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Population structure and spatial distribution of Bertholletia excelsa Bonpl. In Juruena National park, Southern Amazon

Após a decadência do ciclo econômico da borracha, a castanheira constituiu-se no principal produto extrativo. A crescente destruição da floresta Amazônica influi negativamente na ecologia da castanheira. Padrões de distribuição espacial é uma ferramenta muito utilizada para entender o comportamento ecológico da espécie. Foram demarcadas duas áreas no Parque Nacional do Juruena, nas quais continham um módulo do PPBio em cada, e nelas amostradas todas as castanheiras com DAP>10 cm. Os indivíduos amostrados foram divididos em cinco classes: Jovens; adultos jovens; adultos produtivos; adultos maduros; e adultos idosos. Na área I, 1200 ha, foram amostrados 143 indivíduos, e na área II, 500 ha, 18 árvores. A densidade foi de 0,119 e 0,032 indivíduos ha-1 para a área I e área II respectivamente. 82,52% dos indivíduos da área I estão na classe adultos produtivos e 72,22% estão nesta mesma classe na área II. As árvores amostradas na área I possuem idade média de 255 anos, e na área II de 208. O índice de Morisita, para a área I e área II foi de 4,133 e 7,320 respectivamente. A distribuição espacial das castanheiras amostradas em ambas as áreas foi agregada. A área I possui maior densidade, alta concentração de árvores em período produtivo e maior média de idade do que a área II.

Keywords: Castanheira; PNJu; DAP.

Estrutura populacional e distribuição espacial de Bertholletia excelsa Bonpl. parque nacional do Juruena, Amazônia meridional

After the decadence of rubber economic cycle, the Brazil-nut-tree was the principal extractivism product. The increasing destruction of the Amazon rainforest, has a negative impact on the Brazil-nut-tree ecology. Standards of especial distribution is the widely used tool to understand the ecology behavior of specie. Two areas was delimited in Juruena National Park, where one contained module of each PPBio, and them sampled all Brazil-nut-tree with DAP>10cm. The samples was classified in five class: Youngs, youngs adults, productive adults, mature adults and old adults. In the area I, 1200 ha, was sampled 143 individuals, and in area II, 500 ha, 18 trees. The density was 0,119 and 0,032 individuals ha-1 for the area I and area II respectively. 82,52% of individuals of area I was in productive adults class and 72,22% was in same class in area II. The sampled tree in area I have average age of 255 years, and in the area II of 208 years. The Morisita Index, for the area I and area II was 4,133 and 7,320 respectively. The espacialdistribuition was aggregate in the two areas. The area I have more density, higher concentration of tree in productive period and higher average age than area II.

Palavras-chave: Brazil-nut-tree; PNJu; DAP.

Topic: **Ciências Florestais**

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INTRODUCTION

The Brazil nut tree (*Bertholletia excelsa* Bonpl.), of the Lecythidaceae family, is regarded as one of the plants with highest economic value in the Amazon Forest (CUNHA et al., 1997; STAUDHAMMER et al., 2021). It is a semi-deciduous heliophile plant, well developed in warm humid climates, but more common in tropical wet regions with occasional and restrict dry seasons (LORENZI, 2000; SANTOS et al., 2006). It is found in Venezuela, Colombia, Peru, Bolivia and the Guianas, but it is found in Brazil in larger amounts and compact formations, in the states of Pará, Amazonas, Acre, Maranhão, Mato Grosso, Rondônia, Amapá and Roraima (LORENZI, 2000; PINHEIRO, 2004).

With the end of the Amazon rubber boom (*Hevea brasiliensis*), the Brazil nut tree became the main focus of the extractive industry; however, the deforestation resulting from cattle herding is impacting the reproduction and seed spread, causing loss of genetic material, direct wood extraction and risk of extinction (SILVA et al., 2009; FEARNSIDE, 2006; FERREIRA et al., 2021).

The spatial distribution of the species depends on abiotic factors, such as soil type, hydric stress, altitude and light intensity, and biotic factors, such as pollinators, dispersers, predators and competing species (PETERS, 1994; BUDKE et al., 2004). Thus, the environmental variables form the spatial pattern, that may be (1) aggregated, when the individuals are close to one another; (2) random, with randomly distributed individuals; or (3) regular, when there are regular intervals between the individuals (KREBS, 1999).

According to Anjos et al. (2004), the study of spatial distribution patterns is a tool frequently used to understand the ecologic behavior of a species, providing data to assist the management strategies and influence the population structure. individual tree crowns (ITCs) delineation is a challenging task, particularly in tropical forests in which the tree crowns usually overlap and have highly variable sizes and shapes (WAGNER et al., 2018; BRAGA et al., 2020).

The objective of this study was to analyze the population structure and spatial distribution of *B. excelsa* populations in an area of the Southern Amazon localized in the Juruena National Park in Mato Grosso state.

MATERIALS E METHODS

Charactarization of the Study area

The study took place in the Juruena National Park (Parque Nacional do Juruena – PNJu), in 2006, with 195,752,671 ha, being 60% of that area in Mato Grosso and 40% in Amazonas.

The average temperature in the region of the PNJu is 26º C and the annual rain precipitation stays between 2,000 mm and 2,500 mm, vegetation is comprised of Thick Ombrophile Forest – Open Ombrophile Forest 44.15%.

In the portion of the park located in the municipality of Apiacás, Mato Grosso, two areas were delimited: area I with 1,500 ha and area II with 1,200 ha.

The delimitation of the study areas (Figure 1) happened from a narrow trail of 6 km extension for area I and 5 km for area II. By the scanning method, all *B. excelsa* individuals occurring left and right of the trail (2 km for area I and 1 km for area II).

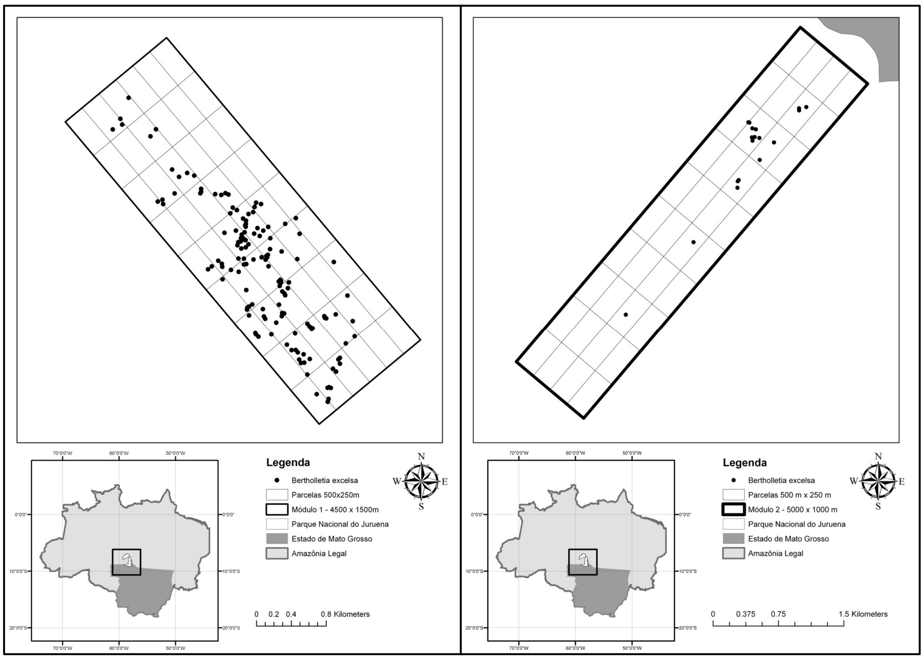

Figure 1: Geographic location of the Juruena National Park, Mato Grosso, and the sampling units. All the *B. excelsa* individuals with DBH (diameter at breast height) greater than 10 cm present in the two study areas were geo-referenced with GarminEtrex® GPS, each having their height estimated and DBH measured.

Data analysis

The mapped individuals were categorized into five classes accordant to Zuidema et al. (2002): Young (DBH=10-40 cm); young adults (DBH=41-80); productive adults (DBH=81–160 cm); mature adults (DBH=161–200 cm), and elderly adults (DBH>200 cm).

The total number of sampled individuals in each area was divided by the size of the respective sampling unity to calculate the density (ind. ha^{-1}), that was compared with the results of other studies realized in the Amazon. The age was calculated by the equation proposed by Camargo et al. (1994).

Age = DBHα

Where: DBH= diameter at breast height

α constant for age for each cm, 1.905

To determinate the spatial distribution, both areas were subdivided in 250x500 m segments, adding up to 54 segments in area I and 40 in area II and then adopting Morisita index (MORISITA, 1959; 1962):

$$I_d = \frac{n.(\Sigma_{i=1}^{s} X^2 - N)}{N.(N-1)}$$

Being: Id: Morisita index; n: total number of sampled segments; N: total number of individuals per species, contained in n segments; X^2: square of the number of individuals per segment; s: number of sampled species.

$$X^2 = \frac{n.\Sigma_{i=1}^{s} X^2}{N} - N$$

The significance of the calculated values to the Morisita index (Id) was obtained via the chi-squared test and a significance level of 0.05 of error probability.

For the spatial distribution, through Program R, Mclu and Muni were determined the top and bottom limits of the Morisita index for a random distribution and imst (Morisita Index Standardized) (HAIRSTON et al., 1971; KREBS, 1999). If imor > mclu, the species has a spatial distribution aggregated, if imor < muni, the spatial distribution pattern is regular. If Imst stays between -0.5 and 0.5, the distribution is random, if below -0.5, the distribution is regular and if over 0.5, the distribution is aggregated.

RESULTS AND DISCUSSION

With 143 sampled individuals in area I and 18 in area II, *B. excelsa*, shows density of, respectively, 0.119 ind. ha^{-1} and 0.032 ind. ha^{-1} (Table 1). According to Scoles et al. (2011), the avarage density of the Brazil nut tree in the Amazon is between 1 and 23 individuals ha^{-1}. Salomão (2009) has also found a density below 1 individual ha^{-1} in Pará.

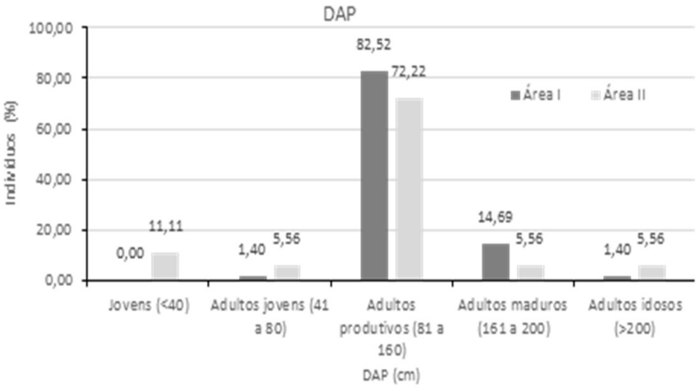

Figure 2: Distribution of sampled *B. excelsa* individuals in PNJu, July 2012, in DBH classes.

Regarding the DBH, both areas I and II have the larger percentage (82.52 and 72.22%, respectively) of productive adults (Figure 2). The average DBH per area was of 134 cm, in area I, and 109 cm, in area II. Area II has a larger percentage of young (16.67%) and elderly (5.56%) trees in comparison to area I. The low percentage of individuals with DBH<80 cm in area I shows a low population regeneration capacity, while the larger amount of young individuals (11.11%) in area II in comparison to area I (0%) shows a greater regenerative capacity in this studied area.

The values of young individuals found in this study are similar to the ones observed by Peres et al. (2003), that reported a variation between 50% and 0% of young individuals in natural populations of *B. excelsa*.

Both areas show most of the individuals distributed between productive adults and mature adults, 97.20% in area I and 77.78%. Scoles et al. (2011) and Wadt et al. (2005) also found the majority of individuals distributed in these classes of DBH (59% and 54%, respectively).

According to the hypsometric dispersion (Figure 03), the majority of the individuals, regardless of which area, have about 40 m of height with DBH nearing 150 cm, similar to the proportions found by Salomão (2009).

Tonini et al. (2005) studied the height-diameter relation of Brazil nut trees in Roraima and concluded that the species develop big vigorous crowns, thus needing more living space and demanding greater initial space, fact that may have happened in both the studied areas.

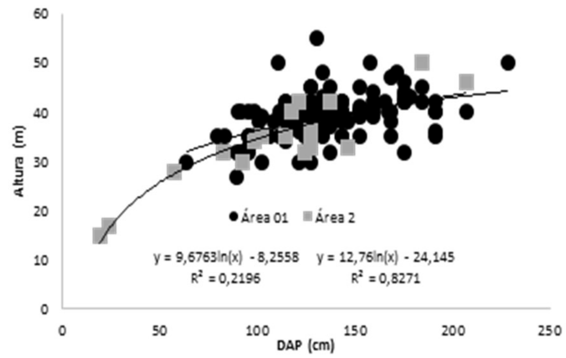

Figure 3: Hypsometric curve distribution of *B. excelsa* individuals sampled in the Juruena National Park, MT.

The average age of area I was 255 years old, having the eldest individual about 435 years old and the youngest about 121 years old; while area II's average age was 208 years old, with an eldest of 394 and a youngest of 36 years old.

Salomão (2009) states that it is usually believed that tropical forest trees have low longevity, rarely surpassing 400 years of age and, even though Peres et al. (2003) report that, in extreme cases, very old Brazil nut trees probably can live over 800 years.

The spatial distribution of the Brazil nut tree in both areas is aggregated (Table 01), since the Imor values were greater than the Mclu values. Area I showed a Morisita index of 2.537, and Standardized Morisita of 0.513. Area II showed 7.320 and 0.569, respectively.

Table 1: Type of spatial distribution, Morisita index (Imor), minimum value for random distribution (Mclu), minimum value for regular distribution (Muni), Regular Morisita index and value of χ^2

Local	Distribution	Imor	Mclu	Muni	Imst	χ^2
Área I	Aggregate	2,537	1,155	0,871	0,513	4,642
Área II	Aggregate	7,320	2,125	0,973	0,569	2,382

Tonini et al. (2008), after sampling two 9 ha portions in Roraima, reported that only young individuals showed aggregated distribution, while the adults showed regular distribution.

Table 2: Comparison of *B. excelsa* density (DBH > 10 cm) in different regions of the Amazon, proportional to the sampling area.

Origin	Area (ha)	Density	Source
El Tigre Forest Reserve, Beni, Bolivia	12	1.7	Zuidema et al. (2002)
Indigenous area of Pinkaiti, Pará, Brazil	28.5	4.8	Peres et al. (1997)
Forest of Saracá-Taquera, Pará, Brazil	203.7	5.6	Salomão (2009)
Extractive reserve of Chico Mendes, Acre, Brazil	420	1.35	Wadt et al. (2005)
National Park of Juruena (Area II), Mato Grosso, Brazil	500	0.032	Present study
National Park of Juruena (Area I), Mato Grosso, Brazil	1200	0.119	Present study
Platô Bela Cruz, Pará, Brazil	1500	0.023	Salomão (2009)
National Forest of Jamari (Rondônia, Brazil)	11011.2	0.55	Santos Junior et al. (2020)
Caracaraí – Roraima, Brazil and Itaúba – Mato Grosso, Brazil	13.5	2.74	Tonini et al. (2019)

Santos Junior et al. (2020) evaluated the distribution of Brazil nut trees in the National Forest (FLONA) of Jamari - RO, with a total area of 11011.2 ha. All Brazil nut trees with DBH ≥ 35 cm were considered (Table 2). Tonini et al. (2019) studied two areas, one in Caracaraí – Roraima state, and the other in Itaúba – Mato Grosso state, resulting in a total area of 13.5 ha, including individuals with DBH ≥ 10 cm in the statistics (Table

2). The different forest types explain the aggregated spatial distribution where the Brazil nut tree naturally occur (WADT et al., 2005) (Table 2). Thus, both the studied areas favor the aggregated spatial distribution.

CONCLUSIONS

According to the density values, the number of productive individuals, the age of the Brazil nut trees and the presence or absence of young individuals in the studied areas, area I shows lower population regeneration capacity than area II.

However, this low capacity relates to the phytophysiognomy of area I's vegetation, which is comprised of close individuals forming a thick canopy, resulting in low necessary luminosity for the establishment of young Brazil nut, as shown in this study.

The results found in area II corroborates this, with lower density, lower concentration of trees in the productive age and lower average age, besides the presence of young individuals and clearings.

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REFERENCES

ANJOS, A.; MAZZA, M. C. M.; SANTOS, A. C. M. C.; DELFINI, L. T.. Análise de distribuição espacial de araucária (*Araucaria angustifolia*) em algumas áreas do Estado do Pará, utilizando a função K de Ripley. **Scientia Forestalis**, v.66, p.38-45, 2004.

BRAGA, G. V.; PERIPATO, J. R.; DALAGNOL, R.P.; FERREIRA, M.; TARABALKA, Y.; ARAGÃO, O. C.; VELHO, L. E. F. C.; SHIGUEMORI, E. H.; WAGNER, F. H.. Tree crown delineation algorithm based on a convolutional neural network. **Remote Sensing**, v.12, n.8, p.12, 2020. **DOI:** http://doi.org/10.3390/rs12081288

BUDKE, J. C.; GIEHL, E. L. H.; ATHAYDE, E. A.; ZÁCHIA, R. A.. Distribuição espacial de *Mesadenella cuspidata* (Lindl.) Garay (Orchidaceae) em uma floresta ribeirinha em Santa Maria, RS, Brasil. **Acta Botanica Brasilica**, v.18, n.1, p.31-35, 2004. **DOI:** http://doi.org/10.1590/S0102-33062004000100004

CAMARGO, P. B.; SALOMÃO, R. P.; TRUMBORE, S.; MARTINELLI, L. A.. How old are large Brazil-nut trees (*Bertholletia excelsa*) in the Amazon? **Scientia Agrícola**, Piracicaba, v.51, n.2, p.389-391, 1994. **DOI:** http://doi.org/10.1590/S0103-90161994000200028

CUNHA, E. S. M.; DANTAS, F. L. C. G.. **O que você precisa saber sobre a castanha-do-Brasil:** de informações técnicas a curiosidades. Macapá: Secretaria de Estado de Meio Ambiente, Ciência e Tecnologia (Sema), 1997.

FEARNSIDE, P. M.. Desmatamento na Amazônia: Dinâmica, impactos e controle. **Acta Amazonica**, v.36, n.3, p.395-400, 2006. **DOI:** http://doi.org/10.1590/S0044-59672006000300018

FERREIRA, M. P.; LOTTE, R. G.; D'ELIA, F. V.; STAMATOPOULOS, C.; DO-HYUNG KIM, D.; RIBEIRO, M. B. N.; BENJAMIN, A. R.. Corrigendum to "Accurate mapping of Brazil nut trees (*Bertholletia excelsa*) in Amazonian forests using WorldView-3 satellite images and convolutional neural network". **Ecological Informatics**, v.64, p.101326, 2021. **DOI:** http://doi.org/10.1016/j.ecoinf.2021.101302

HAIRSTON, N. G.; HILL, R.; RITTE, U.. **The interpretation of aggregation patterns.** Patil: University Park, 1971.

KREBS, C. J.. **Ecological Methodology**. Addison Wesley Educational Publishers, Menlo Park, 1999.

LORENZI, H.. **Árvores brasileiras:** manual de identificação e cultivo de plantas arbóreas nativas do Brasil. 4 ed. Nova Odessa: Plantarum, 2000.

MORISITA, M.. Id-index, a measure of dispersion of individuals. **Researches on *Population* Ecology**, v.4, p.1–7, 1962. **DOI:** http://doi.org/10.1007/BF02533903

MORISITA, M.. Measuring of the dispersion of individuals and analysis of the distributional patterns. **Memories of the Faculty of Science,** v.2, p.215–235, 1959.

PERES, C. A.; BAIDER, C.. Seed dispersal, spatial distribution and population structure of Brazilnut trees (*Berthollethiaexcelsa*) in southern Amazonia. **Journal of Tropical Ecology**, v.13, p.595-616, 1997. **DOI:** http://doi.org/10.1017/S0266467400010749

PERES, C. A.; BAIDER, C.; ZUIDEMA, A.; PIETER, L. H. O.; WADT, K. A.; KAINER, D. A. P. G.; SILVA, R. P.; SALOMÃO, L. L.; SIMÕES, E. R. N.; FRANCIOSI, F. C.; VALVERDE, R.; GRIBEL, G. H.; SHEPARD JUNIOR, M.; KANASHIRO, P.; COVENTRY, D. W.; YU, A. R.; WATKINSON, R. P.; FRECKLETON, N.. Demographic threats to the sustainability of Brazil nut exploitation. **Science**, v.302, n.5653, p.2112-2114, 2003. **DOI:** http://doi.org/10.1126/science.1091698

PETERS, M. C.. Sustainable Harvest of Non-timber Plant Resources in Tropical Moist Forest: An Ecological Primer. **Biodiversity Support Program**, Washington, 1994.

PINHEIRO, M. R. R.. **Estudo de variabilidade genética de *Aspergillus flavus* como base para o desenvolvimento de PCR Multiplex para detecção de fungos produtores de aflatoxinas em castanha-do-Brasil e castanha de caju**. Dissertação (Mestrado em Ciências Genômicas e Biotecnologia) - Universidade Católica de Brasília, Brasília, 2004.

SALOMÃO, R. P.. Densidade, estrutura e distribuição espacial da castanheira-do-Brasil (Bertholletia excelsa H. & B.) em dois platôs de floresta ombrófila densa na Amazônia setentrional brasileira. **Boletim do Museu Paraense Emílio Goeldi Ciências Naturais**, v.4, p.11-5, 2009.

SANTOS, D.; SARROUH, B.; SANTOS, J.; PÉREZ, V.; SILVA, S.. Potencialidades e aplicações da fermentação semi-sólida em Biotecnologia. **Janus**, v.3, n.4, p.164-183, 2006.

SANTOS JÚNIOR, N. R. F.; ROSA, D. M.; ROCHA, J. D. S.; SCCOTI, M. S. V.; BIAZATTI, S. C.; ROCHA, K. J.. Ecological and environmental indicators of Brazil Nut Tree (*Bertholletia excelsa* Bonpl.) in Flona do Jamari, Rondônia. **Revista Ibero Americana de Ciências Ambientais**, v.11, n.7, p.740-751, 2020. **DOI:** http://doi.org/10.6008/CBPC2179-6858.2020.007.0056

SCOLES, R.; GRIBEL, R.. Population structure of Brazil nut (*Bertholletia excelsa*, Lecythidaceae) stands in two areas with different occupation histories in the Brazilian Amazon. **Human Ecology**, v.39, n.4, p.455-464, 2011. **DOI:** http://doi.org/10.1007/s10745-011-9412-0

SILVA, A. N.; COELHO, M. F. B.; GUIMARÃES, S. C.; ALBUQUERQUER, M. C. F.. Germinação de sementes de castanheira-do-pará armazenadas em areia úmida. **Pesquisa Agropecuária Brasileira,** v.44, n.11, p.11-19, 2009. **DOI:** http://doi.org/10.1590/S0100-204X2009001100009

STAUDHAMMER, C. L.; WADT, L. H. O.; KAINER, K. A.; CUNHA, T. A.. Comparative models disentangle drivers of fruit production variability of an economically and ecologically important long-lived Amazonian tree. **Scientific Reports,** v.28, n.1, p.2563, 2021. **DOI:** http://doi.org/10.1038/s41598-021-81948-4

TONINI, H.; COSTA, P. D.; KAMINSKI, P. E.. Estrutura e produção de duas populações nativas de castanheira-do-Brasil (*Bertholletia excelsa* o. Berg) em Roraima. **Floresta**, v.38, p.445-457, 2008. **DOI:** http://doi.org/10.5380/rf.v38i3.12410

TONINI, H.; BALDONI, A. B.. Estrutura e regeneração de *Bertholletia excelsa* Bonpl. em castanhais nativos da Amazônia. **Ciência Florestal**, v.29, n.2, p.607-621, 2019. **DOI:** http://doi.org/10.5902/1980509822112

TONINI, H.; ARCO-VERDE, M. F.. **Dendometria de espécies nativas em plantios homogêneos no estado de Roraima - ANDIROBA (*Carapa guianensis*Aubl.), CASTANHA-DO-BRASIL (*Bertolhetia excelsa* H. & B.), IPÊ-ROXO (*Tabebuia avellanedae*Lorentz ex Griseb.). e JATOBÁ (*Hymenea courbaril* L.)**. Boa Vista: Embrapa Roraima, 2005.

WADT, L. H. O.; KAINER, K. A.; GOMES-SILVA, D. A. P.. Population structure and nut yield of a *Bertholletia excelsa* stand in Southwestern Amazonia. **Forest Ecology and Management**, v.211, p.371-384, 2005. **DOI:** http://doi.org/10.1016/j.foreco.2005.02.061

WAGNER, F. H.; FERREIRA, M. P.; SANCHEZ, A.; HIRYE, M. C.; ZORTEA, M.; GLOOR, E.; PHILLIPS, O. L.; SOUZA FILHO, C. R.; SHIMABUKURO, Y. E.; ARAGÃO, L. E. O. C.. Individual tree crown delineation in a highly diverse tropical forest using very high-resolution satellite images ISPRS J. Photogramm. **Remote Sensing,** v.145, p.362-377, 2018. **DOI:** http://doi.org/10.1016/j.isprsjprs.2018.09.013

ZUIDEMA, P. A.; BOOT, R. G. A.. **Ecology and Management of the Brazil Nut Tree (*Bertholletia excelsa*)**. PROMAB (PROMAB Scientific Series 6), 2002.

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