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ORIGINAL ARTICLE – Conservation of Nature

Floristic and Structure of Woody Vegetation in a Caatinga Area Between 2015 and 2019, in ASSÚ/RN

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Abstract

To characterize the floristic composition and horizontal structure of the National Forest of Açú from 2015 to 2019, 20 permanent plots of 400 m² were allocated, and all woody individuals with a diameter at breast height (CBH) ≥ 2 cm were measured on both occasions. Between 2015 and 2019, there was an increase in floristic richness from 23 to 34 species, especially *Cenostigma pyramidale* and *Handroanthus impetiginosus* due to their high phytosociological values. Although an 8.7% reduction in the number of individuals in the 4.4 cm class center was observed between the respective years, there was a volumetric increase of 4.85 m^3 ha^{-1}, that is 1.21 m^3 ha^{-1} $year^{-1}$. Changes in floristic composition, diameter distribution, and volumetry reflect the development of vegetation and part of its dynamics; indicating its state of conservation and, consequently, the achievement of the conservation objectives proposed by the Unit.

Keywords: Phytosociological parameters, dynamic processes, conservation unit.

1. INTRODUCTION AND OBJECTIVES

The length of the Caatinga biome occupies 11% of the national territory. There are about 27 million people inserted in this area, dependent on the resources extracted from this biome. As for its environmental importance, much of its biological heritage is endemic, that is, it cannot be found elsewhere in the world. Such importance, however, does not prevent 46% of its territory (844,453 km²) from being deforested (Brazil, 2019a).

Given this, over the last few years, the government has sought to solve the issue of deforestation through the initiative of creating more Conservation Units, such as the creation of the Furna Feia National Park in 2012, in the Municipalities of Baraúna and Mossoró, in the state of Rio Grande do Norte, with 8,494 ha. With these new units, the area now protected by conservation units in the biome increased to around 7.5%. Even though the biome will remain one of the least protected in the country as little more than 1% of such units are Full Protection (Brasil, 2018a).

In this reality, the Açú National Forest is inserted, an area occupied by the Caatinga biome in the Rio Grande do Norte. This Flona, which consists of one of the categories called the Conservation Unit for Sustainable Use, aims to make nature conservation compatible with the sustainable use of resources, reconciling the human presence in this conservation unit (Brazil, 2018a).

Thus, for the conservation objectives of these areas to be achieved, it is essential to formulate knowledge about the dynamic processes that occur in them. However, biodiversity conservation represents one of the greatest challenges of this century, due to the high level of anthropogenic disturbances in natural ecosystems. Therefore, it is necessary to carry out studies in forests to provide knowledge and maintenance of biodiversity, in addition to enabling the exploration of its products, goods, and/or services in a planned and rational way, ensuring their continuous flow of the resources that have been explored intensively around the world.

For Feeley et al. (2011) studying changes in composition improves not only the understanding of the ecology of tropical forests and their response to local and regional disturbances but also the ability to predict how future global changes may influence some vital services provided by these ecosystems.

Also, understanding the study of forest dynamics in protected areas allows future predictions regarding the development of the plant community. These studies are generally carried out using data from censuses in permanent plots, where countings, measurements, and then recount and remediation of surviving individuals (losses and gains) are carried out (Sheil & May, 1996).

The amount of studies evaluating the structure and composition of the Caatinga areas in Rio Grande do Norte, Brazil, is still small. Some of the more recent examples are Batista et al. (2019) who analyzed a closed shrub-tree Caatinga area in the municipality of Caicó; and Souza et al. (2020) in the municipality of Serra do Mel, in a shrub-tree Caatinga; among others (Amorim et al., 2005; Oliveira et al., 2012; Souza & Medeiros, 2013; Santana et al., 2016). The low number of studies of this nature in the region of Rio Grande do Norte results in a knowledge gap about the dynamics, structure, and composition of its flora and, consequently, it impoverishes the conservation and preservation policy of the remnant of Caatinga in the state that, currently, is more 2 million hectares - 91% of its total area of natural forests (Brasil, 2018b).

Given the above and the need to know the floristic composition and the behavior of the forest in response to human changes and natural disturbances, the Açú National Forest presents itself as an important resource for the study of these structural elements. Mainly, due to its conservationist character, which, due to its geographical location, is bordered by a local community, in addition to nearby ceramics industries. Thus, the objective of this work was to characterize the floristic composition and structure of the woody vegetation, in the period between 2015 and 2019, in an area of Caatinga in Assú/RN.

2. MATERIALS AND METHODS

2.1. Characterization of the study area

The study area is located in the municipality of Assú, in Rio Grande do Norte, which corresponds to the National Forest of Açú (5º34'20"S; 36º54'33" W), with a total area of 432,518 ha. The climate, according to the Köppen classification, is characterized as BSh (Dubreuil et al., 2018), with an average annual temperature of 28.1°C. The average annual rainfall is 646 mm (IDEMA, 2018). Between January 2015 and September 2019, there was an accumulated rainfall of 2,980.6 mm in the municipality (EMPARN, 2019).

The predominant soil in the region is the Litholic Neosols in association with Latosol. Being it deep and demonstrates a developed weathering stage, with strong removal of silica and soil bases. In addition to the Chernozem, which has a good degree of fertility (Bandeira et al., 2016).

According to the technical manual on Brazilian vegetation (Brazil, 2019b), the vegetation is classified as steppe wooded savanna, once two strata were observed: a sparse upper shrub-tree and a lower grassy-woody one, with the presence of some endemic species that characterize this vegetation, such as *Commiphora leptophloeos* (Imburana) and *Pilosocereus gounellei* (Xique-xique).

From 1950 to 2001, when the area was a forest garden, seedling production activities were carried out, with distribution even to other states. Thus, for playing the role of an experimental station for a long period, two areas of forestry experiment with native species were implanted in Flona, namely: *Auxemma oncocalyx*, *Myracrodruon urundeuva*, *Aspidosperma pyrifolium* and *Mimosa Caesalpiniifolia*, with an area of 2,022 ha, in addition to an area of 3.124 ha designated for the experiment with *Eucalyptus*. However, currently, maintenance activities are not carried out in these experimental areas.

2.2. Data collection

In 2015, twenty permanent plots of 20 x 20 m were randomly installed, corresponding to a sample area of 8,000 m² (Figure 1). In 2019, by partial replacement of parcels, a new forest inventory was carried out. The partial replacement occurred due to the lack of elements (wooden pickets and biodegradable demarcation tapes) that characterized the same parcel, referring to the year 2015. But, in any case, the parcels were very close, because of the use of the corresponding geographical coordinates.

On both occasions (2015 and 2019) all woody shrub-tree individuals with a Diameter at Breast Height (DBH) ≥ 2 cm were measured and labeled. The height of the individuals was estimated using a 6-meter long trimmer.

The unidentified species in the field had their botanical material collected, registering the plant number for later identification. Financial limitations, distance, logistics, and ignorance of the phenological patterns of some species in the Caatinga, made it impossible to travel, coinciding with periods favorable to the collection of fertile material. Therefore, the recognition of the species was based on the experience of the team members, a handyman, a forest worker, who has worked at Flona for many years and, in the absence of this, green branches were collected to assemble dried mushrooms and sent to the Ecology Laboratory of the EAJ/UFRN. For the botanical classification, the APG IV system (2016) was followed.

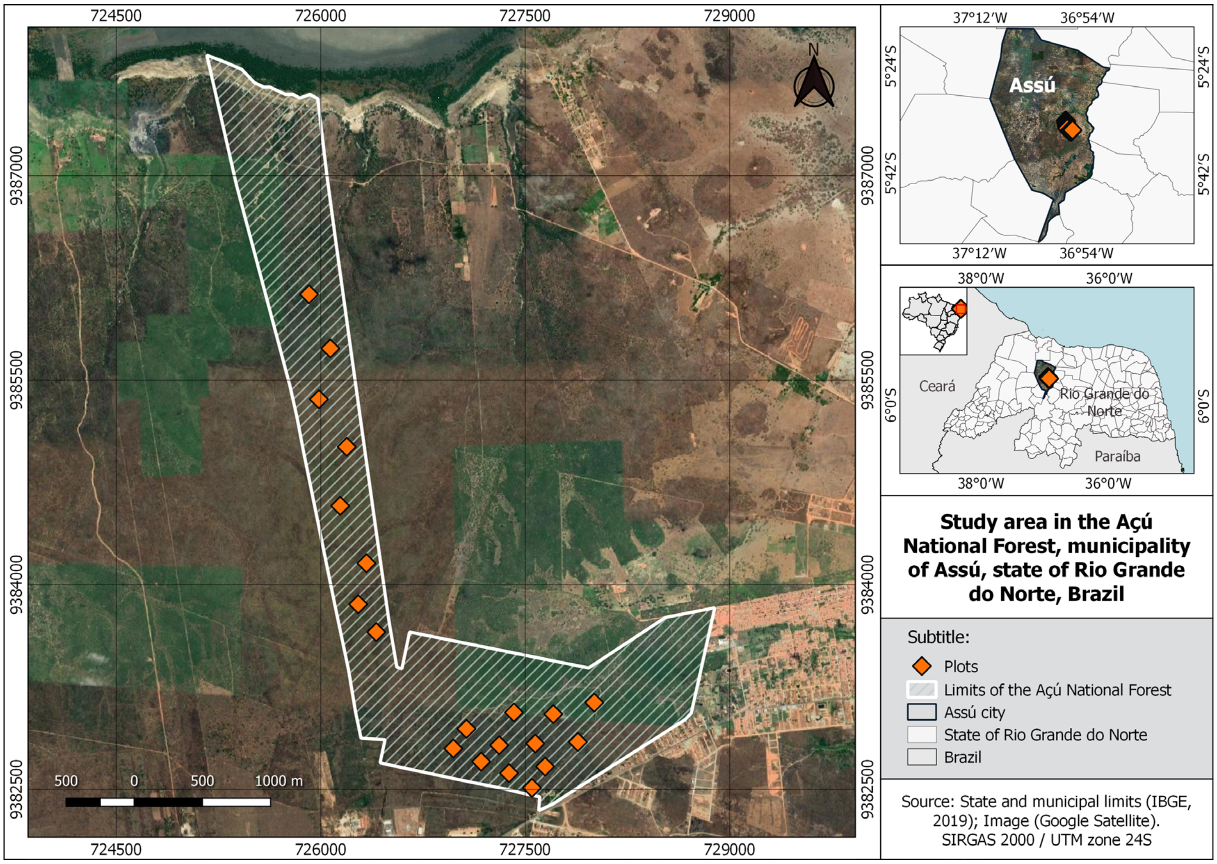

Figure 1. Location of plots within the limits of the National Forest of Açú, in Assú/RN, Brazil.

2.3. Data analysis

To analyze the sample sufficiency for the years 2015 and 2019, the Statistical and Genetic Analysis System (SAEG) was used. The parameters of the horizontal structure and floristic diversity of the vegetation were analyzed according to Felfili & Rezende (2003), and the calculations were performed with the help of the Software Mata Nativa © version 2.0.

The parameters of richness and diversity were calculated for the survey years, as follows: (1) Shannon Index – H' (Shannon, 1948); (2) Pielou Equability – J' (Pielou, 1975); and (3) Simpson dominance – C (Simpson, 1949).

$$H' = -\sum_{i=1}^{S} p_i \ln p_i \tag{1}$$

$$J = \frac{H}{H_{\max}} \tag{2}$$

$$C = \sum_{i=1}^{S} \frac{ni(ni-1)}{N(N-1)} \tag{3}$$

Where: ni = number of individuals sampled from the i-th species; N = total number of individuals sampled; S = number of species or richness; pi = relative abundance of each species, calculated by: ni/N; $H_{max} = \ln(S)$.

To determine the diametric distribution, the Sturges Finger Method (1992) was applied. Considering the existence of trees with more than one shaft in the plots, the equivalent diameter was used to define the diametric classes. This, in turn, was obtained by the following formula 4 (Soares et al., 2011):

$$d_{eq} = \sqrt{\sum DBH^2} \tag{4}$$

Calculations of volume and increment were performed according to UNDP / FAO / IBAMA (1992), applying the following expressions 5, 6 and 7:

$$CV_{c/c} = \frac{\pi (DBH)^2 * CH}{40000} \tag{5}$$

$$AV = CV_{c/c} * ff \tag{6}$$

Where: CVc / c = cylindrical volume of the bark tree; π = 3.1416; DBH^2 = diameter at breast height, squared (cm); CH = commercial height of the tree (m); 40,000 = DBHquadratic conversion factor from centimeters to meters; AV = actual volume (m^3); ff = form factor (0.7 dimensionless).

$$SV = AV * Sf \quad (7)$$

Where: SV = stacked volume (ts); AV = actual volume (m^3); sf = stacking factor (3.14 dimensionless).

The following formula 8 was used to analyze the annual periodic increment (Imaña-Encinas, 2005):

$$PAI = \frac{V_{2019} - V_{2015}}{P} \quad (8)$$

Where: PAI= Periodic Annual Increment, in volume; V_{2015} = Cylindrical volume calculated in 2015 (m^3 ha^{-1} $year^{-1}$); V_{2019} = Cylindrical volume in 2019 (m^3 ha^{-1} $year^{-1}$), P = measuring interval of 4 years.

3. RESULTS AND DISCUSSION

3.1. Floristic and diversity

In both measurements, it was found that the sampled area of 8,000 m^2 was sufficient for the floristic characterization of the remainder, with stabilization of the curve at 4,200 m^2 and 6,800 m^2. That is, for the twenty sample units inventoried between the years 2015 and 2019, the minimum floristically representative area was reached.

In 2015, 2,408 individuals were inventoried, belonging to 15 botanical families and distributed in 23 species. In 2019, 2,271 individuals were sampled, belonging to 16 families and distributed in 34 species, of which, three species were not identified (Table 1).

Considering that in 2015 the species richness (23 species) was lower compared to 2019 (34 species), it is possible to infer that in this interval the vegetation was expressed in a positive floristically.

This increase in richness may be associated with the increase in rainfall recorded between 2015 and 2019. In the year of the first collection, the average rainfall was 449.7 mm, while until September 2019 the average rainfall was 716.4 mm, an increase of 24.03% in precipitation compared to 2015. This issue was also reported by Silva (2017), in a 50-hectare Caatinga fragment in the city of Floresta/PE which, due to the low rainfall recorded between the years 2011 and 2015, it was possible to verify a decrease in the composition and number of individuals (Table 2).

Table 1. List of species found in the 2015 and 2019 surveys, in the National Forest of Açú, in Assú/RN.

Species	Popular name	Habit	2015	2019
ANACARDIACEAE				
Astronium urundeuva (M. Allemão) Engl.	Aroeira	Tree	x	x
APOCYNACEAE				
Aspidosperma pyrifolium Mart. & Zucc.	Pereiro	Tree	x	x
BIGNONIACEAE				
Handroanthus impetiginosus (Mart. Ex DC.) Mattos	Ipê-roxo	Tree	x	x
Tabebuia roseoalba (Ridl.) Sandwith	Peroba	Tree		x
BIXACEAE				
Cochlospermum vitifolium (Willd.) Spreng.	Pacotê	Bush/ Tree	x	x
BORAGINACEAE				
Cordia oncocalyx Allemão	Pau-branco	Tree	x	x
Cordia trichotoma (Vell.) Arráb. ex Steud.	Freijorge	Tree	x	x
BURSERACEAE				
Commiphora leptophloeos (Mart.) J.B. Gillett	Imburana	Tree	x	x
CAPPARACEAE				
Cynophalla flexuosa (L.) J.Presl	Feijão-bravo	Bush	x	x
COMBRETACEAE				
Combretum glaucocarpum Mart.	Sipaúba	Bush/ Tree	x	x
Combretum leprosum Mart.	Mofumbo	Bush	x	x
EUPHORBIACEAE				
Croton blanchetianus Baill.	Marmeleiro	Bush/ Tree	x	x
Jatropha mollissima (Pohl) Baill.	Pinhão-bravo	Bush/ Tree		x
Sapium glandulosum (L.) Morong	Burra-leiteira	Bush/ Tree		x
Sebastiania macrocarpa Müll.Arg.	Ramim-de-leite	Bush/ Tree		x

Table 1. Continued...

Species	Popular name	Habit	2015	2019
FABACEAE				
Anadenanthera colubrina (Vell.) Brenan	Angico	Tree	x	x
Amburana cearensis (Allemão) A.C.Sm.	Cumaru	Tree	x	x
Bauhinia cheilantha (Bong.) Steud.	Mororó	Tree	x	x
Cenostigma pyramidale (Tul.) E. Gagnon & G.P. Lewis	Catingueira	Tree	x	x
Lachesiodendron viridiflorum (Kunth) P.G. Ribeiro, L.P. Queiroz & Luckow	Surucucu	Tree	x	
Libidibia ferrea (Mart. ex Tul.) L.P.Queiroz	Jucá	Tree		x
Mimosa ophthalmocentra Mart. ex Benth.	Jurema-de-embira	Tree		x
Mimosa tenuiflora (Willd.) Poir.	Jurema-preta	Tree	x	x
Mimosa arenosa (Willd.) Poir.	Jurema-branca	Tree	x	x
Pityrocarpa moniliformis (Benth.) Luckow & R.W.Jobson	Catanduva	Tree		x
MALVACEAE				
Pseudobombax marginatum (A.St.-Hil., Juss. & Cambess.) A.Robyns	Embiratanha	Tree	x	x
NYCTAGINACEAE				
Guapira laxa (Netto) Furlan	João-mole	Bush/ Tree	x	x
OLACACEAE				
Ximenia americana L.	Ameixa	Tree	x	x
RHAMNACEAE				
Sarcomphalus joazeiro (Mart.) Hauenshild	Juazeiro	Tree	x	
RUBIACEAE				
Genipa americana L.	Jenipapo	Tree		x
Guettarda angelica Mart. ex Müll.Arg.	Angélica	Bush/ Tree		x
SAPOTACEAE				
Sideroxylon obtusifolium (Roem. & Schult.) T.D.Penn.	Quixabeira	Tree		x
SOLANACEAE				
Brunfelsia uniflora (Pohl) D.Don	Manacá	Bush	x	x

Table 2. Data from some of the studies carried out in Caatinga areas.

Local	P (mm)	Dominant soil	S	DA (ind. ha^{-1})	DoA (m^2 ha^{-1})	Reference
Floresta, PE	503	Luvissolos/ Planossolos	20	580.63	2.437	Silva (2017)
Floresta, PE	503	Luvissolos	23	864.38 (2008); 1070.63 (2011)	2.438 (2008); 2.376 (2011)	Pimental (2012)
Floresta, PE	432	Luvissolos	23	835.63 (2008); 866.88 (2012)	1.726 (2008); 2.759 (2012)	Barreto (2013)
Bom Jesus, PI	1002	Latossolo Amarelo Distrófico	31	1605.77 (2016); 1513.46 (2019)	3.567 (2016); 3.294 (2019)	Silva et al. (2020)
Barra de Santa Rosa, PB	300	-	22	2879	12.118	Almeida Neto et al. (2009)
Serra da Raiz, PB	800-1000	Argissolo Vermelho Amarelo	53	1584	7.822	Cordeiro et al. (2017)

Legend: S – Species richness; DA - Absolute Density; DoA - Absolute Dominance.

As for floristic diversity, the Shannon-Weaver (H') diversity indexes for 2015 and 2019 were: 1.81 nats ind^{-1} and 2.18 nats ind^{-1}, respectively (Table 3). These results corroborate with the interval found by Silva (2017) in areas of Caatinga, where Shannon's diversity index varied from 0.23 to 3.74. While the equability indices (J') remained close to 0.7 in both periods, the dominance index (C) increased in 2019, indicating that certain species stood out in population density.

Table 3. Wealth and diversity parameters between the years 2015 and 2019 in the Açú National Forest, in Assú/RN.

Year	H'	C	J'
2015	1.81	0.76	0.69
2019	2.18	0.96	0.68

Legend: H' – Shannon's Diversity Index; J' – Pielou equability; C – Simpson dominance.

Some authors obtained lower values of H' than that found for Flona de Açú, as shown by Pessoa et al. (2008), in a Caatinga area in the Rio Grande do Norte, whose value was 1.10 nats $ind.^{-1}$, Andrade et al. (2005), in two areas in the Cariri of Paraíba, who reported rates of 1.51 and 1.43 nats $ind.^{-1}$; and Holanda et al. (2015), whose diversity values, for two environments, were 0.8 and 1.21 nats ind^{-1}.

In fragments of Caatinga in the state of Minas Gerais, transition zones with the Cerrado, where the Caatinga has a more arboreal size, Apgaua et al. (2014) and Menino et al. (2015) recorded H 'values greater than 3.0 nats ind^{-1}. As shown by Andrade et al. (2005): the higher the diversity index, the more uniform the distribution of individuals between species; this index has a positive correlation with the number of species.

3.2. Horizontal structure

Regarding phytosociological parameters (Table 4), it is observed that the species with the highest absolute density were repeated in the years of collection, being: *Handroanthus impetiginosus and Cenostigma pyramidale*, representing 53.94% and 54.20% respectively, about the total density of the area.

The species with the highest frequency values, that is, those that occur in all parcels, were repeated for the two years analyzed, being: *Cenostigma pyramidale*, *Mimosa arenosa* and *Handroanthus impetiginosus*, this indicates not only abundance but good distribution in the area. Standing out C. *pyramidale* and H. *impetiginosus* for their high values of density, frequency, and dominance over other taxa, reflecting their relevance in the forest formation of Flona.

Table 4. Phytosociological parameters refer to Absolute Density (AD), Absolute frequency (AF), Absolute dominance (DoA), and importance value (IV) of the woody species sampled in the years 2015 and 2019 in the Açú National Forest, in Assú/RN.

Species	2015				2019			
	DA	AF	DoA	IV	DA	AF	DoA	IV
Cenostigma pyramidale	526	100	4.58	22.63	559	100	5.30	24.88
Handroanthus impetiginosus	1098	90	2.09	21.06	980	85	1.62	18.57
Bauhinia cheilantha	249	100	0.17	6.05	163	75	0.15	4.37
Combretum glaucocarpum	235	85	0.34	5.99	83	55	0.11	2.78
Aspidosperma pyrifolium	73	90	0.69	5.39	45	65	0.43	3.54
Mimosa arenosa	175	95	0.24	5.30	144	80	0.32	4.79
Ximenia americana	151	70	0.26	4.39	20	20	0.04	0.89
Commiphora leptophloeos	35	60	0.54	3.70	30	70	0.51	3.72
Combretum leprosum	100	60	0.19	3.34	4	5	0.00	0.18
Myracrodruon urundeuva	29	60	0.39	3.18	23	55	0.61	3.53
Amburana cearensis	35	35	0.52	2.94	14	30	0.09	1.24
Cynophalla flexuosa	49	65	0.12	2.70	31	50	0.09	1.96
Croton blanchetianus	75	55	0.06	2.53	33	50	0.05	1.87
Pseudobombax marginatum	28	50	0.15	2.15	43	50	0.42	3.08
Auxemma oncocalyx	59	25	0.20	1.94	175	40	0.59	4.88
Anadenanthera colubrina	28	40	0.07	1.62	46	45	0.19	2.32
Cochlospermum vitifolium	20	30	0.08	1.28	35	45	0.10	1.91
Cordia trichotoma	14	35	0.03	1.21	16	30	0.03	1.07
Guapira laxa	14	30	0.02	1.05	8	5	0.02	0.29
Mimosa tenuiflora	10	5	0.11	0.58	9	5	0.08	0.47
Lachesiodendron viridiflorum	6	15	0.01	0.52	-	-	-	-
Brunfelsia uniflora	3	10	0.00	0.31	16	25	0.01	0.90
Sarcomphalus joazeiro	1	5	0.00	0.15	-	-	-	-
Sapium glandulosum	-	-	-	-	194	70	0.22	4.79
Sideroxylon obtusifolium	-	-	-	-	83	40	0.08	2.28
Undetermined III	-	-	-	-	14	25	0.04	0.94
Genipa americana	-	-	-	-	15	25	0.01	0.87
Undetermined I	-	-	-	-	10	25	0.01	0.82
Undetermined II	-	-	-	-	11	15	0.05	0.69
Libidibia ferrea	-	-	-	-	5	15	0.02	0.52
Mimosa ophthalmocentra	-	-	-	-	5	10	0.05	0.48
Sebastiania macrocarpa	-	-	-	-	13	5	0.04	0.40
Tabebuia roseoalba	-	-	-	-	5	10	0.01	0.35
Pityrocarpa moniliformis	-	-	-	-	4	5	0.01	0.21
Jatropha mollissima	-	-	-	-	5	5	0.01	0.21
Guettarda angelica	-	-	-	-	3	5	0.00	0.17
Total	3010	1210	10.86	100	2839	1240	11.31	100

However, it is noteworthy that an isolated phytosociological parameter does not provide a clear ecological idea of the community or plant populations. Together, they can characterize formations, and their subdivisions, and provide information about stages of community development, distribution of environmental resources among populations, and possibilities of using plant resources, among others (Sampaio et al., 1993).

It is understood that these are the species most adapted to the forestry component, mainly concerning site conditions, such as soil texture, regeneration maturity, unevenness, and relief. This demonstrates better adaptability of *H. impetiginosus* and *C. pyramidale* in an area with stony soil, slightly inclined relief, and regeneration in a medium to an advanced stage, indicating that these qualitative characteristics intrinsic to the area, favor the establishment and survival of these species.

Notably, *C. pyramidale* adapts very well to different types of soil, including the poorest, and especially the stony soils, common in the Caatinga (Maia, 2012). Its distribution is not linked to landscape units (Silva et al., 2013), and may occur both on crystalline basement soils and sedimentary sandy surfaces (Cardoso & Queiroz, 2008). It is endemic to the Caatinga biome and has a wide geographical distribution in the Northeast of Brazil, being found in several environments and often occupying the top of the floristic lists in the region (Sampaio, 1996; Sabino et al., 2016; Matias et al., 2017). It is not only environmental but also social, because of its therapeutic and medicinal potential (Silva et al., 2015).

In contrast to the frequency and dominance of *C. pyramidale* in the Flona area, in 2015 and 2019, the species *H. impetiginosus* resulted in a larger number of individuals sampled, therefore having a higher density. This is a species with high landscaping and timber potential, in addition to its ecological value. It demonstrates plasticity to the variation of water and light, with instant and intrinsic efficiency in the use of water under water stress, which favors the survival and establishment of the species in the field (Dombroski et al., 2014).

Thus, the occurrence of a greater number of individuals of *H. impetiginosus* in the years 2015 and 2019, highlights the importance of conservation units, guaranteeing the conservation of species that, due to their vegetative characteristics of social and economic interest, have been targeted by anthropic action. Therefore, it can be said that Flona de Açú has contributed to the perpetuation of this, and other species present in its area of occurrence favoring the conservation of this Caatinga forest remnant.

As for the importance value between the years, 2015 and 2019 indices of less than one percent were found. In 2015, these species with low VI were: *Mimosa tenuiflora* (0,58%), *Lachesiodendron viridiflorum* (0.52%), *Brunfelsia uniflora* (0.31%), and *Sarcomphalus joazeiro* (0.15%), that together represent 17.39% of total species. While in 2019, VI was less than one percent in 48.38% of total species, which are: *Guettarda angélica* (0.17%), *Guapira laxa* (0.29%), *Libidibia ferrea* (0.52%), Undetermined I (0.82%), Undetermined II (0.69%), Undetermined III (0.94%), *Tabebuia roseoalba* (0.40%), *Ximenia americana* (0.89%), *Combretum leprosum* (0.18%), *Mimosa tenuiflora* (0.47%), *Brunfelsia uniflora* (0.90%), *Genipa americana* (0.87%), *Mimosa ophthalmocentra* (0.48%), *Pityrocarpa moniliformis* (0.21%) and *Jatropha mollissima* (0.21%).

It is possible to infer that after four years, there was a significant increase in the percentage of species with VI below one percent, from 17.39% in 2015 to 48.38% in 2019. Possibly, due to the greater number of species found in the 2019 survey. Santana & Souto (2006); Maker & Andrade (2007) state that the presence of a high number of species with VI less than one percent, is not common in areas of Caatinga. Thus, it is noted that the plantations carried out in the area, with native species from the Flona, have been reflected in the increase in the floristic diversity of the area.

In studies on the Caatinga, it is noted that the species with the highest density and importance value commonly remain the same over time (Pimentel, 2012; Barreto, 2013; Silva et al., 2020), Table 2. In this study, this pattern was observed, except for some species that showed an increase in VI in 2019, which are: A. *oncocalyx,* S. *glandulosum,* and P. *marginatum.*

Among the species with a high importance value, *C. leptophloeos* and *M. urundeuva* stand out as indicator species of the protected environment. According to Andrade et al. (2005), these species are commonly found in more protected areas or well-preserved plant formations, and rarely found in areas with a high degree of anthropization.

3.3. Diametric distribution

Regarding the diametric distribution, in both periods, it follows the inverted J curve, common in unequal forests, bringing together most individuals in the smaller diameter classes (Figure 2), which represents the forest's self-regenerative capacity (dynamic balance). The highest values were observed in 2015, in the first (1936) and second (258) classes, corresponding to 80.39% and 10.71% of the total number of individuals, respectively. Similarly, in 2019 there was a greater concentration of individuals in the first two classes, which together make up 90.48% of the total number of individuals.

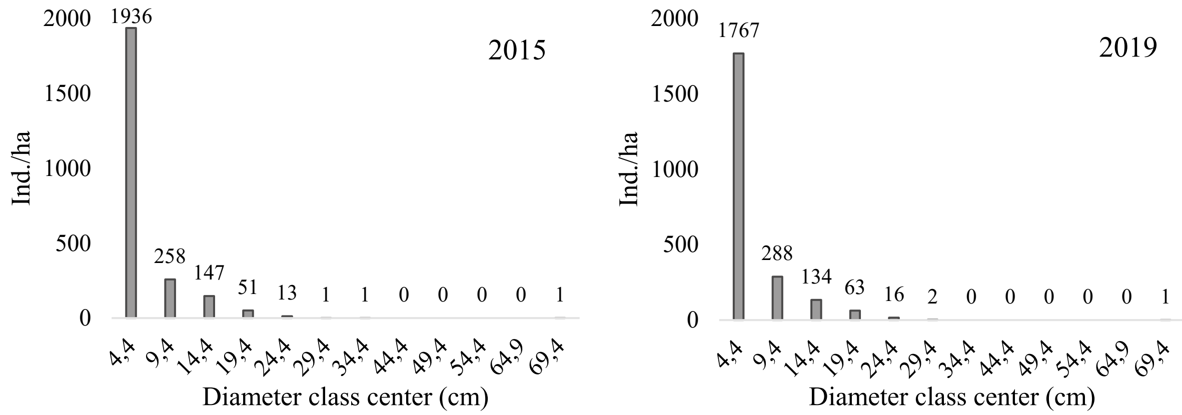

Figure 2. Diametric distribution of individuals inventoried in 2015 and 2019 in the Caatinga area in the Flona de Açú, in Assú/RN.

The reduction of 8,7% of the number of individuals in the first-class center (4,4 cm) between 2015 and 2019 is related to the rain factor since for the years 2015 and 2016 rainfall of 449.7 and 400.0 mm were recorded respectively.

In several studies (Dantas et al., 2010; Pereira Junior et al., 2012; Marangon et al., 2013) carried out in the Caatinga area, the diametric distribution followed the inverted J curve. Like the work developed in Barra de Santa Rosa/PB, where 2,690 individuals were inventoried, of which 73.4% were in the first-class center, followed by 21%, in the second class center (Almeida Neto et al., 2009). Similar results, in heterogeneous multi-forest, were obtained by Lima et al. (2013), Hoffmann (2013), and Silva et al. (2020).

Souza et al. (2006), affirm that the diametric structure of the forest is characterized by the higher frequency of small trees in the smallest diameter classes. For Menino et al. (2015), the high number of young individuals points to a good development of regeneration and the differences in the diametric structure indicate the use of different strategies for vegetation. While in environments with fewer resources, plants tend to adopt conservative strategies, under more favorable conditions, acquisition strategies with greater investment in reproduction and rapid growth predominate (Lohbeck et al., 2015).

3.4. Volumetry and increment

The absolute dominance estimated for the survey in 2015 was 10.85 $m^2\ ha^{-1}$ and, for 2019, 11.31 $m^2\ ha^{-1}$ 2019 (Table 5). This increase between the first and the second collection explains the satisfactory development of the forest community. On the other hand, in an area of Caatinga in Paraíba, still considered to be in the process of natural regeneration, with a tendency of anthropic disturbance for logging, Cordeiro et al. (2017) found a low basal area value (7.82 m^2).

Table 5. Distribution by diameter class of absolute dominance (DoA), Volume, and Periodic Annual Increment (PAI) in a Caatinga area in Flona de Açú, in Assú/RN.

Class of DBH (cm)	DoA ($m^2\ ha^{-1}$)		Vol. Cil. ($m^3\ ha^{-1}$)		PAI ($m^3\ ha^{-1}\ a^{-1}$)	Vol. (st ha^{-1})		PAI (st $ha^{-1}\ a^{-1}$)
	2015	2019	2015	2019		2015	2019	
4.4	2.56	2.45	7.37	7.68	0.08	23.15	24.10	0.24
9.4	2.12	2.22	8.17	9.33	0.29	25.65	29.28	0.91
14.4	2.94	2.60	12.73	12.02	0.18	39.96	37.73	0.56
19.4	1.81	2.17	8.98	11.10	0.53	28.21	34.84	1.66
24.4	0.75	0.89	3.94	4.93	0.25	12.38	15.48	0.77
29.4	0.09	0.16	0.64	0.88	0.06	2.00	2.77	0.19
34.4	0.10	0.00	0.63	0.00	0.16	1.99	0.00	0.50
39.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
44.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
54.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
59.4	0.00	0.33	0.00	1.52	0.38	0.00	4.76	1.19
64.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
69.4	0.49	0.49	2.04	1.91	0.03	6.41	6.01	0.10
Total	10.85	11.31	44.50	49.35	1.21	139.74	154.97	3.80

Stereo volumes for Caatinga areas are directly influenced by anthropogenic factors and changes in the edaphoclimatic conditions inherent to the region, as can be seen in studies conducted by Riegelhaupt et al. (2010) when carrying out the inventory at Fazenda Recanto III, in the municipality of Lagoa Salgada/RN where they estimated a wood volume between 70 and 170 st ha^{-1}, already in the Sobral National Forest, in the municipality of Sobral/CE, these same authors report that the stacked volume varying between 119 to 149 st ha^{-1}.

Taking into consideration the adoption of the conversion factor (ff) 0.7 (UNDP/FAO/IBAMA, 1992), a solid volume of 44.50 m^3 ha^{-1} and 49.35 m^3 ha^{-1} was estimated for 2015 and 2019 respectively, allowing, in four years, a volumetric increase of 4.85 m^3 ha^{-1}, which may be associated with the increase in rainfall and partial replacement of some plots. In the year of the first collection, the average rainfall was 449.7 mm, the second-lowest average among the years in which the study was conducted. In contrast, until September 2019, the average rainfall was 716.4 mm, an increase of 24.03% in rainfall compared to the year 2015 (EMPARN, 2019).

This fact was also confirmed by Barreto (2013), in research on the dynamics of woody species in the Caatinga area, in the municipality of Floresta/PE, where he verified an increase in PAI, possibly associated with the adaptive characteristics of woody species and the higher values of precipitation in the years 2009 and 2010.

In a study on the stocks of volume, biomass, and carbon in the wood of Caatinga species in Caicó/RN, Santos et al. (2016) obtained a volume estimate of 15.5 m^3 ha^{-1}, considered low when compared to the other Brazilian phytophysiognomies. Fact justified by the occurrence of small and spaced trees. Thus, Meira Junior et al. (2016), show that the volume is closely linked to functional diversity and that, based on this relationship, it is possible to infer about the ecosystem services generated.

As for PAI, Araújo & Silva (2010) conducted a study at Fazenda Belo Horizonte, Mossoró/RN, in three years of inventory, obtained a result superior to that found in this work, of 1.83 m^3 ha^{-1} year^{-1}. While at Fazenda Dominga, Caicó/RN, Santos et al. (2016) calculated an increase of 0.77 m^3 ha^{-1}year^{-1}, considered very low by the authors.

Thus, the results presented in Table 5 show a progressive increase in dendrometric variables between the measurement periods, influencing the increase in the volumetric stock. This demonstrates the growth of Flona de Açú in the period from 2015 to 2019, considering the genetic and site factors.

4. CONCLUSIONS

The change in floristic composition in the range from 2015 to 2019 shows the advance of the forest, reflected in the increase in its richness and floristic diversity.

The species *Handroanthus impetiginosus* and *Cenostigma pyramidale* represent, in a more expressive way, the horizontal structure of the National Forest of Açú, presenting higher values of density, frequency, dominance, and importance value; thus, contributing to Flona's forestry formation.

The emphasis given to the species *H. impetiginosus* evidences the need for the continuous preservation of this species on site, to guarantee its survival and permanence in the plant community. Since the predominance of this species has not been common in other studies in the region.

The increase in woody biomass observed between the measurement years reflects the development of the vegetation, indicating its conservation status and part of its dynamics. Consequently, it indicates the achievement of the conservation objectives proposed by the Flona management plan.

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