SCIENCE PANEL FOR THE AMAZON

POLICY BRIEF

THE AMAZON WE WANT
Science Panel for the Amazon

FOREST MANAGEMENT FOR TIMBER PRODUCTION AND FOREST LANDSCAPE RESTORATION IN THE AMAZON: THE WAY TOWARDS SUSTAINABILITY

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KEY MESSAGES

(i) Current guidelines for legal timber harvests from natural forests in the Amazon (around 20 m^3ha^{-1} of timber harvested every 15-35 years) are not sustainable.

(ii) Timber yields from managed natural forests can be substantially enhanced by the application of cost-effective silvicultural treatments that increase stocking and growth of timber trees.

(iii) Growing interest in tropical forest restoration offers opportunities to promote the management of secondary and degraded forests for timber, and mixed plantations with native species. Timber yields from these restored areas would reduce pressure on natural forests – allowing larger areas to be set aside for protection and reducing harvesting intensity in natural forests.

(iv) Community-based forestry could substantially increase the area of production while promoting rural development.

(v) Efforts to promote sustainable forest management are constrained by unfair competition from illegal logging as well as the lack of specialized markets that recognize the added value of timber from responsibly managed natural forests.

RECOMMENDATIONS

(i) Ensure the long-term recovery of timber stocks in managed natural forests, by reducing logging intensities by 50% and increasing minimum allowable cutting cycles to 60 years. With these constraints, the area of natural Amazonian production forests is insufficient to meet the growing demand for timber products.

(ii) Encourage the application of silvicultural treatments to increase stocking and growth of timber trees as well as rates of carbon sequestration.

(iii) Promote and develop other sources of timber to meet the growing demand for timber products. Alternative timber sources include secondary and degraded forests as well as mixed plantations of native timber species that result from forest landscape restoration (FLR) programs.

(iv) Support community-based forestry through appropriate forest policy regulations and strong capacity building on topics including harvest planning and operations, silviculture of managed natural forests, business administration, and marketing.

(v) Increase efforts to halt the supply of timber from illegal logging and deforestation.

(vi) Adapt and develop specialized markets for wood produced legally and sustainably in natural forests. This could incentivize best management practices by offering better prices, acknowledging the higher cost of sustainable management and its environmental benefits.

(vii) Support research on long-term monitoring of permanent forest plots, silviculture, assessments of the forest resources in secondary and degraded forests, and monitoring of illegal logging through remote sensing and traceability tools.

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GRAPHICAL ABSTRACT. Forest management and landscape restoration - the way towards sustainability.

A. THE URGENT NEED TO REVISE FOREST MANAGEMENT PRACTICES

The great majority of tropical forests is disturbed, with logged-over forests now more widespread than intact natural forests [1,2] . In the Amazon, selective logging potentially concern a total area of 246 million ha [-1] [3] (Figure 1). In 2020 alone, logging occurred in an estimated 460,000 ha in the Brazilian Amazon [4] and 131,000 ha in lowland Bolivia. Selective logging is an important economic activity in the Amazon. In 2016, the timber industry in the Brazilian Amazon generated a total income of US $920 million (mainly from sawn wood) and created more than 70,000 jobs [4] .

In 2022, the timber industry in Bolivia generated US $100 million from timber exports and an estimated US $500 million in the internal market [1] . Although illegal, predatory logging is an important cause of forest degradation [5–8] , forest logged sustainably retains much of its carbon stocks and harbors high biodiversity [1,3,9,10] .

Regulations on forest management practices differs between Amazonian countries and territories. The length of the harvest cycle ranges from 15 to 35 years, with French Guiana having cutting cycles substantially longer (65 years) than the Amazonian countries. Allowable logging intensity also varies per country, but values

between 10-30 m^3 ha^{-1} are commonly used. Following these rules may meet timber market demands, but they are not always appropriate for the ecology of the harvested species and generally do not allow the full reconstitution of timber stocks within a cutting cycle [11]. Most studies that assessed the long-term impacts of logging report that while biomass stocks recover in 20-40 years [10,12] and biodiversity is mostly retained [9,13], timber stocks are much slower to recover. Most studies report that, at best without silvicultural treatments, timber volumes only recover 50% of their pre-logging value after the first cutting when the legal minimum harvest cycle duration is followed [9,11]. Logging intensity appears to be the main factor influencing the recovery of biomass, biodiversity, and timber volumes [3,10,11]. A recent simulation of post-logging timber volume recovery rates in the Amazon Basin confirmed these results at the regional level and showed that even with cutting cycles of 65 years and logging intensities of only 20 m^3 /ha, logged forests recover only 70% of their pre-logging timber stocks [3].

The sustainability of timber yield is a major issue for the conservation of Amazonian forests and for tropical forests worldwide. Yet even today, applications of this concept are often confused or misleading due to lack of clear definitions and the different ways that sustainability can be conceived [14,15]. This concept was first applied to timber production by foresters, but it has been more recently expanded to include a variety of forest products and other ecosystem services. In any case, the actions and practices that promote sustainable timber production must ensure both sustained timber yields (STYs) while maintaining the forest's functional integrity, structure, and species composition and diversity.

FIGURE 1: Forest available for timber production in the Amazon biome. All colored areas are forests with medium to high forest integrity[16]. Orange areas are protected forests where timber production is not allowed (IUCN categories I-V; total area: 221 Mha). Other forested areas are considered either available for timber production (in pink), i.e., within 50 km of a road or motorable track or within 20 km of a major river (total area: 246 Mha), or currently inaccessible (in green; total area: 98 Mha). Protected areas were mapped using the World Database on Protected Areas (UNEP-WCMC and IUCN (2023)[2]. The road network was extracted from the Red Amazónica de Información Socioambiental Georeferenciada (RAISG[3]). The map of major rivers was obtained from the World Bank data catalogue.

Emphasis on timber will remain as long as it retains the highest economic value and the most consolidated value chain. At the same time, it seems unrealistic to expect that a logged-over forest will recover the timber volume accumulated over hundreds of years within economically viable cutting cycles of 30, 60, or even 90 years. It is essential to accept that the successive cycles will generate a lower timber production than the first harvest. This difference is referred to as the "primary forest premium"[9,17] as illustrated

in Figure 2. In this context, STY should mean constant timber yields over several cycles (Figure 2), rather than the return to the pre-harvest timber volume level. Consequently, the main challenge for managers is to assess the best logging intensity and cycle duration that will ensure a constant timber yield, and to determine how the timber recovery rate can be enhanced without compromising other forest values. This approach will require managing natural forests with different characteristics than intact natural forests, but with similar levels of biodiversity and environmental service provision. In addition, this approach will only work when strong forest governance is implemented (see section D) and when the timber industry is financially viable in the long-term (see section E).

Most Amazonian timber species are slow growing and suffer competition from neighboring trees and lianas. Silvicultural treatments such as the liberation of future crop trees (FCTs) from competition from other trees or lianas have been promoted as an alternative to enhance the recovery of timber yields[18–20]. For example, in both moist tropical and dry forests of Bolivia such treatments doubled FCT growth rates[17,21,22]. Although demonstrated to be effective, silvicultural treatments are still very poorly applied at large scales, mainly because of cost (but see 23–25) and uncertainty about access to managed forests, for example due to non-renewal of logging permits, invasions by farmers, and social conflict[26]. Finally, current legislation focuses on practices aimed at reducing logging damage (e.g., implementation of reduced-impact logging techniques), rather than on practices that promote forest recovery.

The return to pre-harvest forest conditions after logging is not essential and must not be considered as the main goal of sustainable forest management. Instead, ensuring STY for centuries often may require managed natural forests to differ somewhat from natural forests but with similar suites of functional traits, levels of biodiversity, and environmental services[14,27].

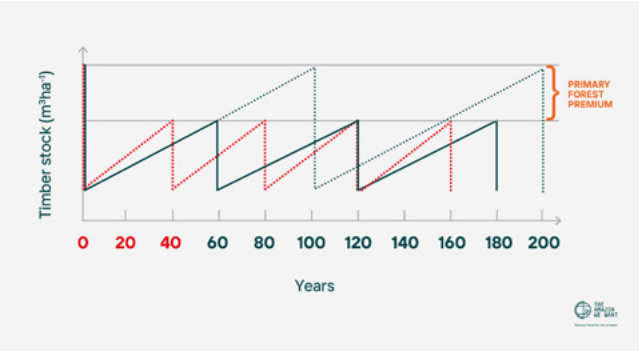

FIGURE 2: Three versions of sustained timber yields (STYs). Dark black line: successive logging cycles with constant yields after the first harvest due to "primary forest premium". Dashed dark line: successive logging cycles with a 100% reconstitution of the original stocks, which necessitates a much longer cycle duration. Red dashed line: Logging with reduced-impact techniques and a silvicultural treatment (liberation) that serve to stimulate timber stock recovery and therefore allow for a shortened cutting cycle length.

A SUSTAINABLE TIMBER YIELD SCENARIO FOR THE AMAZON

A recent simulation of successive logging cycles of different intensities across the Brazilian Amazon indicates that STY is possible with a logging intensity of 10 m^3ha^{-1} every 60 years, providing that the list of species considered commercial is increased (i.e., that 90% of the pre-logging stand volume is from species considered commercial)[27] (Figure 3 below). In the case of the Brazilian Amazon, with a potential concession area of 35 Mha, this scenario would sustainably produce 3.5 Mm^3 annually[a], whereas

[a] Not all 35 Mha that could potentially be allocated in concessions in Brazil will be available for harvesting because forest management regulations require the exclusion of sensitive areas not suitable for timber harvesting (e.g., riparian areas, areas with high slopes) and the designation of protected areas within concessions. In addition, in some areas forest management will not be feasible due to reduced accessibility, lack of local markets, and low volume of commercial species.

current production is estimated at around 11Mm^3 [4]. Natural forests alone, therefore, will be unable to ensure this production in the long term. Consequently, there is an urgent need to implement new tropical silviculture schemes that increases timber production from natural forests as well as from restoration programs. The recent enthusiasm for forest restoration under the Bonn Challenge, and the proclamation of the United Nations Decade of Ecosystem Restoration (2021-2030), provide opportunities to augment timber yields from the Amazon (see section B). Another way to increase legal timber production would be to increase the area of production forests by promoting and facilitating community forest management in conservation units (see section C).

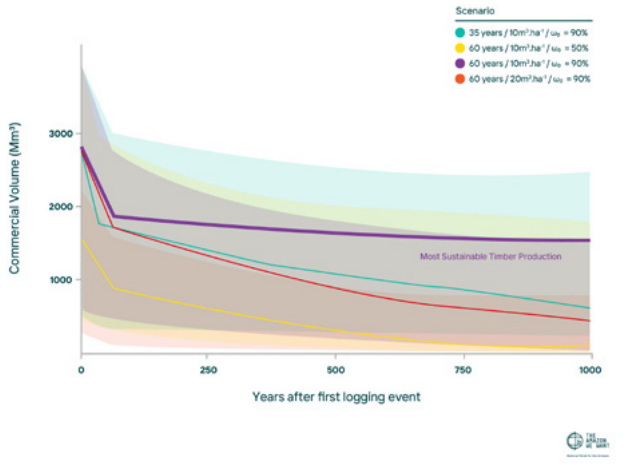

FIGURE 3: Commercial volume stocks under four scenarios for 35 Mha of forest concessions in Brazil[26]. The x-axis is the time after the first logging event (in years); the y-axis is the total commercial volume stocks in the entire area, in Mm^3. The colors represent the 4 scenarios, with the thick lines corresponding to the medians and the shaded areas the 95% credibility intervals. The scenario in which 10 m^{3}ha^{-1} is extracted every 60 years with a proportion of commercial timber of 90 % (top purple line) is the most sustainable, with a median duration >1000 years and an almost constant yield.

B. RESTORATION EFFORTS TO GUARANTEE LONG-TERM TIMBER PRODUCTION

Large-scale restoration programs are urgently needed across the Amazon. These programs include a variety of strategies that aim to increase the extent and permanence of tree cover and contribute to the delivery of multiple benefits[28]. Such programs also provide unique opportunities to develop alternative systems for timber production. These programs should promote the use of native timber species[28] when planting trees on abandoned deforested lands, which cover millions of hectares within the Amazon's 'arc of deforestation'. Forest restoration programs can contribute to the conservation of remaining natural forests by meeting some of the demand for timber[28]. Here we discuss several restoration efforts that could be used to promote timber production.

SECONDARY FORESTS

Secondary forests (SFs) develop in when areas cleared for agriculture (including cattle ranching) are abandoned, due to a variety of reasons (e.g., exhaustion of soil fertility, highly degraded pastures, high costs of weed control, depopulation of rural areas). SFs cover a large area of the tropics; in the Brazilian Amazon alone, in 2020, they covered 163,624 km^2 [29]. The majority of secondary forests (85.6%) are less than 20 years old, with a median age of 7 years[30]. Studies have shown that SFs are able to recover on average 78% of their old-growth values in a relatively short period of time (20 years[31]). Unfortunately, SFs are often converted into new pastures or agricultural lands, resulting in landscapes which are dominated by young secondary forests (<5 years[30]).

One pragmatic solution to avoid the conversion of SFs to other land uses is to increase their economic value by promoting their management for timber, non-timber forest products (NTFPs), biodiversity, and carbon sequestration. The management of these resources could generate economic benefits for their owners and users[32–35]. Old secondary forests (>20 years) have strong potential to be sustainably managed for fast-growing timber species[36,37] that can reach very high timber volumes. Using SFs for timber production will reduce pressure on unmanaged natural forests, at least for timber production from species with less dense wood, with some species having well-established local markets. However, increasing the economic value of these secondary forests must be accompanied by improved forest governance that bans forest conversion and recognizes small farmers and forest communities' land rights.

DEGRADED FORESTS

An estimated 36 Mha of forest was degraded in the Brazilian Amazon from 2001 to 2018, due to fire, edge effects, and timber extraction. This corresponds to 112% of the total area deforested in the same period[38]. A proportion of these so called "degraded" forests could be restored for timber production with silvicultural treatments. One way forward is that restoration programs include degraded forests when defining restoration efforts at the landscape level, as recovering these forests is probably less expensive than reforestation of deforested areas. Restoration programs would need to assess the functioning of these forests and their potential in terms of timber resources to define the best silvicultural treatments to apply to enhance their recovery. Potential silvicultural treatments are enrichment planting and liberation of future crop trees (FCTs) from lianas and other competitors. Another more passive pathway is the protection of degraded forests from further degradation by logging, grazing, wildfires, charcoal production, and illegal activities, so that they have time to recover naturally. Rehabilitation of just half of the area covered by degraded forests could generate an annual timber production of 3 Mm^3 in the next 30 years, based on a productivity of 10m^3ha^{-1} every 60 years.

MIXED PLANTATIONS

Mixed plantations of native timber species are still poorly developed in the Amazon. In Brazil, for example, most plantations are concentrated in the South, covering 9.8 Mha and almost exclusively comprised of non-native eucalypts species (75%) for pulp production[39]. In the Brazilian Amazon, plantations cover around 940,000 ha, of which 80% is also eucalypts [39]. Mixed plantations are reportedly more productive than monocultures, while providing more diverse environmental services. There are examples of mixed plantations in the tropics, but ways to scale up these efforts must be developed and tested. A recent study in French Guiana showed that increasing the share of native timber species from plantations in the overall timber production of the territory could both improve the carbon balance of the wood sector and reduce the area of natural forests undergoing logging[12]. To minimize their environmental and socio-economic impacts, timber plantations should not be established after clearance of natural forests, as was too often done in the past[40]. It is, therefore, essential that timber plantations be planned and established in the context of landscape restoration programs.

C. PROMOTING COMMUNITY-BASED FORESTRY

Expansion of community-based forest management (CBFM) would increase legal timber production in the Amazon. Whereas industrial forest concessions often exclusively produce timber, CBFM often manages multiple forest resources, including timber, NTFPs, and ecotourism[41]. These multiple uses offer additional sources of income, and can therefore better accommodate lower logging intensities and longer cycles, as recommended by Sist et al.[27]. In addition, CBFM also provides a way for Indigenous peoples and local communities to secure legal land rights over their territories, as is the case in lowland Bolivia[42].

CBFM in Latin America is more widespread than in Africa or Asia (Figure 4a), covering around 231 million hectares, or 30% of the total forest cover of the 7 Amazonian countries (Figure 4b[43], no data for Guyana and Suriname). These numbers clearly show the very high potential of the Amazon for CBFM and the promotion of sustainable forest management, improvement of local livelihoods, and forest conservation. In Brazil alone, CBFM could expand to about 55 million hectares[44]. If only half of this area was devoted to CBFM, the annual potential production would be of 4.6 M m^3 with a harvest intensity of 10 m^3 ha^{-1} and a 60-year cycle.

Different forms of CBFM could be promoted, from full management by community members to partnerships between communities, forest settlers, and logging companies[45]. In addition, it is important to consider that many small-scale farmers in the Amazon hold forest areas that are not economically valued and therefore in danger of conversion to more immediately profitable land uses, such as pasture. It is, therefore, crucial that small farmers derive financial benefits from their forests, which is motivation to keep their forests standing[45–48].

Although CBFM and small farmer forest management are recognized as essential for the conservation of natural forests in the Amazon, most Amazonian countries lack forest policies that promote CBFM.

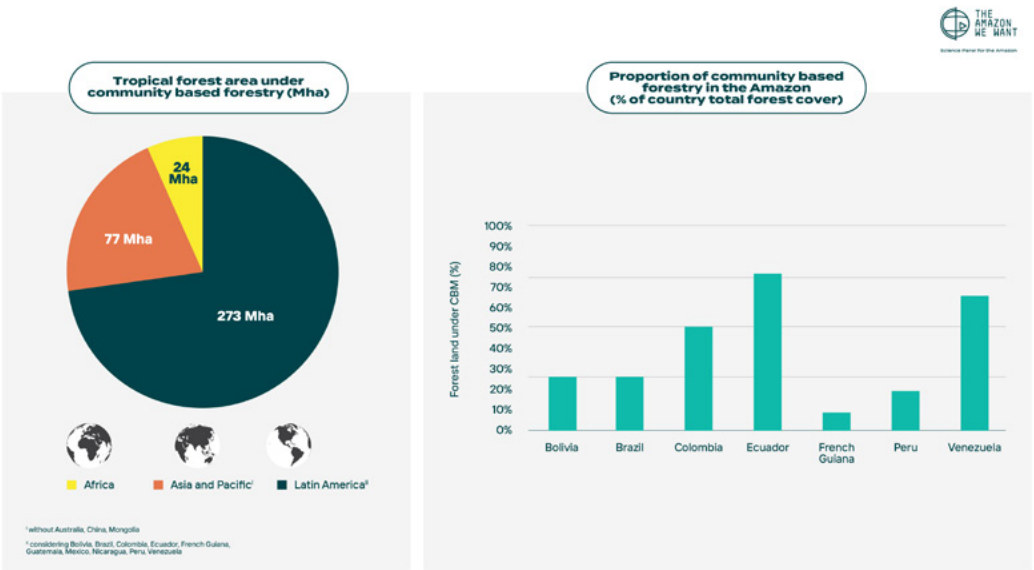

FIGURE 4: Importance of community-based forest management (CBFM) in the world's tropical forests and the Amazon[42]. 4a) Tropical CBFM (Mha) in Africa, Asia and Pacific, and Latin America. 4b) CBFM in Amazonian countries as a percent of that country's forest cover.

D. THE NEED TO HALT ILLEGAL LOGGING AND DEFORESTATION

Responsible forest management with sustained timber yields requires substantial long-term investments and therefore cannot compete with illegal logging. Unfortunately, illegal logging remains an important source of timber throughout the Amazon. For example, in the Brazilian states of Pará and Mato Grosso, which provide around 75% of the timber produced in the Brazilian Amazon, illegal logging occurred in 68% and 44%, respectively, of the total area harvested during 2007-2019[4].

Illegal logging causes significant harm to government finances due to uncollected taxes, poor worker safety, and low wages, as well as harming the environment, impacts which are well known and documented[49]. Unfortunately, government efforts to stop illegal logging remain ineffective even where sophisticated detection protocols are available[49]. Illegal logging also drives down log prices, making it impossible for operations to both adopt costly sustainability practices and remain competitive.

The fight against illegal logging can succeed, as seen in Brazil from 2004 to 2012. Brazil's success in slowing deforestation during this period can be attributed to a synergistic and intersectoral approach to environmental governance, that included frequent forest monitoring with remote sensing, field verification of illegal forest clearing by IBAMA, and the judiciary fining offenders[50]. Such an overarching approach could be used to fight illegal logging across the region. It is worth noting that until recently it was difficult to detect small-scale forest disturbances caused by selective logging using satellite imagery; however, with the launch of new sensors and the development of deep learning methods, forest degradation can now be detected with high spatial detail in near real-time[51,52]. These developments offer new opportunities to use remote sensing to detect illegal logging within and outside legally-designated management areas. Also, new tools for timber tracing allow improved monitoring of the legality of timber along the production chain[53].

In addition to remote sensing techniques for detecting illegal logging, platforms such as *Timberflow* (created in 2007 by IMAFLORA) facilitate cross-checking of the legal authorizations issued by government agencies. Given the proliferation of forged documents, this platform is critical to assess the legality of timber[4].

E. PROMOTE SPECIALIZED MARKETS

The realization of improved forest management in the Amazon requires the long-term financial viability of timber industries, which depends on timber markets. It is vital that markets recognize the added value of wood produced legally from sustainably managed natural forests. Best management practices are needed, starting with forest inventories and planning, through to harvesting with reduced-impact logging (RIL), and including the application of silvicultural treatments to stimulate the regeneration and growth of timber trees. For this to happen, markets should offer a higher price for timber extracted from responsibly managed natural forests [27].

Considering that the use of RIL practices can halve the emissions from selective logging[54], carbon markets should provide some of the finance needed to promote the transition from unsustainable forest exploitation to responsible forest management[55]. However, the development

of carbon markets based on improved forest management in the Amazon is unlikely as long as illegal logging remains the main source of timber. Therefore, transparency and traceability throughout the production chain are essential and must be developed and taken to scale.

A modern timber industry is urgently needed in the Amazon to process more timber species, while substantially increasing the efficiency of processing to reduce waste. Only 40% of the volume entering sawmills today is processed into lumber, with the rest burned or left unused[49]. Improving sawmill efficiency to just 60% would increase timber volume by 50% without harvesting additional trees. In addition, it is important to promote the production and manufacturing of end-products in the region (such as furniture), to add value and increase the economic benefits staying within the region[56]. Finally, it will be important to valorize byproducts of the production chain (e.g., using sawmill waste to produce fuel or composite materials) to reduce waste and increase the economic feasibility of the sector.

F. SUPPORT RESEARCH

Long-term monitoring of forests after timber harvests is essential to understand the impact of both logging and climate change on the recovery and resilience of Amazonian forests. International networks, such as the Tropical managed Forest Observatory (TmFO), have clearly demonstrated that forest management regulations in the Amazon need to be revised to sustain timber yields. It is therefore crucial to support long-term monitoring of forest dynamics of logged and silviculturally treated forests, to understand better how they respond to these impacts and climate change. There are several forest networks in the Amazon that should collaborate to capture the Amazon's regional diversity. Long-term monitoring is warranted but expensive; national and international funds should be made available for this purpose.

Although secondary and degraded forests have great potential for sustainable timber production, our knowledge of their main properties, functioning, and timber volumes is very limited. It is urgent to develop research on the typology and characteristics of these forests so as to have the basis for prescribing management practices for timber production and conservation and avoid their conversion to other land uses.

It is essential to continue developing high-resolution remote sensing methods to monitor forest degradation with great accuracy. Recent technologies and new approaches, including artificial intelligence (AI), could be used to detect small and fleeting disturbances, such as those generated by selective logging. Similarly, it is important to keep developing tools that allow tracing the origin of timber along the production chain.

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