Evaluation of the quality of wood from naturally fallen trees in the central Amazon

Mirella Sousa Vieira1, Claudete Catanhede do Nascimento[2], Niro Higuchi[2], Karla Mazarello Maciel Pacheco[3]

1 Master's Postgraduate Program in Forestry and Environmental Sciences - PPGCIFA, Federal University of Amazonas-UFAM, Manaus/AM, Brazil (mirella.sou@gmail.com)

2Researcher at the National Institute of Amazonian Research / INPA, Manaus / AM, Brazil, 3 Federal University of Amazonas-UFAM

Abstract

The objective of this study was to assess the quality and potential of wood from naturally fallen trees in the forest for product development and to provide subsidies for the use of raw material. The inventory of fallen trees was carried out along the road from the Experimental Station of Tropical Silviculture of the National Institute for Research in the Amazon (EEST / INPA) - Nucleus ZF-2, at km 23 of the ZF-2 road that starts to the left of km 50 of Highway BR-174 (Manaus-Boa Vista). Only trees that had fall characteristics due to natural factors, that is, that had exposed roots, were considered for the inventory. It was also stipulated as a requirement for measurement the diameter class of trees of 25 cm ≤ DBH ≤ 45 cm. From each naturally fallen tree, the diameters (largest and smallest) and their length were measured. 5cm thick discs were removed from the trees to obtain samples for scientific identification of the wood and determination of physical properties. Based on the inventory, it was identified that many of the trees naturally fallen in the forest are in good conditions of use, considering their woody material and their volume. The Alexa grandiflora species presented the highest volume with 2,788 m³ for a single tree, followed by the species Ormósia sp. with 2,287 m³ and Protium tenuifolium Engl with a volume of 1,269 m³. Regarding the health of the inventoried trees, all from the species Byrsonima crispaJuss. had no sign of degradation, followed by the species Croton lanjouwensis and Ingá sp. The most frequent class was medium density with 9 species with a variation of 0.47g/cm3 to 0.62g /cm3. Eperua schomburgkiana Benth was the most dense with 0.78g /cm³.The levels of degradation found and the intrinsic characteristics of the species did not compromise the possibilities of using this wooden product, and can represent an excellent opportunity for economic return, contributing to minimize the pressures exerted around the living forest.

Keywords: forest management, fallen tree wood, wood technology, product design.

1 INTRODUCTION

The woods of naturally fallen trees have been studied for some time, under the context of community forest management, and in Conservation Units in the Amazon. The importance of these studies encompasses both the identification of the volume available in the forest and the development of socioeconomic alternatives for community members of Resexs. In some countries like Costa Rica, this wood is measured and estimated in forest inventories, however its evaluation in economic terms is too limited (ALONSO-MARTINEZ & BEDOYA, 1997; NASCIMENTO et al, 2010).

In Brazil, Bahia was the first Brazilian state to receive a normative act, aimed at the use of forest waste of this nature, for production purposes. And even though it is considered as one of the states that most contributed to the devastation of the Atlantic Forest according to INPI data, it obtained positive results, managing to overcome this situation. Currently, it destines this raw material mainly for the furniture sector, characterizing its products as coming from low impact processes.

Experiences like these demonstrate the excellent opportunity to work with these woods, in view of the scarcity of timber resources in various regions of the world. In addition, it is observed that the forests while managed can offer much more than the living raw material, being possible to find a large volume of wood also in the fallen wood available in the soil (HIGUCHI, 2006). In the Amazon, for example, about twenty-four trees with a diameter greater than 20 cm die per second, in one minute this number corresponds to 1,440 trees, which represents a considerable amount of wood without any use, until then (NASCIMENTO et al ., 2010).

All decaying dead matter is responsible for the emission of gases known to be responsible for the greenhouse effect, such as: carbon dioxide (CO^2), methane gas (CH4) and nitrous oxide (N2O). This phenomenon also occurs as a result of the decomposition of these trees, added to activities such as burning, burning fossil fuels and misuse of the land. However, when this organic matter is used, which significantly contributes to the amount of carbon emitted by the forest into the atmosphere, has its carbon fixed in the wood, preventing its release into the atmosphere (ROCHA, 2010).

In addition, the use of fallen wood is excellent for capturing timber resources fairly, through the use made available naturally by the forest. Making it necessary to study how much can be used and at the same time leave this raw material in the forest for the formation of nutrients in the soil.

Studies carried out in the region have already attested to the existence of a significant volume of wood available for exploration in the soil, even allowing the identification of species in the field. This is relevant, considering the commercial value of many of these, often used in local joinery. Making the investigation into its potential for indisputable use, given the existing volume of raw material found. And although many works have been experimenting with the use of fallen wood in community management practices. It is also necessary to validate products with higher added value and greater competitiveness in the wood products market.

Likewise, it is said that projects of this type have been used in other states of Brazil, however without a regulation that causes a greater impact and change in the practices of using this raw material. Only in Bahia these woods are used for the manufacture of objects of value, while in other states, such as Paraná, a state regulation, restricts the use of fallen wood for energy purposes. Thus, in view of the scarcity of this resource, mainly of some species, the use of fallen wood in the sector is urgent and must be evaluated as a way to be explored.

This investigation was supported by the existing opportunities surrounding the use of fallen wood. And in the utilization experience carried out in other states of Brazil, as well as in the results obtained in research on the volume of fallen wood available in some regions of the Amazon. In order for these studies to provide the technical and scientific knowledge necessary to contribute to the research. However, it is necessary to emphasize that it did not aim at making a specific product, but at investigating the use of wood more widely. Aiming to obtain information and data on its quality, generating records, which favor the use of this raw material for the development of any future products.

Wood technology was also one of the main factors considered in this investigation, since some of the characteristics of wood correspond to its quality and behavior, especially when destined for making products. Among the many reasons that justify the accomplishment of this work, the incentive to form a legislation for the practices of exploration and commercial use, is one of the main ones, without disregarding the importance of the management practices in this process. Thus, it is intended to contribute to the generation of public policies that collaborate for the development of the State's timber sector in a fair manner with the forest.

2. MATERIAL AND METHODS

The inventory of fallen trees was carried out along the road from the Experimental Station of Tropical Silviculture of the National Institute for Research in the Amazon (EEST / INPA) - Nucleus ZF-2 -, at km 23 of the ZF-2 road that starts on the left of km 50 of Highway BR-174 (Manaus-Boa Vista).

The choice of this perimeter was the large number of fallen trees naturally close to the road, as well as the easier access to individuals. Only trees that had fall characteristics due to natural factors were considered for the inventory, that is, those with exposed roots, figures 1A and B. It was also stipulated as a requirement for measurement the diameter class of trees of 25 cm ≤ DBH ≤ 45 cm. Twenty-four trees in total were measured, in view of the difficulties encountered in measuring some. For although the trees were located close to the road, many of them presented unfavorable conditions to the measurements due to the way they fell.

Figure 1 - Tree fallen naturally in the forest

From each naturally fallen tree, the diameters (largest and smallest) and their length were measured. These values obtained in the measurement were used to estimate the volume of the woody material of each individual, using the Smalian equation.

$VL\ (m^3) = (g_1 + g_2) * L/2$ (1)

g_1 = ¶. D 1 ²/ 4

g_2 = ¶. D 2 ²/ 4

The use of this equation was also applied to determine the hollow (void) volume found in some trees. Thus, the real volume of the woody material was estimated through the difference in the total log volume and the hollow volume, expressed by the following equation:

$VR = V1 - V2 (m^3)$

Where:

VR (m^3) = Actual log volume

V1 (m3) = Total log volume

V2 (m3) = Total hollow volume

5cm thick discs were removed from each tree to obtain samples for scientific identification of the wood and determination of physical properties.

Determination of physical properties

Through the collected discs, 2x2x3cm specimens were prepared, properly oriented, to determine the physical properties of the wood, such as basic density and dimensional stability.

The basic density was determined as a function of the green volume, and the samples were subjected to saturation in water (immersion method by displacement of liquid). Subsequently, oven dried at a temperature of ± 103°C, to obtain the dry weight according to ABNT NBR 11,941 (2003).

The retractability of the wood was obtained from measurements on the specimens in the longitudinal, transversal and radial sections, with the aid of a digital caliper, in the saturated and kiln-dried condition. In addition to the contractions of the wood, the anisotropy coefficient was determined in each specimen in the heartwood and sapwood.

In this research, descriptive and experimental statistics were used for data analysis. While the variables studied were: volume of woody material (diameter, length of logs), physical properties (density and dimensional stability).

3. RESULTS AND DISCUSSION

In Table 1, the commercial heights and the diameter of the inventoried trees are identified, noting that the species *Byrsonima* crispa was the most frequent with three trees, followed by *Cecropia sciadophylla* with two trees.

Table 1. Species of fallen wood inventoried

Tree	Species	Family	H (m)	DBH (cm)
1	*Alexa grandiflora* Ducke	Fabaceae	18.9	82
2	*Holopyxidium latifolium*	Lecythidaceae	13.5	49
3	*Ormosia* sp	Fabaceae	-	-
4	*Byrsonima crispa*Juss	Malpighiaceae	17.17	27
5	*Byrsonima crispa*Juss.	Malpighiaceae	10.9	23
6	*Croton lanjouwensis*	Malpighiaceae	9.9	26
7	*Byrsonima crispa*Juss.	Malpighiaceae	12.2	40
8	*Miconia cf. poeppigii*	Melastomataceae	12.3	45
9	*Ocotea cf. caudata* (Neea.) Mez.	lauraceae	9.59	41
10	*Cecropia sciadophylla* Mart	Cecropiaceae	13.2	32
11	*Cecropias ciadophylla* Mart	Cecropiaceae	14	29
12	*Eperua schomburgkiana*Benth.	Caesalpiniaceae	11.95	43
13	*Protium tenuifolium*Engl.	Burseraceae	15	45
14	*Caryocar villosum* (Aubl) Pers	Caryocaraceae	8.6	28
15	*Inga* sp.	Mimosaceae	6.6	20

The heights of the trees identified ranged from 6.6 to 18.9 m, with diameters from 26 to 82 cm. However, of the 24 inventoried trees it was possible to measure the volume of only 14, given the difficulty of access for cubing. Table 2 shows the volume of the commercial shaft, hollow volume and the actual volume of each tree.

Table 2. Volumetry of inventoried trees

Tree	Species	V[1]	V.M.D[2]	V.R.[3]
1	*Alexa grandiflora* Ducke	5.985	3.1978	2,788
2	*Ormosia* sp	2.546	0.2592	2,287
3	*Byrsonima crispa*Juss	0.973	-	0.973
4	*Byrsonima crispa*Juss	0.378	-	0.378
5	*Croton lanjouwensis*	0.506	-	0.506
6	*Byrsonima crispa*Juss	1.242	-	1.242
7	*Miconia cf. poeppigii*	1.150	0.4649	0.685
8	*Ocotea cf. caudata* (Neea.)	1.088	0.126	0.961
9	Mez	0.842	0.359	0.483
10	*Cecropia sciadophylla* Mart.	0.743	0.2352	0.508
11	*Cecropia sciadophylla* Mart	1.502	0.34416	1.158
12	*Eperua schomburgkiana*Benth.	1.701	0.432	1.269
13	*Protium tenuifolium*Engl	0.373	0.0086	0.1987
14	*Caryocar villosum* (Aubl) Pers	0.187	-	0.187
	Inga sp.	**19,251**	**8,527**	**10,689**
	TOTAL			

1) Cubage Volume. (2) VMD = Volume of Degraded Material. (3) VR = Real Volume.

The *Alexa grandiflora* species showed a larger volume of 2,788 m³ for a single tree, followed by the species *Ormósia* sp. with 2,287 m³ and *Protium tenuifolium* Engl with a volume of 1,269 m³. Regarding the health of the inventoried trees, it was observed that all trees of the species ByrsonimacrispaJuss. had no sign of degradation, followed by the species *Croton lanjouwensis* and *Ingá sp*. Studies carried out by Medeiros (2019) to verify the feasibility of using hollow logs wood with a sign of significant degradation of around 40% achieved a satisfactory result when using this raw material in the manufacture of real estate products with fine finishing and high added value, believing It is observed that a similar result can be verified with the wood of trees naturally fallen in the forest.

-Quality of wood of species

As for the density of the species, 13 wood species from fallen trees, had density ranging from 0.35 to 0.89 g / cm³. The greatest variation occurred with the species *Croton lanjouwensis* Jablonski., followed by the species *Byrsonima crispa* Juss in two trees.

Table 3 shows the basic density of the 13 species of wood from fallen trees, with a variation from 0.35 to 0.89 g / cm³.

Table 3. Basic density of the 13 species of fallen tree wood.

Tree	Species	Average	Values		CV (%)
			Min.	Max.	
1	*Ocotea* cf. *caudata* (Neea.) Mez.	0.35	0.31	0.39	8.57
2	*Crotonlanjouwensis*Jablonski.	0.38	0.33	0.43	10.53
3	*Crotonlanjouwensis*Jablonski.	0.42	0.31	0.48	19.05
4	*Cecropiasciadophylla* Mart.	0.47	0.41	0.54	8.51
5	*Holopyxidiumlatifolium* (AC Sm.). R. Knuth.	0.54	0.52	0.56	1.85
6	*Alexagrandiflora*Ducke.	0.54	0.52	0.57	3.70
7	*Byrsonima crispa*Juss.	0.56	0.47	0.63	12.50
8	*Inga* sp.	0.58	0.53	0.63	8.56
9	*Byrsonima crispa*Juss.	0.60	0.48	0.64	11.67
10	*Byrsonima crispa*Juss.	0.62	0.59	0.66	5.56
11	*Miconia* cf. *poeppigii*Triana.	0.67	0.62	0.71	4.48
12	*Ormosia* sp.	0.71	0.64	0.77	7.04
13	*Eperuaschomburgkiana*Benth.	0.89	0.88	0.92	2.25

In the analysis of variance, the F test was significant at a probability level of 1% ($p < .01$) for basic density among the mentioned species. Table 4 shows the comparison test of means of species with the formation of six distinct groups.

Table 4. Test for comparing the average for the basic density values.

Species	D_b (g/cm³)	Groups					
Alexa grandiflora Ducke	0.54	-	-	c	d	-	-
Holopyxidium latifolium (AC Sm.). R. Knuth.	0.54	-	-	-	d	e	-

Ormosia sp.	0.71	-	B	-	-	-	-
*Byrsonima crispa*Juss.	0.62	-	B	c	d	-	-
*Byrsonima crispa*Juss.	0.56	-	-	-	d	e	-
*Crotonlanjouwensis*Jablonski.	0.38	-	-	-	-	-	f
*Byrsonima crispa*Juss.	0.60	-	B	c	d	-	-
Miconia cf. *poeppigii*Triana.	0.67	-	B	-	-	-	-
Ocotea cf. *caudata* (Neea.) Mez.	0.35	-	-	-	-	-	f
Cecropiasciadophylla Mart.	0.47	-	-	-	-	e	-
*Croton lanjouwensis*Jablonski.	0.42		-	-	-	e	f
*Eperuaschomburgkiana*Benth.	0.89	a	-	-	-	-	-
Inga sp.	0.58	-	B	c	d	-	-

Note: Equal letters mean that there is no significant difference between species.

Based on the classification proposed by the ABNT standard, only three groups were considered for the species. The first class is for low density wood, the second medium density and the third high. The most frequent class was medium density with 9 species. While the so-called low density species, they were only *Ocotea* cf. *caudata* (Neea.) Mez. (0.35g / cm³) and *Croton lanjouwensis* Jablonski (0.38g / cm³) and the *Eenthua schomburgkiana* Benth species with 0.89 g / m³.

Basic dimensional stability of wood species from fallen trees

Table 5 contains the minimum, maximum and average data contractions in the tangential and radial directions, which were considered for the determination of the anisotropy coefficient.

Table 5. Dimensional Stability

Species	Contraction								C.A.
	Tangential				Radial				
	Md	Min	Max	CV (%)	Md	Min	Max	CV (%)	
*Alexagrandiflora*Ducke.	6.82	6.45	7.53	8.94	2.72	2.17	3.10	17.65	2.5
Holopyxidiumlatifolium (AC Sm.). R. Knuth	5.74	4.65	6.47	12.89	3.86	3.31	4.32	11.66	1.5
Ormosia sp.	7.55	6.47	8.76	11.79	3.70	3.42	3.86	4.59	2.0

*Byrsonima crispa*Juss	11.75	11.28	12.50	5.57	7.13	6.91	7.35	3.14	1.6
*Byrsonima crispa*Juss	8.00	6.12	9.95	21.38	5.84	5.54	6.44	7.02	1.3
*Crotonlanjouwensis*Jablonski.	5.72	5.40	6.32	7.34	3.23	2.82	3.99	17.03	1.8
*Byrsonima crispa*Juss	8.43	6.50	9.66	14.23	4.81	4.00	5.71	15.38	1.7
Miconia cf. *poeppigii*Triana.	6.15	5.04	8.27	24.21	4.54	4.30	5.03	7.29	1.3
Ocotea cf. *caudata* (Neea.) Mez.	5.64	4.99	7.02	14.72	3.13	2.61	3.80	14.70	1.8
Cecropiasciadophylla Mart.	7.24	6.19	8.16	9.39	4.32	3.04	5.68	19,21	1.7
*Crotonlanjouwensis*Jablonski.	10.09	7.99	11.53	14,87	4.86	3.74	6.15	20.78	2.1
*Eperuaschomburgkiana*Benth.	9.75	8.95	10.55	6.67	4.95	4.58	5.38	7.68	1.9
Inga sp.	7.41	6.24	8.26	14.25	4.38	3.86	5.06	13.98	1.7

Analysis of variance was also performed for data obtained from dimensional stability. In which, the F test showed a significant difference at a confidence level of 1% probability ($p < .01$), and when the Tukey test was applied, five different groups were observed (Table 6).

Table 6. Tukey test for dimensional stability.

Species	**C.A.**	**Groups**				
*Alexagrandiflora*Ducke.	2.5	a	-	-	-	-
Holopyxidiumlatifolium (AC Sm.). R. Knuth.	1.5	-	b	c	d	-
Ormosia sp.	2.0	a	b	c	-	-
*Byrsonima crispa*Juss.	1.6	a	b	c	-	-
*Byrsonima crispa*Juss.	1.3	-	-	c	d	e
*Crotonlanjouwensis*Jablonski.	1.8	a	b	c	d	-
*Byrsonima crispa*Juss.	1.7	a	b	c	-	-
Miconia cf. *poeppigii*Triana.	1.3	-	-	-	d	e
Ocotea cf. *caudata* (Neea.) Mez.	1.8	a	b	c	-	-
Cecropiasciadophylla Mart.	1.7	a	-	-	-	e
*Crotonlanjouwensis*Jablonski.	2.1	a	b	-	-	-
*Eperuaschomburgkiana*Benth.	1.9	a	b	c	-	-

Inga sp.	1.7	-	-	c	d	e

Note: Equal letters mean that there is no significant difference between species.

The highest anisotropy coefficient ranged from 1.3 for *Byrsonina and* Miconiae2.5 for *Alexa grandiflora*, followed *by* Ormosia and croton.

These data corroborate the indication that it is possible to find a great variability of densities among the species of fallen wood available in the forest. It also reinforces the countless possibilities for using these woods, especially for product development.

Some studies show that trees with a lower diameter class decompose faster than large trees (Chambers, et al, 2000). A different result was found in this research with the *Alexa grandiflora* tree with 82cm of DBH showed a 50% degradation level.

This research also made it possible to obtain the values related to the dimensional stability of the species. According to Galvão and Jankowsky (1985), this knowledge has practical implications that make it of great importance, especially to the use of wood. And that it can collaborate for the use of species with less stability, when its characteristics are studied. This is because, stability as a physical property, is also a parameter for drying and depicts the behavior of wood with respect to its use, machining, workability.

The biggest difference between the relation of the averages obtained in the tangential and radial directions were for the species *Croton* lanjouwensis Jablonski , *Eperua* schomburgkiana Benth., *Alexagrandiflora* Ducke and *Ormosia* sp. When these absolute dimensional variations are shown to be high, it means that there may be a greater movement of wood (GALVÃO and JANKOWSKY, 1985).

Based on the range of variation of anisotropy proposed by Galvão and Jankowsky (1985), nine species in this research are classified as normal, for having anisiotropy> 1.5 <2, two stable (> 1.5) and an unstable greater than> 2.6.>> The most stable ones considered to be of excellent quality were *Byrsonima crispa*Juss. E *Miconia* cf. *poeppigii* Triana. And as unstable, differentiating itself from the other classes, the *Alexa grandiflora* Ducke species, with an absolute value of 2.9.

It is noteworthy that the class with the highest frequency observed in this research, has wide use in the timber market according to the diagnosis made by (Sousa in 2015), and currently can be identified in product development, previously developed only with high density wood.

It should also be noted that good parts of the studied species have commercial value and cost on average in the market, around R$ 800.00 per cubic meter. Which represents an economic gain, once they are managed, by the way they can be obtained without exploring the forest. Thus, the management of fallen tree wood for commercial purposes also offers a wide field for its use due to its quality. Combined with the numerous alternatives for adding value through technological insertion, transforming them into solid wood panels, floors, and even high standard furniture, which expands its potential for use and minimizes questions about its quality. The results achieved can be considered as indicators for environmental agencies to release the use of fallen tree wood on a small scale by community members, avoiding unnecessary forest exploitation.

CONCLUSION

Based on the inventory carried out, it was identified that many of the trees naturally fallen in the forest are in good conditions of use, considering their woody material and their volume.

The physical properties analyzed indicate that the wood of the quantified trees has quality for making products.

About 70% of the identified fallen tree species are traded by the timber sector in the municipality of Itacoatiara.

The levels of degradation found and the intrinsic characteristics of the selected species did not compromise the possibilities of using this wood in the manufacture of products, being able to be used in products of high commercial value.

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