

## Floristic and phytosociological study of an urban fragment of secondary Amazonian forest in Capitão Poço – PA

*Estudo florístico e fitossociológico de um fragmento urbano de floresta amazônica secundária em Capitão Poço – PA*

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### ABSTRACT

Secondary forests constitute important regenerating areas and they are expanding rapidly in the Amazonian landscape. The characterization of forest remnants provides essential information for conservation, management and recovery actions. The objective of the present study was to conduct a floristic and phytosociological evaluation of an urban fragment of secondary Amazonian forest (8.12 ha) in Capitão Poço, Pará. Trees with DBH  $\geq$  3.2 cm were inventoried in five 15 m x 30 m plots. The floristic diversity, importance value, and diametric distribution were investigated. In the survey, 236 individuals from 23 species were recorded. The floristic diversity index was 2.58. The most important species were *Cecropia obtusa* Trécul and *Lacistema pubescens* Mart. The curve of distribution of individuals in diametric classes followed a negative exponential pattern (inverted J-shape), with most individuals in the smallest diametric classes. These results imply that the forest presents species typical of initial stages of succession. Thus, conservation actions are needed to increase the local diversity. In addition, the studied forest is essential for academic and environmental education activities. We recommend further floristic studies in the area in order to assess the dynamics of the species in the forest community.

**KEYWORDS:** Amazon; ecological succession; floristic composition; biodiversity; nature conservation.

### RESUMO

As florestas secundárias constituem importantes áreas em regeneração e estão se expandindo rapidamente na paisagem amazônica. A caracterização dos remanescentes florestais fornece informações essenciais para ações de conservação, manejo e recuperação. O objetivo do presente estudo foi realizar uma avaliação florística e fitossociológica de um fragmento urbano de floresta amazônica secundária (8,12 ha) em Capitão Poço, Pará. Árvores com DAP  $\geq$  3,2 cm foram inventariadas em cinco parcelas de 15 m x 30 m. A diversidade florística, valor de importância e distribuição diamétrica foram investigados. No levantamento, foram registrados 236 indivíduos de 23 espécies. O índice de diversidade florística foi de 2,58. As espécies mais importantes foram *Cecropia obtusa* Trécul e *Lacistema pubescens* Mart. A curva de distribuição dos indivíduos nas classes diamétricas seguiu um padrão exponencial negativo (formato de J invertido), com a maioria dos indivíduos nas menores classes diamétricas. Esses resultados implicam que a floresta apresenta espécies típicas de estágios iniciais de sucessão. Assim, ações de conservação são necessárias para aumentar a diversidade local. Além disso, a floresta estudada é essencial para atividades acadêmicas e de educação ambiental. Recomendamos a realização de estudos florísticos na área para avaliar a dinâmica da espécie na comunidade florestal.

**PALAVRAS-CHAVE:** Amazônia; sucessão ecológica; composição florística; biodiversidade; conservação da natureza.

## INTRODUCTION

The Brazilian Amazon region has been affected by a high rate of deforestation for logging and farming activities (COPERTINO et al. 2019, BRANDÃO et al. 2022). The use of inadequate management practices have altered the soil properties and local biodiversity over time, resulting in a reduction of forested areas, compromised environmental sustainability, and a growing number of forest fragments at different successional stages (ALMEIDA et al. 2022, BRANDÃO et al. 2022).

The regenerating ecosystem resulting from the process of ecological succession, with characteristics determined by the degree and sources of disturbance, is known as secondary vegetation (CORDEIRO et al. 2017, ROZENDAAL et al. 2019).

Secondary forests correspond to 4% (130,000 km<sup>2</sup>) of the native vegetation in the Amazon (PROJETO MAPBIOMAS 2022) and occupy 4,358.50 km<sup>2</sup> of the northeastern region of the state of Pará (CORDEIRO et al. 2017). The extent of these forests in this state has been increasing at an alarming pace due to deforestation (COPERTINO et al. 2019, FONSECA et al. 2022, PROJETO MAPBIOMAS 2022), causing the loss of diversity and altering the composition of species in the communities, which may require decades to recover (ROZENDAAL et al. 2019).

Studies conducted in northeastern Pará (MUNIZ et al. 2007, RODRIGUES et al. 2007, CARIM et al. 2007, PINHEIRO et al. 2021, ROCHA et al. 2012) highlight the need for conservation and management strategies to promote environmental recovery.

The knowledge about the phytosociology of secondary forests is fundamental to understand the mechanisms underlying the process of natural regeneration and, consequently, forest succession. The objective of this study was to conduct a phytosociological evaluation of a secondary forest located in the municipality of Capitão Poço, Pará, Brazil. This work is a starting point for the creation of an environmental protection area in Capitão Poço, which will serve for conservation, environmental education, and scientific research purposes in the region.

## MATERIAL AND METHODS

### Study site

The study was carried out in an area of secondary forest located in the campus of the Federal Rural University of Amazonia - UFRA (01°44'05" S; 47°03'11" W), in the municipality of Capitão Poço, northeastern Pará, Brazil. The forest has an area of 8.12 ha and is located near the urban zone of the municipality and inserted in a landscape composed of pasture fields (Fig. 1). The area suffered deforestation for the implementation of agricultural crops, but has been regenerating since 2007.

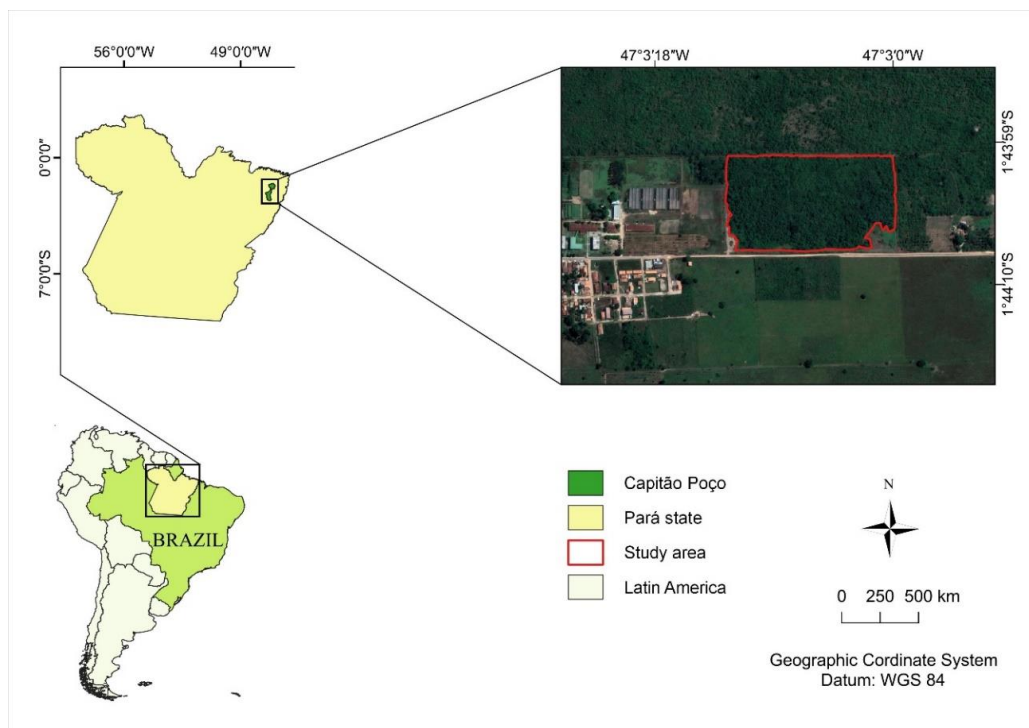


Figure 1. Location of the study area in urban fragment of secondary Amazonian forest in Capitão Poço – PA.

The regional climate is Am type, according to the Köppen classification, with annual precipitation around 2,500 mm, a short dry season from September to November (monthly precipitation around 60 mm), average temperature of 26 °C, and relative humidity of 75% to 89% in the months with less and more precipitation, respectively (SCHWARTZ 2007).

In general, the municipality has soils of the Yellow Latosol type of medium texture. Dense Ombrophilous Forest is the predominant vegetation, but the forest fragments are considerably altered and secondary forests (broad-leafed “capoeiras”) in different stages of development prevail (CORDEIRO et al. 2017).

#### **Data collection**

Five 15 m x 30 m plots (0.225 ha) were randomly established in the studied forest (8.12 ha) to conduct a phytosociological survey. All individuals with DBH (diameter at 1.30 m from the ground) equal or greater than 3.2 cm within the plots were surveyed from October 2016 to May 2017. Samples of botanical material from the individuals measured were collected for later identification at the Herbarium of the Emílio Goeldi Museum of Pará, Belém, Pará. The samples were identified at the family, genus, and species level using the APG IV (Angiosperm Phylogeny Group) classification system (APG 2016). The individuals of the identified species were also classified into the following ecological groups: pioneer (P), early secondary (ES) and late secondary (LS) (GANDOLFI et al. 1995) through literature review.

#### **Calculations and data analysis**

Sample sufficiency was tested by constructing a rarefaction curve (Fig. 2), showing the relationship between the size of the sample area (plot) and the richness of species found in the sample. It was observed that the number of plots used in this study was not sufficient to meet the sampling sufficiency of the data.

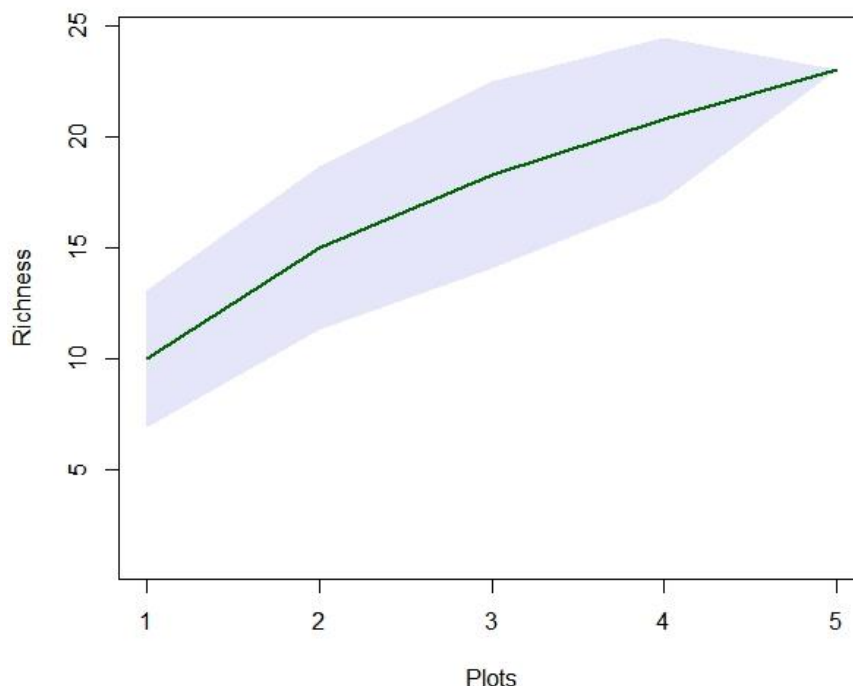


Figure 2. Rarefaction curve of a 0.225 ha sample considering individuals with a minimum diameter of 3.2 cm.

The floristic diversity was calculated by the Shannon Index (SHANNON & WEAVER 1949) and the horizontal structure of the forest was evaluated based on the procedures suggested by FINOL (1971) for absolute and relative frequency, absolute and relative density, absolute and relative dominance. The Importance Value Index (IVI) was obtained by the arithmetic sum of the relative frequency, density, and dominance values. Diameter class intervals were calculated according to WATZLAWICK et al. (2011).

## **RESULTS**

A total of 236 individuals (1,049 ind ha<sup>-1</sup>) of 23 species distributed in 23 genera and 17 families were identified in the survey (Tab. 1). The identity of two species belonging to Loranthaceae and Myrtaceae could not be determined. As for ecological groups, most species were classified as pioneer and early secondary species.

Table 1. Floristic composition and Ecological Group (EG) of species recorded in urban fragment of secondary Amazonian forest in Capitão Poço – PA.

Family	Scientific name	EG
Anacardiaceae	<i>Astronium lecointei</i> Ducke	LS <sup>1</sup>
Apocynaceae	<i>Himatanthus sucuuba</i> (Spruce ex Mull. Arg) Woodson	P <sup>2</sup>
Apocynaceae	<i>Tabernaemontana angulata</i> Mart. ex Mull Arg.	ES <sup>3</sup>
Arecaceae	<i>Astrocaryum gynacanthum</i> Mart.	P <sup>4</sup>
Fabaceae	<i>Abarema cochleata</i> (Willd.) Barneby & J.W. Grimes	P <sup>1</sup>
Fabaceae	<i>Inga macrophylla</i> Humb. & Bonpl ex Willd.	-
Fabaceae	<i>Machaerium quinata</i> (Aubl.) Sandwith	-
Fabaceae	<i>Pterocarpus amazonicus</i> Huber	ES <sup>5</sup>
Fabaceae	<i>Swartzia laurifolia</i> Benth.	P <sup>1</sup>
Humiriaceae	<i>Sacoglottis guianensis</i> Benth.	LS <sup>2</sup>
Hypericaceae	<i>Vismia guianensis</i> (Aubl.) Pers.	P <sup>4</sup>
Lacistemaceae	<i>Lacistema pubescens</i> Mart.	IS <sup>6</sup>
Lecythidaceae	<i>Couratari guianensis</i> Aubl.	LS <sup>1</sup>
Loranthaceae	Indetermined I	-
Melastomaceae	<i>Miconia minutiflora</i> (Bonpl.) DC.	P <sup>1</sup>
Meliaceae	<i>Guarea guidonia</i> (L.) Sleumer	ES <sup>6</sup>
Myrtaceae	Indetermined II	-
Salicaceae	<i>Casearia grandiflora</i> Cambess.	ES <sup>7</sup>
Sapindaceae	<i>Matayba guianensis</i> Aubl.	ES <sup>8</sup>
Sapindaceae	<i>Talisia retusa</i> R. S. Cowan	ES <sup>9</sup>
Sapotaceae	<i>Pradosia granulosa</i> Pires & T.D. Penn.	-
Simaroubaceae	<i>Simarouba amara</i> Aubl.	ES <sup>3</sup>
Urticaceae	<i>Cecropia obtusa</i> Trécul	P <sup>4</sup>

Where: P= pioneer; ES = early secondary; LS = late secondary; <sup>1</sup>AMARAL et al. (2009); <sup>2</sup>LIMA et al. (2011); <sup>3</sup>CONDÉ & TONINI (2013); <sup>4</sup>NARDUCCI et al. (2020); <sup>5</sup>SILVA et al. (2016); <sup>6</sup>CARVALHO et al. (2006); <sup>7</sup>LOPES et al. (2012); <sup>8</sup>SÁ et al. (2012); <sup>9</sup>SILVA & MOURA (2021).

The Shannon Diversity Index for the studied area was 2.58 nats ind<sup>-1</sup>, likely related to low equitability and uniformity of the distribution of individuals among the species, which is typical of areas in initial stages of succession. Information on frequency, abundance, dominance, and IVI values are presented in Table 2. Of the 23 species found in the survey, six were represented by only one individual and had an IVI of 2.4, frequency of 20%, density of 4.4 trees ha<sup>-1</sup>, and dominance of 0.001 to 0.006 m<sup>2</sup> ha<sup>-1</sup>. The total basal area in the studied area was 1.23 m<sup>2</sup> ha<sup>-1</sup>. The species with the highest IVI belong to the pioneer and early secondary ecological groups. *Cecropia obtusa* Trécul was the species with the highest IVI (98) and occurred in four of the five plots. *Cecropia obtusa* together with *Lacistema pubescens* Mart., *Pterocarpus amazonicus* Huber, and *Vismia guianensis* (Aubl.) Choisy represented almost two thirds in proportion of importance in the floristic complex.

The 236 individuals measured in the forest were distributed into 9 diametric classes, with fixed intervals of 2.3 cm. The curve obtained (Fig. 3) followed a negative exponential pattern (inverted j-shape) with 87.28% of the individuals in the first three diameter classes (3.3 cm to 10.2 cm). Only four species presented individuals with diameters above 10 cm: *C. obtusa* with 21 individuals, which placed this species prominently in the largest diametric class (21.7-24.0 cm); *V. guianensis* (22 individuals); *S. guianensis* (3 individuals); and *P. amazonicus* (one individual).

Table 2. Horizontal structure of urban fragment of secondary Amazonian forest in Capitão Poço – PA.

Species		FA (%)	FR (%)	DA (ár. ha <sup>-1</sup> )	DR (%)	DoA (m <sup>2</sup> ha <sup>-1</sup> )	DoR (%)	VI
<i>C. obtusa</i>	7	80	8	208.9	19.9	21.844	70.091	8.0
<i>L. pubescens</i>	9	100	10	173.3	16.5	2.292	7.355	3.9
<i>P. amazonicus</i>	6	100	10	115.6	11.0	1.576	5.056	6.1
<i>V. guianensis</i>	2	60	6	97.8	9.3	3.076	9.869	5.2
<i>M. minutiflora</i>	7	60	6	75.6	7.2	0.453	1.455	4.7
<i>M. quinata</i>	1	60	6	48.9	4.7	0.235	0.755	1.4
<i>A. colhleata</i>		80	8	26.,7	2.5	0.170	0.547	1.1
Und. I	0	60	6	44.4	4.2	0.235	0.753	1.0
<i>S. amara</i>	0	60	6	44.4	4.2	0.178	0.571	0.8
<i>S. guianensis</i>	0	40	4	44.4	4.2	0.715	2.295	0.5
Und. II		40	4	22.2	2.1	0.026	0.084	.2
<i>M. guianensis</i>		20	2	35.6	3.4	0.159	0.511	.9
<i>A. gynacanthum</i>		20	2	35.6	3.4	0.109	0.350	.7
<i>P. glanulosa</i>		40	4	13.3	1.3	0.031	0.099	.4
<i>C. guianensis</i>		20	2	13.3	1.3	0.020	0.065	.3
<i>T. retusa</i>		20	2	13.3	1.3	0.014	0.045	.3
<i>C. grandiflora</i>		20	2	8.9	0.8	0.010	0.032	.9
<i>S. laurifolia</i>		20	2	4.4	0.4	0.006	0.019	.4
<i>I. macrophylla</i>		20	2	4.4	0.4	0.006	0.018	.4
<i>A. lecointei</i>		20	2	4.4	0.4	0.004	0.014	.4
<i>G. guidonia</i>		20	2	4.4	0.4	0.003	0.008	.4
<i>H. sucuuba</i>		20	2	4.4	0.4	0.001	0.004	.4
<i>T. angulata</i>		20	2	4.4	0.4	0.001	0.003	.4

Where: N= number of individuals found in the sample, AF = Absolute Frequency, RF = Relative Frequency, DA = Absolute Density, DR = Relative Density, DoA = Absolute Dominance, DoR = Relative Dominance and IVI = Importance Value Index.

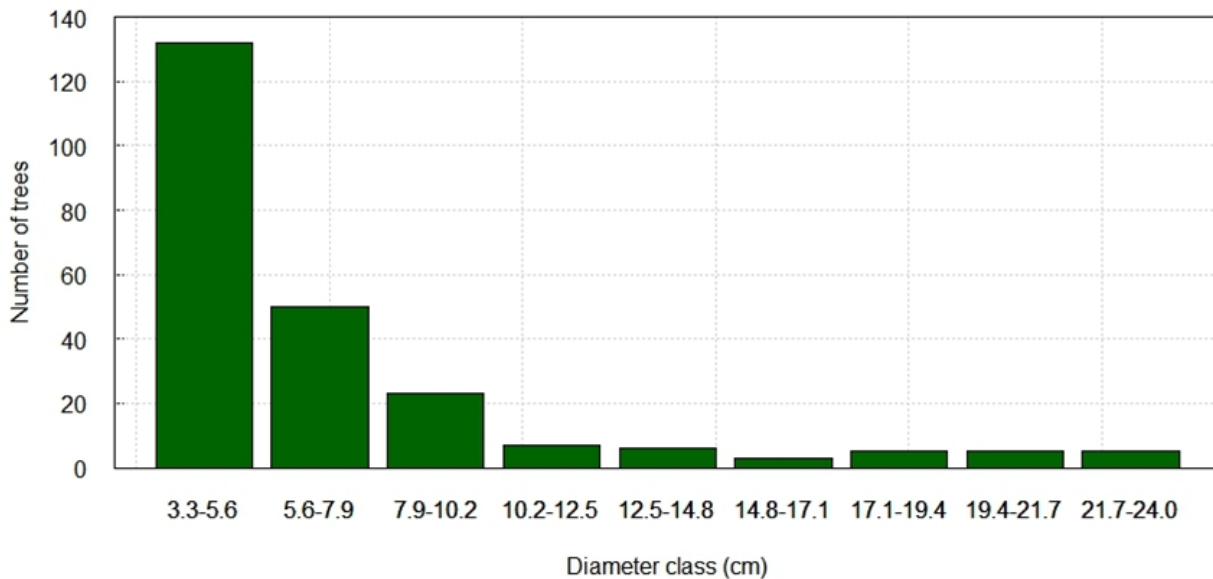


Figure 3. Diametric distribution of the number of individuals with DBH  $\geq$  3.2 cm in a 2.250 m<sup>2</sup> sample.

## DISCUSSION

Of the 17 families recorded in the studied forest, Fabaceae had the highest number of species (five). This family is known to predominate in primary and secondary forests in Brazil (BFG 2015, FLORA E FUNGA DO BRASIL 2021). The predominance Fabaceae in secondary forests is often observed and explained by the ability of its species to establish in a variety of environments and at different stages of ecological succession, as well as the ability to fix nitrogen, which facilitates the permanence of the species in naturally regenerating areas (HASANUZZAMAN et al. 2020).

As for the number of species, the richness was higher than that found in a study conducted in Belém (ROCHA et al. 2012) but lower than that found in another survey conducted in secondary forests of rural communities in Capitão Poço (PINHEIRO et al. 2021). These differences can be explained in part by the different times of secondary succession and sampling methods used in the studies.

The diversity index indicated that the studied forest is at initial stage of succession. This was also observed in other studies, such as some conducted in northeastern Pará (RODRIGUES et al. 2007, SILVA et al. 2016). Indices ranging from 2.4 to 3.9 were found in these studies, with a predominance of species of the most initial groups of succession, which was understood to be associated with high solar incidence, rapid colonization restricted to a few species, and high competition, leading to a low number of species in the floristic composition of the forests.

The number of species is expected to fall in areas under anthropic disturbance, which culminates in the simplification of the biota and the low number of species with high density of individuals (FREITAS et al. 2016). This pattern is common in tropical and subtropical forests, where the majority of the species have few individuals (EISFELD et al. 2014).

The species *C. obtusa*, *L. pubescens*, *P. amazonicus* and *V. guianensis* were the most important according to IVI and were present in all plots (Tab. 2). *Cecropia obtusa*, *L. pubescens* and *V. guianensis* were also the most abundant species in secondary forests in other studies conducted in the northeastern region of Pará (ARAÚJO et al. 2005, MUNIZ et al. 2007, PRATA et al. 2010, PINHEIRO et al. 2021). The high abundance of these species can be attributed to their ability to regrow and subsequently reproduce within short time intervals. In addition, *L. pubescens* and *C. obtusa* are species that occur frequently in early successional areas, acting as indicators of natural regeneration, being typical of altered areas, and important for the process of forest regeneration (PRATA et al. 2010).

Among the species found in the forest, *P. granulosa* presented a low abundance of individuals. This species is classified as vulnerable to extinction due to overexploitation for timber production and conversion of natural habitats for activities such as mining (MARTINELLI & MORAES 2013, IUNC 2022).

The greater frequency of individuals in the smallest diametric classes leads to a negative exponential accumulation curve, a pattern commonly found in natural forests (SANTOS et al. 2016). The diametric distribution curve and the predominant ecological groups of species found in the studied forest allow us to

infer that the forest is at an initial stage of succession with the possibility of changes to an intermediate stage, requiring new surveys of species. The occurrence and dominance of species of some ecological groups (specimens of the genera *Lacistema*, *Inga*, *Vismia*) in early stages of succession was also observed by CARVALHO et al. (2022) in fallow areas after deforestation for mining.

The basal area of the forest ( $1.23 \text{ m}^2 \text{ ha}^{-1}$ ) was lower than that found by PINHEIRO et al. (2021) in a secondary forest also located in the municipality of Capitão Poço. The authors found from  $9.2$  to  $11.5 \text{ m}^2 \text{ ha}^{-1}$  in a 20-year-old fallow forest. Thus, we recommend new studies in order to evaluate the population dynamics of the forest.

We recommend the inclusion of the studied area in conservation plans aimed at promoting the enrichment of the forest, such as the possible establishment of ecological corridors to favor the gene flow of the species and the advancement of ecological succession (MANESCHY et al. 2022, CORDEIRO et al. 2017).

## CONCLUSION

The forest studied presented characteristics of an early successional stage, with the presence of regenerating species, greater frequency of individuals in the smallest diametric classes, and prevalence of initial secondary species. We recommend that further floristic studies in the area be conducted (continuous inventories), including studies with a focus on natural regeneration (individuals in smaller diameter classes).

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