will run until 2024. This is a loan for a total of USD110 million some of which will be allocated to the improvement and expansion of forest management in several departments including Loreto, Madre de Dios and Ucayali. This will support infrastructure improvement, provision of equipment, furniture, and technological tools as well as development and strengthening of capacities. GIZ Peru also developed an open-code software called *DataBosque*. It can be used both as a management and decision-making platform, enabling companies to track wood and monitor costs, machines, and workers in one place. This software was transferred to SERFOR in 2018 along with training on its use. Despite these efforts, as of January 2020, only an estimated 50% of operations use *DataBosque* (Rodríguez 2020).
- **Conservation International (CI)** provides overall support for region's transition to green growth development modes. CI supports REDD+ processes, establishes conservation agreements with small landholders to stop deforestation and increase restoration, and promotes agro-forestry activities (coffee and cocoa). CI is currently seeking to train Peruvian forest technicians in RIL-C protocols. Once trained, these crews will build on the work of Goodman et al. (2019) to establish a baseline for logging emissions from the Peruvian Amazon. The hope is that once this baseline is established RIL-C carbon credits will be marketable.
- ***Amazon Business Alliance (ABA)*** *(*supported by CI and USAID) is a platform to facilitate investment through grants or loans in forest-based adaptation and mitigation activities through development of business models to leverage funds from the public sector and support local communities and conservation. Initiatives are meant to be integrated with local plans and seek ways to scale up through public and private additional support, including from international cooperation.

[40] ProMADERA Project. *Promoviendo el manejo forestal sostenible y empresas forestales competitivas en el Perú.* GIZ. 8 pp.

- ***Nuestros Futuros Bosques–Amazonia Verde*** (French government funding) supports 26 Indigenous and local communities to improve land management for conservation by identifying productive supply and value chains, capacity-building, and promotion of learning and experience sharing.

Annex 4. Organizations in the Forestry Sector in Mato Grosso, Brazil

Governmental Organizations

- ***Servicio Florestal Brasileiro (SFB) (***Brazilian Forest Service) is an agency of the Ministry of Agriculture (during the Presidency of Bolsonaro but previously under the Ministry of the Environment) whose mission is to promote the economic and sustainable use of Brazilian forests with a view to integrate forest-based development into the country's economic and strategic agendas. They lead and support the definition of public policies, management of natural resources, and development of plans for the use and conservation of forests. SFB also carries out the National Forest Inventory to continuously monitor forest resources throughout the country and coordinates the National Forest Information System (SNIF). SNIF is a platform that gathers information on topics related to forests and the forest sector. In addition to the information produced by the agency, SNIF provides data produced by Brazilian and foreign institutions, both public and private. The objective is to facilitate obtaining and managing this information in an organized and updated way by the whole of society, including for the formulation and execution of policies for sustainable use, conservation, and recovery of forest resources
- ***Secretaria de Estado de Meio Ambiente do Mato Grosso* (SEMA-MT).** In general, the Secretariats of the Environment within each state develop state forest policies and regulations. Some institutes, for example the Forest Institute in São Paulo and the State Institute of Forests in Minas Gerais, are responsible for the licensing, control, and supervision of forest activities. Other states have branches within the Secretariat of the Environment that are solely responsible for forest management, as in Mato Grosso and Pará (SFB 2013). SEMA-MT works to make sure the timber sector remains active through overcoming regulatory bottlenecks. This regulatory flow has greatly improved particularly thanks to the new version of SISFLORA (2.0), *Sistema de Comercialização* e *Transporte de Produtos Florestais (*Marketing and Transporting Forest Products State System). There are complementary systems that control the origin of forest products like *Sistema Nacional de Controle da Origem dos Produtos Florestais* (SINAFLOR), which was made mandatory in 2018. Other tools include the *Documento de Origem Florestal* (DOF) (document of forest origin), which operates at the national level in titles on Federal lands and in states that do not operate their own system.

  SEMA-MT recently organized a 2-day workshop to discuss monitoring of degradation in Mato Grosso and the Amazon region where the *Sistema de Monitoramento da Exploração Madeireira* (SIMEX) (Amazon System for Monitoring Timber Harvesting) was presented, along with other degradation monitoring methods and tools. This event an outcome of the collaboration of the now consolidated *Rede SIMEX*. A network was set up in 2020 was led by IMAZON and joined by *Conservação* e *Desenvolvimento Sustentável* (IDESAM), *Instituto de Manejo* e *Certificação Florestal* e *Agrícola* (IMAFLORA) and ICV. IMAZON created the monitoring system in 2008.

Other Organizations/ Projects

- **USAID** works closely with the Brazilian government, local organizations, and the public, to seek landscape-scale solutions to issues affecting forests conservation and livelihoods, including forest restoration on Indigenous lands. Collectively they develop forest and fire management strategies to protect public lands, strengthen biodiversity conservation, and enhance livelihoods in the Amazon Region through adaptation of activities, for instance developing ecotourism and reforestation, and value chains to climate change.

  At the recent Summit of the Americas (May 2022), Brazil and the United States announced the creation of a high-level ministerial working group to launch a bilateral rapid response to achieve immediate results and reverse deforestation in the Brazilian Amazon and other biomes, called the Joint Initiative on Climate Change. The Initiative is implemented through a new high-level United States-Brazil Climate Change Working Group (CCWG) aimed at enhancing bilateral cooperation on

issues relating to land use, clean energy, and adaptation, as well as policy dialogues on domestic and international climate issues. Efforts will also be made to reduce illegal national and international wildlife trafficking, illegal mining, and illegal timber trade, with a focus on the roles of international financial systems in illegal trade of forest products. The stated goal is the reduction of illegal deforestation by 15% per year from 2022 to 2024, 40% below prior year levels in 2025 and 2026, and 50% below prior year levels in 2027, to achieve zero illegal deforestation in 2028.

- **USFS and USFS International Programs (USFS-IP)** implement an important fraction of USAID activities in Brazil. They are in charge of projects related to fire control and management, including prevention, suppression through training, research, on public and private lands, including indigenous lands. They are also response for advancing restoration activities on Indigenous lands degraded by fire. They plan to continue strengthening partnerships to boost fire management and prevention in light of the soon-to-be launched National Integrated Fire Management Policy in Brazil and the several jurisdictional proposals to the LEAF initiative for access to voluntary market funds. Together with USAID, USFS implements the Sustainable Landscapes program, which aims to improve the monitoring, reporting and verification of greenhouse gases for REDD+ (reduction of emissions from deforestation and forest degradation). USFS has collaborated directly with SFB over the years, and the last activity was a series of Technical Dialogues, including the 2019 Second US-Brazil Forum for Innovative Forest Investment, and the 2021 Technical Dialogues for Forest Development. These aimed to increase adoption of smart agricultural practices, improve monitoring of net emissions from forests, and learn about forest restoration finance, for example USFS Technical Exchange.[41]

  In collaboration, the Department of State (DoS), USAID, and USFS are developing a proposal under the Support Hub for Forest Finance and Landscape Engagement to support the State of Mato Grosso to map forest degradation and to quantify carbon losses and gains from forest degradation and regeneration. This activity will allow incorporating forest degradation in the estimates and analysis of errors and uncertainties in emissions calculations. Potential partners include SEMA-MT, ICV, *Empresa Brasileira de Pesquisa Agropecuária* (EMBRAPA), *Universidade Federal dos Vales do Jequitinhonha e Mucuri*, and the *Centro de Gestão de Pesquisa, Desenvolvimento e Inovação*. The hope is to shape this effort into both a monitoring and management intervention. This project would potentially span 2022-23.

  USFS-IP developed an internal proposal to work with SFB on forest concessions to support demonstration sites that could include carbon monitoring. It is not clear whether this initiative has moved ahead nor whether proponents are considering use of the RIL-C protocol to measure logging related emissions.

  A range of non-governmental organizations, including ICV, IMAFLORA, IFT, IMAZON, *Bolsa Verde do Rio de Janeiro* (BVRio) and *Centro da Indústrias Produtoras e Exportadoras de Madera do Mato Grosso* (CIPEM), have generated knowledge to support the forestry sector. Collectively, they have worked to identify the fundamental constraints to responsible forest management and sought opportunities to improve forest governance considering current climate change mitigation and adaptation agendas. We present some information about these institutions' activities that may be relevant in future agendas regarding implementation of our proposed mechanisms.

- ***Instituto Centro da Vida* (ICV)** has mapped and analyzed timber, logging and deforestation patterns, particularly to understand the level of illegality since 2003. In 2011, ICV launched the *Programa de Desenvolvimento do Bom Manejo Florestal no estado de Mato Grosso* (PRODEMFLOR) in the municipality of Cotriguaçu in Mato Grosso, supported by ONF International. The program focused on providing technical skills training to develop PMFSs. The program also sought to adopt RIL through voluntary, written agreements with small to medium-sized timber companies as a way of supporting the completion of more PMFSs, more quickly. The training was provided by IFT (see below). However, the project did not proceed as expected because of difficulties with getting PMFS approved (Guerra et al., 2014). ICV recently started to work with the Environmental Investigation

[41] https://www.fs.usda.gov/managing-land/shared-stewardship/background/conservation-finance

Agency, among others, in other projects that focus on the movement of timber from property to market. ICV is also collaborating on a new project with the USDA Forest Service to map different logged areas (ranging from low to high impact) using LiDAR and then extrapolating to all areas identified by SIMEX to model carbon stocks in logged forests and to support methods development for degradation monitoring. We do not know whether they are using the RIL-C protocol for ground-truthing but recommend that they do.

- ***Instituto de Manejo e Certificação Florestal e Agrícola*** **(IMAFLORA**) is a well-established socio-environmental NGO, active since the mid-90s. IMAFLORA aims to advance capacities and improve activities related to land use and climate change in agricultural and forestry sectors; and to verify responsible forestry and agricultural supply chains and those associated with consolidation of territorial development by local and Indigenous communities. It also runs a timber legality and value chain verification system (*LegalSource*/*Forest Legality*) and supports forest management certification through training of auditors and performing audits. It recently created the platform *TimberFLow* in partnership with the *Instituto de Ciências Matemáticas e de* Computação (ICMC) of the *Universidade de São Paulo* (USP). This tool allows visualization of information related to transport, processing, and commercialization of wood in the Brazilian Amazon. ICV/ IMAZON and other SIMEX partners are collaborating with IMAFLORA to link SIMEX with *TimberFLow*. This tool focuses on mapping where timber moves in the market, which is key to transparency and will be useful in studies of the Brazilian timber sector.

BOX 6 *INSTITUTO FLORESTA TROPICAL* (IFT)

IFT's main goal is to promote good forest management practices for the conservation of natural resources and to improve quality of life for forest workers and communities. A Center of Excellence in Forestry in the Amazon biome, IFT's vision is centered on developing a fair, sustainable and inclusive forestry sector, supported by industry participants. This vision is based on building technical and legal capabilities, centering the importance of traditional communities' knowledge.

IFT has pioneered training activities over 25 years in forest management, including community forest management and applied research. Its work has contributed to decision-making for the use and management of natural resources. During this period, IFT has trained more than 8,800 technicians, workers, communicators, decision makers and forest engineers in practical application of forest management and the business-side of forestry.

IFT courses include how to plan and execute forest management with Reduced-Impact Logging (RIL); operating costs; management and accounting; botanical identification; legislation applied to forest management; wood and NTFP; forest insurance; forest concessions; and health and safety at work. The courses are both *in-* and ex-*situ* and provide invaluable field experience to participants. Over the years, IFT has worked with several partners: (timber producer associations: *Associação das Indústrias Exportadoras de Madeiras do Estado do Pará* -AIMEX); universities, including the Federal Rural University of the Amazon, Federal University of Pará, *Escola Superior de Agricultura "Luiz de Queiroz"* at USP; technical institutes; NGOs, including IMAFLORA and IMAZON; government; and the private sector, including Stihl, Cikel, and Carterpillar. IFT's work was financed by several national and international partners: the Moore Foundation, Climate Land Use Alliance (CLUA); USAID and USFS, the International Tropical Timber Organization (ITTO), Fundo Vale, Fundo Amazônia, among others.

IFT advocates for transition from forest exploitation to forest management in ways that reconcile conservation with profitable timber stand management; and that generates environmental products and services while improving the quality of life and access to income and employment opportunities for local communities. There are few organizations working with forest management, and virtually none offering the hands-on training delivered by IFT. As an innovative NGO, IFT has flexibility and the opportunity to establish partnerships and advance goals that benefit society-at-large.

IFT has tried over the years to engender a forestry culture that strives towards sustainable forest management. They try to dispel the widespread misperception that the timber sector's agenda is inextricably linked to deforestation. They understand the need for coordination among actors interested in advancing the forestry agenda. They also understand that it is necessary to take advantage of the business environment and policies to encourage forest production, such as forest concessions and land tenure regularization for small producers, to advance forest management and restoration of altered forest fragments in Brazil. IFT's expertise in forestry extends beyond the borders of Brazil, and they have carried out training activities in Bolivia, Peru, Colombia, Guyana, Suriname, and elsewhere.

Consolidation of a forestry economy depends on planning and monitoring infrastructure, working in concert with a government structure to maintain long-term productivity of these forests. IFT is interested in working to recover environmental suitability within the *Reserva Legal,* thus its interest in forest restoration.

- ***Instituto do Homem e Meio Ambiente da Amazônia* (IMAZON)** is a non-for-profit research and capacity-building organization established in 1990 with the goal to promote conservation and sustainable development in the Amazon. Its members have over 700 publications and contribute to the most important debates in the country's socio-environmental agenda through strategic training of key municipal and other personnel. Along with SIMEX, IMAZON also developed PrevisIA, an AI modeling tool to predict the risk of deforestation[42].
- ***Bolsa Verde do Rio de Janeiro* (BVRio)** was created in 2011, BVRio is a non-profit organization working to develop and offer market solutions for different types of environmental assets, based on the perspective that market mechanisms, e.g., tradeable credits or environmental reserve quotas (*Cota de Reserva Ambiental*: CRAs),[43] are efficient instruments for the execution of environmental public policies that promote a green economy. BVRio works to bolster the efficiency of environmental policies. They do this by bringing the power of markets for environmental assets and associated benefits to individuals, and both public and private sectors, to support compliance with environmental legislation. Strengthening compliance is complemented by activities promoting timber legality and due diligence processes. BVRio also co-led the creation of the *Aliança REDD+ Brasil*, to streamline REDD+ mechanism implementation in support of government agendas, rural and Indigenous communities and the private sector. BVRio supports the development of voluntary carbon markets because it argues that carbon credits traded in voluntary private markets can all contribute to national NDCs. Those same credits cannot be reflected in the national accounts of those buying them, for instance as a safeguard against double-counting. BVRio provides a free negotiation platform to promote the trading of timber products from legal or certified sources, like FSC, creating transparency, efficiency, and liquidity to this market. The platform has a built-in risk assessment system to assist users in conducting the due diligence of traded timber consignments. The objective of the platform is to connect buyers and sellers of legal and certified timber products in a safe, transparent, and user-friendly environment. Participants can post their requests and offers and receive replies online, increasing market efficiency. Platform use is free of charge.

Other Support for Forestry Activities

- **Amazon 21 Bill** (America Mitigating and Achieving Zero-Emissions Originating from Nature for the 21st Century Act), if passed, the law would provide USD 9 billion for long-term bilateral agreements to reduce carbon emissions and protect tropical forests in developing countries.[44] This initiative is strongly endorsed by civil society organizations including Indigenous people, research institutions, private sector and other organizations in Brazil who last May sent a communication to the US Congress stating their views (Coalizão 2022b). This initiative will also favor Peru and other Amazon regions.
- **National Fund for Forest Development (NFFD)** launched in 2006 and is a public fund maintained by the Federal Government and managed by the SFB. The main purpose of the NFFD is to finance the development of sustainable activities and promote technological innovation in the forestry sector. The fund is primarily financed by a share of the concession fees levied on National Forests. It also receives donations from national and international entities, both public and private.

- **UNEP's Climate Finance Unit** works with member states, as well as corporate and finance leaders, to unlock public and private finance for sustainable agriculture, forestry, and landscape restoration. The unit aims to demonstrate proof-of-concept, working towards a new asset class for 'net zero, nature positive' agriculture and forestry; and make sustainable deforestation-free and nature positive land use the new norm rather than the exception.

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[42] https://imazon.org.br/imprensa/plataforma-de-inteligencia-artificial-estima-risco-de-desmatamento-de-15-mil-km%C2%B2-na-amazonia-em-2022

[43] CRAs: titles that represent the additional area of native vegetation existing or under recovery on rural properties, exceeding the legally mandated reserve (*Reserva Legal – RL*). Each CRA corresponds to 1 hectare of surplus native vegetation and can be used to compensate for the deficit of *RL* area in properties that have less vegetation than the law determines and consolidation of UC.

[44] Full text here: https://www.congress.gov/bill/117th-congress/house-bill/5830/text

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