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Biology – Botany

Urban conservation and tree diversity: a case study in Parque Xokleng, Nova Veneza, Southern Santa Catarina

Conservação urbana e diversidade de árvores: um estudo de caso no Parque Xokleng, Nova Veneza, Sul de Santa Catarina

Júlia Gava Sandrini [I], Vicente Nava Lenhani [I], Iara Zaccaron Zanoni [I], Kristian Madeira [I], Robson Santos [I], Guilherme Alves Elias [I]

[I] Universidade do Extremo Sul Catarinense, Criciúma, SC, Brasil

ABSTRACT

Urban forests can be defined as sets comprising vegetation fragments and isolated or grouped trees inserted in urban or peri-urban areas. Within this mosaic, urban fragments are important for biodiversity conservation. The aim of this study is to contribute to the knowledge about the structure of vegetation in an urban forest in the town of Nova Veneza, Santa Catarina, Brazil. The study was conducted in the Parque Natural Municipal Xokleng (PNMX). A phytosociological survey was conducted in the forest, using the plot method, in which 30 continuous plots of 10 m x 10 m were established. We considered a tree every individual that had a diameter at breast height greater than or equal to 5 cm. In this study, 497 individuals belonging to 75 species and 32 families were sampled, along with 14 dead individuals, three individuals identified only at genus level, and one unidentified individual. The species with the highest importance values were *Tetrorchidium rubrivenium*, *Machaerium stipitatum*, *Ficus adhatodifolia*, *Cabralea canjerana*, *Mollinedia triflora*. The vegetation structure is similar to the structure observed in other secondary forest fragments in the southern region of Santa Catarina. The presence of secondary species in the canopy and with high dominance values reflects the regeneration process the forest is undergoing.

Keywords: Atlantic Forest; Floristic; Secondary forest; Phytosociology; Vegetation

RESUMO

As florestas urbanas podem ser definidas como conjuntos que incluem fragmentos de vegetação e árvores isoladas ou agrupadas inseridas em áreas urbanas ou periurbanas. Dentro desse mosaico, os fragmentos urbanos são importantes para a conservação da biodiversidade. O objetivo deste estudo é contribuir para o conhecimento sobre a estrutura da vegetação em uma floresta urbana em Nova Veneza, Santa Catarina, Brasil. O estudo foi conduzido no Parque Natural Municipal Xokleng (PNMX).

Foi realizado um levantamento fitossociológico na floresta, utilizando o método de parcelas, no qual foram estabelecidas 30 parcelas contínuas de 10 m x 10 m. Consideramos como árvore todo indivíduo que possuía um diâmetro à altura do peito maior ou igual a 5 cm. Neste estudo, foram amostrados 497 indivíduos pertencentes a 75 espécies e 32 famílias, juntamente com 14 indivíduos mortos, três indivíduos identificados apenas em nível de gênero e um indivíduo não identificado. As espécies com os maiores valores de importância foram *Tetrorchidium rubrivenium*, *Machaerium stipitatum*, *Ficus adhatodifolia*, *Cabralea canjerana*, *Mollinedia triflora*. A estrutura da vegetação é semelhante à observada em outros fragmentos secundários de Floresta Ombrófila Densa na região sul de Santa Catarina. A presença de espécies secundárias no dossel e ocupando altos valores de dominância reflete o processo de regeneração pelo qual a floresta está passando.

Palavras-chave: Mata Atlântica; Florística; Floresta secundária; Fitossociologia; Vegetação

1 INTRODUCTION

Urban forests can be defined as sets comprising vegetation fragments and isolated or grouped trees in urban or peri-urban areas (FAO, 2016). Within this mosaic, urban forest fragments configure important places for biodiversity conservation, local microclimate and pollution control, erosion prevention, carbon capture, and enable greater water infiltration in the soil (Melo et al., 2011; FAO, 2016). Moreover, these locations are part of the original local ecosystem and may harbor a significant richness of plant and animal species, enabling their survival and the occurrence of interspecific interactions (Feiber, 2004).

Liu et al. (2016) highlight that urbanization can alter essential ecosystem services for humans, as the conversion of natural environments into urban areas has reduced carbon storage capacity in these locations. Furthermore, the presence of green areas in cities positively impacts mental health and life quality of the city residents, as they represent environments for the execution of recreational activities, physical exercise, and nature appreciation (Muñoz & Freitas, 2017; Silva, 2020).

Mitchell and Devisscher (2022) point out that the provision of ecosystem services by urban forests depends on aspects such as vegetation composition and structure. In Santa Catarina state, which is entire within the domain of the Atlantic

Forest, data from the Inventário Florístico Florestal de Santa Catarina (IFFSC) indicate impoverished and structurally simplified forests (Vibrans et al., 2012), which can compromise these processes. Among the threats observed for urban forests in the Atlantic Forest, it is worth highlighting urbanization, indiscriminate wood exploitation, mowing, fragmentation, and geographic isolation of the forest fragments (Vibrans et al., 2012; Souza, 2013).

In this context, the implementation of protected areas is one of the most effective tools for the protection of natural environments, such as urban fragments (Grelle et al., 2021). However, despite the importance of these spaces in forest conservation, knowledge of biodiversity in protected areas is still scarce, and there are several knowledge gaps to be filled (Pinto et al., 2017), including those regarding vegetation in these locations.

Some of the topics addressed in publications about Brazilian urban forests include quality of these forests (Longo et al., 2019), the effects of fragmentation and urbanization (Dardengo et al., 2018; Jung et al., 2018), urban afforestation (Araújo et al., 2019) and the contributions of these forests to improving the health and quality life of the population (Viezzer & Biondi, 2021; Arbilla et al., 2023). Other discussed themes are structure and floristic composition of forests located in Brazilian urban centers. However, for the Santa Catarina state, only Elias et al. (2018) and Turmina et al. (2017) studied the structure of urban forests fragments, from which only the first study was conducted in a protected area, showing that this topic is a knowledge gap for the state. In this context, the aim of this study is to understand the structure of vegetation in an urban forest in the town of Nova Veneza, Santa Catarina, Brazil, and contribute with the knowledge about Santa Catarina urban forest structure.

2 MATERIAL AND METHODS

The study was conducted in the Parque Natural Municipal Xokleng (PNMX), a protected area in Nova Veneza municipality, in southern Santa Catarina (figure 1). Nova Veneza has 295,061km² and 13,664 inhabitants, with 99.4% of schooling for people between 6 and 14 years of age. The Human Development Index (HDI) is 0.768 and the Gross Domestic Product (GDP) is 725,540,000.00 (IBGE, 2024). The age pyramid of the municipality follows the national trend, with a decreasing base, which corresponds to a decrease in the birth rate (IBGE, 2024). The economic activity of Nova Veneza is based on agriculture, especially of rice, metallurgical industry, textile manufacturing and tourism, especially gastronomic and ecological (Mastella & Farias, 2020).

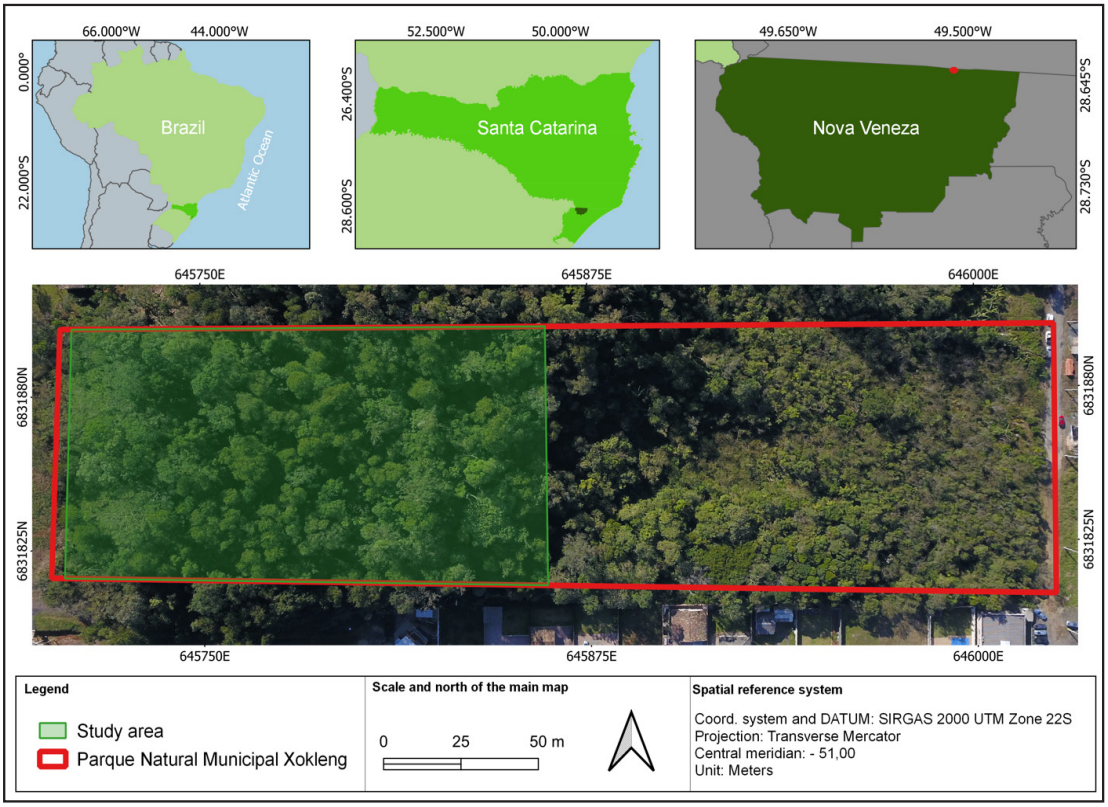
The PNMX is in the urban zone of Nova Veneza and covers an area of 3.4 hectares and altitudes ranging from 67 to 100 m at coordinates 28°37'55.58"S, 49°30'28.10"W (Nova Veneza, 2020). The surroundings of the protected area are occupied by residences, forest fragments and small monocultures of Musa sp. and Eucalyptus spp. The PNMX is going through the structuring process, thus, until now, only receives visitors for education and research purposes.

According to the Köppen climate classification, the climate in PNMX is classified as Cfa: humid subtropical, with hot summers with temperatures higher than 22°C and no dry season throughout the year (Alvares et al., 2014).

Four distinct environments can be observed in PNMX. The first one, located to the West, has elevations ranging from 80 to 100 m above sea level, with an area of about 1.5 hectares, and is a fragment of Submontane Dense Ombrophilous Forest with trees, shrubs, lianas, and epiphytes. The second environment, located in the middle portion, is also part of the continuous forest fragment of PNMX. However, this environment is influenced by the humidity from a wetland area to the east of the protected area, which results in structural and floristic composition differences compared to the first

environment. The third environment has altitudes around 60 m and is a wetland area with the presence of pioneer and hygrophytic species. In addition, the fourth environment is a place that has been under anthropogenic interference through the planting of fruit-bearing species for consumption and currently constitutes a small orchard.

Figure 1 – Location of Parque Natural Municipal Xokleng (PNMX), in Nova Veneza, Southern Santa Catarina, Brazil



Source: Authors (2024)

This study was conducted exclusively in the 1.5 hectares Submontane Dense Ombrophilous Forest of PNMX (study area in the figure 1). The choice of environment was made especially considering the forest area of the PNMX, since the objective of the study is to understand the structure of the tree component and compare it to other studies carried out in the same region. The plot method was employed, as described by Mueller-Dombois and Ellenberg (2002), in which 30 continuous plots of 10 m x 10 m were established. We considered a tree every individual that had a diameter at breast

height (DBH) greater than or equal to 5 cm, including individuals with arboreal habits such as palms and tree ferns. Ground-level branched individuals were included in the sampling when at least one of the branches reached the inclusion criteria established (DBH ≥ 5 cm), as described by Moro and Martins (2011).

The adopted classification systems used were APG IV (2016) for the angiosperms and PPG I (2016) for ferns. The species names were presented according to the Flora and Funga of Brazil (Flora e Funga do Brasil, 2023). The fertile materials were collected and incorporated to the collection of the Pe. Dr. Raulino Reitz Herbarium (CRI) of the Universidade do Extremo Sul Catarinense (UNESC), with the aim of documenting the local flora through preserved specimens.

For the phytosociological analysis, the structural descriptors of density, frequency, dominance, and Importance Value Index were established according to Mueller-Dombois and Ellenberg (2002). The Importance Value Index aggregates the variables of relative density, relative frequency and relative dominance, through the sum of them (IVI = RF + RD + RDo), which results in a total IVI of 300%, and shows which species have greater contribution to the community (Moro & Martis, 2011).

The analysis of area diversity and heterogeneity was performed using the Shannon index (H') and Pielou's evenness (J) (Pielou, 1975; Magurran, 1988). To better understand the structure of the tree component, we provided a profile diagram of the forest. The diagram was built from field observations associated with average data on density and size of species present throughout the sampled area (Durigan, 2012). The species were distributed into nine height classes, from 2 m (lowest recorded height) to 18 m (highest recorded height), with the aim of portraying the distribution of species in vertical strata.

3 RESULTS AND DISCUSSION

3.1 Phytosociology

In this study, 497 individuals belonging to 75 species and 32 families were sampled, along with 14 dead individuals, three individuals identified only at genus level, and one unidentified individual. The total density obtained was 1,657 individuals.ha^{-1} (table 1).

Table 1 – Phytosociological parameters estimated for the sampled tree and arborescent species in the Submontane Dense Ombrophilous Forest in Parque Natural Municipal Xokleng, Nova Veneza, southern Santa Catarina, for individuals with diameter at breast height (DBH) greater than 5 cm, in descending order of Importance Value Index (IVI), where: AF = Absolute Frequency (%), RF = Relative Frequency (%), AD = Absolute Density (number of individuals.ha-1), RD = Relative Density (%), ADo = Absolute Dominance (m2.ha-1), and RDo = Relative Dominance (%)

(continue)

Species	AF	RF	AD	RD	ADo	RDo	IVI
Tetrorchidium rubrivenium Poepp.	36.67	3.31	60.00	3.62	8.13	16.31	23.25
Machaerium stipitatum Vogel	50.00	4.52	136.67	8.25	2.68	5.38	18.15
Ficus adhatodifolia Schott in Spreng.	10.00	0.90	10.00	0.60	7.85	15.75	17.26
Cabralea canjerana (Vell.) Mart.	73.33	6.63	113.33	6.84	1.68	3.37	16.84
Mollinedia triflora (Spreng.) Tul.	70.00	6.33	143.33	8.65	0.72	1.44	16.42
Allophylus edulis (A.St.-Hil. et al.) Hieron. ex Niederl.	50.00	4.52	113.33	6.84	1.24	2.50	13.85
Euterpe edulis Mart.	66.67	6.02	106.67	6.44	0.69	1.38	13.84
Piptadenia gonoacantha (Mart.) J.F.Macbr.	26.67	2.41	33.33	2.01	3.11	6.24	10.66
Cupania vernalis Cambess.	46.67	4.22	70.00	4.23	0.61	1.22	9.66
Nectandra oppositifolia Nees & Mart.	20.00	1.81	30.00	1.81	2.22	4.45	8.07
Nectandra membranácea (Sw.) Griseb.	23.33	2.11	26.67	1.61	2.00	4.01	7.72
Jacaranda puberula Cham.	40.00	3.61	60.00	3.62	0.24	0.48	7.72
Citharexylum myrianthum Cham.	23.33	2.11	26.67	1.61	1.93	3.88	7.60
Dead individuals	30.00	2.71	46.67	2.82	0.94	1.89	7.42
Alsophila setosa Kaulf.	10.00	0.90	63.33	3.82	0.40	0.79	5.52
Guapira opposita (Vell.) Reitz	33.33	3.01	33.33	2.01	0.19	0.39	5.41
Cedrela fissilis Vell.	13.33	1.20	13.33	0.80	1.68	3.38	5.39
Palicourea sessilis (Vell.) C.M.Taylor	20.00	1.81	33.33	2.01	0.65	1.31	5.13

Table 1 – Phytosociological parameters estimated for the sampled tree and arborescent species in the Submontane Dense Ombrophilous Forest in Parque Natural Municipal Xokleng, Nova Veneza, southern Santa Catarina, for individuals with diameter at breast height (DBH) greater than 5 cm, in descending order of Importance Value Index (IVI), where: AF = Absolute Frequency (%), RF = Relative Frequency (%), AD = Absolute Density (number of individuals.ha-1), RD = Relative Density (%), ADo = Absolute Dominance (m2.ha-1), and RDo = Relative Dominance (%)

(continue)

Species	AF	RF	AD	RD	ADo	RDo	IVI
Moquiniastrum polymorphum (Less.) G. Sancho	3.33	0.30	3.33	0.20	2.15	4.31	4.82
Mollinedia schottiana (Spreng.) Perkins	26.67	2.41	30.00	1.81	0.10	0.21	4.43
Myrcia splendens (Sw.) DC.	13.33	1.20	16.67	1.01	0.96	1.92	4.13
Trichilia lepidota Mart.	20.00	1.81	30.00	1.81	0.21	0.43	4.05
Sorocea bonplandii (Baill.) W.C.Burger *et al*.	23.33	2.11	23.33	1.41	0.13	0.25	3.77
Lonchocarpus cultratus (Vell.) A.M.G.Azevedo & H.C.Lima	16.67	1.51	16.67	1.01	0.47	0.93	3.45
Annona emarginata (Schltdl.) H.Rainer	16.67	1.51	23.33	1.41	0.25	0.51	3.42
Ilex microdonta Reissek	6.67	0.60	6.67	0.40	1.19	2.39	3.39
Inga marginata Willd.	13.33	1.20	23.33	1.41	0.35	0.69	3.31
Alchornea glandulosa Poepp. & Endl.	16.67	1.51	16.67	1.01	0.39	0.78	3.29
Casearia sylvestris Sw.	16.67	1.51	16.67	1.01	0.24	0.49	3.00
Virola bicuhyba (Schott ex Spreng.) Warb.	16.67	1.51	20.00	1.21	0.12	0.24	2.96
Psychotria suterella Müll.Arg.	16.67	1.51	20.00	1.21	0.07	0.13	2.85
Didymopanax morototoni (Aubl.) Decne. & Planch.	3.33	0.30	3.33	0.20	1.11	2.24	2.74
Lamanonia ternata Vell.	6.67	0.60	6.67	0.40	0.77	1.54	2.55
Zanthoxylum petiolare A.St.-Hil. & Tul.	6.67	0.60	10.00	0.60	0.56	1.13	2.34
Syagrus romanzoffiana (Cham.) Glassman	10.00	0.90	10.00	0.60	0.39	0.78	2.28
Magnolia ovata (A.St.-Hil.) Spreng.	10.00	0.90	10.00	0.60	0.35	0.71	2.21
Maclura tinctoria (L.) D.Don ex Steud.	10.00	0.90	13.33	0.80	0.21	0.42	2.13
Myrcia neolucida A.R.Lourenço & E.Lucas	10.00	0.90	16.67	1.01	0.10	0.19	2.10
Rudgea jasminoides (Cham.) Müll.Arg.	10.00	0.90	16.67	1.01	0.07	0.14	2.05
Annona sp.	10.00	0.90	10.00	0.60	0.07	0.15	1.65
Daphnopsis fasciculata (Meisn.) Nevling	10.00	0.90	10.00	0.60	0.07	0.14	1.65
Aspidosperma olivaceum Müll.Arg.	10.00	0.90	10.00	0.60	0.06	0.12	1.63
Eugenia handroana D.Legrand	10.00	0.90	10.00	0.60	0.04	0.07	1.58
Guarea macrophylla Vahl	10.00	0.90	10.00	0.60	0.03	0.05	1.56
Brosimum lactescens (S.Moore) C.C.Berg	3.33	0.30	3.33	0.20	0.49	0.99	1.49
Non identified	3.33	0.30	3.33	0.20	0.49	0.98	1.49
Annona dolabripetala Raddi	6.67	0.60	6.67	0.40	0.23	0.46	1.47

Table 1 – Phytosociological parameters estimated for the sampled tree and arborescent species in the Submontane Dense Ombrophilous Forest in Parque Natural Municipal Xokleng, Nova Veneza, southern Santa Catarina, for individuals with diameter at breast height (DBH) greater than 5 cm, in descending order of Importance Value Index (IVI), where: AF = Absolute Frequency (%), RF = Relative Frequency (%), AD = Absolute Density (number of individuals.ha-1), RD = Relative Density (%), ADo = Absolute Dominance (m2.ha-1), and RDo = Relative Dominance (%)

(continue)

Species	AF	RF	AD	RD	ADo	RDo	IVI
Sloanea guianensis (Aubl.) Benth.	6.67	0.60	6.67	0.40	0.14	0.29	1.29
Bathysa australis (A.St.-Hil.) K.Schum.	6.67	0.60	6.67	0.40	0.10	0.21	1.21
Ilex brevicuspis Reissek	6.67	0.60	6.67	0.40	0.06	0.11	1.12
Casearia decandra Jacq.	6.67	0.60	6.67	0.40	0.04	0.09	1.09
Cyathea delgadii Sternb.	6.67	0.60	6.67	0.40	0.04	0.08	1.08
Guapira hirsuta (Choisy) Lundell	6.67	0.60	6.67	0.40	0.02	0.05	1.05
Endlicheria paniculata (Spreng.) J.F.Macbr	6.67	0.60	6.67	0.40	0.02	0.03	1.04
Gymnanthes klotzschiana Müll.Arg.	3.33	0.30	10.00	0.60	0.03	0.06	0.97
Myrcia brasiliensis Kiaersk.	3.33	0.30	6.67	0.40	0.05	0.10	0.80
Myrcia anacardiifolia Gardner	3.33	0.30	6.67	0.40	0.02	0.04	0.74
Guatteria australis A.St.-Hil.	3.33	0.30	3.33	0.20	0.09	0.18	0.68
Posoqueria latifolia (Rudge) Schult.	3.33	0.30	3.33	0.20	0.07	0.14	0.65
Ocotea silvestres Vattimo-Gil	3.33	0.30	3.33	0.20	0.07	0.14	0.64
Myrcia loranthifolia (DC.) G.P.Burton & E.Lucas	3.33	0.30	3.33	0.20	0.06	0.13	0.63
Lafoensia vandelliana Cham. & Schltdl.	3.33	0.30	3.33	0.20	0.06	0.12	0.63
Cinnamomum pseudoglaziovii (Lorea-Hern.) Van der Werff	3.33	0.30	3.33	0.20	0.04	0.08	0.58
Cinnamomum triplinerve (Ruiz & Pav.) Kosterm.	3.33	0.30	3.33	0.20	0.03	0.06	0.56
Myrcia tijucensis Kiaersk.	3.33	0.30	3.33	0.20	0.03	0.05	0.55
Citronella paniculata (Mart.) R.A.Howard	3.33	0.30	3.33	0.20	0.02	0.05	0.55
Machaerium hirtum (Vell.) Stellfeld	3.33	0.30	3.33	0.20	0.02	0.04	0.54
Neomitranthes cordifolia (D.Legrand) D.Legrand	3.33	0.30	3.33	0.20	0.02	0.04	0.54
Cybistax antisyphilitica (Mart.) Mart.	3.33	0.30	3.33	0.20	0.02	0.04	0.54
Miconia ligustroides (DC.) Naudin	3.33	0.30	3.33	0.20	0.02	0.04	0.54
Jacaranda micrantha Cham.	3.33	0.30	3.33	0.20	0.02	0.03	0.54
Nectandra megapotamica (Spreng.) Mez	3.33	0.30	3.33	0.20	0.02	0.03	0.54
Tabernaemontana catharinensis A.DC.	3.33	0.30	3.33	0.20	0.02	0.03	0.54
Myrsine umbellata Mart.	3.33	0.30	3.33	0.20	0.02	0.03	0.53
Aiouea saligna Meisn.	3.33	0.30	3.33	0.20	0.01	0.03	0.53

Table 1 – Phytosociological parameters estimated for the sampled tree and arborescent species in the Submontane Tropical Forest in Parque Natural Municipal Xokleng, Nova Veneza, southern Santa Catarina, for individuals with diameter at breast height (DBH) greater than 5 cm, in descending order of Importance Value Index (IVI), where: AF = Absolute Frequency (%), RF = Relative Frequency (%), AD = Absolute Density (number of individuals.ha^{-1}), RD = Relative Density (%), ADo = Absolute Dominance (m^2.ha^{-1}), and RDo = Relative Dominance (%)

(conclusion)

Species	AF	RF	AD	RD	ADo	RDo	IVI
Monteverdia gonoclada (Mart.) Biral	3.33	0.30	3.33	0.20	0.01	0.03	0.53
Leandra variabilis Raddi	3.33	0.30	3.33	0.20	0.01	0.03	0.53
Hieronyma alchorneoides Allemão	3.33	0.30	3.33	0.20	0.01	0.02	0.52
Total	1,106.67	100	1,656.67	100	49.84	100	300

Source: Organized by the authors (2024)

The 10 species with the highest importance values were *Tetrorchidium rubrivenium*, *Machaerium stipitatum*, *Ficus adhatodifolia*, *Cabralea canjerana*, *Mollinedia triflora*, *Allophylus edulis*, *Euterpe edulis*, *Piptadenia gonoacantha*, *Cupania vernalis*, and *Nectandra oppositifolia*.

Tetrorchidium rubrivenium, which had the highest importance value, is a species associated with early succession, often found in secondary forests near the slopes in Santa Catarina (Smith et al., 1988), a situation observed in PNMX. In this perspective, the population of *T. rubrivenium* recorded in this study consists of well-established individuals in the community, with large size, an average height of around 14 m, and a total basal area of 2.44 m².

Two species recorded in this study are threatened of extinction at the global level (IUCN, 2022): *Cedrela fissilis* (VU) and *Neomitranthes cordifolia* (EN). At a national level (Brasil, 2022), the two species are also threatened of extinction in the same categories, with the addition of *Euterpe edulis* (VU) and *Virola bicuhyba* (EN).

Euterpe edulis is a slow growth species, lacking the ability to resprout, and dependent on well-preserved forests (CNCFlora, 2022), a situation that differs from

the data provided by IFFSC for Santa Catarina, which reveals a decrease in habitats and forest quality where this species occurs (Vibrans et al., 2013; Elias et al., 2019). In addition to that, the intense exploitation of the species through stem cutting for heart-of-palm commercialization has led to the classification of the species as threatened of extinction under the vulnerable category (VU) (Elias et al., 2019; CNCFlora, 2022). Although *E. edulis* showed one of the highest importance values in PNMX, when compared to studies conducted in more preserved natural environments (Martins, 2005, 2010; Pasetto, 2008; Colonetti et al., 2009), it has low density in this study. According to Reitz (1974), *E. edulis* stands out among the species in the Atlantic Rainforest for its abundance, with primary forests having an average of 1,000 individuals.ha^{-1} for the species, considering those with a height above 1.5 m. The lower presence of *E. edulis* in this study, compared to the previously mentioned studies, may be because PNMX houses a young forest passing through process of natural regeneration, which has experienced past disturbances, including heart-of-palm harvesting.

Dead individuals had the 14th highest importance value. In small areas, tree mortality is considered a result of increased edge effects due to fragmentation (Scariot et al., 2003). However, this importance value does not necessarily indicate huge representation of dead trees in the studied community, as the first 10 species accumulate about 50% of the importance value in PNMX, and the remaining species and dead individuals have significantly lower values.

Figure 2 – Field photographs of the species with the highest Importance Value Index recorded in the Parque Natural Municipal Xokleng, Nova Veneza, southern Santa Catarina, Brazil. A – *Machaerium stipitatum* (leaves and inflorescences), B – *Allophylus edulis* (leaves and fruits), C – *Cabralea canjerana* (fruits), D – *Piptadenia gonoacantha* (leaves and inflorescences), E – *Tetrorchidium rubrivenium* (fruits), F – *Euterpe edulis* (fruits), G – *Ficus adhatodifolia* (leaves and fruits), H – *Cupania vernalis* (leaves and inflorescences), I – *Nectandra oppositifolia* (flowers). Authors: Luís Adriano Funez (A, D, E, H and I), João Paulo Gava Just (B and C), Júlia Gava Sandrini (F) and Eduardo Dalabeneta (G)

Source: Authors (2024)

The diameters of the sampled individuals in PNMX ranged from 5 cm to 136 cm, with a mean diameter of 14 cm for the tree component. Most of the values were concentrated in the first diameter class (5-10 cm), which accounted about 57% of the sampled individuals. The more representative species in this class were *Mollinedia*

triflora (35 individuals), *Euterpe edulis* (23), *Cabralea canjerana* (20), *Cupania vernalis* (19), *Alsophila setosa* (18), and *Allophylus edulis* (17). The larger diameter classes (≥65 cm) were represented by only six individuals (1% of the total sampled), including two *Ficus adhatodifolia* individuals (105 cm and 136 cm), one *Moquiniastrum polymorphum* (90.6 cm), one *Nectandra oppositifolia* (71.1 cm), one *Piptadenia gonoacantha* (66.5 cm), and one *Didymopanax morototoni* (65.2 cm).

The obtained results are consistent with other studies conducted in the Dense Ombrophilous Forest of southern Santa Catarina, where the majority trees have a diameter at breast height (DBH) equal to or less than 10 cm (Martins, 2005, 2010; Pasetto, 2008; Colonetti *et al*., 2009). Elias et al. (2018) showed that 65% of the sampled individuals in an urban forest fragment of Submontane Dense Ombrophilous Forest in the city of Criciúma had diameters between 5 cm and 10 cm. This pattern, although influenced by the inclusion criteria used, reflects the history of exploitation and fragmentation of the Atlantic Forest (Stehmann et al., 2009) in the southern region of Santa Catarina.

The estimated heights ranged from 2 to 18 m, with an average height of 7.83 m for the tree component. The tallest recorded heights were associated to individuals of *Citharexylum myrianthum* and *P. gonoacantha*, both reaching 18 m. In terms of vertical distribution, most individuals (72%) were concentrated in the middle stratum of the forest, in classes between 4.5 m and 11 m. This stratum presented greater abundance of *Mollinedia triflora*, *Machaerium stipitatum*, *Allophylus edulis*, *Cabralea canjerana*, and *E. edulis*. For the lower stratum classes (between 2 m and 4 m), a high occurrence of *Alsophila setosa*, dead individuals and the species *M. triflora* and *Mollinedia schottiana* was observed. This stratum also has abundant presence of *Psychotria suterella* and *Rudgea jasminoides*, however, several individuals of these species did not reach the sampling criteria. In addition, the tallest height classes were dominated by canopy species *Tetrorchidium rubrivenium*, *Piptadenia gonoacantha*, and *Citharexylum myrianthum*.

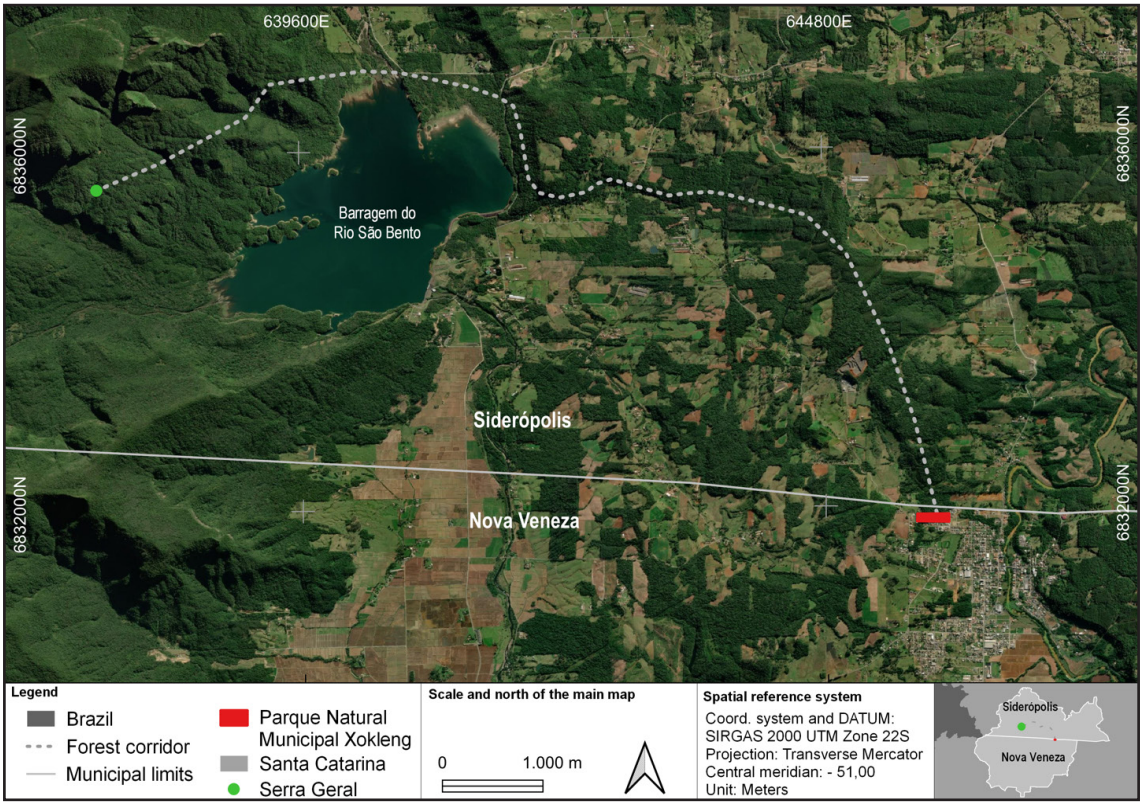
The Shannon index was H' = 3.65, and Pielou's evenness index was J = 0.84, with

a species richness of 77 species. The obtained diversity is consistent with the average for the southern region of Santa Catarina (H' = 3.76) (Martins, 2005, 2010; Colonetti et al., 2009; Guislon, 2014), but lower when compared to studies conducted in larger and more preserved areas (Martins, 2005, 2010; Guislon, 2014). The evenness is high, being greater than most of the compared studies (Martins, 2005, 2010; Colonetti et al., 2009) and equal to that obtained by Guislon (2014) in the Montane Forest of the Parque Estadual da Serra Furada (PAESF), indicating homogeneity in species participation in the studied community.

Guislon (2014) suggests that the higher diversity and richness observed in PAESF compared to Submontane Forests may be a result of low human intervention in the area, which is hindered by its distance from urban centers and its topography. The opposite situation is observed in PNMX, as it is located within Nova Veneza urban zone and is susceptible to disturbances, such as isolation by fragmentation of the other forest fragments nearby and the intensification of the edge effect. These factors may explain the lower diversity value obtained for PNMX compared to preserved forests. However, it is important to highlight that the found diversity is significant and demonstrates the importance of urban areas in biodiversity conservation.

According to Resolução n° 004/1994 of the Conselho Nacional do Meio Ambiente (Brasil, 1994), the studied fragment is in a medium stage of natural regeneration, as the average height of the individuals is below 12 m, the average DBH is below 15 cm, and the average basal area is approximately 15 m^2.ha-1. Additionally, there is dense natural regeneration in the area, along with the presence of clearings in different points, especially where pioneer species are completing their life cycle. However, it is worth noting that the protected area is currently conserved and progressing towards an advanced stage of succession.

Figure 3 – Map showing the connection of the Parque Natural Municipal Xokleng, in Nova Veneza, Santa Catarina, with other forest fragments in the surrounding area



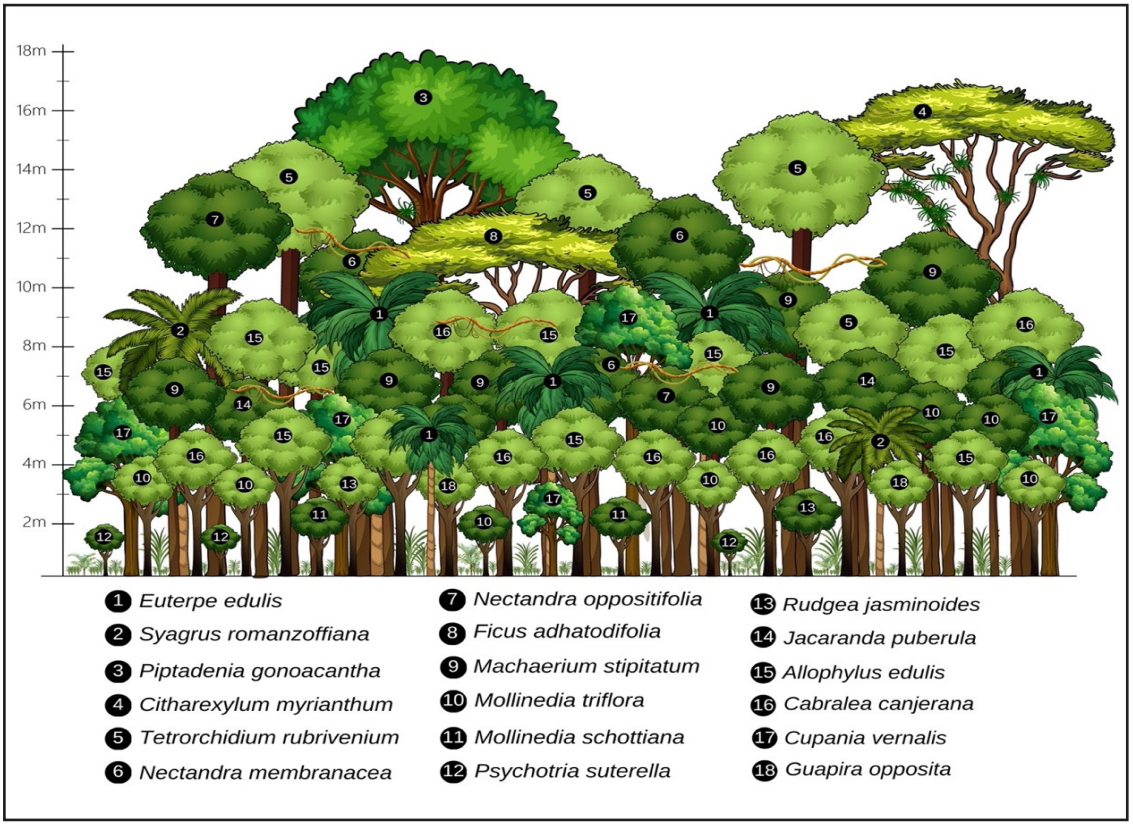
Source: Authors (2024)

The protected area is an important biodiversity core in the urban area of Nova Veneza, allowing, along with other forest fragments, the movement of animals from the slopes of the Serra Geral to the center of the municipality. Gava-Just (2022) recorded the presence of birds typical of high altitudes in the PNMX and attributed this presence to the connection of forest fragments that depart from the PNMX and reach the slopes of Serra Geral (figure 3).

3.2 Profile diagram

By constructing the profile diagram (figure 4), it was possible to synthesize and illustrate the general structural and compositional aspects of PNMX forest.

Figure 4 – Profile diagram of the Submontane Dense Ombrophilous Forest of Parque Natural Municipal Xokleng, in Nova Veneza municipality, southern Santa Catarina



Source: Authors (2024)

The presence of Arecaceae arborescent species confers particular physiognomic aspects to tropical forests (Peixoto et al., 1995). In the studied fragment, *Euterpe edulis* and *Syagrus romanzoffiana* were the most important species of the family. The canopy species are *Tetrorchidium rubrivenium*, *Citharexylum myrianthum*, *Nectandra oppositifolia*, *Nectandra membranacea*, and *Machaerium stipitatum*, which have also been recorded in this stratum in other forests (Martins, 2005; Colonetti et al., 2009; Bosa et al., 2015; Elias et al., 2018). Additionally, senescent individuals of *Piptadenia gonoacantha* are observed at various points in the PNMX. The presence of this pioneer species at the end of its life cycle reinforces the process of ecological succession occurring in the forest.

The understory is densely populated by individuals of *M. stipitatum*, *Allophylus*

edulis, *Cabralea canjerana*, *Mollinedia triflora*, *E. edulis*, and *Cupania vernalis*. It also includes arborescent fern species such as *Alsophila setosa* and *Cyathea delgadii*, which are not represented in the diagram due to their lower frequency in the forest but are found concentrated in specific areas of the zone. The main shade-tolerant species in the tree community of PNMX are *Psychotria suterella* and *Rudgea jasminoides*, which are characteristic of lower strata in the southern region of Santa Catarina (Martins, 2005, 2010; Colonetti et al., 2009; Bosa et al., 2015; Elias et al., 2018).

The natural regeneration in the fragment is dense, especially in areas near the edge or those that have recently experienced disturbances, such as the opening of gaps due to the death of large trees, for example, individuals of *P. gonoacantha*. In these areas, species such as *Sorocea bonplandii*, *R. jasminoides*, *E. edulis*, *Guapira opposita*, *C. vernalis*, *M. triflora*, *Mollinedia schottiana*, and *P. suterella* are observed with abundance.

4 CONCLUSIONS

The vegetation structure is similar to the observed in other secondary fragments of Dense Ombrophilous Forest in the southern region of Santa Catarina. The higher concentration of individuals between 5-10 cm in diameter and 4-11 m in height reflects the past interventions that the forest has undergone. However, the presence of secondary species in the canopy and occupying high dominance values reflects the regeneration process the forest is undergoing.

The studied area has experienced disturbances in the past. However, the forest ecosystem has been reestablishing itself through natural regeneration processes in recent decades. Thus, it is important to manage the area with the objective of reducing edge effects and connecting this fragment with others nearby. Through this connection, it will be possible to establish new ecological corridors and facilitate greater gene flow among species.

The protected area is connected to other forest fragments in Nova Veneza, which allows the movement of animals from the slopes of the Serra Geral to the center of the municipality. The diversity found reaffirm the significance of this urban fragment as a site for biodiversity conservation.

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Authorship Contributions

1 – Júlia Gava Sandrini

Universidade do Extremo Sul Catarinense
https://orcid.org/0000-0002-5389-5042 • juliagsandrini@unesc.net
Contribution: conceptualization, data curation, formal analysis, investigation, project administration, writing – original draft

2 – Vicente Nava Lenhani

Universidade do Extremo Sul Catarinense
https://orcid.org/0000-0002-9848-6218 • v.lenhani@hotmail.com
Contribution: investigation, writing – review & editing

3 – Iara Zaccaron Zanoni

Universidade do Extremo Sul Catarinense
iara_zanoni@hotmail.com • https://orcid.org/0000-0001-6735-6130
Contribution: writing – review & editing

4 – Kristian Madeira

Universidade do Extremo Sul Catarinense
https://orcid.org/0000-0002-0929-9403 • kristian@unesc.net
Contribution: formal analysis, writing – review & editing

5 – Robson Santos

Universidade do Extremo Sul Catarinense
https://orcid.org/0000-0002-0018-6066 • rsa@unesc.net
Contribution: conceptualization, funding acquisition, writing – review & editing

6 – Guilherme Alves Elias

Universidade do Extremo Sul Catarinense
https://orcid.org/0000-0001-6339-4762 • guilherme@unesc.net
Contribution: conceptualization, funding acquisition, writing – original draft

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