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CHARACTERIZATION OF TREE COMMUNITY IN A FOREST POST EXPLORATION AREA, SOUTH OF TOCANTINS STATE

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Abstract: Considering the lack of data and studies in post-forestry areas, the objective of the study was to evaluate the floristics, phytosociology and the distribution in height and diameter classes of the tree species after forest management of the Wood Industry Rio Formoso located in the municipality of Dueré, State of Tocantins. Made from a forest inventory with systematic sampling, where 22 plots measuring 20 m by 50 m were installed, totaling 2.2 ha of sample area. All arboreal individuals with a circumference of 1.30 m from the ground ≥ 15 cm were sampled, botanically identified, and classified into ecological groups. Phytosociological parameters were analyzed, and volume, biomass and carbon stocks were determined from equations for the region. In the area were found 821 individuals distributed in 27 species and 18 botanical families; Shannon's density, dominance and diversity values are considered low for comparison purposes with other studies. The diametric structure showed an unbalanced "inverted J" pattern. The volume stock was 355,068 m^3. ha^{-1}, the biomass was 67,867 ton. ha^{-1}; and carbon was 33,934 ton. ha^{-1}.
Keywords: Seasonal forest, forest management, floristic survey.

INTRODUCTION

The savannah corresponds to the second largest vegetation formation present in Brazil, occupying around 22% of the national territory, second only to the Amazon. The State of Tocantins has about 277,621 km^2 of territorial extension, of this total, it still has 72% of the remaining vegetation of the savannah biome, configuring itself among the states with the highest rates of this type of coverage (Brasil, 2015).

Forest environments perform important environmental services related to the maintenance of surface and groundwater, in addition, they are great sources of raw material (wood, fruits, resins) of great economic value. These environments also store a large amount of carbon in their arboreal and soil compartments, playing an important role in balancing the global carbon stock (PAN et al., 2011).

However, in the last decades, the loss of biodiversity involving species of the savannah has intensified with the fragmentation of the biome, and the exploitation has been unsustainable and without application of the sustainability criteria of forest management, which characterizes loss of cover. forestry and species diversity. In general, forest management is centered on the concept of using forest resources sensibly and sustainably, so that future generations can enjoy the same benefits as the present generation.

In this context, the development of studies that aim to guide decision-making through the analysis of the structure of a forest is undoubtedly essential for the sustainable use of natural resources (Santos et al., 2016). Therefore, knowing the floristic composition and structure of the forest are aspects that must be considered in the planning and execution of forest management, in addition to leading the forest to a balanced structure (Vieira et al., 2014).

Natural forests have tree species with different sizes, heights, ages and physiological characteristics; for this reason, knowing how the diameter of individuals is distributed is an essential tool to understand the behavior and structure of a forest massif in relation to anthropogenic disturbances. From this perspective, the analysis of the diameter distribution in uneven forests enables a better knowledge and understanding of the species that make up the forest, enabling better planning for the establishment of appropriate strategies for conservation and management (Batista et al., 2015).

Another fundamental aspect for floristic studies is the analysis of the vertical structure, as it gives us an idea of the importance of the species considering its participation in the vertical strata that the stand presents (Souza, 2009, apud Piris, 2019). According to them, the vertical strata found in the forest can be divided into: dominant, intermediate and dominated species. Those species that have a greater number of representative individuals in each of these strata will certainly present a greater ecological importance in the population under study.

Studies of floristic and structural development of a forest, in areas impacted by forest management activities, are still little known, but essential to assess the ecological sustainability of forest management, as well as to verify the conditions in which the forest is found.

Considering the gap in data and studies in post-logging areas, the hypothesis tested is that sustainable forest management does not alter the floristic and phytosociological composition of the forest. In this context, the objective of the study was to evaluate the horizontal and vertical structure, as well as the carbon and biomass volume of the aerial part of the tree species of the forest management plan of the Wood Industry Rio Formoso located in the municipality of Dueré, south of the State of Tocantins.

MATERIAL AND METHODS

CHARACTERIZATION OF THE STUDY AREA

The study was carried out in an area of altered seasonal semideciduous alluvial forest, after forest exploitation of the annual production unit 1 (UPA 1) in 2015, under the following geographical coordinates - latitude 11º 8’ 26” S and longitude 49º 22’ 03” W. The area is part of the sustainable forest management plan - PMFS belonging to the company POIANI & BIANCHI Ltda., under the trade name, Wood Industry Rio Formoso, located in the municipality of Dueré, south of the State of Tocantins.

Exploration in the area is carried out in accordance with the regulations established by the state environmental agency Naturatins, which determines and authorizes up to 45 m^3 per ha with commercial species of DBH ≥ 50 cm and technical guidelines determined by Sabogal et al. (2000). The commercial species exploited in the area are: *Vochysia tucanorum*, *Apuleia leiocarpa*, *Calophyllum brasiliensis*, *Hymenaea parvifolia* and *Aspidosperma álbum*. Since the intensity of exploration and harvest cycles obey the productivity of the forest, known through forest inventories.

The Dueré region is characterized by a climate of type C2wA´a´, according to the Koppen classification, which corresponds to a humid sub-humid climate with moderate water deficit, potential evapotranspiration with an annual average of 1,700 mm, temperature varying between 25.5 and 27ºC (SEPLAN-TO, 2017). While the soils found in the region are classified as predominantly gleisols and plintosols (SEPLAN-TO, 2017).

SAMPLING AND DATA COLLECTION

A forest inventory was carried out in the annual production unit 1 (UPA 1), with an area of 440 hectares divided into 18 strips (each strip with approximately 24.44 ha), using the systematic sampling procedure, with randomization of the first sampling unit. A tape measure was used to measure the circumference of the tree, while the diameter at 1.30 m from the ground (DBH) was obtained by the mathematical relationship between the circumference of the trunk and the number π. The total height (HT) of the individuals was obtained in meters using the Haglof digital clinometer.

In total, 22 sampling units measuring 20 m by 50 m (fixed area) were installed, distributed in 5 strips to cover the entire sampled area, totaling 2.2 ha of pilot inventory sample area. The sampling intensity was defined based on the values found for DBH (trunk diameter at 1.30 m from the ground) greater than 5 cm, corresponding to the number of 20.66 plots for the final inventory, that is, the pilot inventory starts to be definitive.

The taxonomic identification of the species sampled in the study area was carried out through comparisons with material from the UFT Herbarium, Porto Nacional campus, and consultations with specialists, when necessary. The classification system adopted was the "Angiosperm Phylogeny Group" (APG IV, 2009). The spelling and authorship of the specific binomials were confirmed in the databases "Lista de Espécies da Flora do Brasil" of the Herbarium Virtual-Reflora. According to the classification by Gandolfi et al. (1995, apud Milhomem, 2013), the species sampled were classified in the following ecological groups pioneer (P); initial secondary (SI); and late secondary (ST).

DATA ANALYSIS

Phytosociological Parameters

For each species sampled, the phytosociological parameters were calculated: Absolute Density (DA), Relative Density (DR), Absolute Dominance (DoA), Relative Dominance (DoR), Absolute Frequency (FA), Relative Frequency (FR), Importance Value (VI), and Coverage Value (VC).

The richness and abundance of species in the studied area were evaluated using the Shannon diversity index (H'). The distribution of individuals among the species in the area was analyzed by the Pielou Uniformity Index. (J'), which is derived from the Shannon diversity index (Brower & Zar, 1977). Also according to the authors, this index represents the proportion of the diversity of species found in the current sampling in relation to the maximum diversity that the community can reach.

Vertical stratification

The height of the individuals was segmented into the following strata: lower, middle and upper. According to Souza (2009, p. 16, apud Piris, 2019), the stratification criterion is based on the total height (HT) of the individual in relation to the difference or the sum between the average height ($\bar{H}$) and the standard deviation (σ), being that:

- Lower stratum: confers the trees with HT < ($\bar{H}$ - σ);
- Middle stratum: confers the trees with ($\bar{H}$ - σ) $\leq$ HT $\leq$ ($\bar{H}$ + σ);
- Upper stratum: comprises trees with HT > ($\bar{H}$ + σ).

Volume, Biomass and Carbon Stock

All equations selected according to the study of the Mapping of Phytoecological Regions and Forest Inventory of the State of Tocantins - Forest Inventory of the Southern Range (Haidar et al., 2013). The volume of individuals sampled was estimated from the equation developed by Colpini et al., (2009) in an area of open ombrophilous forest, in the region of Mato Grosso. The study area is closer to the state of Tocantins, and the equation presented a coefficient of determination above 95%, and with a standard error of 1.16%, these results and the graphical analyzes indicate good significance and precision of this equation.

$$Ln\,(VT) = -\,9{,}1892 + 1{,}9693\,Ln\,(DAP) + 0{,}837\,Ln\,(HT)$$

Where: Ln = natural or natural logarithm; VT = total volume (m^3); DAP = diameter in cm taken at 1.30 m from the ground in centimeters; HT = total height in meters.

The biomass of each sampled individual was determined from the equation developed by Higuchi et al. (1998) for a rain forest of upland rainforest in the Amazon, which obtained coefficients of determination above 96% and a percentage standard error of 2.56%. According to the authors, the equation proves to be consistent and accurate for different sample sizes. While to determine the carbon accumulation of the woody shoot, a 2:1 ratio between biomass and carbon stock was considered, that is, the biomass estimate was multiplied by 0.5 to obtain the carbon stock.

$$BA= [0{,}077+0{,}492\ DAP^{\wedge 2}\ HT]\ 0{,}6$$

Where: BA = shoot woody biomass stock (ton. ha^{-1}); DBH = diameter at 1.30 m from the ground in meters; HT = total height in meters

Diametric distribution and Liocourt quotient

The sampled individuals were grouped into diameter frequency classes and height frequency classes, respecting the rule proposed by Sturges, which determines the number of classes as a function of the number of individuals, while the class interval was calculated from the amplitude (difference between the maximum value and the minimum value) in relation to the number of classes.

Then the Liocourt quotient was determined to identify the discrepancy between mortality and recruitment percentages for each diameter class. He calculated the Liocourt quotient "q" by dividing the number of individuals in a diametric class by the number of individuals in the previous class (Liocourt, 1898, apud Meyer, 1952).

$$q = \frac{n2}{n1}$$

Where: n1 = number of trees of the previous diameter class; n2 = number of trees of the posterior diameter class.

RESULTS AND DISCUSSION

A total of 821 individuals were sampled, distributed in 27 species and 18 botanical families (Table 1). These values corroborate the study carried out by Carvalho et al. (2016), according to which they found about 26 species distributed in 18 botanical families, in a forest remnant of cerradão, in the municipality of Gurupi, State of Tocantins.

The absolute density was 373,18 ind. ha^{-1} per hectare, while the sum of absolute dominance was 25,75 m^2. ha^{-1}. It was found that the basal area obtained was lower than that found in an unmanaged seasonal forest in Minas Gerais (Amaro et al., 2013), which obtained a basal area of 27,70 m^2. ha^{-1}. However, absolute dominance is within the estimates observed in seasonal forests and unmanaged ecotone areas in the State of Tocantins, which ranged from 14,04 to 37,49 m^2. ha^{-1} (Haidar et al., 2013). The same was observed in the study by Vieira et al. (2015), in two ombrophilous forests, after forest management in the State of Pará, which presented densities of 254,8 e 472,56 ind. ha^{-1}, and dominance of 18.5 and 26,26 m^2. ha^{-1}.

The exploitation of wood in the managed area directly affects the basal area, and may also cause some damage to the remaining vegetation, since many trees suffer from injuries, contributing to the reduction of the total number of species (Vieira et al., 2014). Furthermore, it must be mentioned that the reduction in basal area is expected, and is around 80% of the original.

Among the botanical families found in the area, the most representative within the forest were: Annonaceae with about 172 individuals, Calophyllaceae with 209 individuals, Burseraceae with 106 individuals and Lecythidaceae with 105 individuals.

Analyzing the number of individuals sampled for each species, we can observe that the species: *Annona crassiflora; Annona squamosa; Calophyllum brasiliense; Caraipa densifolia; Eschweilera ovata; Inga vera; Protium heptaphyllum* e *Psidium guajava* stood out for corresponding together about 673 individuals, reflecting in 81.97% of the individuals concentrated in only 8 species.

In mapping the phytoecological regions and forest inventory of the southern strip of the State of Tocantins (SEPLAN-TO, 2013), the species: *Calophyllum brasiliense*, *Protium heptaphyllum* and *Caraipa densifolia* stand out for their wide geographic distribution. in relation to species *Eschweilera ovata*, according to Gusson et al. (2005), this species has great importance in forest restoration, since it has the characteristic of becoming an anthropic pioneer in areas that have suffered degradation and, with this, tends to colonize these areas. The success of the species of the genus Annona is due to their wide geographic distribution and their adaptive strategies regarding the dispersion of their seeds, since they have fruits that are attractive to the local fauna (Mosca et al., 2006).

However, the rest of the 148 individuals were distributed in about 19 species, with the following species: *Albizia niopoides*, *Cecropia pachystachya, Ficus adhatodifolia, Handroanthus albus, Hymenaea courbaril, Theobroma cacao*, showed the occurrence of only one individual each. However, it was observed that the density of these species is very low or absent when compared to unmanaged areas of the same plant typology (Haidar et al., 2013; SEPLAN-TO, 2013; Amaro et al., 2013), demonstrating that it is a natural feature of these species.

The highest percentages of IVI were found in the following species: *Caraipa densifolia* (20,17%) and *Protium heptaphyllum* (12,61%),

Scientific name	Family	N I	DR (%)	FR (%)	DoR (%)	VI (%)	VC (%)
Species: pioneers							
Psidium guajava	Myrtaceae	54	6,58	7,21	6,66	6,82	6,62
Rauvolfia sellowii	Apocynaceae	12	1,46	2,4	1,19	1,69	1,33
Mabea fistulifera	Euphorbiaceae	9	1,1	1,92	0,7	1,24	0,9
Virola sebifera	Myristicaceae	8	0,97	2,88	0,51	1,46	0,74
Cecropia pachystachya	Urticaceae	1	0,12	0,48	0,09	0,23	0,1
	Total	84	10,23	14,89	9,15	11,44	9,69
Species: Initial secondary							
Caraipa densifolia	Calophyllaceae	148	18,03	10,58	31,91	20,17	24,97
Protium heptaphyllum	Burseraceae	106	12,91	9,13	15,78	12,61	14,35
Inga vera	Fabaceae	67	8,16	9,13	3,95	7,08	6,05
Hirtella glandulosa	Chrysobalanaceae	29	3,53	0,48	1,19	1,74	2,36
Vochysia tucanorum	Vochysiaceae	10	1,22	0,48	0,54	0,75	0,88
Buchenavia tetraphylla	Combretaceae	2	0,24	0,96	0,3	0,5	0,27
Cupania vernalis	Sapindaceae	2	0,24	0,96	0,21	0,47	0,23
Theobroma cacao	Malvaceae	1	0,12	0,48	0,01	0,2	0,06
	Total	365	44,46	32,21	53,89	43,52	49,17
Species: late secondary							
Annona crassiflora	Annonaceae	96	11,69	6,25	5,94	7,96	8,82
Eschweilera ovata	Lecythidaceae	75	9,14	5,29	3,59	6,01	6,36
Annona squamosa	Annonaceae	66	8,04	9,62	4,31	7,32	6,18
Calophyllum brasiliense	Calophyllaceae	61	7,43	10,1	12,34	9,95	9,88
Cariniana estrellensis	Lecythidaceae	30	3,65	6,25	4,75	4,88	4,2
Mouriri acutiflora	Melastomataceae	12	1,46	3,85	0,98	2,1	1,22
Enterolobium timbouva	Fabaceae	9	1,1	3,85	1,88	2,28	1,49
Hymenolobium excelsum	Fabaceae	9	1,1	1,92	1,68	1,57	1,39
Duguetia lanceolata	Annonaceae	8	0,97	2,88	0,41	1,42	0,69
Rollinia mucosa	Annonaceae	2	0,24	0,96	0,16	0,45	0,2
Albizia niopoides	Fabaceae	1	0,12	0,48	0,03	0,21	0,07
Ficus adhatodifolia	Moraceae	1	0,12	0,48	0,8	0,47	0,46
Handroanthus albus	Bignoniaceae	1	0,12	0,48	0,05	0,22	0,09
Hymenaea courbaril	Fabaceae	1	0,12	0,48	0,06	0,22	0,09
	Total	372	45,3	52,89	36,98	45,06	41,14

Table 1. Phytosociological parameters of the tree species of the forest management plan, of the Wood Industry Rio Formoso located in the municipality of Dueré, south of the State of Tocantins.

which reflected in the species with the highest CVI values, around 24.97% and 14.35%. Corroborating the results found by Fernandes et al. (2016), in an alluvial semideciduous forest in Mato Grosso do Sul, according to which it was found that the species:*Protium heptaphyllum* and *Calophyllum brasiliense* were among the 5 species with the highest levels of importance.

The Shannon diversity index for the area was 2,57 nats. ha^{-1}, while Pielou's uniformity index (J) was 0.79, theoretically, this value indicates that an increase of 21% of species would be necessary to reach the maximum diversity of the plant community (Brower & Zar, 1977).

It was found that the shannon diversity index of the studied area is lower than that found in a semideciduous seasonal forest remnant, in the state of Mato Grosso (Negrelle, 2013), which corresponded to 2,67 nats. ha^{-1}. Diversity was also lower than that reported by Haidar et al. (2013), in seasonal forests and ecotone areas in the State of Tocantins, which ranged from 2.75 to 4,59 nats. ha^{-1}, while the Pielou equability ranged from 072 to 0.86. In addition to these, it was found that the diversity of the area was lower than that of post-forest management forests (Vieira et al., 2014), which showed diversity of species. 4,41 nats. ha^{-1}, and Pielou equability of 0.86. It was also lower than that reported by Vieira et al. (2015), in two areas of dense ombrophylous forest, which presented diversity of 2.93 and 3,89 nats. ha^{-1}, and evenness of 0.84 and 0,86.

These results indicate the influence of forest exploitation on the ecology of the area, however these values can also be explained due to the environmental selectivity that occurs in forests with alluvial soils, due to the hydromorphy of the soils, since relatively few tropical tree species have developed adaptive mechanisms that allow their survival under anaerobic conditions.

Regarding the ecological groups present in the area (Table 1), the sampling indicated the composition of 5 pioneer species (18.52% of species) with about 84 individuals, 8 initial secondary species (29.63%) with 365 individuals and 14 late secondary species (51.85%) with a total of 372 individuals. In the successional classification of an alluvial semideciduous seasonal forest, Fernandes et al. (2013) obtained 41.1% of the species being early secondaries, 35.5% of late secondaries and 11.8% of pioneers.

The ecological group of pioneer species showed low floristic representation in the area, corresponding to the lowest relative values of density (10.23%), frequency (14.90%) and dominance (9.14%), compared to the other ecological groups. Consequently, this was reflected in the lower importance value (11.42%) and coverage value (9.69%) indices.

Regarding relative density, the ecological group of late secondary groups had the highest percentage (45.31%) for the studied area, however, this data did not decisively influence the relative dominance (36.88%), since the early secondary ones (53 .88%) had the highest percentage of relative dominance. Consequently, this was reflected in the area's coverage indices, with the initial species presenting a percentage (49.17%) higher than that found by the late secondary group (41.14%), indicating that the area has not yet reached its full development in ecological succession. Milhomem et al. (2013), considers that the high floristic representation of the initial secondary species can be an indication of a good stage of conservation.

Analyzing the relative frequency of the area, we observed that the ecological group of late secondary showed a high percentage, about 52.89%, demonstrating how these individuals are distributed throughout the sampled area. In contrast, the group of pioneer species presented a low relative frequency

(14.90%), this result indicates how little is the dispersion of these individuals, being able to be found in restricted areas or clearings formed by falling branches and trees.

Also according to Table 1, it was observed that the importance value found by the group of early secondary species (43.52%) was close to those found by late secondary species (45.06%). Secondary species often appear prominently in seasonal semideciduous forests, and this fact is generally attributed to the history of disturbance of these formations according to Gandolfi et al. (1995, apud Milhomem, 2013). In this sense, the predominance of intermediate and final species of succession indicates a tendency of these fragments to reach more advanced stages of succession, mainly because of the possibility that intermediate species provide favorable conditions for the propagules of final species to establish themselves in these locations (Fernandes et al., 2013).

The estimated volume for the study area was 355,068 m^3. ha-1, and of this total, 54.86% correspond to the group of initial secondary species, which totaled about 194,781 m^3 ha^{-1} (table 2). Then the late secondary species, with about 129,101 m^3. ha^{-1}, corresponding to 36.36% of the total volume. Finally, the pioneer species with about 31,186 m^3. ha^{-1}, corresponding to 8.78% of the total volume. Among the most prominent species in terms of volume of wood in the area, stands out *Calophyllum brasiliense*, *Protium heptaphyllum*, and *Caraipa densifolia.*

It must be noted that although the late secondary group had the largest number of individuals in the area, this did not decisively influence the values found for the volume, since its volume was lower than that found by the early secondary ones. This corroborates the results obtained by the initial secondary schools, referring to the values of dominance and area coverage (Table 1), indicating an intermediate stage regarding the successional development of the forest.

Analyzing the total volume, it was verified that the result obtained was superior to that found by Amaro et al. (2013), in a seasonal semideciduous forest in the State of Minas Gerais, with a volume with281,51 ± 105,80 m^3. ha^{-1}. It was found that estimates of the total volume of woody material for seasonal forests and riverine formations (gallery and riparian forests) in the southern belt of Tocantins (SEPLAN-TO, 2013; Haidar et al., 2013) fluctuated. from 133,50 to 380,75 m^3. ha^{-1}, corroborating the estimates of the present study. Observing the woody volume in post-forest management areas, Vieira et al. (2015) analyzed the arboreal structure of two dense ombrophilous forests, in Pará State, obtained woody volume of 266.80 and 324,10 m^3. ha^{-1}.

The estimated biomass was 204,67 ton. ha^{-1}, a superior result than the biomass estimates for seasonal forests and riverine formations (gallery and riparian forests) in the southern strip of the state of Tocantins (HAIDAR et al., 2013), which fluctuated from 78,44 to 158,80 ton. ha^{-1}. However, this result was lower than the biomass found in forests of the same forest typology in the state of Minas Gerais Amaro et al., (2013), which was of 227,40 ton. ha^{-1}. The estimated aerial carbon stock was 102,33 ton. ha^{-1}, superior result than the biomass estimates for seasonal forests and riverine formations in the southern strip of the state of Tocantins (HAIDAR et al., 2013), which fluctuated from 39,22 to 79,40 ton. ha^{-1}.

The diameter (DBH) presented an average of 25.92 cm, this result was superior to the values found for the median with 21.96 cm and for Pearson's mode with 14.05 cm (Table 3). Of the total of 821 individuals sampled, it was found that about 501 individuals had diameters smaller than the average diameter (25.62 cm), that is, this value corresponds to

Scientific name	Family	N I	Volume (m^3. ha^{-1})	Biomass (ton^3. ha^{-1})	Air carbon (ton^3. ha^{-1})
		Pioneer species			
Psidium guajava	Myrtaceae	54	23,249	13,317	6,659
Rauvolfia sellowii	Apocynaceae	12	3,622	2,096	1,048
Mabea fistulifera	Euphorbiaceae	9	2,333	1,406	0,703
Virola sebifera	Myristicaceae	8	1,828	1,112	0,556
Cecropia pachystachya	Urticaceae	1	0,154	0,09	0,045
	Total	84	31,186	18,021	9,011
		Initial secondary species			
Caraipa densifolia	Calophyllaceae	148	120,499	67,867	33,934
Protium heptaphyllum	Burseraceae	106	57,071	32,462	16,231
Inga vera	Fabaceae	67	12,609	7,822	3,911
Hirtella glandulosa	Chrysobalanaceae	29	2,002	1,504	0,752
Vochysia tucanorum	Vochysiaceae	10	0,773	0,544	0,272
Buchenavia tetraphylla	Combretaceae	2	0,925	0,514	0,257
Cupania vernalis	Sapindaceae	2	0,898	0,529	0,264
Theobroma cacao	Malvaceae	1	0,004	0,023	0,011
	Total	365	194,781	111,265	55,632
		Late secondary species			
Annona crassiflora	Annonaceae	96	19,09	11,72	5,86
Eschweilera ovata	Lecythidaceae	75	9,695	6,324	3,162
Annona squamosa	Annonaceae	66	13,316	8,111	4,056
Calophyllum brasiliense	Calophyllaceae	61	46,738	26,259	13,13
Cariniana estrellensis	Lecythidaceae	30	17,966	10,166	5,083
Mouriri acutiflora	Melastomataceae	12	2,756	1,635	0,818
Enterolobium timbouva	Fabaceae	9	7,502	4,224	2,112
Hymenolobium excelsum	Fabaceae	9	6,588	3,738	1,869
Duguetia lanceolata	Annonaceae	8	1,237	0,784	0,392
Rollinia mucosa	Annonaceae	2	0,438	0,259	0,129
Albizia niopoides	Fabaceae	1	0,056	0,047	0,023
Ficus adhatodifolia	Moraceae	1	3,451	1,946	0,973
Handroanthus albus	Bignoniaceae	1	0,136	0,087	0,044
Hymenaea courbaril	Fabaceae	1	0,132	0,082	0,041
	Total	372	129,101	75,382	37,692

Table 2. Estimates of the volume stock (m^3. ha^{-1}), aerial biomass (ton. ha^{-1}), and aerial carbono (ton. ha^{-1}) of the tree species in the forest management plan, of the Wood Industry Rio Formoso locates in the municipality of Dueré South of the state of Tocantins.

Descriptive statistics	Diameter (cm)	Height (m)	Volume (m^3. ha^{-1})	Biomass (ton^3. ha^{-1})	Air carbon (ton^3. ha^{-1})
Average	25,92	15,74	0,43	0,25	0,12
Standard Erro	0,50	0,20	0,02	0,01	0,01
Median	21,96	15,20	0,20	0,12	0,06
Mode	14,32	12,00	0,22	0,13	0,07
Standard deviation	14,38	5,61	0,66	0,36	0,18
Sample variance	206,79	31,46	0,44	0,13	0,03
Kurtosis	6,92	-0,59	76,96	77,76	77,76
Asymmetry	1,74	-0,06	6,26	6,34	6,34
Break	142,28	25,50	10,75	5,92	2,96
Minumum	4,77	2,50	0,00	0,02	0,01
Maximum	147,06	28,00	10,75	5,94	2,97
Counting	821,00	821,00	821,00	821,00	821,00
Trust level (95,0%)	0,99	0,38	0,05	0,02	0,01

Table 3. Result of the descriptive statistics of the diameter (cm), height (m), volume stock (m^3 ha^{-1}), aerial biomass (ton. ha^{-1}), and aerial carbon (ton. ha^{-1})) of tree species in the forest management plan, from the Wood Industry Rio Formoso located in the municipality of Dueré, south of the state of Tocantins.

about 61.02% of individuals with diameters below the average.

Analyzing the values of standard deviation (14.38 cm) and coefficient of variation (55.47%) of the variable diameter, it is observed how much the values vary around the mean. Studying the structure of a semideciduous seasonal forest remnant in Mato Grosso, Negrelle (2013) obtained an average diameter of 24.19 ± 16.60 cm.

The skewness coefficient was 0.826, while the kurtosis was 0.252 (lower than the standard coefficient of 0.263). These values indicate that the frequency distribution graph of the diameters has positive and leptokurtic asymmetry, that is, the frequency curve distribution has a lower degree of openness than a normal distribution, causing the graph to taper with a certain deviation (called tail) to the right side (concentration of individuals with DAP below average, and gradually distributing towards the right side).

In the study carried out by Vieira et al. (2014), comparing the structure of a managed and unmanaged forest, it was found that there was a concentration of individuals in the first diameter frequency classes, successively decreasing. In this context, for the study by Santos et al. (2016) in an unmanaged ombrophilous forest, the asymmetry and kurtosis curves tend to follow the profile of the diameter structure of the vegetation, in this case the inverted "J" shape, therefore, a high dispersion in the distribution of the diameter curve is expected. , because the species follow a normal distribution pattern, sometimes because of ecology, sometimes because of biotic and abiotic factors that influence them.

Analyzing the total height (HT), it is observed that the arithmetic mean was 15.74 m, this result was superior to the values for the median with 15.20 m and for Pearson's mode with 14.11 m. Of the total of 821 individuals, about 421 individuals presented total height below the average, that is, in percentage it corresponds to about 51.28% of the individuals with values below the average. The arithmetic mean of height was close to the values found for the median and Pearson's mode, indicating that, despite the individuals being concentrated below the mean, there are no marked discrepancies for them. This corroborates the values found for standard deviation (5.61 m) and coefficient of variation (35.62%), which, despite being high, demonstrate that the distribution of heights is not very heterogeneous.

Studying the structure of a semideciduous seasonal forest remnant in Mato Grosso, Negrelle (2013) obtained an average height of 15.12 ± 7.13 cm. The asymmetry coefficient for height was 0.291, while kurtosis was 0.267, a result higher than the standard coefficient of 0.263. These values indicate that the height frequency distribution graph has positive and platykurtic asymmetry, that is, the frequency curve distribution has a greater degree of openness than the normal curve distribution, with a degree of deviation to the right side.

The volume variable presented an average of 0,432 m^3 ha^{-1}, this result proved to be superior to the values found for mode with 0,224 m^3 ha^{-1} and for median with 0,196 m^3 ha^{-1}. Consequently, reflecting if in 575 individuals with volume below the average, while only 246 individuals had volume values above the average volume. Regarding the biomass variable found for the study area, an average value of 0,249 ton. ha^{-1}, being higher than the mode values (0,131 ton. ha^{-1}) and the median (0,118 ton. ha^{-1}), which influenced about 578 individuals with below-average biomass, and 243 individuals with above-average biomass. While the air carbon variable showed an average value of 0,125 ton. ha^{-1}, demonstrated to be superior to the mode of 0,065 ton. ha^{-1} and the median 0,059 ton. ha^{-1}. However, considering the 2:1 ratio between biomass and aerial carbon, we found that both variables presented the same amounts of individuals below and above the average.

Regarding the distribution of individuals in vertical strata, the average total height of the trees was 15.74 meters and the standard deviation was 5.61 meters. Thus, the lower stratum comprised all individuals with height less than or equal to 10.13 meters; the upper stratum comprised all individuals with height greater than or equal to 21.35 meters; and the middle stratum corresponded to all individuals with height greater than 10.13 meters and less than 21.35 meters (Table 4).

The middle stratum presented the highest result, corresponding to about 532 individuals (64.80%), then the lower stratum with a total of 146 individuals (17.78%), and finally, the upper stratum with about 143 individuals. (17.42%). This demonstrates the presence of a continuous canopy, which influences the intermediate stage of ecological succession. For Milhomem et al. (2013), the lower richness of the regeneration stratum (lower stratum) in relation to the intermediate stratum may suggest some failure in the colonization of species, in addition to possible changes in the future plant community, mainly due to the presence of some abundant species in the mature stratum of the forest. little or none of the individuals among the regenerants.

The ten best situated species, in decreasing order of phytosociological position in the lower vertical stratum were: *Hirtella glandulosa, Eschweilera ovata, Caraipa densifolia, Protium heptaphyllum, Annona squamosa, Vochysia tucanorum, Inga vera, Annona crassiflora, Calophyllum brasiliense* and *Mouriri acutiflora*, indicating the ability of these species to enter individuals into regenerative strata.

In relation to the ecological groups in the lower vertical stratum, the highest percentage of individuals was found in the group of the initial secondary with about 54.11%; then the late secondary ones with about 39.73%, and finally the pioneers with 6.16%. For Milhomem et al. (2013), the tree and regenerative strata showed, respectively, a higher proportion of early secondary species (61.04% and 62.32%)

Species	GE	Total of individuals	Number of individuals per stratum		
			Lower	Medium	Superior
Albizia niopoides (Spruce ex Benth.) Burkart	ST	1	1	0	0
Annona crassiflora Mart.	ST	96	9	82	5
Annona squamosa L.	ST	66	11	51	4
Buchenavia tetraphylla (Aubl.) R.A.Howard	SI	2	0	2	0
Calophyllum brasiliense Cambess.	ST	61	5	37	19
Caraipa densifolia Mart	SI	148	17	74	57
Cariniana estrellensis (Raddi) Kuntze	ST	30	1	19	10
Cecropia pachystachya Trécul	P	1	1	0	0
Cupania vernalis Cambess.	SI	2	0	1	1
Duguetia lanceolata A.St.-Hil	ST	8	2	6	0
Enterolobium timbouva Mart.	ST	9	0	5	4
Eschweilera ovata Cambess Miers	ST	75	21	52	2
Ficus adhatodifolia Schott in Spreng.	ST	1	0	0	1
Handroanthus albus (Cham.) Mattos	ST	1	0	1	0
Hirtella glandulosa Spreng.	SI	29	28	1	0
Hymenaea courbaril L.	ST	1	1	0	0
Hymenolobium excelsum Ducke	ST	9	1	5	3
Inga vera Willd.	SI	67	9	57	1
Mabea fistulifera Mart.	P	9	2	6	1
Mouriri acutiflora Naudin	ST	12	5	7	0
Protium heptaphyllum (Aubl.) Marchand	SI	106	14	71	21
Psidium guajava L.	P	54	5	40	9
Rauvolfia sellowii Müll.Arg.	P	12	1	9	2
Rollinia mucosa (Jacq.)	ST	2	1	1	0
Theobroma cacao L.	SI	1	1	0	0
Virola sebifera Aubl.	P	8	0	5	3
Vochysia tucanorum Mart.	SI	10	10	0	0
Total		821	146	532	143

Table 4. Number of individuals in the strata: lower (HT ≤ 10.13 m), medium (10.13 m < HT < 21.35 m) and upper (HT ≥ 21.35 m), with their respective ecological groups (GE), of the tree species of the forest management plan, of the Wood Industry Rio Formoso located in the municipality of Dueré, south of Tocantins.

and late secondary species (31.17% and 28.99%), and a lower proportion of pioneers. (7.79% and 8.70%).

The ten best-placed species in decreasing order of phytosociological position in the middle stratum were: *Annona crassiflora, Caraipa densifolia, Protium heptaphyllum, Inga vera, Eschweilera ovata, Annona squamosa, Psidium guajava, Calophyllum brasiliense, Cariana estrellensis, Raufolia sellowii.*

Regarding the ecological groups, the late secondary ones had the highest percentage of individuals (50%) in the middle height stratum; then it was the group of the secondary initials with about 38.72% of the individuals; and finally, the ecological group of pioneers with about 11.28% of the individuals. For Milhomem et al. (2013), the tree and regenerative strata showed, respectively, a higher proportion of early secondary species (61.04% and 62.32%) and late secondary species (31.17% and 28.99%), and a lower proportion of pioneers. (7.79% and 8.70%).

In the upper stratum, the ten best situated species, in decreasing order of phytosociological position, were: *Caraipa densifolia, Protium heptaphyllum, Calophyllum brasiliense, Cariniana estrellensis, Psidium guajava, Annona crassiflora, Annona squamosa, Enterolobium timbouva, Annona squamosa, Virola sebifera.* As in the lower stratum, the ecological group of the initial secondaries had the highest percentage of individuals (55.94%); followed by the group of late secondary with 33.57%; and finally the group of pioneers with 10.49%.

It is important to emphasize the small representation found by the ecological group of pioneers, since they presented the lowest percentages for the lower, middle and upper strata. This indicates that the continuous canopy of the area directly influenced the stage of successional development, since the low incidence of light in the lower strata favored the presence of individuals capable of developing in shady environments such as forests or understories and hindered the development of individuals dependent on conditions of greater luminosity.

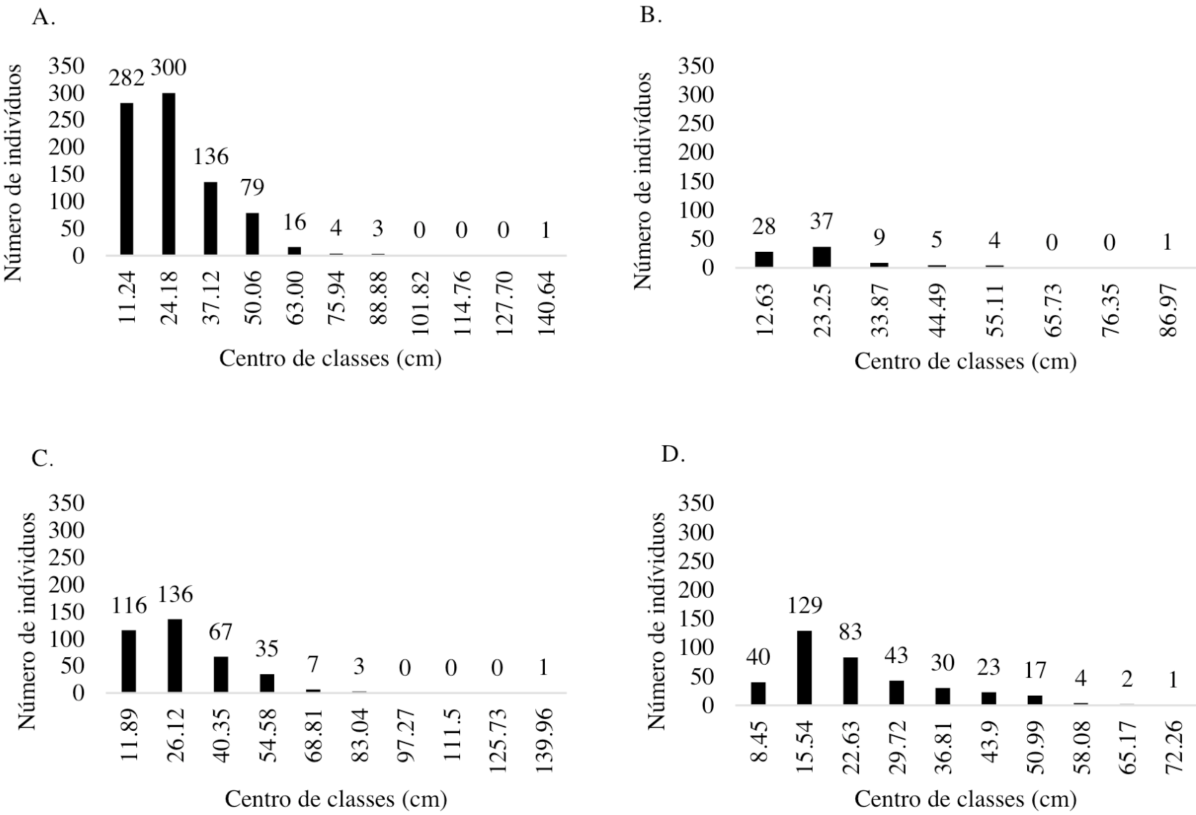
In addition, it must be noted that the species: *Annona crassiflora, Annona squamosa, Calophyllum brasiliense, Caraipa densifolia* e *Protium heptaphyllum,* showed good representation, as they were among the ten best placed species for all strata. For Vieira et al. (2015), species that are present in all strata ensure their representation in the structure of the plant community, however, those that do not follow these rules may not be present in the plant community in the long term, as they do not reproduce or regenerate locally, with the exception of those that are characteristic of the lower and middle strata of the forest.

The individuals found for each ecological group were grouped into diametric classes in order to observe the successional stage in which the vegetation of the area is. In the graph of all individuals (A), the 821 trees were grouped into 11 diameter classes, with an amplitude of 142.29 cm and a class interval of 12.94 cm (Figure 1).

The diameter structure of the individuals showed an unbalanced pattern with the apex of individuals in the second diameter class, this behavior was also observed in each of the ecological groups. However, the first two classes represent about 70.89% of the 821 individuals distributed in the area.

Taking into account that the area has already been managed, the distribution did not show the typical pattern of uneven forests forming a reverse "J" (Meyer, 1952). It was found that tree species in managed forests in the State of Pará presented balanced diametric structure, despite the evident decrease in absolute density (Vieira et al., 2014; Vieira et al., 2015).

Due to the forest management that took



** Número de indivíduos = number of individuals*

** Centro de classes(cm) = center of classes (cm)*

Figure 1. Diametric distribution of individuals (A), and of pioneer ecological groups (B), early secondary (C) and late secondary (D); of tree species in the forest management plan, from the Wood Industry Rio Formoso, Dueré municipality, Tocantins.

place in the area, it was observed that the distribution of diameters presented a smaller number of individuals in the diameter classes above 50 cm, this pattern in behavior was also observed in the distribution of individuals of each ecological group.

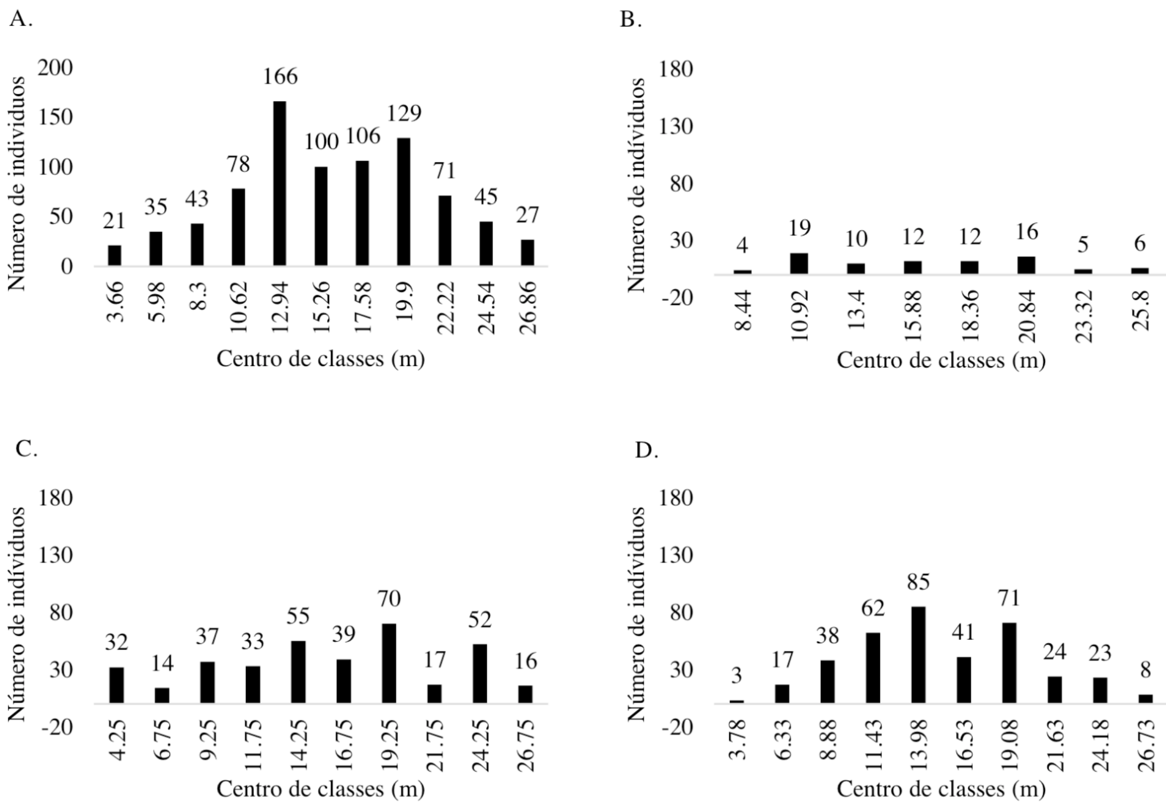
The diametric distribution corroborates the results found by the asymmetry and kurtosis coefficient, which say that the frequency distribution has a positive and leptokurtic asymmetry, presenting a frequency peak and then a curve reduction with a certain degree of deviation to the right side. The Liocourt quotient was calculated to observe whether there is a discrepancy between mortality and recruitment percentages for each diameter class (Table 5).

The values of Liocourt's "q" quotient for the studied region showed that there was not a constant ratio between the classes, indicating that the recruitment rate is not similar to the mortality rate, and the distribution can be considered irregular or unbalanced, since that their values did not remain constant, even considering a great capacity for natural regeneration. In addition, the Liocourt values demonstrate that there was no recruitment of individuals in the larger diameter classes.

Then, the distribution of individuals into height classes was carried out (**figure 2**);

Ecologic groups	Liocourt Coefficient "q" ratio										
	q1	q2	q3	q4	q5	q6	q7	q8	q9	q10	q11
All	2,7	0,7	0,5	0,8	0,8	0,4	0,4	0,3	0,7	1,0	0,0
Pioneer	1,3	0,2	0,6	0,8	0,0	0,0	0,0	0,0	-	-	-
Initial Secondary	1,2	0,5	0,5	0,2	0,4	0,0	0,0	0,0	0,0	0,0	-
Late secondary	5,7	2,2	1,6	1,4	0,5	1,7	0,3	1,0	0,3	0,0	-

Table 5. Liocourt's "q" quotient between the diameter classes of the trees in the studied area.



** Número de indivíduos = number of individuals*

** Centro de classes(m) = center of classes (m)* the evaluation of the height variable better describes the vertical stratification of a forest, which is of great value for forest management studies (Carvalho et al., 2016). Figure 2. Distribution in height classes of individuals (A), and for ecological groups pioneer (B), early secondary (C) and late secondary (D), the tree species of the forest management plan, from Wood Industry Rio Formoso, located in the municipality of Dueré, south of Tocantins.

When evaluated, all individuals together, a normal distribution of total height (70.15%) is observed. When analyzed by ecological group, the behavior of the species indicates that they react to the environment in a varied way, thus expressing a very heterogeneous growth in height. For Cunha & Finger (2013), the growth of a tree can be influenced by climatic, environmental, biological factors and by the competition itself with other trees and other types of vegetation, causing them to present different variations in their dimensions in height, diameter, volume, basal area and weight.

CONCLUSION

The highest values of importance were found by the species: *Caraipa densifolia, Protium heptaphyllum, Calophyllum brasiliense, Annona crassiflora, Annona squamosa*, indicating that the area is within the context of recovery, since the commercialized species are among the highest IVI, corroborating the richness of the Annonaceae, Calophyllaceae, Burseraceae and Lecythidaceae botanical families.

The middle stratum had 532 individuals (64.80%), demonstrating the presence of a continuous canopy, which influences the stage of ecological succession. This corroborates the phytosociological parameters found by the initial secondaries, indicating an intermediate stage regarding the successional development of the forest.

The volume, biomass and aerial carbon stocks were 355,068 m^3. ha^{-1}, 204,67 ton. ha^{-1} and 102,335 ton. ha^{-1}, respectively, being represented mostly by the species *Caraipa densifolia* (V= 120,499 m^3. ha^{-1}; B= 67,867 ton. ha^{-1}; CA= 33,934 ton. ha^{-1}); *Protium heptaphyllum* (V= 57,071 m^3. ha^{-1}; B= 32,462 ton. ha^{-1}; CA= 16,231 ton. ha^{-1}) and *Calophyllum brasiliense* (V= 46,738 m3. ha^{-1}; B= 26,259 ton. ha^{-1}; CA= 13,130 ton. ha^{-1}). Wood extraction caused changes in canopy opening, but no significant differences were found in floristic, p hytosociological composition or volume when compared with unmanaged forest formations of the same typology in the State of Tocantins, validating the hypothesis of this work.

However, the analysis of the diametric structure showed a typical pattern of "inverted-J" unbalanced, as it presented a smaller number of individuals in the first class. The values of Liocourt's "q" coefficient for the studied region showed that there was not a constant ratio between the classes, indicating that the recruitment rate is not similar to the mortality rate, and the distribution can be considered unbalanced or unbalanced, since that their values did not remain constant.

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