Sensory characteristics of wood from naturally fallen Amazonian trees for manufacture of products in Extractive Reserves

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Abstract

In view of the national and international demand for wood for industrial use, solutions are being created to combat and reduce deforestation. One such solution is to use wood from naturally fallen trees. However, there has been limited evaluation of the technological potential of this material. This study therefore aimed to assess the general characteristics of wood from naturally fallen tree species in the Auatí-Paraná Extractive Reserve (RESEX), for potential use in product development. The characteristics analyzed were color, texture, grain, heartwood, sapwood and density. The species of naturally fallen trees were assessed using online databases, specialized literature and the xylotheque at the Wood Anatomy and Identification Laboratory of the National Institute of Amazonian Research (LAIM/INPA). This study and its results confirm the great quantity and quality of wood from naturally fallen trees with technological potential for the development of products, based on the classification of the sensory characteristics of the woods.

Keyword: necromasses, protected areas, technological potential

1. Introduction and Objectives

Given the growing pressure from national and international demand for wood for industrial use, solutions are being created to combat and reduce the rate of deforestation (FRÓES *et al*, 2019). One of these solutions is to use wood from naturally fallen trees (forest waste with low environmental impact). Researchers from the National Institute of Amazonian Research (INPA) have carried out numerous studies involving the Extractive Reserves of the State of Amazonas. In one such study, Rocha (2010) addressed the use of naturally fallen trees in protected areas, showing the technological potential of the wood for manufacturing products.

Despite deforestation in the Amazon, the number of standing trees (live trees) authorized for felling by the timber industry by the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA) corresponds to the same number of naturally fallen trees in the forest, known as necromasses. According to Freitas *et al.* (2019), in natural forests necromass is found in abundance in the form of standing dead trees, fallen trunks and fallen thick branches. Many of these trees are in good condition and can serve as inputs for the production chain, as long as forest extraction limits are respected (ROCHA, 2010 and SILVA, 2013). There is a strong relationship between the use of necromasses and the creation of protected areas, as according to Carvalho (2019, p. 13), the "creation of Protected Areas in Brazil is intended to conserve biological diversity *in loco* and provide a framework for natural resource use".

In other countries, forest inventories include the measurement and inclusion of naturally fallen trees. However, the evaluation of the potential use of wood from necromass is still limited, since there is currently little information available. In some places in Brazil there are regulations for the use of such raw material for pre-established purposes, as is the case in Paraná, where wood is used for energy generation through incineration. In Bahia, cocoa farmers use it to make furniture and construct facilities (NASCIMENTO *et al.*, 2011).

The use of this natural resource requires some level of control in order to avoid predatory exploitation. Forest inventories were conducted for the implementation of sustainable management at the Auatí-Paraná Extractive Reserve (RESEX). These identified a number of species of fallen trees using GPS, as well as waste wood that could be transformed into products. Forest management that uses wood from naturally fallen trees contributes to the reduction of the impact caused to the environment due to unregulated exploitation. However, it is still necessary to observe the amount of wood waste produced by the mechanical processing of these trees. When there is no planning for the use of this waste, it may be disposed of incorrectly or incinerated (CARVALHO, 2018).

Based on the above considerations, this study aimed to assess the naturally fallen tree species in the RESEX Auatí-Paraná regarding the general characteristics of the woods for use in product development. The characteristics analyzed were color, texture, grain, heartwood, sapwood and density.

1.1.Profiling of Amazonian woods

A single timber species can have several common or vernacular names, as is the case with the 'purpleheart' species known as *violeta*, which is also locally known as *pau-roxo*, *roxinho*, etc., depending on the region. Thus, in order to identify and profile wood species more precisely, it is important to observe the way the species are named and the two large groups into which they are classified (PEREIRA, 2013).

The botanical nomenclature adopted today makes use of the binomial classification system. This system uses two words to compose the name of the species: the first refers to the genus and the second to the specific epithet. This name is written in italics and based on the Latin language. The genus name may be used without the epithet, but the epithet only makes sense if used in combination with the genus. The species name may also be accompanied by the name of the author who first described the plant. For example, the scientific name of the 'purpleheart' timber wood species known as *violeta* is *Peltogyne catingae* Ducke, where *Peltogyne* is the genus (written in italics with the first letter always capitalized and the rest in lowercase), *catingae is* the species epithet (written in italics and always in lowercase), and Ducke is the name of the author (PEREIRA, 2013; MELO and CAMARGOS, 2016).

The two major groups are *Angiosperms* (from the Greek *angi*, 'envelope' and *sperma* 'seed', plants where the eggs are protected by flowers and fruits) and *Gymnosperms* (from the Greek *gymnos*, 'naked' and *sperma* 'seed', plants with eggs that are not enclosed by flowers and fruits) (PEREIRA, 2013). Furthermore, according to Melo and Camargos (2016), "each species belongs to a genus. Groups of similar genera make up a family, families, in turn, are arranged in orders, and orders in other, broader divisions of the plant kingdom".

In addition to the scientific name, the general or sensory and organoleptic characteristics of wood are properties that enable the identification and classification of timber species. According to Pereira (2013, p. 73), IBDF/DPq-LPF (1988, p. 25), Melo and Camargos (2016, p. 33), and Freitas and Vasconcelos (2019, p. 47), the main characteristics are:

- **Grain -** term used to describe the direction or parallelism of the vertical cellular elements of the wood, in relation to the longitudinal axis of the trunk. The grain has a decisive influence on the quality of sawn wood, its defects, dimensional stability, and mechanical durability of bent pieces and during bending. The grain can be classified as: straight, interlocked, inclined, spiral and wavy, straight to interlocked, straight and interlocked, straight to wavy, straight and wavy. However, the main types are: straight, interlocked and inclined.
- **Smell -** the smell can be classified as: imperceptible, perceptible, characteristic, unpleasant and pleasant. The smell is always compared with known odors and can be observed in samples of freshly polished or slightly moistened wood;
- **Taste** - caution is required when checking the taste, as some species can cause allergic reactions and even intoxication;
- **Texture -** classed as fine, medium and coarse, depending on the size of the tangential diameter and visibility of the parenchyma. A fine texture provides a smooth and uniform surface, while a coarse texture requires more sanding and is not suitable for use in objects requiring a fine finish;
- **Density -** is classified as low density or light wood (≤ 0.50 g/cm^3), medium density wood (0.50 g/cm^3 to 0.72 g/cm^3) and high density or heavy wood (> 0.72 g/ cm^3). Generally, low density woods are lighter colored, while high density woods are much darker. Several other properties of wood are related to density, which is why this is an important requirement when choosing woods for a particular use;
- **Lustre -** observed in the longitudinal planes, it can be classified as dull, bright, moderate or accentuated;
- **Color -** the color is observed in the longitudinal planes, preferably on the tangential surface. It is necessary to differentiate the colors between the heartwood and the sapwood, but generally the color given for a wood refers to the color of its heartwood. According to Pereira (2013), the main colors of wood are: white, pink, gray, yellow, brown, reddish-brown, olive, red, purple and black;
- **Pattern or figure -** any characteristic that stands out on the surface of the wood, resulting mainly from the color difference caused by the growth layer and the constituent elements of the wood;
- **Heartwood and sapwood -** the heartwood has a much greater natural durability than the sapwood. These are classified as distinct (different colors, darker heartwood with lighter sapwood), indistinct (same colors) and slightly distinct (similar colors).

Coradin and Camargos (2002, p. 27) describe the following procedures for the identification of timber species:

1. Always use recently planed wood for identification;
2. Check the condition and humidity of the sample and whether it has been treated in any way;
3. Verify whether the sample was taken from the heartwood or sapwood;
4. Consider the source of the material;
5. Check the common name by which the species is marketed, in advance;
6. Consider any notable characteristics of the species;
7. Analyze the general characteristics (color, weight, smell, figure, etc.);
8. Analyze macroscopic characteristics (using 10x magnifying glass);
9. Conduct a general analysis, comparing all data found;
10. Proceed with a new analysis if data are found that are not compatible with the presumed species;
11. Send any samples that were not identified in the field to a wood anatomy laboratory.

2. Materials and Methods

The site selected for the study was the Auatí-Paraná Extractive Reserve (RESEX), located in the municipalities of Fonte Boa, Maraã and Japurá in the State of Amazonas, Brazil (FIGURE 1). RESEX Auatí-Paraná is located at 02º 23 '09.60" S 66º 40' 55.20" W (SAD 69), in the Amazon biome and has an area of 146,948.05 hectares. According to ICMBio (2011) the climate of the region fits into climate group A, type f (Tropical Rainforest Climate), of the Köeppen classification. According to the Gaussen classification, the area falls within the thermaxeric (equatorial) bioclimatic region. The population of the Reserve is approximately 1500 inhabitants (ROCHA, 2010), the majority being farmers, with the general activity of managing pirarucu fishing.

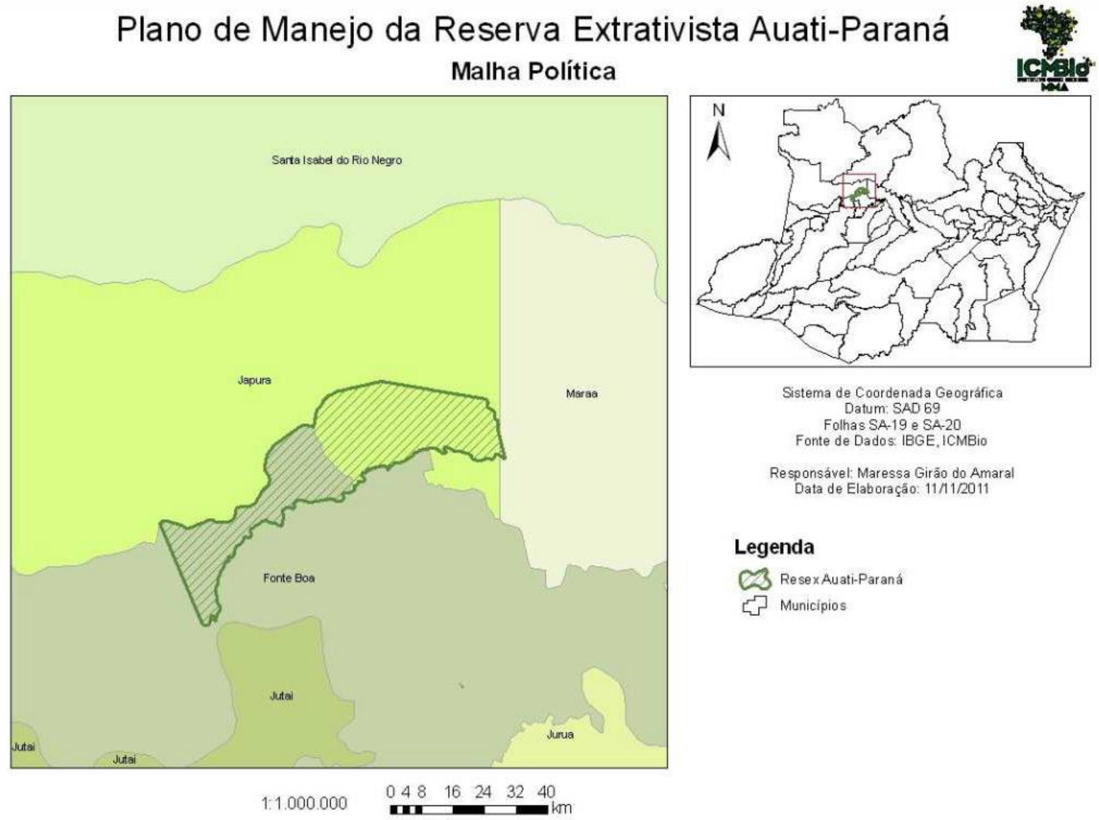

Figure 1. Location of the RESEX in Amazonas. Source: ICMBIO (2011).

The population for the study consists of the most frequently occurring species of naturally fallen trees within the area of the RESEX. The sample is non-probabilistic, as it is defined by accessibility. Therefore, the criterion defined to establish the population sample was the cross-checking of research already carried out at the RESEX and of reports by ICMBio, the institution responsible for extractive reserves and other Conservation Units. Thus, 41 species were selected as a sample of the most frequently occurring species of naturally fallen trees, based on the work of Rocha (2010).

The species of naturally fallen trees were profiled using online databases, such as those of the Institute for Technological Research (Instituto de Pesquisas Tecnológicas, 2020) and the Brazilian Forest Service (Serviço Florestal Brasileiro, 2020), specialized literature, and the xylotheque at the National Institute of Amazonian Research's (LAIM/INPA) Wood Anatomy and Identification Laboratory. The tools used were: notebook, pen, smartphone camera (Rear camera: 13 MP - f/2.0, 1.12µm), notebook computer (Aspire F 15, FE-573G-50KS), multifunction printer, magnifying glass with 10 times magnification for macroscopic assessment, and stylus. The software used were: Corel Draw (2020 version), Word (2016 version), Excel (2016 version) and Photoshop CC 2017. The online systems consulted were: the Brazilian Forest Service's *Database of Brazilian Woods* (Serviço Florestal Brasileiro) and the Institute for Technological Research's *Consultas Online – Informações sobre madeiras* (Instituto de Pesquisas Tecnológicas).

The timber species were obtained from the research conducted by Rocha in 2010, in which the author identified a total of 41 species of naturally fallen forest trees in the Auatí-Paraná Extractive Reserve, using a forest inventory. All information was compared with that of the *Catálogo de Árvores do Brasil* (Catalog of Trees of Brazil) developed by Camargos *et al* (2001). This information was organized in the form of a table with the Family, Species and Common Name identified.

The woods were profiled based on the procedures proposed by Coradin and Muñiz (1992) and Coradin and Camargos (2002). As such, the data collected were related to Family, Scientific Name, Common Name, General Characteristics, Density and Use. This was achieved using specialized literature from the following authors: Freitas *et al* (1990), Camargos *et al* (2001), *Catálogo de Madeiras da Amazônia* (1991), Loureiro *et al* (2000), Loureiro and Lisboa (1979), Loureiro (1976), Loureiro and Silva (1968), Mainieri and Chimelo (1989), Melo and Camargos (2016), Record and Hess (1949), Siqueira *et al* (1991), The Plant List (2013) and Souza, Magliano and Camargos (2002).

Data for profiling two of the species could not be found in the literature featuring the aforementioned authors. Therefore, these were profiled using materials available at the LAIM/INPA Xylotheque. This involved a search of the archives and selection of the wood identification cards. The identification cards then enabled consultation of the books of records present at LAIM/INPA and the wood samples were selected for profiling (FIGURE 2). This procedure was performed by the specialist responsible for the laboratory through until the end of this study.

Figure 2. Samples of timber species.

After profiling the wood species in terms of their general characteristics, the colors of the wood were then identified by searching the online databases of the Institute for Technological Research and the Brazilian Forest Service using the scientific name of each of the 41 species. Images were also obtained from the work of Pereira (2013) and the *Catálogo de Madeiras da Amazônia* (Amazonian Woods Catalog) (1991). Some of the images of the wood species were obtained from the specialized literature and online databases, while the rest were acquired from LAIM/INPA and LEAM/INPA by scanning wood samples in a multifunctional printer scanner. The samples were identified, separated and prepared for scanning (FIGURE 3).

Figure 3. Wood samples scanning process.

Some of the samples that did not have a flat surface or had some kind of finish were sanded in two stages: firstly, on a bench sander with 100 grit sandpaper and then manually with 120 grit sandpaper. A showcase of Brazilian woods with 90 cards by Pereira (2013) was then used to classify the color. It has a set of 10 colors of wood, namely: white, pink, gray, yellow, reddish-brown, brown, olive, red, purple and black. The images of the wood from the 41 species were printed on white 75 g/cm³ A4 paper using as inkjet printer with print quality in optimal mode.

The printed images were compared with those of the showcase (PEREIRA, 2013). However, the quality of the prints proved to be inferior to that of the showcase. As such, the images in the showcase were scanned using a multifunctional printer scanner. Then the images of the wood samples were compared with the images of the showcase using the Corel Draw program.

3. Results and Discussion

The Auatí-Paraná Extractive Reserve covers 146,950 ha, with 2.32 ± 0.77m³/ha in volume of naturally fallen wood that could be used. The fallen tree with the largest diameter in the inventory had a diameter at breast height (DBH) of 180 cm. Chart 1 shows the forty-one species with the highest occurrence. Note that the botanical families with the highest number of individual fallen trees are Lecythidaceae and Sapotaceae*,* according to Rocha (2010).

Chart 1. List of Naturally Fallen Tree species in the Auatí-Paraná Extractive Reserve

		SPECIES	COMMON NAME
01	Apocynaceae	***Himatanthus articulatus*** (Vahl) Woodson	Sucuuba/janaguba
02	Burseraceae	***Protium puncticulatum*** J. F. Macbr	Breu vermelho
03	Caesalpiniaceae	***Dimorphandra*** sp.	Faveira
04	Caesalpiniaceae	***Macrolobium acacifolium*** (Benth.) Benth	Arapari
05	Caesalpiniaceae	***Peltogyne catingae*** Ducke	Violeta
06	Chrysobalanaceae	***Licania macrophylla*** Benth	Macucu-terra
07	Fabaceae	***Bowdichia nítida*** Spruce	Sucupira Preta
08	Fabaceae	***Dipteryx ferrea*** Ducke	Cumaru ferro
09	Fabaceae	***Dipteryx odorata*** (Aubl.) Willd	Cumaru

10	Goupiaceae	***Goupia glabra*** Aubl.	Cupiuba
11	Guttiferae	***Symphonia globulifera*** L. f.7	Anani
12	Icacinaceae	***Discophora guianensis*** Miers	Mamãozinho
13	Lauraceae	***Aniba duckei*** Kosterm	Pau rosa
14	Lauraceae	***Aniba*** sp.	Louro
15	Lauraceae	***Beilschmiedia brasiliensis*** (Kosterm.) Kosterm	Anoerá
16	Lauraceae	***Licaria cannella*** (Meisn) Kostern	Louro Pirarucu
17	Lauraceae	***Mezilaurus itauba*** (Meins.) Taub. exMez	Itaúba
18	Lauraceae	***Ocotea cymbarum*** Kunth	Louro-inhamuí
19	Lauraceae	***Ocotea myriantha*** Mez	Louro abacate
20	Lecythidaceae	***Cariniana micranta*** Ducke	Tauari-vermelho
21	Lecythidaceae	***Lecythis paraensis*** Huber exDucke	Castanha sapucaia
22	Mimosaceae	***Dinizia excelsa*** Ducke	Angelim Ferro
23	Mimosaceae	***Enterolobium schomburgkii*** (Benth.) Benth	Sucupira Amarela
24	Mimosaceae	***Parkia multijuga*** Benth	Faveira
25	Mimosaceae	***Pithecelobium racemosum*** Ducke	Angelim Rajado
26	Moraceae	***Brosimum guianense*** (Aubl.) Huber	Amapá-folha-larga
27	Moraceae	***Brosimum parinarioides*** Ducke	Amapá
28	Moraceae	***Clarisia racemosa*** Ruiz &Pav	Guariuba
29	Myristicaceae	***Iryanthera paraensis*** Huber	Ucuubarana
30	Myristicaceae	***Virola surinamensis*** (Rol.) Warb.	Virola
31	Olacaceae	***Curupira tefeensis*** G. A. Black	Castanha-sucupira
32	Rubiaceae	***Calycophyllum spruceanum*** Benth	Mulateiro
33	Sapotaceae	***Manilkara amazonica*** (Huber) Chevalier	Maparajuba
34	Sapotaceae	***Micropholis venulosa*** (Mart. &Eichler) Pierre	Abiurana
35	Sapotaceae	***Micropholis williamii*** Aubr. &PelLegrand	Abiurana
36	Sapotaceae	***Pradosia praealta*** Ducke	Casca doce
37	Simaroubaceae	***Simaba cedron*** Planch	Pau-paratudo
38	Simaroubaceae	***Simarouba amara*** Aubl	Marupá
39	Sterculiaceae	***Theobroma microcarpum*** Mart.	Cacau-rana
40	Vochysiaceae	***Qualea homosepala*** Ducke	Mandioqueira
41	Vochysiaceae	***Vochysia vismiaefolia*** Spruce ex. Warm	Quaruba-vermelha

Source: adapted from Rocha (2010).

The species were profiled by family, scientific name, common name, general characteristics (organoleptic properties), density and use, in addition to classification by color using images, as shown in Figure 4. Five sources were used to obtain images of the 41 species described, namely: Pereira (2013), Catálogo de Madeiras da Amazônia (1991), Instituto de Pesquisas Tecnológicas (2020), Serviço Florestal Brasileiro (2020) and scanning of samples from the xylotheque at LAIM/INPA.

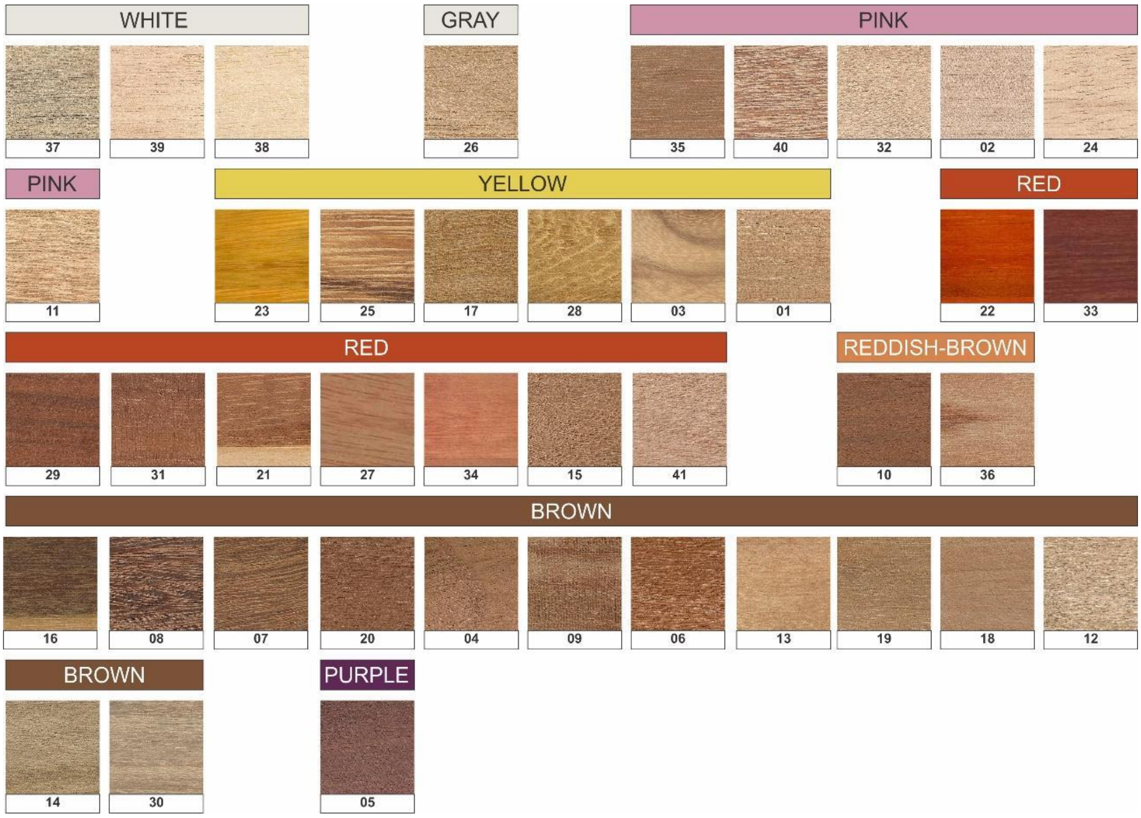

Figure 4. Classification of timber species according to Pereira's color standard (2013)

Although some species can be found in all 5 sources, the images were collected for comparison in terms of quality and degree of similarity. Images of all species were obtained from scanning of samples at the INPA laboratory (FIGURE 5), while only 41.46% were obtained from the online database of the Brazilian Forest Service (Serviço Florestal Brasileiro, 2020). The others were obtained from the work of Pereira (2013), from the online database of the Institute for Technological Research (Instituto de Pesquisas Tecnológicas, 2020) and from the Catálogo de Madeiras da Amazônia (1991), as shown in figure 5.

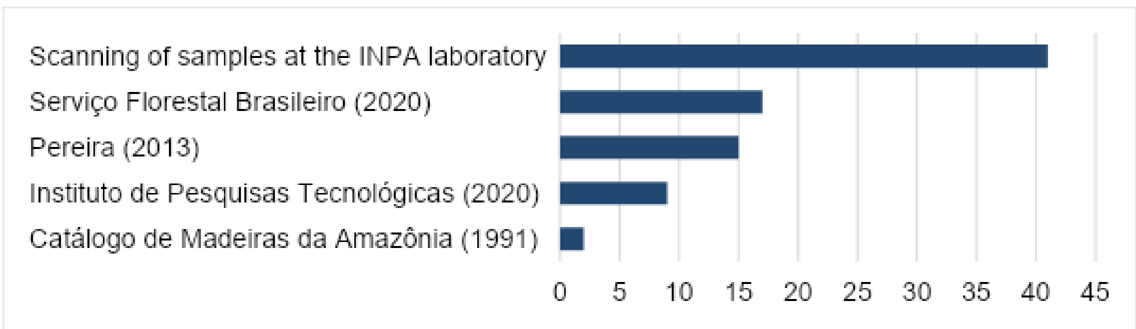

Figure 5. Number of images of woods obtained from each source used.

Although Rocha (2010) states that all of these wood species have potential for commercial management, the number of images found in online databases and specialized literature is limited by the fact that some of the 41 species of fallen timber trees in Auatí-Paraná are not yet recognized by the market. Pereira (2013) also points this out when selecting 90 native species from among the 100 most commercialized in Brazil between 2008 and 2009. Thus, only 22 (53.65%) of the 41 species identified in Auatí-Paraná can be found among the species considered as commercial by Pereira (2013), Serviço Florestal Brasileiro (2020) and Instituto de Pesquisas Tecnológicas (2020). These are: *Protium puncticulatum* JF Macbr; *Macrolobium acacifolium* (Benth.) Benth; *Peltogyne catingae* Ducke; *Lycania macrophylla* Benth; *Bowdichia nitida* Spruce; *Dipteryx odorata* (Aubl.) Willd*;* *Goupia glabra* Aubl.; *Symphonia globulifera* L. f.7; *Beilschmiedia brasiliensis* (Kosterm.) Kosterm; *Mezilaurus itauba* (Meins.) Taub. Ex Mez; *Cariniana micranta* Ducke; *Lecythis paraense* Huber ex Ducke; *Dinizia excelsa* Ducke; *Enterolobium schomburgkii* (Benth.) Benth; *Parkia multijuga* Benth; Ducim *Brosimum parinarioides*; *Clarisia racemosa Ruiz* & Pav; *Virola surinamensis* (Rol.) Warb.; *Manilkara amazonica* (Huber) Chevalier; *Micropholis venulosa* (Mart. & Eichler) Pierre; *Simarouba amara* Aubl; and *Vochysia vismiaefolia* Spruce ex. Warm.

Despite the data presented, the 41 species have potential for product development, as indicated by their density, grain, texture and color. Of the 41 woods profiled, 51% have a basic density of greater than 0.72 g/cm³. Such dense woods are generally used in civil construction and for making more robust products. As for the other woods, 39% are medium density and 10% are low density, i.e. they are light woods (FIGURE 6).

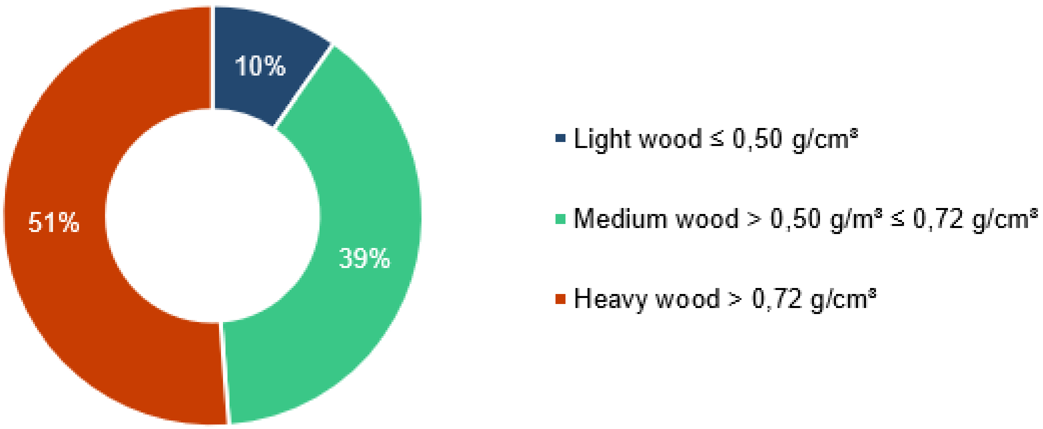

Figure 5. Woods classified by basic density.

The study shows that most of the woods described have straight grain (12 species) and regular grain (9 species), as shown in Figure 7. These species have greater mechanical resistance and are easier to saw and work with, according to Coradin and Camargos (2002). However, wood with straight or regular grain does not present ornamental or special figures on its tangential and radial surfaces, maintaining a regular aspect, according to ANPM (2018).

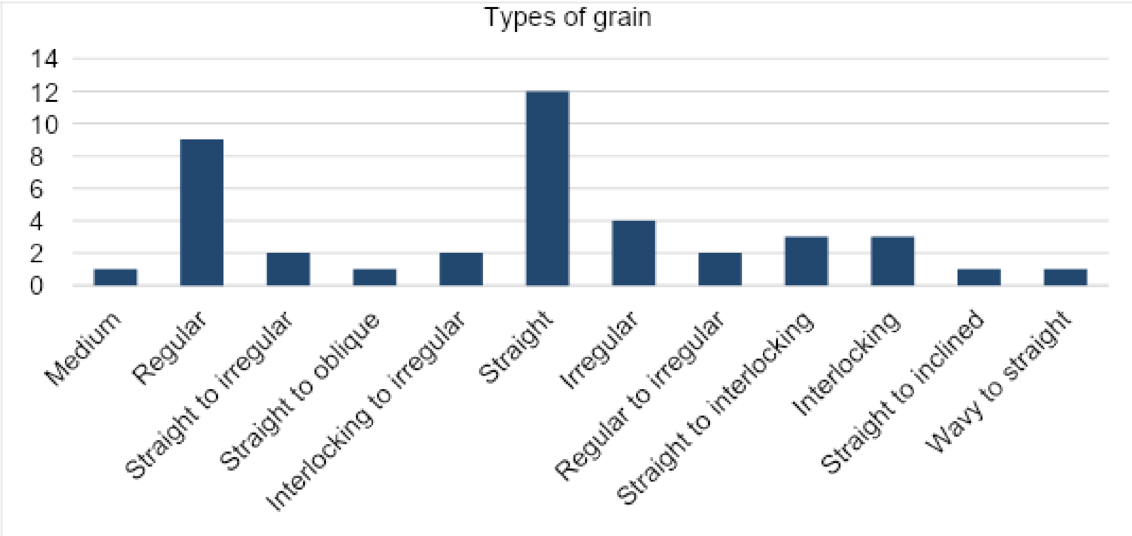

Figure 7. Woods classified by type of grain.

As for texture, 22 (53.65%) of the wood species have medium texture (FIGURE 8). Thus, they are woods that do not have a totally smooth surface like those with a fine texture, but do not necessarily require extra sanding like those with a coarse texture, as discussed by Melo and Camargos (2016).

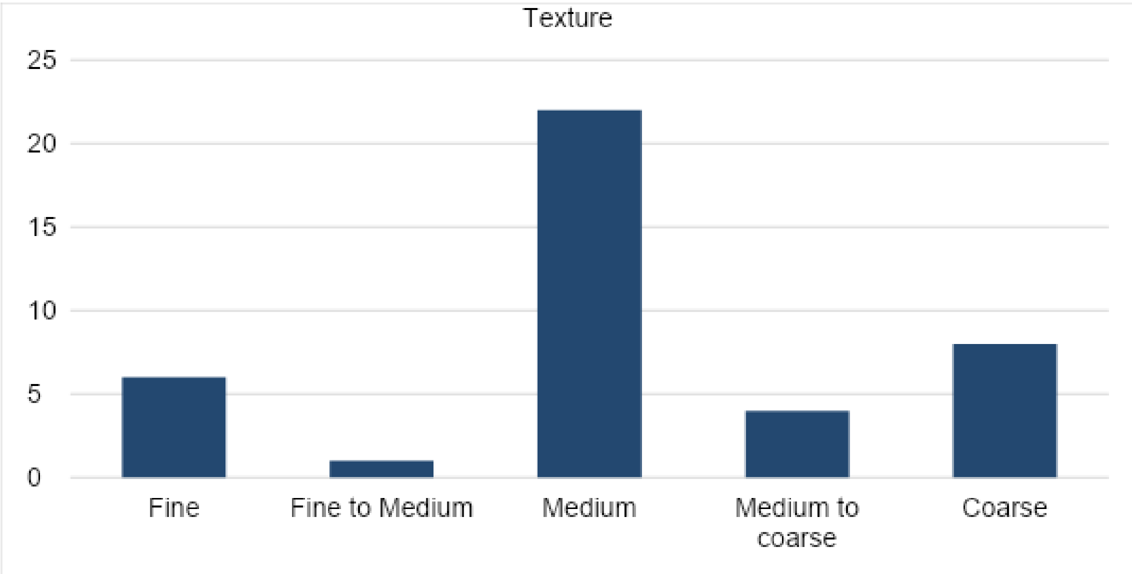

Figure 8. Wood classified by texture.

Given the reality on the ground in the RESEX Auatí-Paraná as regards logistics, infrastructure, and quantity and quality of machines and tools, processing wood with such characteristics facilitates the product design process. In the RESEX, the species *Peltogyne catingae* Ducke and *Simarouba amara* Aubl were used to make a set of coffee tables by Silva (2018), as shown in Figure 9. Regarding the species *Peltogyne catingae* Duck*e*, it was found that the species showed good workability during processing. Because of its weight (high density) it was used to make the smaller table. The favorable characteristics of the wood for making such a product were the color, heartwood and density. The species *Simarouba amara* Aubl demonstrated superior workability. Because of its low density, the process of making the table was faster and easier, with less effort required for finishing. The favorable sensory characteristics in the wood were color, texture and density.

Figure 9. Coffee table developed from necromasses. Source: adapted from Silva (2018).

4. Conclusions

This study and its results confirm the great quantity and quality of wood from naturally fallen trees with technological potential for the development of products, based on the classification of the sensory characteristics of the woods.

5. References

Associação Nacional de Pisos de Madeira (ANPM). Conheça as características da madeira. 2018. Available in: <https://www.anpm.org.br/conheca-caracteristicas-da-madeira>. Accessed on: 13 dez. 2020.

Camargos JAA, Coradin VTR, Czarneski CM, Oliveira D, Meguerditchian I. Catálogo de Árvores do Brasil. Brasília, DF: Ibama, 2001. 896 p.

Carneiro Filho A, Manzi A, Santos J, Rocha R, Higuchi N. A floresta e o clima. In: M.I.G. HIGUCHI e N. HIGUCHI, (Eds.). A floresta Amazônica e suas múltiplas dimensões: uma proposta de educação ambiental. Manaus: INPA/CNPq. 2004.

Carvalho ACN. Uso da biodiversidade nas Reservas Extrativistas do rio Jutaí - AM e Médio Juruá - AM. 2019. 100 f. Dissertação (Mestrado) - Curso de Programa de Pós-graduação em Geografia, Instituto de Filosofia, Ciências Humanas e Sociais, Universidade Federal do Amazonas, Manaus, 2019.

Carvalho SA. Resíduos de espécies madeireiras de manejo florestal para produção de móveis. 2018. 60 f. Dissertação (Mestrado) - Curso de Programa de Pós-graduação em Ciências Florestais e Ambientais, Faculdade de Ciências Agrárias, Universidade Federal do Amazonas, Manaus, 2018.

CATÁLOGO de Madeiras da Amazônia: Características tecnológicas; Área da Hidrelétrica de Balbina. Manaus: Instituto Nacional de Pesquisas da Amazônia, CNPq/INPA/CPPF, 1991.

Coradin VTR, Muñiz GIB. Normas e procedimentos em estudos de anatomia da madeira: I – Angiospermae, II – Gimnospermae. Brasília, DF: IBAMA, DIRPED, LPF (IBAMA, Série Técnica, n. 15), 1992. 19p.

Coradin VTR, Camargos JAA. A Estrutura Anatômica da Madeira e Princípios para a sua Identificação. Brasília: LPF, 2002. 28 p.

Freitas FC, Azevedo CP, Souza CR. Estoque de necromassa em floresta não manejada e floresta manejada na Amazônia Central. Scientia Forestalis, 2019. DOI: dx.doi.org/10.18671/scifor.v47n121.02

Freitas JA, Vasconcelos FJ. Identificação prática de madeiras comerciais da Amazônia: método macroscópico de comparação. 2. ed. Manaus: Inpa, 2019. 54 p. INCT - Instituto Nacional de Ciência e Tecnologia - Madeiras da Amazônia; CT - Amazônia/CNPq: alternativas de uso de resíduos florestais na Amazônia Central.

Freitas JA, Vasconcelos FJ, Silva NB, Loureiro AA. Madeiras da Amazônia que apresentam raios largos. Acta Amazônica, Manaus, v. 22, n. 1, p. 91-161, 31 jul. 1990. Trimestral.

Fróes DF, Nascimento CC, Freitas JA, Silva GM, Araujo RD, Dantas GS, Filho PDFSP. (2019). Managing the Technological Potential of Eschweilera truncata A. C. Sm in the Amazon. International Journal for Innovation Education and Research, 7(11), 585–598. DOI: https://doi.org/10.31686/ijier.vol7.iss11.1912

Hummel AC. Situação da atividade madeireira no Estado do Amazonas. In: Encontro da Associação dos Engenheiros Florestais do Amazonas. Manaus: 1997. 26 p.

IBDF/DPq-LPF. 1988. Madeiras da Amazônia: características e utilização. Estação Experimental de Curuá-Una. Brasília. v. 2, 236 p.

Instituto Chico Mendes de Conservação da Biodiversidade. Plano de Manejo Participativo da Reserva Extrativista Auatí-Paraná. Tefé: ICMBIO, 2011. 359 p.

Instituto de Pesquisas Tecnológicas. IPT. Informações sobre madeiras. 2020. Available in: <https://www.ipt.br/consultas_online/informacoes_sobre_madeira/busca>. Accessed on: 24 jan. 2020.

Loconte CO. A sustentabilidade volumétrica do manejo florestal madeireiro. 2018. 140 f. Dissertação (Mestrado) - Curso de Mestrado em Recursos Florestais, Escola Superior de Agricultura Luiz de Queiroz, Universidade de São Paulo, Piracicaba, 2018.

Loureiro AA. Estudo anatômico macro e microscópico de 10 espécies do Gênero Aniba (Lauraceae) da Amazônia. Acta Amazônica, Manaus, v. 6, n. 2, supl. 1, p. 5-85, junho 1976. Available in: < https://doi.org/10.1590/1809-43921976062s005>. Accessed on: 23 oct. 2020.

Loureiro AA, Freitas JA, Ramos KBL, Freitas CAA. Essências Madeireiras da Amazônia. Manaus: MCT/INPA/CPPF, 2000. 191 p.

Loureiro AA, Lisboa PLB. Madeiras do Município de Aripuanã e suas utilidades (Mato Grosso). Acta Amazônica, Manaus, v. 9, n. 1, p. 5-88, mar. 1979. Trimestral. FapUNIFESP (SciELO). DOI: http://dx.doi.org/10.1590/1809-43921979091s005.

Loureiro AA, Silva MF. Catálogo de Madeiras da Amazônia. Belém: Sudam, 1968-1968. 2 v.

Mainieri C, Chimelo JP. Fichas de Características das Madeiras Brasileiras. 2. ed. São Paulo: Instituto de Pesquisas Tecnológicas, 1989.

Melo JE; Camargos JAA. A madeira e seus usos. 1. ed. Brasília: SFB/LPF/MMA, 2016. p. 228.

Nascimento CC, Rocha JA, Higuchi MIG, Lima AJN, Paula EVCM, Batista JF, et al. O uso de madeiras de arvores caídas em comunidades extrativistas: estratégia econômica e de sustentabilidade ambiental. Cartilha. Edição do autor, Manaus, 2011. 48p.

Pereira AF. Madeiras brasileiras: guia de Combinação e Substituição. São Paulo: Blucher, 2013. 136 p.

Record SJ, Hess RW. Timbers of the new world. 4. ed. New Haven: Yale University, 1949. 640 p.

Rocha JA. Madeira caída como oportunidade para o manejo florestal comunitário em unidades de conservação no Amazonas. 2010. 79 f. Dis-sertação (Mestrado) - Curso de Ciências de Florestas Tropicais, Instituto Nacional de Pesquisas da Amazônia, Manaus, 2010.

SERVIÇO FLORESTAL BRASILEIRO. Database of Brazilian Woods. 2020. Available in: <http://sistemas.florestal.gov.br/madeirasdobrasil/>. Accessed on: 25 jan. 2020.

Silva GM. Proposta para utilização de madeiras de árvores caídas naturalmente na confecção de artefatos com identidade regional: RESEX AUATIPARANA/Fonte Boa. Manaus: FAPEAM, 2018. INCT Madeiras da Amazônia.

Silva MS. Estudo da qualidade de madeiras de árvores caídas em área de manejo florestal para o desenvolvimento de produtos. 2013. 100 f. Dissertação (Mestrado) - Curso de Programa de Pós-graduação Scricto Sensu em Ciências Florestais e Ambientais – PPGCIFA, Faculdade de Ciências Agrárias, Universidade Federal do Amazonas, Manaus, 2013.

Siqueira GDCL. et al. (Coord.). Madeiras do Acre: Caracterização físico-mecânica (Espécies comercializadas e/ou com possibilidades comerciais). 1. ed. Rio Branco: Fundação de Tecnologia do Acre, 1991.

Souza MH, Magliano MM, Camargos JAA, Souza MR, 2002. Madeiras tropicais brasileiras, segunda ed. Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis, edições IBAMA, Brasília, DF, Brasil, 152 pp.

THE PLANT LIST. The Plant List: a working list of all plant species. 2013. Collaboration between the Royal Botanic Gardens, Kew and Missouri Botanical Garden. Available in: <http://www.theplantlist.org>. Accessed in: 27 out. 2020.