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Availability and Potential Use of Non-Wood Forest Products (Nwfps) in a Traditional Community of the Amazon

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Abstract

Background: Tropical forests maintain much of the planet's biodiversity and one of the main strategies to conserve them is the sustainable exploitation of non-wood forest products (NWFPs). In the Amazon, non-wood forest products are a vital resource for the survival of a large portion of the residents who are living near the forests. In addition, to subsistence and income potential, these products provide food security. However, the use of NWFPs as a source of income for the inhabitants of forest regions are presenting some difficulties. **Objective:** This work aimed to evaluate the potential species for non - wood forest products in a community located in the Amazon. **Results**: We evaluated two studied areas in the community of Ponta de Pedras, Santarém, Pará. The results show a total of 2,425 arboreal individuals and 296 palm trees. Analyzing the number of arboreal individuals, 84 species were included in area I and 61 in area II, including potential and non-potential species for NWFPs exploitation. We identified 4 arboreal species indicated for NWFPs that are used by the community and 3 palm trees indicated for NWFP that are not used. The interviewees mentioned 32 species belonging to 21 botanical families used in the community, being Fabaceaethe most representative family with 6 species. The use of the NWFPs in Ponta de Pedras are mainly destined to self-consumption, with a small proportion destined to commercialization with other localities. **Conclusion:** The species *Anacardium occidentale* L., *Bertholletia excelsa* Bonpl and *Carapa guianensis* Aubl were the species that presented the greatest potential for NWFP, although they were not present in the study area according to the Forest Inventory. The sample inventory, together with the semi-structured questionnaire, found that there is a lack of raw material potential for NTFP trade in the community of Ponta de Pedras.

Key words: Multilevel inventory, Coefficient of the importance of species, Natural regeneration, Rainforest.

INTRODUCTION

Tropical forests maintain much of the planet's biodiversity and one of the main strategies for conserving them is the sustainable exploitation of non-wood forest products (NWFPs) (Tonini, 2013). It is an ancestral practice that can be economically viable when performed in a sustainable way. Although with less economic expression, currently the NWFPs with their potential, they can make a significant contribution to the conservation of Amazon rainforest as well as they can enrich the life of the native population (Carvalho, 2010).

In the Amazon, non-wood forest products are a vital resource for the survival of a large portion of the residents who are living near the forests. In addition, to subsistence and income potential, these products provide food security. However, the use of NWFPs as a source of income for the inhabitants of forest regions are presenting some difficulties, such as the lack of works and researchers on the economy and potential value of these products; the distribution of forest resources; the inconsistent production; the unstable quantity; the lack of management information, the reduced price/value, and the instability of their markets. Therefore, the determination of some limitations, the economic opportunities and the sustainable management of NWFPs has been emphasized in the last years (Silva *et al*., 2011).

The amazon region uses wood forest products. For many years, people believe they are the only way to get income from forest. However, many communities and companies that uses products from forests are interest in NWFPs because they have economic potential and higher diversity that apply to sell they in many markets. So, the knowledge of these products, their valuation and processing are important to develop NWFP market (Homma, 2012)

The managed extraction allows to preserve and to value the standing forest, as well as it develops the various social actors involved in this process generatinga low environmental impact (Paes-de-Souza *et al*., 2011). In order to perform a sustainable management of the species or to plan/implement policies for their promotion, some information about the ecology, commercialization, forest condition in terms of quantity produced and consumed are required (Silva *et al*., 2011).The use of forest products should be planned from a forest inventory, estimating parameters such as frequency, density, and species dominance, as well as their ecological, economic and social values (Souza and Soares, 2006).These estimates allow the characterization of forest quality and productivity. However, for

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the benefit of a non-destructive management, it is necessary the consistency of scientifically proven methodologies for this purpose, avoiding the empirical and harmful collection of these forest products.

Despite the great potential of the Amazon Forest for the management of NWFPs, there is a lack of information to perform sustainable works. Nowadays, have a growing interest of science and government about NWFPs. Nevertheless, the low socioeconomic indices and the difficulties resulting from the lack of urban infrastructure are some aggravating factors for the region, and these deficiencies are creating negatively influences on the process of improvement of the productive chain of forest resources. As a result, the cost of production is higher, making it difficult to aggregate value and to trade these products, causing a reduction in economic profitability (Celentano and Veríssimo, 2007).

Thus, this work aimed to evaluate the potential species for non-wood forest products in a community located in the Amazon.

METHODS AND MATERIALS

The study was conducted in the Ponta de Pedras community, situated at 2° 24'52"S and 54° 42'36"W. It is located in the municipality of Santarém, State of Pará, Brazil, in the Lower Amazon mesoregion, on the right bank of the Tapajós River in its confluence with the Amazon River.

The climate of the region is the humid tropical type classified as Ami in the Köppen system. The mean annual temperature ranges between 25°C and 28°C, the mean air humidity is 86% and the mean annual rainfall is 1,920 mm, with the highest values observed in the months of January to May. The predominant type of soil is the Dystrophic Yellow Latosol (IBGE, 2010).

The Ponta de Pedras community is 36 km far from the municipality of Santarém, and its population is about 300 people. The majority of the inhabitant's income is obtained from NWFPs exploitation. Although local residents have knowledge about the species, technical difficulties cause limitations in the use of these products (Gonçalves *et al*., 2012).

Information obtained from the forest inventory has the advantage of increasing the knowledge about the species and the planning of the exploration (Soares *et al*., 2011). The inventory for the characterization of potential NWFP was conducted in two areas of native forest. The dimensions of areas I and II were approximately 13.6 and 21.0 hectares with 14 and 18 allocated plots, respectively.

For both areas, systematic sampling was performed at two levels. In the 20x50 m plots, the individuals with diameter at the breast height at 1,30 meters of soil (DBH) ≥ 8.0 cm were measured. In the 20x25 m subplots, individuals with 3.2 ≤ DBH<8.0 cm were measured. The palm trees present in the areas were counted and the total height was estimated in the presence of stipe. The lianas were identified in the inventoried trees, counting the number of green and mature. For the identification of green and mature vines, the following definitions were used: wire (the same as root), green wire (the one not yet fixed to the ground, easily foldable and tender) and mature wire (when forest floor, it is woody and roars when pressed or forced to fold) (Ruiz and Bobot, 2008; Amapá, 2009).

For data analysis, individuals with DBH ≤ 8 cm were considered as natural regeneration, and those with DBH> 8 cm as the adult stratum. The horizontal structure of the forest was calculated according to Souza and Soares (2013). The individuals were distributed in classes of diameter with an amplitude of 10 cm. The It performed a Pearson correlation analysis between the number of vines and the center of diameter class to verify the relation between them.

In order to know the current way of using the species with potential for NWFPs and to draw the profile of the residents of this community, we applied 19 semi-structured questionnaires. From the answers obtained with the questionnaire, we calculated the Species Importance Coefficient (SIC) (Equation 1) proposed by Bentes-Gama *et al*. (1999):

$$SIC = \frac{3.LU+2.BI+DC}{6} \quad (1)$$

where: LU = level of use; BI = biophysical importance; DC = demand for commercialization.

According to Bentes-Gama *et al*. (1999), LU expresses the importance of the species as regards its functionality for the family and it can be classified as widely used (species with three or more uses), used (species with two uses) and little used (species with a single use). BI represents the occurrence of species categorized according to the high frequency (70 to 100%), medium (31 to 69%) and low (≤ 30%). DC is related to the commercialization potential of the species, where the demand ranges between high, medium, low or nonexistent.

The data processing and the tests applied in the analysis were performed in the R Core Team (2017) version 3.4.3, with the RStudio platform.

Results:

Species analyses

The results show a total of 2,425 arboreal individuals and 296 palm trees. Analyzing the number of arboreal individuals, 84 species were included in area I and 61 in area II, including potential and non-potential species for NWFPs exploitation (Table 1).

In area I, in the natural regeneration stratum, the tree species with potential for NWFP were *Hymenaea parvifolia* with absolute density (*AD*) of 10.0 and *Hevea brasiliensis* with *AD* of 1.43. In the adult stratum, the species were *Andira surinamensis*, *Byrsonima crassifolia* and *H. parvifolia* with *AD* of 1.43, 1.43 and 5.71, respectively (Table 1). The *H. parvifolia* species was the only one found in the adult stratum as well as in the natural regeneration stratum. The three species of palm trees found in area I with potential use for NWFP are not used in the community, they are: an unidentified palm – locally knownas "paeiro" (*AD* = 82.86), *Syagrus coccoides* Mart.(*AD* = 80.71) and *Astrocaryum aculeatum* Meyer (*AD* = 1.43).

In the natural regeneration stratum of the area II, two species with a potential of use already registered in the community were found (Table 1). They are: *H. parvifolia* and *H. brasiliensis* with *AD* of 36.67 and 5.56, respectively. In the adult stratum, the registered species were *A. surinamensis* (*AD* = 1.11), *H. parvifolia* (*AD* = 21.67) and *B. crassifolia* (*AD* = 13.89). The *S. coccoides* palm is present in the area II with 40 individuals per ha, while it has potential for NWFP use, this species is not used in the community.

Table 1: Horizontal structure of species with potential for non-wood forest products in the Ponta de Pedras community, Santarém - PA, Brazil.

Area I								
Species	AD	RD	AF	RF	ADo	RDo	CVI	IVI
Natural Regeneration								
Hymenaea parvifolia	10,00	1,64	21,43	1,58	0,0242	1,77	1,71	1,66
Hevea brasiliensis	1,43	0,23	7,14	0,53	0,0016	0,12	0,18	0,29
Others	600,00	98,13	1.328,57	97,89	1,3361	98,11	98,11	98,05
Total	611,43	100,00	1.357,14	100,00	1,3619	100,00	100,00	100,00
Adult stratum								
Andira surinamensis	1,43	0,30	14,29	0,67	0,0552	0,32	0,31	0,43
Byrsonima crassifólia	1,43	0,29	14,29	0,66	0,0432	0,25	0,27	0,40
Hymenaea parvifolia	5,71	1,18	57,14	2,66	0,5086	2,99	2,08	2,27
Others	476,43	98,23	2.064,29	96,01	16,4104	96,44	97,34	96,90
Total	485,00	100,00	2.150,01	100,00	17,0174	100,00	100,00	100,00
Palms*								
NI	82,86	50,22	100,00	48,28	-	-	-	-
Syagrus coccoides	80,71	48,92	92,86	44,83	-	-	-	-
Astrocaryum aculeatum	1,43	0,87	14,29	6,90	-	-	-	-

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	Area II							
Natural Regeneration								
Hymenaea parvifolia	36,67	6,00	83,33	6,85	0,0907	6,09	6,05	6,32
Hevea brasiliensis	5,56	0,91	22,22	1,83	0,0112	0,75	0,83	1,16
Others	567,78	93,09	1.111,12	91,32	1,3871	93,16	93,12	92,52
Total	610,01	100,00	1.216,67	100,00	1,4890	100,00	100,00	100,00
Adult stratum								
Andira surinamensis	1,11	0,26	5,56	0,37	0,0555	0,36	0,31	0,33
Byrsonima crassifólia	13,89	3,25	27,78	1,85	0,3810	2,48	2,87	2,52
Hymenaea parvifolia	21,67	5,07	88,89	5,90	1,1285	7,36	6,21	6,11
Others	390,56	91,42	1.383,33	91,88	13,7795	89,80	90,61	91,04
Total	427,23	100,00	1.505,56	100,00	15,3445	100,00	100,00	100,00
Palms*								
Syagrus coccoides	40,00	67,69	72,73	50,00	-	-	-	-
Others	19,10	32,31	72,73	50,00				
Total	59,10	100,00	145,46	100,00				

* For palms trees the ADo, RDo, CVI and IVI were not calculated.
Where: AD = absolute density per hectare; RD = relative density in %; RF = relative frequence in %; ADo = absolute dominance in $m^2.ha^{-1}$; RDo = relative dominance in %; CVI= coverage value index in %; IVI = importance value index in %; NI = unidentified species.

The mean height for the *S. coccoides* and *A. aculeatum* palms in the area I was 3.94 and 4.00 m, respectively. In area II the mean height was 1.60 m for the individuals of *S. coccoides*.

In both areas, the study observed only 1 species of*vine*. It was the *Philodendron megalophyllum* Schott, popularly known as "cipó tracuá". In area I, this species was associated with other 23 species. It had a density of 153.57 threads per ha, being the mature vines equals to 58.57 per ha and the green ones to 95.00 per ha. In area II, *P. megalophyllum* was associated with 16 species, with a density of 180 threads per ha, being the mature vines equals to 103.88 per ha and the green vines to 76.11 per ha.

Correlation analysis

This study identified a significant negative correlation (r) at 95% probability between the presence of vines and their distribution by DAP class center of their host trees. The values of r calculated were -0.60 with p.value of 0.030 and -0.69 with p.value of 0.002, for area I and II, respectively. It shows that the larger the diameter of the trees, the less the presence of vines. Also, we can highlight that the result is more evident for area II in view of the higher r value that can be associated with the low tree density in the larger diameters (Table 2).

Table 2: Number of individuals per hectare, absolute dominance in $m^2.ha^{-1}$ and number of vines per hectare in each DAP class center in areas I and II in the community of Ponta de Pedras, Santarém-PA.

Center of DBH Class	Area I			Area II		
	$N.ha^{-1}$	ADo	$Nv.ha^{-1}$	$N.ha^{-1}$	ADo	$Nv.ha^{-1}$
5	705,71	1,9660	20,00	713,89	2,1528	87,78
15	252,86	3,8795	75,71	225,56	3,4059	34,44
25	85,00	4,0173	3,57	52,22	2,4662	30,00
35	24,29	2,3340	2,86	24,44	2,2412	27,78
45	19,29	2,9277	12,86	10,56	1,6733	-
55	5,00	1,0674	-	3,89	0,9331	-
65	2,14	0,7077	7,14	2,22	0,6756	-
75	1,43	0,6147	-	1,11	0,4885	-
85	-	-	-	2,78	1,6015	-
95	-	-	-	-	-	-
105	-	-	-	-	-	-
115	-	-	-	-	-	-
125	0,71	0,8646	-	-	-	-
135	-	-	-	-	-	-
145	-	-	-	-	-	-
155	-	-	-	-	-	-
165	-	-	-	0,56	1,1954	-

Where: $N.ha^{-1}$ = Number of trees per hectare; ADo = absolute dominance in $m^2.ha^{-1}$;$Nv.ha^{-1}$= Number of vines per hectare.

Importance of the species for NWFP – People questionnaire

The profile of the community residents obtained by the semi-structured questionnaire showed that 74% of the respondents were women and 26% were men. Most of them are born and resident in this community (53%) and the age is about 40 and 65 years old (63%). The main occupation of the interviewed residents consists of autonomous activity (47%), retirees (21%) and those who work on the property (21%). The remaining 11% do not engage in any paid activity.

The interviewees mentioned 32 species belonging to 21 botanical families (Table 3) that are used in the community. Of these, the most representative family was Fabaceae with 6 species. The others were represented by values equal to or less than three species. In general, the species most commonly cited as used in the community were *Anacardium occidentale*, *Theobroma grandiflorum* and *B. crassifolia*, mentioned by eight interviewees. Following is *A. surinamensis* cited by sixand *Euterpe oleracea* mentioned by four interviewees. About the uses of plant species in the community, 39.5% are for food, 39.5% for medicinal use and 21% for artisanal handicrafts.

According to the questionnaire, 53% of the interviewees did not obtain any income from the products used and 47% indicated that the trade of the products contributes to the family income. There are several difficulties in marketing NWFPs. The main challenges related were poor production (23%), lack of government support, quality production, poor road conditions (18% each) and low product valuation (23%).

The UL encompasses three forms of use: food, medicinal use, and artisanal handicrafts. This variable indicates the use of 9 species that are required for two purposes. The other 23 species are little used since they are intended for a single purpose. No species was classified as widely used by residents of the community, it means that has no species with three forms of use.

According to the SIC found (Table 3), *A. occidentale*, *Bertholletia excelsa* and *Carapa guianensis* were the most important species in terms of local frequency, demand for commercialization and level of use. They presented, respectively, the SIC equal to 2.00, 1.83 and 1.83. *A. occidentale* is mainly used for medicinal and food purposes and it has an average trade demand because this species is being used by most of the interviewees. *B. excelsa* is used for food and handicraft purposes, it has a high trade demand and high consumption in the community. Finally, *C. guianensis* is used for handicrafts and medicinal purposes and it is highly commercialized.

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Table 3: Plant resources usage in the Ponta de Pedras community, Santarém-PA, Brazil.

Família	Nome Científico	Nome Regional	H	UP	FU	SIC
Anacardiaceae	*Anacardium occidentale* L.	Caju	tree	ba/fr/se	me/fo	2,00
Lecythidaceae	*Bertholletia excelsa* Bonpl.	Castanha-do Pará	tree	se	fo/ar	1,83
Meliaceae	*Carapa guianensis* Aubl.	Andiroba	tree	ba/se/ex	me/ar	1,83
Fabaceae	*Andira surinamensis* (Bondt) Splitg. ex Pulle	Barbatimão	tree	ba	ar/me	1,67
Arecaceae	*Euterpe oleracea* Mart.	Açai	pal	fr/se	fo/ar	1,67
Anacardiaceae	*Mangifera indica* L.	Mangueira	tree	ba/fr	me/fo	1,67
Passifloraceae	*Passiflora* sp.	Maracujá	herb	fr	ar/fo	1,67
Fabaceae	*Dalbergia monetaria* L.	Verônica	tree	ba	ar/me	1,67
Malpighiaceae	*Byrsonima crassifólia* (L.) Rich	Muruci	tree	fr/se	fo	1,50
Verbenaceae	*Lippia alba* (Mill.) N.E.Br.	Cidreira	herb	lf	ar/me	1,50
Malvaceae	*Theobroma grandiflorum* (Willd. ex Spreng.) K. Schum.	Cupuaçu	tree	fr	fo	1,50
Araceae	*Heteropsis* spp.	Cipó-titica	vine	ci	ar	1,33
Musaceae	*Musa* spp.	Bananeira	herb	fr	fo	1,17
Bromeliaceae	*Ananas comosus* (L.) Merril	Abacaxi	herb	fr	fo	1,17
Oxalidaceae	*Averrhoa carambola* L.	Carambola	tree	fr	fo	1,17
Arecaceae	*Cocos nucifera* L.	Coqueiro	pal	fr	fo	1,17
Euphorbiaceae	*Hevea brasiliensis* (Willd. ex A. Juss.) Müll. Arg.	Seringueira	tree	se	ar	1,17
Malpighiaceae	*Malpighia glabra* L.	Acerola	shr	fr	fo	1,17
Anacardiaceae	*Spondias* sp.	Taperebá	tree	fr	fo	1,17
Fabaceae	*Caesalpinia ferrea* Mart.	Jucá	tree	fr/se	me	1,00
Fabaceae	*Dipteryx odorata* (Aubl.) Willd.	Cumaru	tree	se	me	1,00
Apocynaceae	*Himatanthus sucuuba* (Spruce ex Muell. Arg.) Woodson	Sucuúba	tree	ba/ex	me	1,00
Fabaceae	*Hymenaea courbaril* L.	Jatobá	tree	ba	me	1,00
Acanthaceae	*Justicia acuminatissima* (Miq.) Bremek.	Sara-tudo	vine	lf/ro	me	1,00
Lauraceae	*Persea americana* Mill.	Abacate	tree	fr	fo	0,83
Annonaceae	*Annona muricata* L.	Graviola	tree	fr	fo	0,83
Apocynaceae	*Aspidosperma* sp.	Carapanaúba	tree	ba	me	0,83
Rutaceae	*Citrus aurantifolia* (Christm.) Swingle	Limão	tree	fr	fo	0,83
Rutaceae	Citrus sinensis (L.) Osbeck	Laranja	tree	fr	fo	0,83
Fabaceae	*Hymenaea parvifolia* Huber	Jutaí	tree	ba	me	0,83
Euphorbiaceae	*Jatropha gossypiifolia* L	Pião	herb	ba	me	0,83
Rubiaceae	*Uncaria* sp.	Unha-de-gato	shr	vine	me	0,83

Where: H = habit (herb – herbaceous; pal – palm; shr – shrub; tree–tree; vine–vines); UP = utilized part of the plant (ba–bark; ex – exudate; fr–fruit; lf–leaf; ro–root; se –seed; vine – vines); UF = usage form (ar – artisanal handicraft; fo–food; me – medicinal use); SIC = Species Importance Coefficient

Discussion:

The existence of palm trees with potential use for NWFP exploitation that are not used by local inhabitants reinforces the need for studies to enable and publicize other potential uses of NWFPs that are existent in this community. For instance, inventoried palm trees can be used for artisanal handicrafts, which uses the drier parts of the plant, such as thinner branches. The use of these segments leads to the production of baskets, costume jewelry, sculptures, rustic constructions, food for fauna, among others. It is worth mentioning that, to make the use of these palms more viable, more research would be necessary.

The higher presence of vines in smaller individuals is an alert because even the management of NWFP requires the planning and application of some silvicultural techniques to achieve the good quality of these products in future. It is necessary because the presence of vines impairs forest management and forest growth (Costa *et al*., 2008). Therefore, in the studied region, a special attention should be paid to the individuals present in the smaller diameter classes, aiming at the future management of the species. Although the vines were found in only one species that is used by the community, this information is indicative of the habitat preference of the vines species in question, being it an NWFP.

In the community of Ponta de Pedras, NWFPs are mainly linked to self-consumption. However, the commercialization of some products, even on a small scale, contributes to the supplementation of the residents' income. The analysis of the profile of the residents shows the dependence of the community with NWFPs with other localities.

The highest values of the SIC indicate the alternative species for commercialization. Consequently, management practices should be considered for them. Considering the species reported in the questionnaire, 87.5% were not sampled in the forest inventory. This fact demonstrates the dependence of the Ponta de Pedras community with other neighboring communities and municipalities to acquire the raw material, such as *Heteropsis* spp. and *C. guianensis.*

NWFPs should be evaluated differently for each species since each species presents a different life, uses, and effects of the change in the characteristic environment (Camacho, 2008). Therefore, the knowledge about the potential of these species will help the local community to develop management strategies and techniques to improve its products.

Camacho (2008), emphasizes that the sustainability of the resources uses occurs as long as the collection of NWFP does not exceed the capacity of the populations. All in all, in view to achieve the NWFP sustainability studies like this are fundamental, besides it is contributing to the knowledge of the society about the topic and it can enrich the local community lifestyle.

Conclusion:

H. parvifolia, *H. brasiliensis*, *A. surinamensis* e *B. crassifólia* are present in area I and II according to forest inventory. They are species used by community for medicinal, artisanal handicraft and food.

The species *A. occidentale*, *B. excelsa* and *C. guianensis* presented the greatest potential for NWFP in the Ponta de Pedras community. The sample inventory with the semi-structured questionnaire showed a reduced number of potential raw material for NWFP trade in Ponta das Pedras community. Also, by the forest inventory a reduced number of species is founded in areas I and II.

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