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Phytosociology, diversity and ecological groups of the adult tree component of a forest remnant in Pernambuco – Brazil

Raquel Elvira Cola^{1*}, Anne Carolyne Silva Vieira², Lucas Galdino da Silva², Sthéfany Carolina de Melo Nobre¹, Maurício Leodino de Barros², Mayara Dalla Lana³, Regis Villanova Longhi⁴ and Carlos Frederico Lins e Silva Brandão²

¹Department of Forest Science, Federal Rural University of Pernambuco, PE, Brazil

²Engineering and Agrarian Sciences Campus, Federal University of Alagoas, AL, Brazil

³Federal Institute of Pernambuco – Garanhuns, PE, Brazil

⁴Institute of Biological Sciences, Federal University of Alagoas, AL, Brazil

ABSTRACT

The main objective of this study is to characterize the floristic richness, phytosociological structure, and classify the ecological groups of the adult tree component species in an area of ecological tension (Seasonal Forest and Caatinga) in Pernambuco - Brazil. The study was conducted in Atlantic Forest stretch in Pernambuco – Brazil, from April 2019 to February 2020. Methods adopted for this study includes the allocation of 20 plots, with dimensions of 10 m x 25 m, spaced in 25 m. Each adult individual, with a circumference at breast height (CBH 1.30 m) \geq 15 cm, was identified in the field. The softwares Mata Nativa version 2 and Excel 2019 were used to process the collected data. Sample sufficiency, classification of ecological groups, diversity, and phytosociology were analyzed. As a result of the research, the density of the adult tree component in the fragment was 1,888 ind.ha⁻¹, and the dominance was 21.64 m².ha⁻¹. These values are following the standards of other studies in Atlantic Forest in the State of Pernambuco. The botanical families with greatest richness are, respectively, Fabaceae, Myrtaceae, Annonaceae, Lauraceae, Elaeocarpaceae, Sapindaceae and Sapotaceae. Regarding the ecological groups, 46% of the species were classified as initial secondary. The species of greatest Value of Importance were *Guapira nitida*, *Buchenavia tetraphylla*, *Manilkara* sp., *Byrsonima crassifolia*, and *Sloanea obtusifolia*, respectively. The Shannon-Wiener Diversity Index (H') value was 3.21 nats.ind⁻¹, and the Pielou Uniformity Index (J) was 0.73. According to the results obtained, the development process of the adult tree component of the fragment was directly affected by the pasture matrix. However, species diversity has not been compromised, indicating the area's resilience potential.

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Keywords: horizontal structure, successional classification, area of ecological tension, brazilian northeast.

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24 **1. INTRODUCTION**

25
26 The Atlantic Forest is considered one of the regions with top priority for the conservation of
27 its biodiversity, where most species officially threatened with extinction in Brazil inhabit this
28 type of formation [1]. The forests inserted in the Northeast region of Brazil are the ones that
29 suffered most anthropic disturbances over the years, being completely fragmented.
30 Currently, most of its area is characterized by secondary forests [2,3].

31 The discontinuity and isolation of forests, a process that characterizes forest fragmentation,
32 causes higher sensitivity to disturbances, directly affecting the spatial distribution, availability
33 of natural resources, and, consequently, the survival of species occurring in the region and
34 the environmental services provided [4]. It is necessary to further study the effects of
35 fragmentation in the Atlantic Forest on its biodiversity [5]. Therefore, research works that
36 value the individualities of each region are essential to enable forest management more
37 faithful to nature. These studies involve analyzing the characteristics of the plant community
38 of a given area, such as successional classification, phytosociology, and diversity.

39 Secondary forests, formed by anthropic or natural disturbances, have ecological succession
40 as the main indicator of vegetation development. They may suffer the influence of invasive
41 species during the process, causing severe disturbances in the forest, according to the
42 degree of competition and the fragility of the environment in this phase [6,7]. Thus, to
43 analyze this process, the classification of ecological groups analyzes the successional stage
44 of the species found about many indicators such as the requirement for sunlight, life span,
45 dispersion, maturation, among other important aspects that will define, throughout the
46 succession process, the establishment of the individual in the community [8]. In this context,
47 ecological succession is one of the primary studies used to understand what measures are
48 needed to be taken to improve the condition of forest remnants, as well as whether these
49 measures are having an effect over time [9].

50 In addition to ecological succession, studies such as phytosociology allow the
51 characterization of diversity and biological structure in a given ecosystem. This type of study
52 aims to describe the quantitative characteristics of plant communities [10]. It can determine
53 the most important species within the tree component and, in this way, prioritize them and
54 define which measures are a priority for the preservation of the community [11,12]. This type
55 of analysis is widely used in other Brazilian states within the domain of the Atlantic Forest,
56 such as those by Araújo et al. [13], Marchiori et al. [14] and Fantini et al. [15] in the Rio
57 Grande do Norte, São Paulo and Santa Catarina, respectively.

58 The diversity of forest species is based on two aspects: richness and uniformity. While
59 richness refers to the number of species existing in the community, uniformity indicates how
60 many individuals exist for each species [10]. These analyses present the establishment of
61 populations of certain species in the environment. The forest remnants of the Brazilian
62 northeast have high diversity. The richness level of the species is higher when the area has
63 more protection from anthropic interference [16].

64 In this context, the objective of this study was to characterize the floristic richness,
65 phytosociological structure and classify the ecological group of species of the adult tree
66 component in an area of ecological tension (Seasonal Forest and Caatinga) in Pernambuco
67 – Brazil.

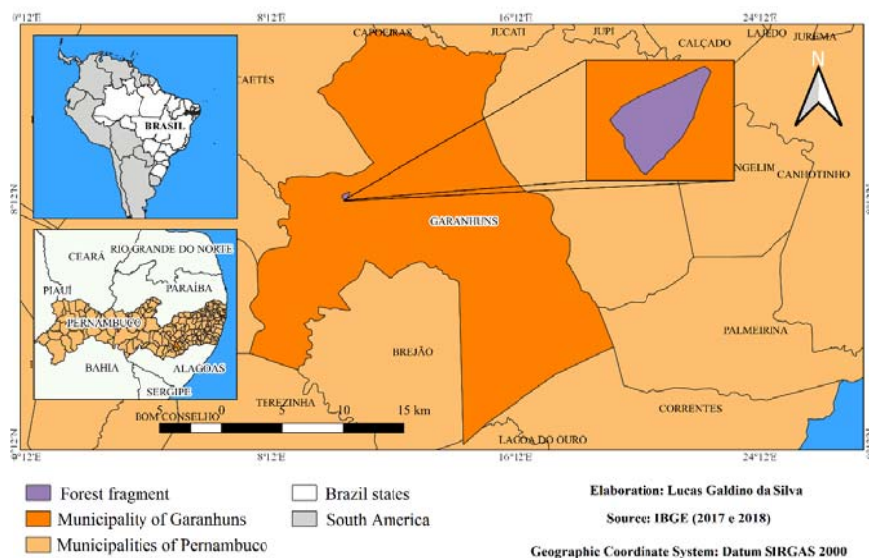
69 **2. MATERIAL AND METHODS**

70
71 **2.1 Study Area and Data Collection**

72
76 The municipality of Garanhuns, located in the State of Pernambuco - Brazil, has 458,552
77 km² of the territorial unit area [17]. The climate of this region is humid coastal tropical (As),
78 with an annual temperature average of 21.4°C and annual precipitation of 909 mm [18].
79 Also, it is a mountainous region with altitude quotas around 900 m [19].

83 Garanhuns is inserted in an area of ecological tension of the ecotone type between
84 Seasonal Forest and Caatinga [20]. The interaction between vegetation types is considered
85 as an area of ecological tension, where they can be divided into two groups: ecotones or
86 enclaves [20,21]. Ecotone is a transition system, where two or more types of vegetation
87 occur and cause an interpenetration, forming floristic transitions and edaphic contacts [22].
88 In these areas, there is a lack of studies regarding the understanding of the species behavior
89 [23].

86 Figure 1 shows the location of the section within the municipality of Garanhuns. The area of
87 the present study has 23 ha, with a perimeter of 2.1 km and the coordinates longitude
88 5°26'08.34" E and latitude 8°54'20.53" S.



87
88 **Fig. 1. Location of an Atlantic Forest stretch in Pernambuco, Brazil.**

93 Based on the researches of Silva et al. [24], Lima et al. [25], and Silva et al. [26], 20
94 permanent plots of 10 m x 25 m (spaced by 25 m) were systematically allocated, totaling a
95 sample area of 0.5 ha (Fig. 2). The plots were implanted in three tracks, being Track 1 with
96 seven, Track 2 with eight, and Track 3 with five plots. All adult individuals with a
97 circumference at breast height (CBH 1.30 m) ≥ 15 cm were identified in the field.



93
94 **Fig. 2. Trails representation, where the plots were allocated for the study of the adult**
95 **tree component of an Atlantic Forest stretch located in Pernambuco, Brazil.**

96
97 The identification of the individuals was made in the field with the help of a specialist,
98 according to the Angiosperm Phylogeny Group IV system [27], and the unidentified species
99 were photographed for consultation in herbarium or online literature, describing the species
100 according to their morphological characteristics. For the classification of ecological groups, it
101 was researched the classification of each species in books, scientific articles, theses, and
102 dissertations in regions close to the present study. For example, all volumes of Lorenzi's
103 book *Brazilian Trees* [28] were used, and the works of Carnaúba et al. [29] and Brandão et
104 al. [30].

105 The classification of ecological groups divided the species into: Pioneer – light-dependent
106 species that do not occur in the undergrowth; Initial Secondary – species that occur in
107 conditions of medium shading or not very intense luminosity; Late Secondary – species that
108 develop in the undergrowth in conditions of light or dense shade; and No Classification
109 [31,32].

110 **2.2 Sample Sufficiency and Data Analysis**

111
112 The statistical software Mata Nativa version 2 [33] was used for the calculation of sample
113 sufficiency, data processing, and analysis of phytosociological parameters. Excel for
114 Windows™ 2019 software was used for the generation of graphics.

115 The sample sufficiency of the survey was calculated for the basal area and density of the
116 individuals, considering a sampling error of at most 20% for 95% confidence probability. The
117 sufficiency of floristic richness was determined by the curve species x area, based on the
118 Fazenda Fojos's 23 ha stretch.

119 Species diversity was determined by Shannon-Wiener Diversity (H') and Pielou Uniformity
120 (J) indexes. According to Mueller-Dombois and Ellenberg [34] the following parameters
121 presented in Table 1 were used for the phytosociological analysis.

122

123 **Table 1. Phytosociological parameters used to analyze the horizontal structure of**
 124 **the adult tree component of an Atlantic Forest stretch located in Pernambuco, Brazil.**

Parameter	Expression	Variables
Absolute Density (AD)	$DA = \frac{n}{\text{Area}}$	n = number of individuals of a certain species.
Relative Density (RD)	$DR = \left(\frac{n}{N}\right) * 100$	N = total number of individuals.
Absolute Frequency (AF)	$FA = \left(\frac{pi}{P}\right) * 100$	Pi = number of plots (sample units) with occurrence of species i. P = total number of plots (sample units) in the sample. AFi = absolute frequency of a certain species.
Relative Frequency (RF)	$FR = \frac{FAi}{\sum FA} * 100$	∑AF = sum of the absolute frequencies of all sampled species.
Absolute Dominance (ADo)	$DoA = \frac{gi}{\frac{\pi \cdot DAP^2}{4}}$	gi = basal area of a certain species. DAP = diameter at the breast height.
Relative Dominance (RDo)	$DoR = \left(\frac{gi}{G}\right) * 100$ $G = \sum gi$	G = basal area of all sampled species.
Value of Importance (VI)	$VI = DR + FR + DoR$	

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126 The density expresses the total number of individuals in a given community concerning its
 127 area; the frequency is given by the number of times that a given species occurs in the
 128 sample units and represents the spatial uniformity of that species in the area; dominance
 129 indicates how much space area the species occupies by the basal area. Finally, the value of
 130 importance is given by adding the parameters mentioned above, pointing out which species
 131 is more important, in fact, for that community [10].

132

133 **3. RESULTS AND DISCUSSION**

134

135 The analysis of sample sufficiency (Table 2) for the 23 ha fragment showed that the number
 136 of plots implanted was sufficient to represent the population of the adult tree component to
 137 both parameters since six plots would be necessary according to the basal area, and 11
 138 plots according to density. Through the values of mean standard error (0.0246 m² e 3.1618
 139 ind/0.025 ha), coefficient of variation (20.54% e 30.28%), and sampling error (9.5% e 14%),
 140 it is possible to define statistically that the sampling of the study is satisfactory since the
 141 maximum error admitted was of 20%.

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143 **Table 2. Sample sufficiency and statistical data from the study on the adult tree component of an Atlantic Forest stretch located in Pernambuco, Brazil.**

Parameters	Basal Area (m ²)	Density (ind)
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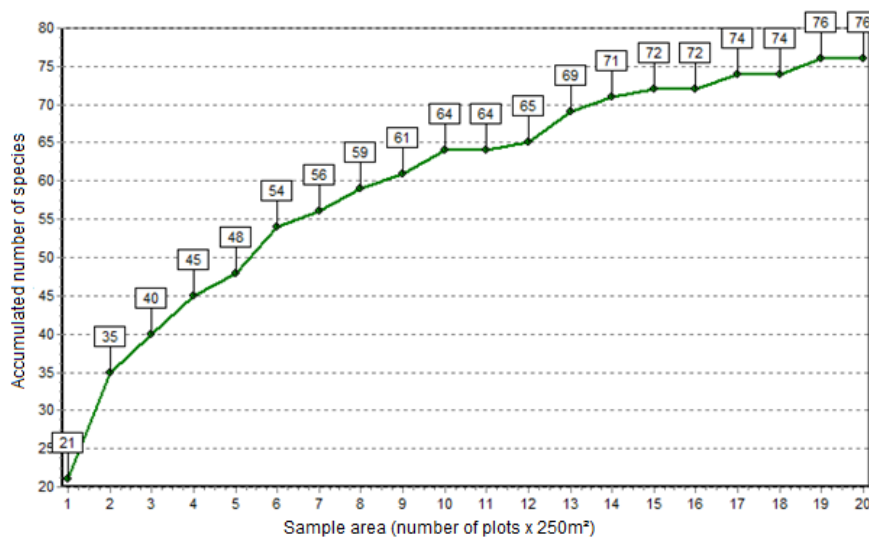
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n (optimal number of plots)	6 un.	11 un.
Total	10.818 m ²	944 ind.
Mean	0.5409 m ² /0.025ha	47.2 ind/0.025ha
Standard Deviation	0.1111 m ² /0.025ha	14.2961 ind/0.025ha
Variance	0.0123 (m ² /0.025ha) ²	204.3789 (ind/0.025ha) ²
Mean Variance	0.0006 (m ² /0.025ha) ²	9.9968 (ind/0.025ha) ²
Mean Standard Error	0.0246 m ² /0.025ha	3.1618 ind/0.025ha
Coefficient of Variation	20.5453 %	30.2884 %
Tabulated t value	2.093	2.093
Absolute Sampling Error	0.0514 m ² /0.025ha	6.6177 ind/0.025ha
Relative Sampling Error	9.5104 %	14.0204 %

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144 Figure 3 shows the curve of species x area, demonstrating that the number of species tends
 145 to stabilization from the 17th plot. Consequently, it is possible to affirm that the number of
 146 plots implanted in the study is enough to represent the floristic richness in the analyzed
 147 section.



148 **Fig.3. Species x area curve of the adult tree component of an Atlantic Forest stretch**
 149 **located in Pernambuco, Brazil.**
 150

151 Twenty-nine families, 45 genera, and 74 species were identified in the analyzed section
 152 (Table 3), of which 45 were identified at the species level, 16 at the genus level, seven at the
 153 family level, and six undetermined. The non-identification of all species occurred mainly in
 154 very high individuals, or in cases where it was not possible to collect fertile material.

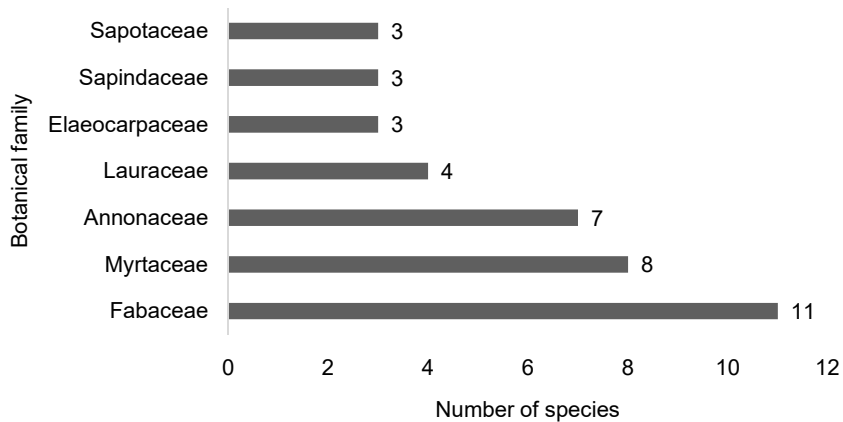
155 **Table 3. List of species found in the adult tree component of an Atlantic Forest**
 156 **stretch located in Pernambuco, Brazil.**

Family/Species	Ecological Group
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Anacardiaceae	
<i>Tapirira guianensis</i> Aubl.	IS
Annonaceae	
Annonaceae 1	NC
Annonaceae 2	NC
<i>Guatteria</i> sp. 1	IS
<i>Guatteria</i> sp. 2	IS
<i>Guatteria pogonopus</i> Mart.	IS
<i>Xylopia frutescens</i> Aubl.	P
<i>Xylopia ochrantha</i> Mart.	P
Boraginaceae	
<i>Cordia</i> sp.	NC
<i>Cordia superba</i> Cham.	IS
Burseraceae	
<i>Protium heptaphyllum</i> (Aubl.) Marchand	LS
<i>Protium</i> sp.	NC
Capparaceae	
<i>Crateva tapia</i> L.	P
Celastraceae	
<i>Maytenus distichophylla</i> Mart. ex Reissek	IS
<i>Maytenus erythroxyla</i> Reissek	IS
Chrysobalanaceae	
<i>Licania</i> sp.	NC
Clusiaceae	
<i>Clusia nemorosa</i> G.Mey.	IS
Combretaceae	
<i>Buchenavia tetraphylla</i> (Aubl.) R.A.Howard	IS
Elaeocarpaceae	
<i>Sloanea guianensis</i> (Aubl.) Benth.	LS
<i>Sloanea obtusifolia</i> (Moric.) Schum.	IS
<i>Sloanea</i> sp.	NC
Erythroxylaceae	
<i>Erythroxylum squamatum</i> Sw.	IS
Euphorbiaceae	
<i>Maprounea guianensis</i> Aubl.	IS
Fabaceae	
<i>Abarema</i> sp.	NC
<i>Albizia pedicellaris</i> (DC.) L.Rico	IS
<i>Bowdichia virgilioides</i> Kunth	P
<i>Chamaecrista ensiformis</i> (Vell.) H.S.Irwin & Barneby	IS
Fabaceae 1	NC
Fabaceae 2	NC
<i>Inga capitata</i> Desv.	IS
<i>Inga laurina</i> (Sw.) Willd.	IS
<i>Machaerium aculeatum</i> Raddi	P
<i>Stryphnodendron pulcherrimum</i> (Willd.) Hochr.	LS
<i>Tachigali densiflora</i> (Benth.) L.G.Silva & H.C.Lima	IS
Lauraceae	
Lauraceae 1	NC

<i>Ocotea gardnerii</i> (Meisn.) Mez	IS
<i>Ocotea glomerata</i> (Nees) Mez	IS
<i>Ocotea</i> sp.	NC
Lecythidaceae	
<i>Eschweilera ovata</i> (Cambess.) Mart. ex Miers	LS
Malpighiaceae	
<i>Byrsonima crassifolia</i> (L.) Kunth	P
Moraceae	
<i>Brosimum guianense</i> (Aubl.) Huber	IS
<i>Ficus</i> sp.	NC
Myrtaceae	
<i>Campomanesia</i> sp. 1	NC
<i>Campomanesia</i> sp. 2	LS
<i>Myrcia guianensis</i> (Aubl.) DC.	IS
<i>Myrcia splendens</i> (Sw.) DC.	IS
<i>Myrcia sylvatica</i> (G.Mey.) DC.	IS
Myrtaceae 1	NC
Myrtaceae 2	NC
<i>Psidium</i> sp.	NC
Nyctaginaceae	
<i>Guapira opposita</i> (Vell.) Reitz	IS
<i>Guapira nitida</i> (Mart. ex J.A.Schmidt) Lundell	IS
Ochnaceae	
<i>Ouratea hexasperma</i> (A.St.-Hil.) Baill.	IS
Peraceae	
<i>Pogonophora schomburgkiana</i> Miers ex Benth.	LS
Phyllanthaceae	
<i>Hieronyma alchorneoides</i> Allemão	IS
<i>Richeria</i> sp.	NC
Primulaceae	
<i>Myrsine guianensis</i> (Aubl.) Kuntze	P
Rubiaceae	
<i>Alseis pickelii</i> Pilg. & Schmale	IS
<i>Psychotria carthagenensis</i> Jacq.	IS
Rutaceae	
<i>Zanthoxylum rhoifolium</i> Lam.	IS
Salicaceae	
<i>Casearia sylvestris</i> Sw.	P
Sapindaceae	
<i>Allophylus</i> sp.	NC
<i>Cupania oblongifolia</i> Mart.	IS
<i>Cupania racemosa</i> (Vell.) Radlk.	IS
Sapotaceae	
<i>Chrysophyllum cainito</i> L.	IS
<i>Manilkara</i> sp.	NC
<i>Pouteria</i> sp.	NC
Simaroubaceae	
<i>Simarouba amara</i> Aubl.	IS

158 Regarding richness, the families that stood out were Fabaceae (14.8%), Myrtaceae (10.8%),
 159 Annonaceae (9.4%), Lauraceae (5.4%), Elaeocarpaceae (4%), Sapindaceae (4%) and
 160 Sapotaceae (4%) (Fig. 4).



161
 162 **Fig. 4. Botanical families with more species of the adult tree component of an Atlantic**
 163 **Forest stretch located in Pernambuco, Brazil.**

164 The richest family in this study was Fabaceae, represented by 11 species, *Abarema* sp.,
 165 *Albizia pedicellaris*, *Bowdichia virgilioides*, *Chamaecrista ensiformis*, Fabaceae 1, Fabaceae
 166 2, *Inga capitata*, *Inga laurina*, *Machaerium aculeatum*, *Stryphnodendron pulcherrimum*, and
 167 *Tachigali densiflora*. Fabaceae is one of the richest families among Brazil's ecosystems, with
 168 212 genera and 2,807 native species in Brazil [35,36]. This family has the characteristic of
 169 fixing nitrogen in the soil, which makes it a key-species in the recovery of degraded areas
 170 [37,38].

171 The Myrtaceae was represented by the species *Campomanesia* sp. 1, *Campomanesia* sp. 2,
 172 *Myrcia guianensis*, *Myrcia splendens*, *Myrcia sylvatica*, Myrtaceae 1, Myrtaceae 2 and
 173 *Psidium* sp. With about 1,000 species belonging to 23 genera, this family is dominant mainly
 174 in Atlantic Forests [39,40]. It has economic importance and is the eighth family with the
 175 highest diversity in the Brazilian Northeast [41].

176 Annonaceae is a family of pantropical distribution, with 30 genera and 260 species in all
 177 Brazilian forest formations [42,43]. In this study, it was represented by the species
 178 Annonaceae 1, Annonaceae 2, *Guatteria* sp. 1, *Guatteria* sp. 2, *Guatteria pogonopus*,
 179 *Xylopia frutescens*, and *Xylopia ochrantha*.

180 Lauraceae presented the species Lauraceae 1, *Ocotea gardnerii*, *Ocotea glomerata*, and
 181 *Ocotea* sp. Occurring mainly in neotropical regions, in lowland forests or intermediate
 182 altitudes, the family covers 18 genera and 125 species in the Brazilian Northeast, being one
 183 of the rich in diversity in different communities [44,45]. It is one of the families with the
 184 highest number of endangered species in Brazil (36 species), according to the Red List of
 185 Threatened Species [46].

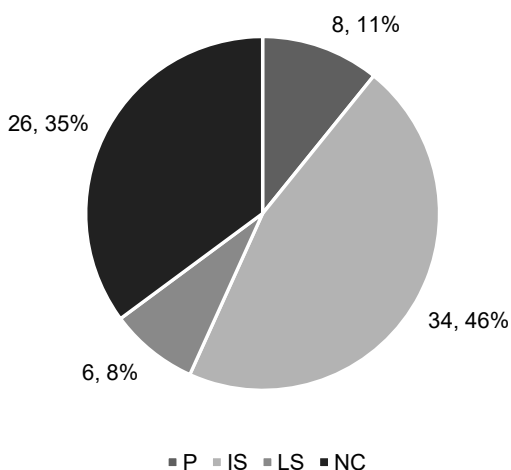
186 Elaeocarpaceae was represented by the species *Sloanea guianensis*, *Sloanea obtusifolia*,
187 and *Sloanea* sp. Its occurrence has a greater diversity in the Amazon but also occurs in the
188 biomes Caatinga, Cerrado, Atlantic Forest, and Pantanal [36].

189 Sapindaceae was represented by the species *Allophylus* sp., *Cupania oblongifolia*, and
190 *Cupania racemosa*. It is a family very characterized by endemism, with 88 endemic species
191 of 411 species occurring in Brazil, belonging to 25 genera [47,48]. It inhabits tropical and
192 subtropical regions, with some genera occurring in temperate regions [49].

193 Finally, the species *Chrysophyllum cainito*, *Manilkara* sp., and *Pouteria* sp. represented the
194 Sapotaceae family. This family has 13 genera in Brazil, encompassing 233 species [50]. In
195 addition to having food potential, the species of the genus *Pouteria* and *Manilkara* are great
196 attractions for the timber industry [51].

197 The relationship of ecological groups between the species found (Fig. 5) was 46% (34) for
198 initial secondary, 35% (26) for no classification, 11% (8) for pioneers, and 8% (6) for late
199 secondary. The representation of species with no classification occurred due to the species
200 identified at the level of genus, family, or indeterminate, where it is not possible to define the
201 ecological group. In the work of Sobrinho [52] and Santos [53], in two forests of
202 Ombrophilous Forest in the State of Pernambuco, the initial secondary ones were also more
203 represented in the classification of ecological groups of the reference ecosystem analyzed.
204 Carnaúba et al. [29] also found the same result in an Ombrophilous Lowland Forest.

205 The domain of species classified as initial secondary or pioneer suggests that the forest is
206 young [32], mainly because it means that most of the species there are come from the seed
207 bank, that is, it is a forest that was regenerated naturally not long ago.



208
209 **Fig. 5. Successional classification of the species of the adult tree component of an**
210 **Atlantic Forest stretch located in Pernambuco, Brazil.**

211 In the phytosociological survey, 944 adult individuals were measured, representing an
212 absolute density of 1,888 ind.ha⁻¹ and dominance of 21.64 m².ha⁻¹ (Table 4). The values
213 found are close to those of other authors who researched in the State of Pernambuco, such

214 as Nascimento and Rodal [54], who found a density of 1,553 ind.ha⁻¹ and dominance of 39
 215 m².ha⁻¹, and Costa Junior et al. [55], in which the density was 1,049 ind.ha⁻¹ and dominance
 216 of 23.6 m².ha⁻¹.

217 **Table 4. Phytosociological survey of the adult tree component of an Atlantic Forest**
 218 **stretch located in Pernambuco, Brazil.**

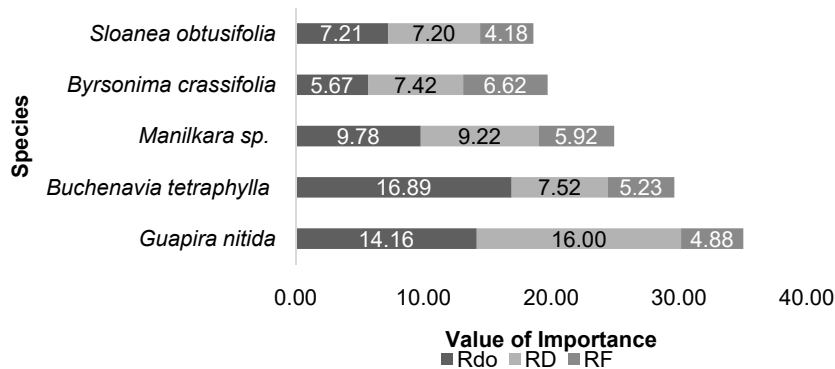
Species	NI	<i>ΣG</i>	ADo	RDo	AD	RD	AF	RF	VI
<i>Guapira nitida</i>	151	1.532	3.0635	14.16	302	16.00	70	4.88	35.03
<i>Buchenavia tetraphylla</i>	71	1.827	3.6539	16.89	142	7.52	75	5.23	29.64
<i>Manilkara</i> sp.	87	1.058	2.1150	9.78	174	9.22	85	5.92	24.91
<i>Byrsonima crassifolia</i>	70	0.613	1.2263	5.67	140	7.42	95	6.62	19.70
<i>Sloanea obtusifolia</i>	68	0.780	1.5608	7.21	136	7.20	60	4.18	18.60
<i>Bowdichia virgilioides</i>	48	0.494	0.9878	4.57	96	5.08	90	6.27	15.92
<i>Clusia nemorosa</i>	31	0.734	1.4678	6.78	62	3.28	60	4.18	14.25
<i>Guapira opposita</i>	31	0.751	1.5021	6.94	62	3.28	25	1.74	11.97
<i>Protium heptaphyllum</i>	38	0.220	0.4393	2.03	76	4.03	75	5.23	11.28
<i>Tapirira guianensis</i>	30	0.444	0.8876	4.10	60	3.18	45	3.14	10.42
<i>Cupania oblongifolia</i>	37	0.218	0.4366	2.02	74	3.92	60	4.18	10.12
<i>Guatteria pogonopus</i>	35	0.194	0.3878	1.79	70	3.71	60	4.18	9.68
<i>Alseis pickelii</i>	25	0.257	0.5137	2.37	50	2.65	55	3.83	8.86
<i>Campomanesia</i> sp. 2	29	0.106	0.2122	0.98	58	3.07	50	3.48	7.54
<i>Chrysophyllum cainito</i>	17	0.213	0.4267	1.97	34	1.80	30	2.09	5.86
Myrtaceae 1	22	0.064	0.1275	0.59	44	2.33	40	2.79	5.71
<i>Ocotea</i> sp.	24	0.215	0.4298	1.99	48	2.54	15	1.05	5.57
<i>Guatteria</i> sp. 2	15	0.076	0.1511	0.70	30	1.59	45	3.14	5.42
<i>Cordia superba</i>	12	0.076	0.1519	0.70	24	1.27	20	1.39	3.37
<i>Pouteria</i> sp.	3	0.137	0.2746	1.27	6	0.32	10	0.70	2.28
<i>Casearia sylvestris</i>	5	0.037	0.0745	0.34	10	0.53	20	1.39	2.27
<i>Cordia</i> sp.	6	0.021	0.0424	0.20	12	0.64	15	1.05	1.88
<i>Erythroxylum squamatum</i>	5	0.024	0.0479	0.22	10	0.53	15	1.05	1.80
<i>Sloanea</i> sp.	4	0.060	0.1191	0.55	8	0.42	10	0.70	1.67
<i>Sloanea guianensis</i>	5	0.034	0.0683	0.32	10	0.53	10	0.70	1.54
Lauraceae 1	3	0.090	0.1799	0.83	6	0.32	5	0.35	1.50
<i>Licania</i> sp.	3	0.014	0.0286	0.13	6	0.32	15	1.05	1.50
<i>Cupania racemosa</i>	3	0.013	0.0260	0.12	6	0.32	15	1.05	1.48
<i>Stryphnodendron pulcherrimum</i>	3	0.013	0.0253	0.12	6	0.32	15	1.05	1.48
<i>Albizia pedicellaris</i>	2	0.053	0.1059	0.49	4	0.21	10	0.70	1.40
<i>Pogonophora schomburgkiana</i>	1	0.070	0.1406	0.65	2	0.11	5	0.35	1.10
<i>Maytenus erythroxyla</i>	3	0.006	0.0128	0.06	6	0.32	10	0.70	1.07
<i>Myrcia splendens</i>	3	0.006	0.0125	0.06	6	0.32	10	0.70	1.07
<i>Brosimum guianense</i>	1	0.064	0.1289	0.60	2	0.11	5	0.35	1.05
<i>Protium</i> sp.	2	0.006	0.0125	0.06	4	0.21	10	0.70	0.97
<i>Ouratea hexasperma</i>	2	0.005	0.0101	0.05	4	0.21	10	0.70	0.96
<i>Ocotea gardnerii</i>	2	0.030	0.0598	0.28	4	0.21	5	0.35	0.84
<i>Crateva tapia</i>	1	0.036	0.0719	0.33	2	0.11	5	0.35	0.79
<i>Xylopia ochrantha</i>	3	0.010	0.0201	0.09	6	0.32	5	0.35	0.76

Comment [KM13]: or *Σgi*. In this line all variables are in italics.

<i>Chamaecrista ensiformis</i>	3	0.010	0.0195	0.09	6	0.32	5	0.35	0.76
<i>Abarema</i> sp.	3	0.008	0.0159	0.07	6	0.32	5	0.35	0.74
<i>Machaerium aculeatum</i>	2	0.016	0.0322	0.15	4	0.21	5	0.35	0.71
Undetermined 4	2	0.011	0.0219	0.10	4	0.21	5	0.35	0.66
<i>Guatteria</i> sp. 1	2	0.010	0.0193	0.09	4	0.21	5	0.35	0.65
<i>Maytenus distichophylla</i>	2	0.006	0.0119	0.06	4	0.21	5	0.35	0.62
<i>Maprounea guianensis</i>	1	0.015	0.0294	0.14	2	0.11	5	0.35	0.59
<i>Inga capitata</i>	1	0.014	0.0289	0.13	2	0.11	5	0.35	0.59
<i>Tachigali densiflora</i>	1	0.013	0.0257	0.12	2	0.11	5	0.35	0.57
Fabaceae 2	1	0.010	0.0201	0.09	2	0.11	5	0.35	0.55
<i>Ficus</i> sp.	1	0.010	0.0201	0.09	2	0.11	5	0.35	0.55
<i>Ocotea glomerata</i>	1	0.008	0.0162	0.07	2	0.11	5	0.35	0.53
<i>Eschweilera ovata</i>	1	0.007	0.0143	0.07	2	0.11	5	0.35	0.52
Myrtaceae 2	1	0.006	0.0118	0.05	2	0.11	5	0.35	0.51
Undetermined 6	1	0.006	0.0117	0.05	2	0.11	5	0.35	0.51
Annonaceae 2	1	0.006	0.0112	0.05	2	0.11	5	0.35	0.51
<i>Zanthoxylum rhoifolium</i>	1	0.006	0.0110	0.05	2	0.11	5	0.35	0.51
<i>Hieronyma alchorneoides</i>	1	0.005	0.0108	0.05	2	0.11	5	0.35	0.50
<i>Psychotria carthagenensis</i>	1	0.005	0.0100	0.05	2	0.11	5	0.35	0.50
<i>Myrcia sylvatica</i>	1	0.005	0.0099	0.05	2	0.11	5	0.35	0.50
Annonaceae 1	1	0.005	0.0094	0.04	2	0.11	5	0.35	0.50
<i>Simarouba amara</i>	1	0.004	0.0084	0.04	2	0.11	5	0.35	0.49
<i>Campomanesia</i> sp. 1	1	0.003	0.0069	0.03	2	0.11	5	0.35	0.49
Undetermined 1	1	0.003	0.0066	0.03	2	0.11	5	0.35	0.48
<i>Myrsine guianensis</i>	1	0.003	0.0061	0.03	2	0.11	5	0.35	0.48
<i>Xylopia frutescens</i>	1	0.002	0.0050	0.02	2	0.11	5	0.35	0.48
Undetermined 3	1	0.002	0.0049	0.02	2	0.11	5	0.35	0.48
Undetermined 5	1	0.002	0.0049	0.02	2	0.11	5	0.35	0.48
<i>Psidium</i> sp.	1	0.002	0.0049	0.02	2	0.11	5	0.35	0.48
Undetermined 2	1	0.002	0.0048	0.02	2	0.11	5	0.35	0.48
Fabaceae 1	1	0.002	0.0046	0.02	2	0.11	5	0.35	0.48
<i>Inga laurina</i>	1	0.002	0.0041	0.02	2	0.11	5	0.35	0.47
<i>Richeria</i> sp.	1	0.002	0.0041	0.02	2	0.11	5	0.35	0.47
<i>Allophylus</i> sp.	1	0.002	0.0036	0.02	2	0.11	5	0.35	0.47
<i>Myrcia guianensis</i>	1	0.002	0.0036	0.02	2	0.11	5	0.35	0.47
Total	944	10.818	21.64	100	1888	100	1435	100	300

219 *Where: NI = number of individuals sampled in the area of 0.5 ha; ΣG = sum of basal area
220 ($m^2 \cdot ha^{-1}$); ADo = absolute dominance ($m^2 \cdot ha^{-1}$); RDo = relative dominance (%); AD =
221 absolute density (individuals $\cdot ha^{-1}$); RD = relative density (%); AF = absolute frequency (%);
222 RF = relative frequency (%); VI = value of importance (%).

223 The species *Buchenavia tetrphylla*, *Guapira nitida*, and *Manilkara* sp. obtained the highest
224 values about relative dominance, density, and frequency, differing only the order between
225 them according to each parameter. Therefore, the five species of most significant value of
226 importance in the analyzed fragment were, respectively, *Guapira nitida*, *Buchenavia*
227 *tetrphylla*, *Manilkara* sp., *Byrsonima crassifolia*, and *Sloanea obtusifolia* (Fig. 6).



228
229 **Fig. 6. Five species with the highest value of importance of the adult tree component**
230 **of an Atlantic Forest stretch located in Pernambuco, Brazil.**

231 *Guapira nitida*, the most important species of the analyzed fragment, is part of the family
232 Nyctaginaceae. It is an initial secondary species, endemic to Brazil, and presents a shrubby
233 arboreal habit [56]. It occurs in Atlantic forests, being dense and open ombrophilous forest or
234 in sandbanks, or seasonal semi-deciduous lowland forest [57,58], but prefers the interiors of
235 the coastal Atlantic Forest, with the presence of humidity and shade [59].

236 *Buchenavia tetraphylla* belongs to the family Combretaceae, and it is characterized as initial
237 secondary. It is neotropical, occurring from the island of Cuba to the State of Rio de Janeiro
238 [60].

239 The genus *Manilkara* sp., of the Sapotaceae family, was identified in 19 species in Brazil, in
240 23 different vegetational formations, being them Amazon forest, Atlantic Forest, Caatinga
241 and Cerrado, with 12 occurring in the Brazilian Northeast [61,62]. However, some species of
242 the genus are not collected due to the vast territorial area of the States or the lack of
243 expeditions and research [63].

244 The species *Byrsonima crassifolia* is a pioneer species belonging to the family
245 Malpighiaceae, which occurs in all regions of Brazil, except in the southern region. It prefers
246 dry and elevated soils of sandy and poor soils [64]. Also, according to the author, *Byrsonima*
247 *crassifolia* is a deciduous, heliophytic, and selective xerophytic plant. Its frequency is
248 moderate to discontinuous, and its density varies according to the vegetation and region of
249 occurrence. This species is essential for the maintenance of solitary bees, animals that
250 naturally have their populations reduced [65].

251 *Sloanea obtusifolia* belongs to the family Elaeocarpaceae and occurs in the Atlantic Forest,
252 where there has been a drastic reduction of the original vegetation in the last ten years. It
253 belongs to the group of initial secondary. The population of the species is significantly
254 reduced due to the use of wood for various purposes, being considered "vulnerable" by the
255 Flora Red List of the Espírito Santo [66,67].

256 From these data, the Shannon-Wiener Diversity Index (H') calculated for this fragment was
257 3.21 nats.ind⁻¹. On the other hand, the Pielou Uniformity Index (J) was 0.73, that is, 73% of
258 uniformity.

259 The Shannon-Wiener Diversity Index (H') values in forest environments usually vary
260 between 1.5 and 3.5, sometimes exceeding 4 nats.ind⁻¹ [68]. The value found for this
261 parameter is following those found in other studies of different forest phytophysiognomies in
262 the State of Pernambuco, such as Cola et al. [69], with 3.44 nats.ind⁻¹; Silva Júnior et al. [70]
263 found 3.91 nats.ind⁻¹; and Rocha et al. [71] showing 3.6 nats.ind⁻¹. The value calculated in
264 the present study is within the forest environment standards mentioned earlier. Despite
265 being a secondary forest surrounded by pastures, the diversity index was not compromised.
266 As no exotic/invasive species were found, the process of regeneration of the environment is
267 satisfactory in terms of species diversity.

268 The Pielou Uniformity Index indicates that 27% more species are missing for the fragment to
269 reach its maximum point of diversity [72]. A similar result to those found by Santos [53],
270 which was 78%, and by Holanda et al. [73] of 77%, both in the State of Pernambuco. It can
271 be stated that the uniformity of the analyzed fragment is under the pattern of the fragments
272 of the region.

273 Although the property adopts agricultural and livestock production, these indices indicate
274 high diversity and uniformity. This aspect can be encouraged by the adjacent areas to the
275 fragment that were abandoned and allowed to regenerate.

276 4. CONCLUSION

277
278 In the present study, 74 tree species were found, belonging to 29 families, with a density of
279 1,888 ind.ha⁻¹ and the dominance of 21.64 m².ha⁻¹. These values agree with the values
280 found in studies in nearby regions. The botanical families greatest richness are, respectively,
281 Fabaceae, Myrtaceae, Annonaceae, Lauraceae, Elaeocarpaceae, Sapindaceae and
282 Sapotaceae.

283 Regarding the ecological groups, 46% of the species were classified as initial secondary.
284 This information demonstrates that the fragment is in a medium or secondary stage of
285 development, where, with no anthropic interference in the dynamics of the fragment, it can
286 reach maturity.

287 The most important species being *Guapira nitida*, *Buchenavia tetrphylla*, *Manilkara* sp.,
288 *Byrsonima crassifolia*, and *Sloanea obtusifolia*, respectively, four of them are characterized
289 as initial secondary and one of them as a pioneer. This information corroborates with the
290 analysis of succession found in the studied area, pointing to the medium stage of
291 regeneration.

292 The value of the Shannon-Wiener Diversity Index (H') was 3.21 nats.ind⁻¹, and the Pielou
293 Uniformity Index (J) was 0.73. They indicate that the analyzed stretch has a high diversity
294 and a good pattern of uniformity of the adult tree component species, making it essential to
295 continue its conservation. These values are a consequence of regeneration in the areas
296 adjacent to the fragment.

297 The pasture matrix that surrounds the forest remnant directly impacts the development
298 efficiency of the tree community, which has been in this process for at least 18 years. Thus,
299 the species that stood out belong to the initial stage of succession, and there is a
300 predominance of species classified as initial secondary and pioneer in general. Despite this,
301 the diversity and uniformity indexes are essential parameters that indicate high diversity and,
302 therefore, good fragment resilience potential.

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304
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306

307 **COMPETING INTERESTS**

308
309 "Authors have declared that no competing interests exist."
310

311 **AUTHORS' CONTRIBUTIONS**

312
313 This work was carried out in collaboration among all authors. Authors REC, ACSV, LGS,
314 SCMN, MLB, MDL and CFLSB collected the data. Authors RVL and CFLSB identified the
315 plants. Author REC managed the literature searches, the analyses of the study, and
316 wrote the first draft of the manuscript. Author RVL performed the statistical analysis and
317 reviewed the work. Author CFLSB designed the study, wrote the protocol, managed the
318 analyses of the study, and reviewed the work..... All authors read and approved the final
319 manuscript.
320

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