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WOOD PRODUCTION AND DIVERSITY OF TREE SPECIES LOGGED IN THE BRAZILIAN AMAZON: CURRENT SITUATION AND RECOMMENDATIONS FOR THE FOREST SECTOR [1]

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SUMMARY

Throughout Brazilian history, valuable timber species have been indiscriminately logged to the brink of extinction. The very name of the country comes from a species heavily logged in the Brazilian Atlantic Forest since the time of discovery, the Pau-brasil (Paubrasilia echinata). This still occurs in the Amazon nowadays, while more than half of the timber production from natural forests is based on the logging of 15-20 species. If well used, the wide diversity of Amazon timber species would offer an alternative so that we do not deplete other valuable woods. However, there is a gap in information even about how many species are currently logged. This manuscript aims to present quantitative and qualitative information on logged species in the Brazilian Amazon that were registered at least once in the official forest control systems (DOF/SINAFLOR, SISFLORA Mato Grosso, and SISFLORA Pará) between 2007 and 2020. We also conducted an extensive review of the species contained in these databases to remove inconsistencies and replications represented by botanical synonyms. We estimate that 998 species were logged by the Amazon timber industry between 2007 and 2020, implying that a significantly larger proportion of the regional diversity of tree species is used than previous studies have estimated. The analyses presented in this manuscript also show that the most recent frontiers of logging have a smaller set of species offered to the market compared to older frontiers, suggesting that the depletion of high-value timber has stimulated the insertion of new species in the old frontiers. We then investigate the spatial patterns of logging of five important species for the Amazon timber industry over time, demonstrating that these patterns can vary significantly depending on factors such as the level of logging of the species, its acceptance in the markets, and the time elapsed since the beginning of its logging at scale. The concentration of logging on a limited set of species demonstrates the serious strategic fragility of the Amazon timber industry regarding future stocks of valuable timber. That is, even if a broad and stable forest base was established for the regional timber industry, this industry would have to evolve substantially in terms of the use of greater volumes of a wider range of commercial species, as well as investments in technology and the development of new products. As recommendations, we discuss the importance of advances for better identification of logged species, with the effective adoption of technical and scientific procedures in the preparation of forest inventories, a measure already provided for since 2009 through Conama Resolution 406. Next, there is a need for greater robustness in species registration systems, avoiding incorrect entries or botanical synonyms. Third, greater transparency of the data coming from the control systems is needed, it would allow not only robust sectoral planning by the wood industry leaders but also greater participation of civil society in monitoring and proposing solutions for markets and combating illegal logging. Finally, it is crucial to support the generation of information about the occurrence of little-logged species, including research on the ecological behavior of such species.

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PRESENTATION AND BACKGROUND

Although logging has been practiced for more than three centuries in the Brazilian Amazon, it was the opening of official roads in the 1960-70s that provided access to large stocks of wood in the solid ground forests of the region. It was from this point that the regional timber industry gained scale at a speed rarely seen in other economic sectors. It was also from this point that the forest sector started having at its disposal a much wider range of timber species. By the end of the 1980s, there were more than three thousand timber companies in the Amazon (Angelo, 1998; Barros and Uhl, 1996).

To a large extent, the remarkable growth rate of the regional timber industry was benefited by factors such as the wide availability of feedstock and species diversity, public incentives for forest destruction for the establishment of subsidized agricultural activities, and the growing demand for feedstocks useful for civil construction in the southern domestic and international markets. In the subsequent decades, this industry concentrated along the 'arc of fire and deforestation' in a disorganized manner, establishing a pattern of predatory use of forests. By the mid-1990s, more than 90% of the logging activity was concentrated in the three main producing states - Pará, Mato Grosso, and Rondônia - with companies clustered in 60 production centers.

Not only in the Amazon, but throughout the history of the development of the Brazilian timber sector, the stocks of slow-growing timber species, which have a higher market value, have been intensively logged to exhaustion, to the detriment of the conservation of future stocks of these species. The very name of our country refers to a species endemic to the Brazilian Atlantic Forest, the Pau-brasil (Paubrasilia echinata), which had its wood massively logged for centuries, bringing the species to the brink of extinction. We then repeated this predatory model with other timber species such as Mahogany (Swietenia macrophylla) and the Brazil Nut (Bertholletia excelsa). This over logging in a restricted group of commercially valuable trees remains in the forest sector and is one of the main obstacles to its sustainability. For example, in past issues of this newsletter series, we discussed the issue of Ipê (Handroanthus spp.), which due to its high market value, is the target of overlogging in the forest, running the risk of extinction (Lentini et al. 2021). In fact, today the specialized scientific literature knows a great number of cases of highly logged species in the Amazon that, due to their ecological characteristics, run the risk of being over logged in production forests, and their occurrence in future cutting cycles may be compromised. [2]

Despite this context and these concerns, we still do not know how many timber species are currently logged in the Brazilian Amazon. Studies suggest that the Amazon is home to 6,000 to 16,000 forest species (Cardoso et al., 2017; Hopkins, 2007; ter Steege et al., 2016, 2013, 2019). Despite this remarkable biodiversity, authors such as Martini et al. (1994) estimate that only about 350 species of

[2] In fact, a series of instruments have been edited in Brazil with the purpose of regulating or even restricting the logging of timber species considered as threatened and/or vulnerable, highlighting MMA Ordinance 443/2014, Normative Instruction 01/2014 and, more recently, MMA Ordinance 561/2021. We will return to the theme of vulnerable and threatened species in the Amazon Forest sector in a future issue of this series of technical newsletters.

timber are traded in the region. More recent sources, such as Richardson et al. (2016), analyzed 824 forest enterprises and arrived at a similar figure, concluding that only 314 forest species are logged for timber purposes in the Brazilian Amazon. In fact, due to inconsistencies in species identification (Ferreira et al., 2004) and the lack of quality of the information available in forest control databases, the uncertainty about the number of species logged in the Amazon for timber production purposes is unquestionable. In this newsletter, we attempt to advance on this information gap by compiling and analyzing a historical series of production data from the Brazilian Amazon (2007 to 2020) extracted from the country's official forest control systems.

PURPOSE OF THIS NEWSLETTER

This publication is part of a series edited by IMAFLORA with the purpose of disseminating updated information about the forest sector in the Amazon. The newsletters are part of an effort to build a platform of transparency for the forest sector, support legality, encourage good forest management, and promote markets for responsibly sourced forest products.

In this study, we intend to elucidate the diversity and volumetry of species logged in the Brazilian Amazon and analyze the spatial distribution of this information. Finally, we will discuss the 15 most logged species in the Amazon and their main markets, with the objective of making recommendations for the sustainable development of the forest sector, highly dependent on the intense extraction of a small diversity of timber species nowadays.

For this newsletter, we analyzed a database developed by IMAFLORA from forest guides (for transportation, commercialization, and processing of timber and other products) made available by IBAMA, through the DOF/SINAFLOR (forest origin document) system, SISFLORA Mato Grosso [3] and SISFLORA Pará, from January 2007 to December 2020 [4]. These databases underwent sanitization routines to remove any typing and compilation errors.

[3] Data for the authorized forestry guides in the SISFLORA forest control system of the State of Mato Grosso were obtained through the cooperation term 0303/2018 signed between the State Secretariat of Environment of Mato Grosso and IMAFLORA.

[4] Data from the DOF/SINAFLOR system, SISFLORA/MT and SISFLORA/PA systematized and analyzed by IMAFLORA. It is noteworthy to inform that the data for the year 2021 were not included in this analysis because they have not yet been made publicly available.

We then reviewed the existing botanical synonyms based on the Flora of Brazil 2020 database made available by the Botanical Garden of Rio de Janeiro. We define here as synonymy those species that have one or more outdated nomenclatures in the databases of the official control systems. In the end, due to the large volume of official data, as well as the uncertainties due to timber products that were not registered at the genus level, we estimated the number of existing species based on a sample of species registered in the DOFs and forest guides [5]. Finally, to understand the geographic distribution of the species, we associated the geographic coordinates based on the centroid [6] of the municipalities of origin of the logging and developed heat maps with the species and the respective volumes logged.

HOW MANY SPECIES ARE LOGGED IN THE AMAZON?

We estimate that 998 species were harvested by the logging industry in the Brazilian Amazon between 2007 and 2020 [7]. In relation to this result, some important caveats are worth mentioning. First, about the limitations of the databases themselves in relation to the way species are declared, enabling many species not to be declared or to be declared incorrectly. Second, the very fact that this number is based on species declared by the companies themselves, with few independent checks about the logging of these species, and there has been little progress in adopting robust procedures for identifying species in forest management operations. Anyway, this number suggests a use of forest species diversity by the regional timber industry that is much higher than studies conducted previously, highlighting Martini et al. (1994) and Richardson et al. (2016), as we presented in the previous section of this manuscript.

The actions of identification and subsequent registration of logged species are fundamental to the sustainability of forest management since this information provides subsidies for regulatory agencies to issue permission on which trees will be logged or protected based on the maintenance of future stocks of the production forest. Article 20 of Conama Resolution 406/2009 establishes the mandatory adoption of technical-scientific procedures that ensure the identification of managed species by their respective scientific and popular names.

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[5] Based on the sample of species taken, we calculated a correction factor equal to 0.48 between the number of species registered in the official databases and the actual number of species after identification of botanical synonyms.

[6] The centroid of the logging municipality was used as a reference point because the geographic coordinates of the production forests are not available for a significant portion of the DOFs and forest guides in the official control system databases.

[7] Initially, 3,248 logged species were counted during the period of analysis. Of this total, 41% of the species (1,325) had nomenclatures registered in the official control system databases with gross typing errors, such as names written with genus and epithet without spacing. After correcting the typing errors, this number decreased to 1,923 species and, by applying the synonymy correction factor, it was reduced to 998 forest species, of which 203 records were identified only at the genus level.

Thus, even though botanical identification of managed tropical forest species is mandatory for issuing logging permits, this procedure still faces numerous difficulties ranging from the inadequate collection in the field to the permissibility of inserting outdated names and typos in official records, such as those verified in this study[8]. Such conditions demonstrate the need to advance in the correct identification of species in forest inventories, as suggested by Obermuller et al. (2011), considering that the authors found that incorrect identification in the field could generate an error of up to 70% in forest inventories. Besides being just an item of compliance with a legal requirement, advances in species identification are fundamental from the point of view of intelligence and market strategy because they allow more accurate trend projections and actions to promote species of less current use in markets. In addition, the correct identification is elementary to the advancement of research and development of wood technology for adequate use by the market.

DIVERSITY OF TIMBER SPECIES LOGGED

During the period studied, the timber sector in the Brazilian Amazon maintained a relatively stable pattern of the number of species logged annually, with an average of 292[9]. In this same period, we did not find an increase in the number of species logged over time, which was, in principle, one of the hypotheses we formulated for the analysis (Figure 1).

However, when we analyze the trend by State, we observe two distinct cases of the evolution of the forest sector in relation to the diversity of species logged in Amazonas and Mato Grosso. In the Amazonas, the number of species logged was decreasing throughout the analyzed period. In 2007, 328 species were harvested, and this number reduced to 249 in 2014 and 240 in 2020. On the other hand, in Mato Grosso, this trend was the opposite, with 471 species harvested in 2007, rising to 510 in 2015 and reaching 481 species in 2020. Furthermore, the data show that, historically, the main producing States, such as Mato Grosso, Rondônia and Pará, had a higher average diversity of logged species than the other States, showing, therefore, a positive correlation between the production of roundwood per State and the number of logged species[10].

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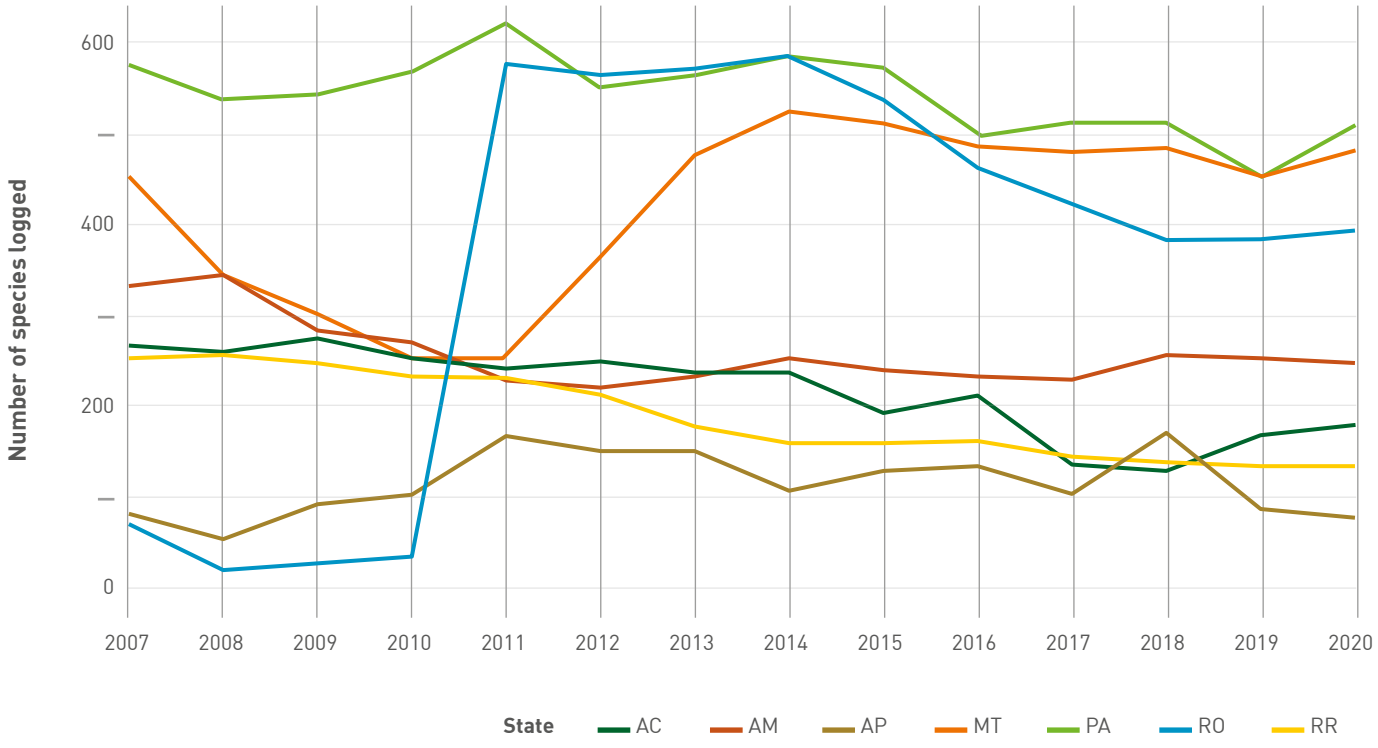
[8] It is noteworthy to note that there is apparently progress, albeit slow, in the quality of species records made in the official forest control databases. When looking at the species that have lost most volume over time, the records registered with identification only at the genus level stand out. For example, of the 10 species that have lost most annual harvested volume over the last decades, six are records described only at the genus level, such as Vochysia spp., Hymenolobium spp., Qualea spp., Apuleia spp., Hymenaea spp., and Ocotea spp. It is possible that the decrease in volume of these species is associated with the advancement of the inclusion of scientific names (genus + epithet) in forest control systems.

[9] The calculated standard deviation of this estimate is 172

[10] It is worth noting that, until 2010, the Rondônia databases were incomplete and therefore do not represent the reality of the number of species logged until this period, which explains the sudden increase in the diversity of species logged in this state in later years.

The average values per State indicate that the *oldest logging frontiers*[11] have a greater range of species offered to the market. This phenomenon might be associated with a strategy to maintain the supply of raw material despite the gradual depletion of high value timber in these regions over time. This suggests that the reduction of the main sources of supply, that is, the most valuable woods, acts as a driver for the diversification of production based on other alternative species. While increased diversification of timber species is critical to the long-term sustainability of the industry, it is equally important that this strategy is put into motion before the exhaustion of high commercial value species.

Figure 1. Diversity of species logged in the Brazilian Amazon States, 2007-2020
(Source: databases of the official forest control systems, analyzed and compiled by IMAFLORA).



[11] *In the first issue of this technical newsletter series, we classified as old frontier the regions in which the logging industry established itself more than four decades ago along the 'arc of fire and deforestation', moving in the last two decades to the more central portions of the Amazon due to the depletion of higher-value species in these regions (Lentini et al. 2019).*

VOLUME PRODUCED OF THE MAIN SPECIES

As we identified in previous fascicles of this technical newsletter series, the production and market for tropical wood from the Amazon are concentrated in a small set of commercially valuable species, although there is enormous diversity, as we report in this manuscript. Although there are, as we estimated earlier, at least a thousand species logged in official forest control databases, only 20 species account for about half of the volume of roundwood production between 2007 and 2020 (~79 million cubic meters) (Table 1).

Furthermore, despite technical and market advances aimed at trying to increase the diversity of species logged in production forests, the main commercial species remain the same as in past decades. The 20 most logged species in the last biennium of analysis (2019-20) still represent more than half of the volume of timber logged in the Brazilian Amazon (57%) (Figure 2). In this period of analysis (2019-2020), when compared with data from the last decades (2007 to 2020), only two new species stood out among those showing the highest volume of production, Amesclão (*Trattinnickia burseraefolia*) and Marupá (*Simarouba amara*).

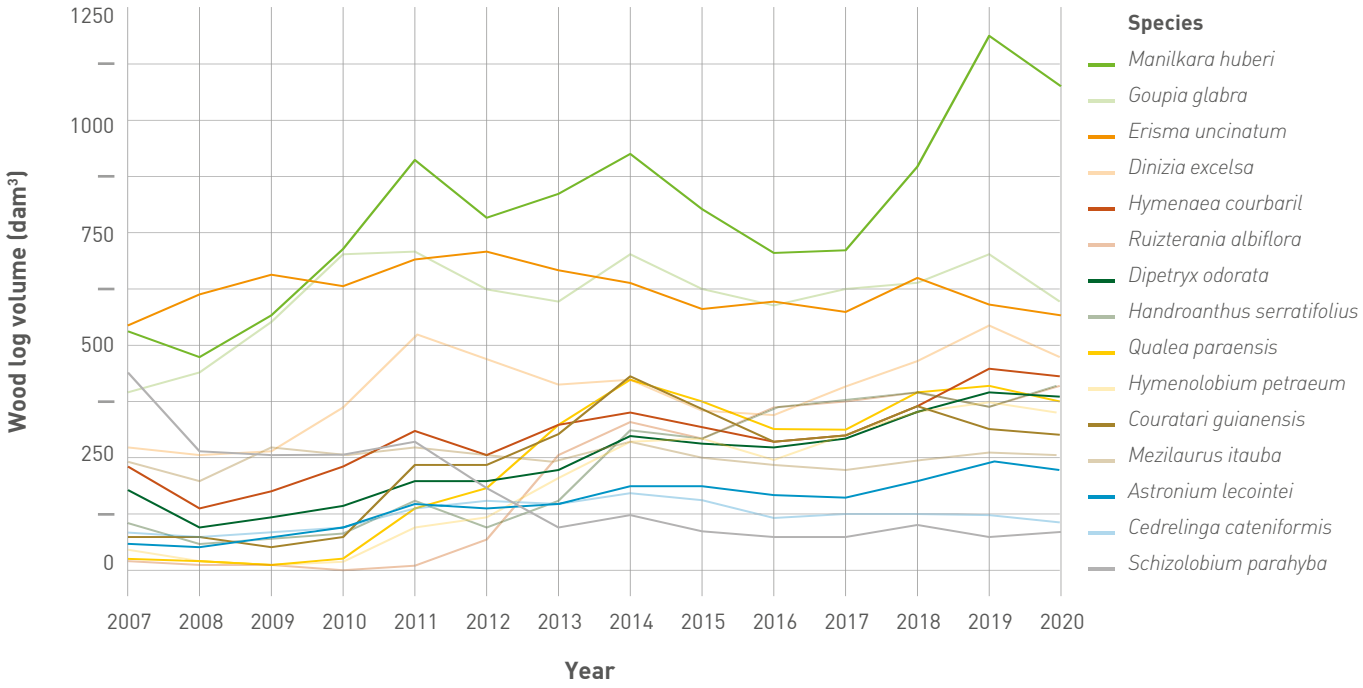
Table 1. Volume and relative participation of the main species logged in the Brazilian Amazon, 2007-2020 (Source: databases of the official forest control systems, analyzed and compiled by IMAFLORA).

Ranking	Scientific name	Popular name	Accumulated volume (2007-2020) (m^3)	% Total production (2007-2020)
1	*Manilkara huberi*	Maçaranduba	11,181,124.7	**7.23**
2	*Erisma uncinatum*	Cedrinho	8,950,737.9	**5.79**
3	*Goupia glabra*	Cupiúba	8,640,006.9	**5.59**
4	*Dinizia excelsa*	Angelim vermelho	5,664,303.1	**3.66**
5	*Hymenaea courbaril*	Jatobá	4,218,287.3	**2.73**
6	*Qualea spp.*	Cambará	4,141,291.9	**2.68**
7	*Apuleia leiocarpa*	Garapeira	3,958,492.6	**2.56**
8	*Mezilaurus itauba*	Itaúba	3,653,779.0	**2.36**
9	*Dipteryx odorata*	Cumaru	3,529,624.6	**2.28**
10	*Couratari guianensis*	Tauari	3,453,812.5	**2.23**
11	*Qualea paraenses*	Cambará	3,342,602.5	**2.16**
12	*Handroanthus serratifolius*	Ipê roxo	3,032,365.5	**1.96**
13	*Ruizterania albiflora*	Mandioqueiro	2,949,885.6	**1.91**

Table 1. Volume and relative participation of the main species logged in the Brazilian Amazon, 2007-2020 (Source: databases of the official forest control systems, analyzed and compiled by IMAFLORA).

Ranking	Scientific name	Popular name	Accumulated volume (2007-2020) (m^3)	% Total production (2007-2020)
14	*Hymenolobium petraeum*	Angelim pedra	2,747,361.1	**1.78**
15	*Schizolobium parahyba*	Paricá	2,444,969.5	**1.58**
16	*Astronium lecointei*	Muiracatiara	2,119,079.9	**1.37**
17	*Hymenolobium ssp.*	Angelim	1,968,692.6	**1.27**
18	*Cedrelinga cateniformis*	Cedrorana	1,749,366.8	**1.13**
19	*Cariniana micrantha*	Jequitibá	1,724,397.7	**1.12**
20	*Simarouba amara*	Marupá	1,531,860.7	**0.99**
Total logged (2007/20)			**81,002,042.5**	**52.4**

Figure 2.Volume of the main species logged in the Brazilian Amazon, 2007-2020 (Source: databases of the official forest control systems, analyzed and compiled by IMAFLORA).



The main timber species logged in the Amazon are of great relevance to the markets for construction products, both nationally and internationally. Of these fifteen main logged species (Figure 2), all have a wide range of published studies on the physical and chemical characteristics and potential uses of the wood.

Maçaranduba (*Manilkara huberi*), with an average of 860 thousand cubic meters of logs produced annually, is the species with the highest volume of harvesting in the Brazilian Amazon, followed by Cedrinho (*Erisma uncinatum*), Cupiúba (*Goupia glabra*), Angelim-vermelho (*Dinizia excelsa*), and Jatobá (*Hymenaea courbaril*) (Table 1). Even with its notable relevance in the wood market, Maçaranduba is a species that has been pointed out in studies with serious problems in its correct botanical identification, which constitutes a risk to the maintenance of future stocks of this species in production forests.

Studies such as Bieber et al. (2004) found that, in forest management plans, individuals of other species such as Manilkara bidentata and M. cavalcantei are classified as *Manilkara huberi* in forest inventories. Besides Maçaranduba, highly logged species such as Jatobá, Cumaru (*Dypterix odorata*), and Ipê-roxo (*Handroanthus serratifolius*) are reported in specialized studies (e.g. Schulze et

GEOGRAPHICAL DISTRIBUTION OF LOGGING

Understanding the economic geography of the timber industry as a function of the logged species is fundamental for monitoring and planning the forest sector. To verify the geographic logging trend by species, we created heat maps as a function of the volume harvested throughout the adopted period of analysis. We chose as themes for the confection of these maps, besides the species of greatest importance in the regional timber sector, such as Maçaranduba, species that presented patterns of logging over time that differed among themselves. By observing these patterns, we concluded that they can vary significantly depending on factors such as the level of logging of the species, its acceptance in the markets, and the time that has elapsed since the beginning of its logging at scale.

In 2007, Maçaranduba, the main species logged in the Amazon, was more concentrated in the northeastern portion of Pará and the northern portion of Mato Grosso, with some prominence in the mid-Amazon region. The patterns of logging of this species show a remarkable dispersion of its logging in the Amazon in the subsequent period. Over the years, there was an increase in logging in Amapá and Roraima. After 2010, it is notable an advance to the more central regions of the Amazon, especially in western Pará and southern Amazonas, and an increase in the volume of harvesting in northern Mato Grosso and Rondônia.

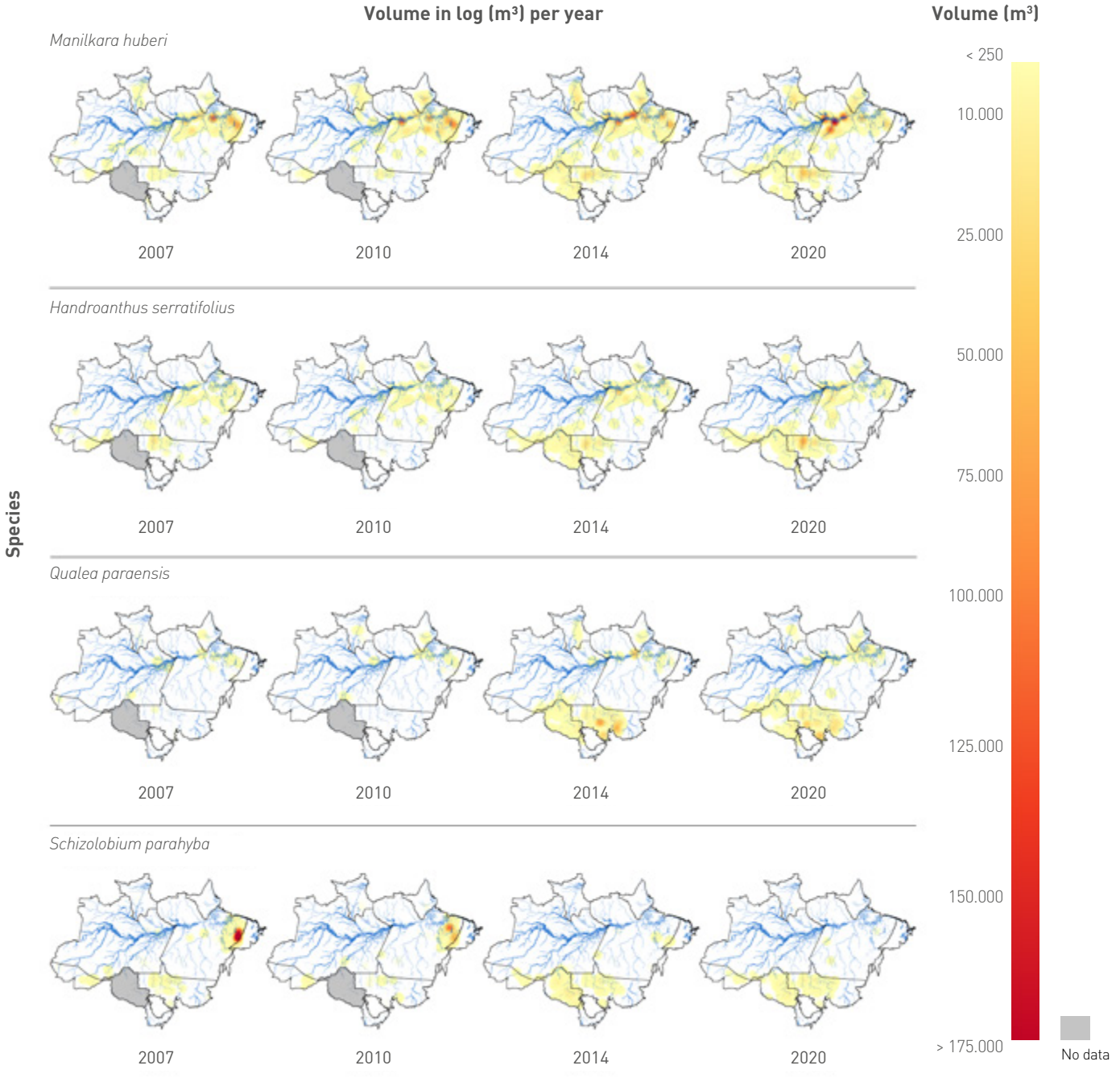
The Ipê-roxo, a species with an emblematic increase in production in recent years, 2007 presented a geography of logging more concentrated in the northeast/northwest of the state of Pará and northern Mato Grosso. Over the years, Pará remained the most relevant state in the logging of the species, and although it has remained the main producer, the north of Mato Grosso, south of Amazonas and Rondônia also showed significant values in the volume of logging after 2010.

The Cambará (Qualea paraensis), on the other hand, compared to the geographic evolution of the logging of Ipê and Maçaranduba, presented low importance of production in 2007. In this period, it presented logging of about 19.5 thousand cubic meters in logs, which jumped in a magnitude of 20 times until 2020, reaching a total of 373 thousand cubic meters. This production advance was more restricted to the old frontier, such as in the central-southern portion of Rondônia, northern Mato Grosso, and northeastern Pará, although a slight increase can be observed in the southern portion of Amazonas from 2014 [12]. The pattern of the spatial evolution of production over time of this species represents an example of the insertion of new species in frontiers where the stocks of valuable wood have been depleted over time, especially in the poles located along the 'arc of fire and deforestation'.

Finally, Paricá (Schizolobium parahyba) production dropped over the years, from 262 thousand cubic meters of logs in 2010 to 87 thousand cubic meters in 2020. It is possible to observe that, in the first years of this analysis, logging was concentrated in the northeastern region of Pará and northern Mato Grosso and, as the years went by, it dropped in Pará, becoming more restricted to Mato Grosso and Rondônia. This condition is probably associated with the increased production and extraction of this species in forest plantations that do not require the inclusion of the volume logged in the DOF/SINAFLOR and SISFLORA system, only in the Federal Technical Registry of Potentially Polluting Activities and Users of Environmental Resources (CTF/APP).

[12] The Cambará is a species with medium basic density, good mechanical strength and moderate durability. The individuals of this species have been gaining market space in tropical wood, especially in civil construction. It is estimated that, only in Mato Grosso, where the species presented the highest volume of harvesting, the Cambará generated revenue of R$ 1 billion between 2004 and 2010, representing 19% of all revenue obtained in the tropical timber market (Ribeiro et al., 2016).

Figure 3. Heatmap of the volume logged of Manilkara huberi, Handroanthus serratifolius, Qualea paraensis, and Schizolobium parahyba, based on the geography of logging in the periods 2007, 2010, 2014, and 2020[13] (Source: databases from the official forest control systems, analyzed and compiled by IMAFLORA).



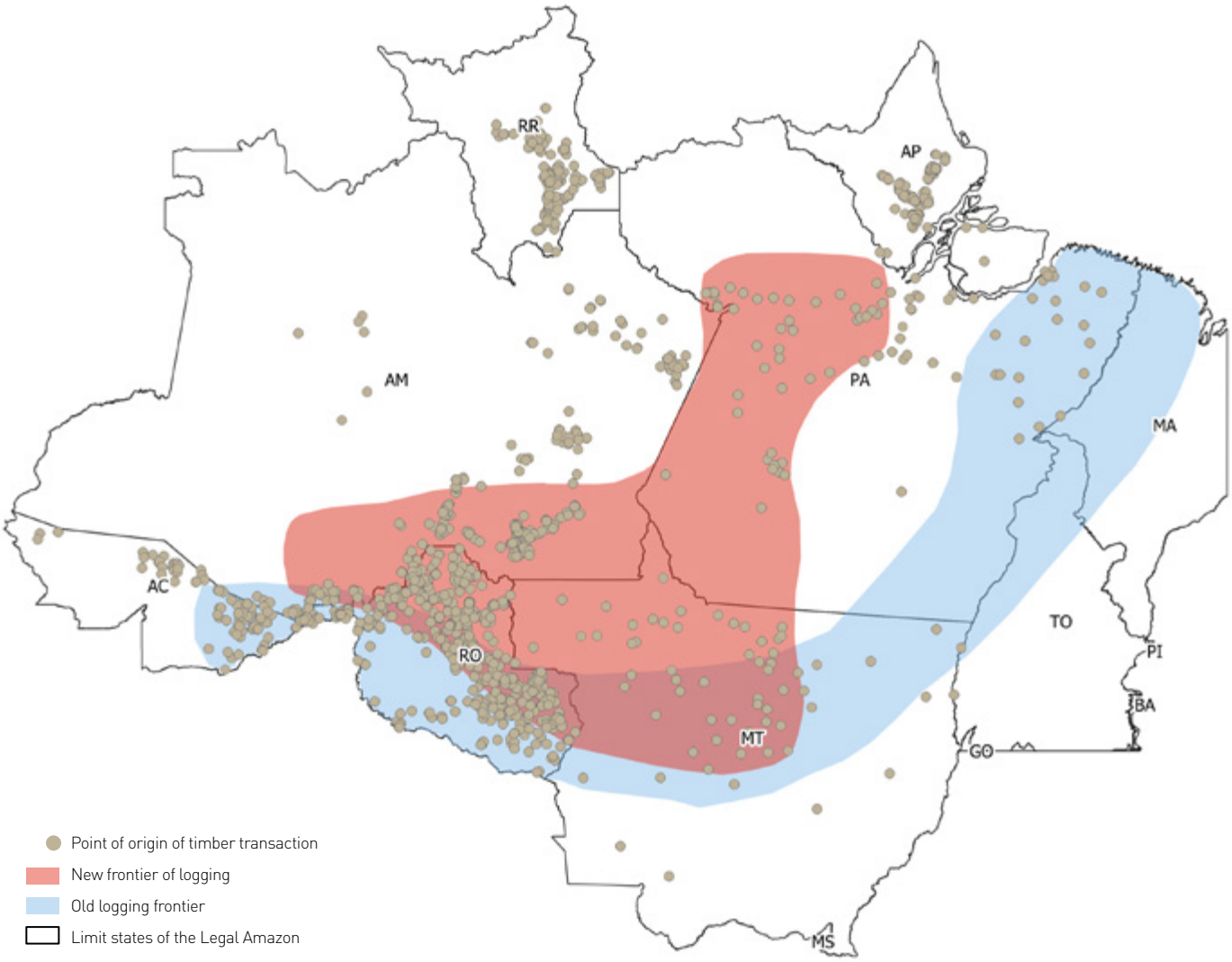
[13] *Adotamos como raio de exploração a partir dos centroides dos municípios nos quais tais espécies foram exploradas de 100km, com base em dados compilados por Pereira et al. 2010.*

SPECIES LOGGED IN THE LOGGING FRONTIERS

Throughout this series of technical newsletters we have described, based on analysis of official data from official forest control systems, the migration of the Amazonian logging industry, once concentrated near the 'arc of fire and deforestation', or in the region's former colonization frontiers, gradually moving to the central Amazonian regions over the past 20 years. Consistent with this narrative, in the 2019-20 biennium, the fifteen highest-producing species were concentrated in the Amazon's new logging frontiers. We note that 70% of the documents issued (DOF or GF) (965,000) are concentrated along western Pará, northern/northwestern Mato Grosso, northern Rondônia, and southern Amazonas. Additionally, only 20% (273,000) originated in the old logging frontier, and 10% (139,000) are in regions outside these frontiers (Figure 4).

In both the old and new frontiers, the fifteen species of greatest production represented approximately 60% of the total volume in this biennium. These forest species with the greatest logging pressure are common in both in relative terms. However, among the fifteen main species in the new frontier, only three are not among the most commonly logged in the old frontier, the Ipê-roxo, the Muiracatiara (*Astronium lecointei*) and the Tatajuba (*Bagassa guianensis*). These species occupy less prominent production positions on the old frontier. As an example, the Ipê, in the biennium 2019-20, presented an average annual volume of 48 thousand cubic meters, occupying the 17th position among the most logged, while in the new frontier for the same period the species occupied the 4th position with about 319 thousand meters logged annually. This tendency also occurs with the Muiracatiara for the same period, presenting a volume logged four times less in the old frontier, and with the Tatajuba, presenting a production six times less in the same comparison between frontiers (17 thousand cubic meters and 79 thousand cubic meters, respectively) (Table 2).

Figure 4. Map of the logging frontiers of the Brazilian Amazon containing the points of origin of the logs logged from the fifteen main species, 2019-20 (Source: databases from the official forest control systems, analyzed and compiled by IMAFLORA).



It is possible to note an inversion in the contribution of the main species between the frontiers. For example, the five main species logged on the new frontier, the Maçarandura, Angelim-pedra *(Hymenolobium petraeum)*, Cupiúba, Ipê and Angelim--vermelho, are the species that occupy the lowest positions on the old frontier among logged species, except for of Cupiúba, which remains among the main positions on both frontiers (Table 2). Such circumstance corroborates what studies have been warning about the sustainability of the sector for decades, being inherent to the dynamic condition of advancement of the logging frontiers, suggesting the slow exhaustion of valuable wood stocks due to failures in the public planning of logging and in the adoption of forest management practices.

Table 2. Comparison of the main forest species logged in the Brazilian Amazon by logging frontier, 2019-20 (Source: databases of official forest control systems, analyzed and compiled by IMAFLORA).

	New Frontier		Old Frontier	
Ranking	**Scientific name**	**Annual volume m³ (2019/20)**	**Scientific name**	**Annual volume m³ (2019/20)**
1	*Manilkara huberi*	829,754.5	*Erisma uncinatum*	378,692.9
2	*Hymenaea courbaril*	330,778.3	*Ruizterania albiflora*	331,186.6
3	*Goupia glabra*	32,9751.6	*Qualea paraensis*	264,428.0
4	*Handroanthus serratifolius*	319,682.7	*Goupia glabra*	202,061.3
5	*Dinizia excelsa*	263,793.6	*Apuleia leiocarpa*	155,893.9
6	*Apuleia leiocarpa*	241,781.5	*Mezilaurus itauba*	135,291.1
7	*Hymenolobium petraeum*	225,380.7	*Dipteryx odorata*	132,025.9
8	*Couratari guianensis*	196,765.2	*Trattinnickia burseraefolia*	128,221.3
9	*Erisma uncinatum*	180,441.6	*Hymenolobium petraeum*	107,626.1
10	*Dipteryx odorata*	178,185.5	*Manilkara huberi*	93,780.1
11	*Astronium lecointei*	167,148.0	*Couratari guianensis*	93,363.0
12	*Mezilaurus itauba*	108,513.2	*Dinizia excelsa*	67,973.9
13	*Bagassa guianensis*	79,132.1	*Hymenaea courbaril*	60,219.9
14	*Qualea paraensis*	78,472.9	*Cariniana micrantha*	50,630.5
15	*Simarouba amara*	76,687.1	*Handroanthus serratifolius*	48,366.9
Total	**59% total production**	**3,606,268.7**	**57% total production**	**2,249,761.5**

FINAL CONSIDERATIONS AND RECOMMENDATIONS

Despite the limitations on the use of data from official forest control systems, we found that the Amazonian timber sector, strategic from the point of view of local job and currency generation, uses a significantly greater proportion of the regional diversity of tree species than previous studies have estimated. In the period 2007-20, such databases reveal that approximately 1,000 tree species were harvested for timber products, mainly for the construction market in Brazil and abroad.

However, on the other hand, at least half of Amazonian roundwood production (in recent years in the range of 10-12 million cubic meters per year) is based on the use of 15-20 species of greatest relevance in such markets. This fact shows the serious strategic fragility of the Amazonian timber industry regarding future stocks of valuable woods, perpetuating a cycle of exhaustion of Brazilian forest resources that goes back to discovery. In short, the country that has the name of a tree harvests the most valuable species until its stocks are exhausted, and then moves on to the next wood that will be assimilated by the market. In the old timber frontiers of the region, as an example, we find evidence of the fall in production of species of exceptional economic value, as is the case of Ipê, and these products are being replaced by other species. At the root of the problem is the lack of large-scale public planning that offers the timber sector a broad forest base managed through forest management practices that allow such production areas to be conserved in the long term.

It is worth mentioning that there are important perspectives in this direction today. It is noteworthy, for example, the advent of a system of public forest concessions in Brazil that has been in operation for the last 16 years. Together with public territories of the community domain able to conduct forest management through partnerships with companies, the concessions could quickly guarantee a forest base of enough size to supply the timber industry in the Amazon in the long term. Today, we estimate that an area of 25 million hectares, which would be equivalent to 5% of the Legal Amazon, would fulfill this role. We have made progress in recent years, albeit slowly, toward this goal.

It is also important to say that today's science understands that not even areas under the best management and conservation techniques will be able to maintain stable stocks of valuable wood species in the long term. This is because many of the most coveted species by the markets have ecological characteristics that prevent the replacement of harvestable wood stocks in the periods between logging cycles, while the production forests remain fallow. The only way to guarantee the replacement of these stocks would be to resort to silvicultural treatments or longer cutting cycles, which would be prohibitive from the economic point of view.

In other words, even if a broad and stable forest base were established for the regional timber industry, this industry would have to evolve substantially in terms of using larger volumes of a wider range of commercial species, in addition to investments in technology and the development of new products. The use of lesser-known species from proven managed enterpri-

ses (such as concessions and certified areas), besides investment´s attraction for the development of engineered wood products from such species, would be good starting points. We will return to such topics in future issues of this series of technical newsletters edited by IMAFLORA. Returning to the results presented in this manuscript, we give the recommendations and specific reflections described below.

1) **Better identification of logged species.** Since 2009, with the approval of Resolution 406, it has been mandatory to adopt technical and scientific procedures to correctly identify the species harvested under forest management. Without this identification, and advances in the generation of reliable forest inventories, little progress can be expected in terms of strategic sectoral planning for the timber industry in the Amazon. This is not a point that depends only on more effective regulation and enforcement by state environmental agencies. Crucial points in this agenda include the training of practical parataxonomists capable of conducting such inventories, financial resources for research on forest species, and the entire structure of herbariums and research entities working in this area. Public investments in this agenda have strongly regressed in the last decades.

2) **Bigger robustness in the species registration systems.** In addition to the recommendation above, the systems for species registration in the official forest control systems need to evolve. Some data, such as species names, are sensitive and cannot suffer from input errors such as the inclusion of characters, numbering, and lack of spacing between genus and epithet. In addition, species data should be updated with the currently accepted name and not by synonyms. In this case, the best way to handle the data would be to promote a system of equivalence, in which the system would accept the inclusion of synonymy by the user but would recognize it and adjust it to the name accepted on the platforms indicated by the academy. If by chance the user chose to include a new species in the systems, this inclusion should be possible upon validation by an expert registered by the forestry control agency.

3) **Satisfactory data transparency.** Despite important progress in this direction, the data from the official control systems are not widely available to society in an open, accessible, complete, updated, and machine-readable way. Even the SisDOF data, made available in September 2018 after an extensive debate with civil society and the creation of an open data plan, had its opening discontinued in February 2021. In the same direction, data from the SISFLORA systems (Pará and Mato Grosso) are not widely available. The lack of such data hinders not only robust sectoral planning by the leaders of the Amazon timber industry, but also compromises the participation of civil society in monitoring and proposing solutions in terms of sustainable markets and combating illegal logging. Finally, the lack of transparency hinders the State itself in complying with the Law regarding the need for sustainable public procurement of wood products.

4) **Generation of information on the occurrence of little-logged species.** Different actions are important to promote the introduction of lesser-known species in the markets, which will be the subject of a later edition of this series of technical newsletters. However, the basic gap that prevents such actions from being developed refers precisely to the uncertainties about the occurrence of such species, again linked to incomplete or unreliable forest inventories, lack of procedures for the correct identification of these species, and reliable registration of them in the official control systems. Next, detailed basic research on the ecological behavior of such species is still needed. In particular, the occurrence and abundance of such species in proven managed enterprises would be of great value to indicate the most promising species. This would avoid leveraging again the consumption of species that are ecologically sensitive, endemic, or logistically unavailable in the main consumer markets, which would only feed the model linked to the continuous exhaustion of valuable Brazilian woods that was established during the time of discovery.

5) **Leverage forest concessions.** The decline in the production of economically valuable species in the old timber frontiers demonstrates the lack of long-term planning and organization of the forest industry in the Brazilian Amazon. In this sense, forest concessions in Brazil can be important allies in public planning for the consolidation of the broad-based timber industry in the long term and, consequently, for the stabilization of the logging frontiers.

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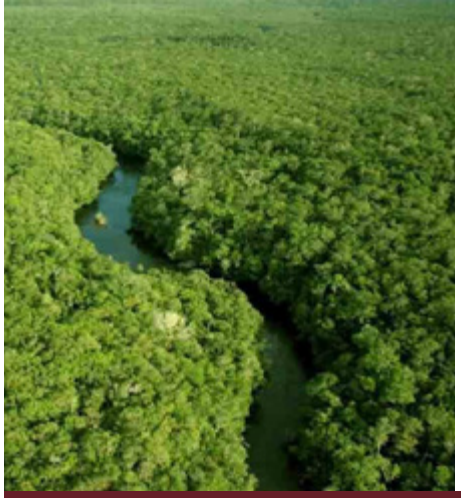

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