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FLORISTIC AND PHYTOSOCIOLOGICAL COMPOSITION OF THE SQUARES IN THE CITY OF SANTARÉM, PARÁ

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Resumo

Composição florística e fitossociológica das praças da cidade de Santarém, Pará. A composição vegetal nas áreas verdes desempenha um papel importante na obtenção dos benefícios ecossistêmicos dentro destes espaços. Assim, esta pesquisa teve como objetivo caracterizar a composição florística e fitossociológica da arborização das praças de Santarém, Pará. Para isso, foi realizado um levantamento florístico em 38 praças, considerando árvores com altura superior a 1,5 m. As informações taxonômicas e fitogeográficas das árvores foram identificadas, e os parâmetros fitossociológicos: frequência (FA e FR), densidade (DA e DR), dominância (DoA e DoR), índice de valor de cobertura (IVC), índice de valor de importância (IVI) e índice de diversidade de Shannon-Wiener (H'), foram avaliados. Foram identificadas 686 árvores no total, sendo 54,60% delas de espécies nativas do Brasil e 45,40% de exóticas no país. A família Fabaceae se destacou com maior número de espécies (19), enquanto Anacardiaceae apresentou o maior número de indivíduos (219). As espécies com maior FA e FR foram *Mangifera indica* (78,95 - 14,71%) e *Moquilea tomentosa* (43,74 - 8,33%), em DA e DR, se destacaram *M. indica* (10,51 - 27,16 ind/ha) e *Azadirachta indica* (4,72 - 12,21 ind/ha). Para DoA e DoR, se destacaram *M. indica* (7,85 - 48,48 m^2/ha) e *Spondias mombin* (1,67-10,32 m^2/ha). Em IVI, *M. indica* também se destacou (90,34%). O H' geral das praças foi de 2,85, sobressaindo-se as praças Parque da Cidade (2,85) e Jati (2,23). Apenas duas praças apresentaram diversidade moderada a alta (H' > 2,22). A composição florística é composta predominantemente por indivíduos exóticos (54,60%), sobretudo da espécie *M. indica*.
Palavras-chave: Biodiversidade urbana; Ecossistemas urbanos; Planejamento urbano; Sustentabilidade urbana.

Abstract

The vegetation composition in green areas plays an important role in obtaining ecosystem benefits within these spaces. Therefore, this research aimed to characterize the floristic and phytosociological composition of the tree canopy in the squares of Santarém, Pará. To achieve this, a floristic survey was conducted in 38 squares, considering trees with a height greater than 1.5 m. Taxonomic and phytogeographical information of the trees was identified, and phytosociological parameters such as frequency (AF and RF), density (AD and RD), dominance (ADo and ADr), cover value index (CVI), importance value index (IVI), and Shannon-Wiener diversity index (H') were evaluated. A total of 686 trees were identified, with 54.60% of them being native species of Brazil and 45.40% exotic to the country. The Fabaceae family stood out with the highest number of species (19), while Anacardiaceae had the highest number of individuals (219). The species with the highest Af and Rf were *Mangifera indica* (78.95 - 14.71%) and *Moquilea tomentosa* (43.74 - 8.33%), and for Da and Dr, *Mangifera indica* (10.51 - 27.16 ind/ha) and *Azadirachta indica* (4.72 - 12.21 ind/ha) were prominent. In terms of DoA and DoR, *Mangifera indica* (7.85 - 48.48 m2/ha) and *Spondias mombin* (1.67-10.32 m^2/ha) were highlighted. In IVI, *M. indica* also stood out (90.34%). The overall H' for the squares was 2.85, with Parque da Cidade (2.85) and Jati (2.23) squares being the most prominent. Only two squares showed moderate to high diversity (H' > 2.22). The floristic composition is predominantly composed of exotic individuals (54.60%), especially the species *M. indica*.
Keywords: Urban Biodiversity; Urban Ecosystems; Urban Planning; Urban Sustainability.

INTRODUCTION

Squares are fundamental elements for the quality of life in cities, as they provide green spaces for the population, offering benefits such as the reduction of air pollution, mitigation of heat island effects, promotion of mental health, and conservation of biodiversity (CORRÊA; CORRÊA, 2012; BIONDI, 2015; MARTINI; BIONDI, 2015). Among the elements that make up these spaces, the tree component is the main provider of ecosystem services, acting in the capture of air pollutant particles, microclimatic regulation, air cooling, and wildlife refuge (MARTINI; BIONDI, 2015). Moreover, wooded environments also play an important aesthetic function, contributing to the heterogeneity of the urban landscape and as areas for contemplation and leisure (WOOD, 2018). The importance of the arboreal component in these spaces becomes even more evident in cities located in tropical regions, where the need for shade and thermal comfort is essential to make these environments usable at any time of the day (CORRÊA; CORRÊA, 2012).

Floristic composition and phytosociology are fundamental factors for understanding the composition and relationships of vegetation within urban green areas, thereby ensuring that these spaces provide ecosystem services satisfactorily (SILVA; ALMEIDA, 2016; FABRICANTE *et al.,* 2017; WOOD, 2018).

Floristic composition refers to the description of the plants that make up a particular environment, quantifying and characterizing them according to their family, species, and life habit. In turn, phytosociology aims to understand the species present in a given area, assessing their behavior within the community and the interactions between them and the environment through quantitative phytosociological parameters for each species (SILVA; ALMEIDA, 2016).

Research on the street tree planting in the city of Santarém has found that the majority of species present are of exotic origin (BAUMANN et al., 2019; SANTARÉM, 2023). In a partial inventory of street tree planting, carried out between 2015 and 2018, in nine neighborhoods of the northern zone and one neighborhood of the central zone, it was found that the tree-lined streets were mainly composed of three species: *Mangifera indica* L. (mangueira) - 28.32%, *Moquilea tomentosa* Benth (oiti) - 17.31%, and *Azadirachta indica A. Juss* (nim) - 13,99% (SANTARÉM, 2023).

Thus, the hypothesis of this study was that the floristic composition of the squares in Santarém shows a predominance of exotic species with low species diversity, similar to the roadside tree planting, with species such as *Mangifera indica* and *Azadirachta indica* standing out. This hypothesis is based on the fact that urban tree planting in Brazilian cities is influenced by the population (BIONDI; PEDROSA-MACEDO, 2008), and that in the Northern region of Brazil, the population tends to have a preference for these species, especially *M. indica* (SILVA, 2018). It is important to note that the use of exotic species in urban forestry can lead to biological invasion and serious environmental impacts, reducing the native vegetation in the invaded areas (FABRICANTE *et al.,* 2017). Therefore, Law 21,871, of December 29, 2022, which deals with the Master Plan for Tree Planting in the Municipality of Santarém, advocates the use of native species in the city's tree planting and foresees the gradual replacement of specimens of *Ficus benjamina* L. (figueira-benjamina) and *A. indica* (SANTARÉM, 2022).

In this context, this research aimed to characterize the floristic and phytosociological composition of the tree planting in public squares located in the city of Santarém, Pará.

MATERIAL E METHODS

Study area

The current study conducted an assessment of 38 squares located in the urban area of the municipality of Santarém, Pará. According to data obtained from the Regional Nucleus of the Municipal Secretary of Environment of Santarém (SEMMA), the referred municipality has a total of 42 squares. However, four of these areas were excluded from the assessment because they were located beyond the urban limits or were situated within ecclesiastical areas that restricted public access to these spaces.

Santarém is geographically located in the western region of the state of Pará, at the coordinates 2°24'52"S and 54°42'36"W (FIGURE 1). The urban perimeter of the municipality covers an area of 97 km², which corresponds to 0.54% of the total extent of the municipality, encompassing 17,898.39 km². The urban zone of the municipality is divided into 48 neighborhoods, which in turn are distributed among five administrative zones: Central, North, South, East, and West.

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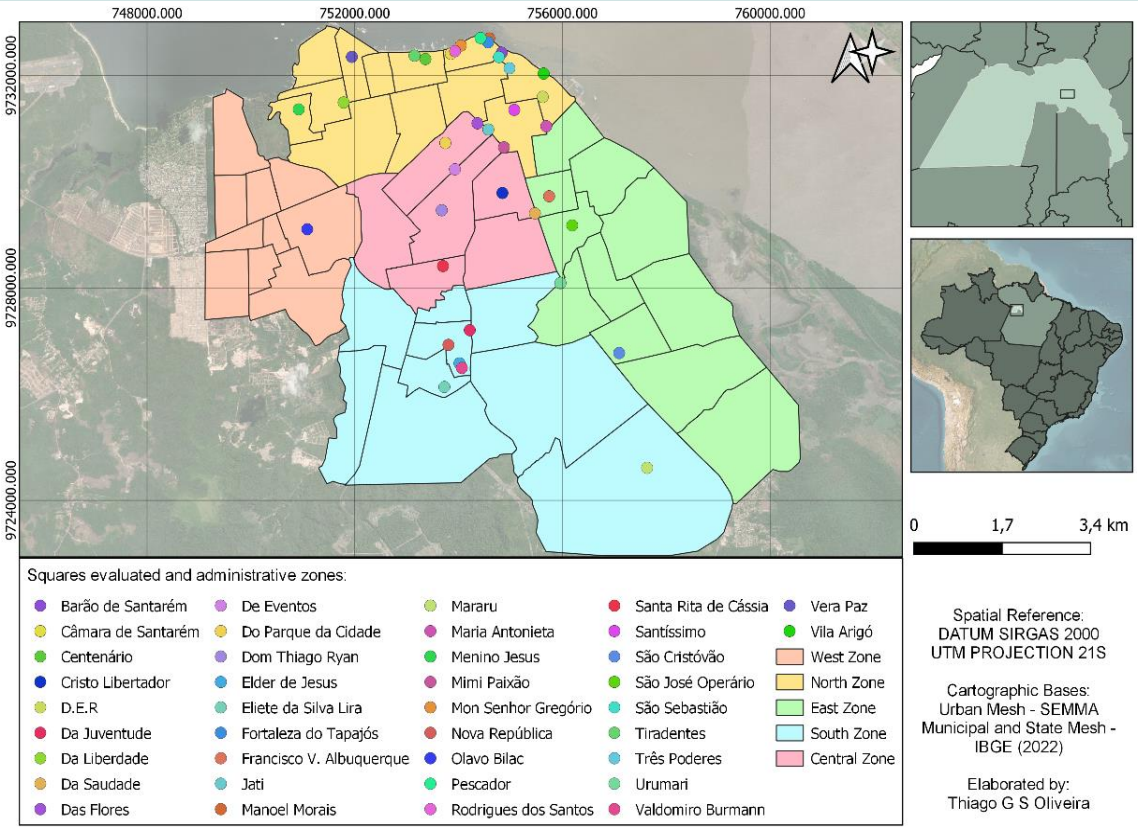

Figure 1. Location map of the urban area and distribution of squares in the city of Santarém - PA.
Figura 1. Mapa de localização da área urbana e distribuição das praças na cidade de Santarém - PA.

The municipality of Santarém has 331,937 inhabitants and a demographic density of 18.55 inhabitants per square kilometer (IBGE, 2023). According to the Köppen-Geiger classification, the predominant climate in the region is characterized as Am, with rainfall concentrated mainly in the first half of the year (winter) and high temperatures from June to November (summer). The annual precipitation varies from 1900 to 2200 mm, and the average annual temperature fluctuates between 25 and 27 °C, with extremes ranging from 22.6 to 32.8 °C, with significant differences between winter and summer (ALVAREZ et al., 2013). In the urban area of Santarém, temperatures can reach levels of 33 to 34 °C, especially during the summer period (CORRÊA; CORRÊA, 2012).

Data collection

To carry out the floristic survey, a quantitative census was conducted in the selected squares, encompassing all tree individuals with a height of 1.5 meters or more. The taxonomic identification of the trees was carried out in the field, at the family, genus, and species levels. The number of individuals per species and their phytogeographic distribution were recorded, according to the list of species from the Flora of Brazil. To categorize the species, their origin was considered as exotic, native to Brazil, or native to the Amazon biome, as defined by the REFLORA/CNPq Program. Furthermore, the horizontal structure of the arboreal community in the squares was assessed using the phytosociological parameters of absolute frequency (AF) and relative frequency (RF), absolute density (AD) and relative density (RD), absolute dominance (ADo) and relative dominance (RDo), cover value index (CVI), and importance value index (IVI). To calculate dominance, the variable Diameter at Breast Height (DBH) was replaced by Canopy Diameter (CD) in the basal area calculation, given that in an urban environment the canopy area is the tree component with the greatest environmental contribution (BOBROWSKI; FERREIRA; BIONDI, 2016). The CD of each tree corresponds to the average of the radii in the north-south and east-west directions squared and multiplied by π (pi). Additionally, the floristic diversity within the squares was assessed using the Shannon-Wiener diversity index (H').

$$H' = \sum_{i=0}^{n} pi * lnpi$$

Where: H' = Shannon-Wiener diversity index., n the number of species sampled, N = total number of individuals sampled, ni = number of individuals sampled of the nth species, ln = logarithmic neperian and pi = number of individuals sampled from the nth species divided by the total number of individuals sampled.

The Pielou Equity Index (J') was also calculated, which indicates the uniformity of the distribution of cases at the site, based on the proportion between diversity found (H') and maximum expected diversity (H"max).

$$J' = \frac{H'}{Hmáx}$$

Where: J' = Pielou's Evenness Index, H' = Shannon-Wiener diversity index, Hmax = natural logarithm of the total number of species

Data collection was conducted in March and June of 2022, and the data was later processed and analyzed in the form of tables and graphs using Microsoft Excel® 2021 software.

RESULTS

Floral Composition

The tree component of the 38 squares comprised a total of 686 trees, encompassing 55 species belonging to 22 botanical families. In this research, 695 trees were recorded, distributed across 55 species and 22 botanical families. The Fabaceae family was the most numerous, with 19 species (34.55%), followed by Anacardiaceae with 5 species (9.09%), and Myrtaceae, Bignoniaceae, and Malvaceae, each with 4 species (19.99%). Meliaceae, Malpighiaceae, and Sapotaceae contributed with 3 species each, accounting for 10.91% of the total. The other 14 botanical families contributed one species each, collectively representing 25.45%. Meliaceae, Malpighiaceae, and Sapotaceae each presented 3 species, with a combined contribution of 10.91%. The remaining 14 botanical families contributed one species each, collectively accounting for 25.45% of the total (TABLE 1).

Table 1. Common name, scientific name, and origin of tree species inventoried in the squares of Santarém - PA.
Tabela 1. Nome comum, científico e origem das espécies arbóreas inventariadas nas praças de Santarém - PA.

Scientific name	Common name	Family	N	O
Mangifera indica L.	Mangueira	Anacardiaceae	188	Ex
Azadirachta indica A.Juss.	Nim	Meliaceae	85	Ex
Handroanthus serratifolius (Vahl) S.Grose	Ipê-amarelo	Bignoniaceae	56	NBA
Handroanthus impetiginosus (Mart. ex DC.) Mattos	Ipê-rosa	Bignoniaceae	40	NBA
Moquilea tomentosa Benth	Oiti	Chrysobalanaceae	37	NB
Clitoria fairchildiana R.A.Howard	Palheteira	Fabaceae	29	NBA
Bowdichia virgilioides Kunth	Sucupira	Fabaceae	28	NBA
Ficus benjamina L.	Figueira-benjamina	Moraceae	27	Ex
Handroanthus spp.	Ipê	Bignoniaceae	26	NB
Terminalia catappa L.	Castanhola	Combretaceae	21	Ex
Syzygium jambos (L.) Alston	Jambeiro	Myrtaceae	20	Ex
Spondias mombin L.	Taperebazeiro	Anacardiaceae	18	NBA
Pinus sp.	Pinus	Pinaceae	10	Ex
Anacardium occidentale L.	Cajueiro	Anacardiaceae	8	NBA
Andira inermis (W.Wright) DC.	Alvineira	Fabaceae	7	NBA
Byrsonima crassifolia (L.) Kunth	Muruci	Malpighiaceae	7	NBA
Adenanthera pavonina L.	Tento-carolina	Fabaceae	6	Ex
Simarouba amara Aubl.	Marupá	Simaroubaceae	6	NBA
Pithecellobium dulce (Roxb.) Benth.	Acácia-mimosa	Fabaceae	5	Ex
Swietenia macrophylla King	Mogno-brasileiro	Meliaceae	5	NBA
Talisia esculenta (Cambess.) Radlk.	Pitombeira	Sapindaceae	5	NBA
Acacia mangium Willd.	Acácia	Fabaceae	4	Ex

Cassia ferruginea (Schrad.) Schrad. ex DC.	Chuva-de-ouro	Fabaceae	4	NBA
Mezilaurus itauba (Meisn.) Taub. ex Mez	Itaúba-amarela	Lauraceae	4	NBA
Pouteria bilocularis (H.K.A.Winkl.) Baehni	Abiurana-vermelha	Sapotaceae	4	NBA
Tapirira guianensis Aubl.	Tatapipirica	Anacardiaceae	4	NBA
Cordia alliodora (Ruiz & Pav.) Cham.	Louro-amarelo	Cordiaceae	3	NBA
Psidium guajava L.	Goiabeira	Myrtaceae	3	Ex
Xylopia brasiliensis Spreng.	Pimenta-de-macaco	Annonaceae	3	NB
Cassia fistula L.	Cássia	Fabaceae	2	Ex
Cenostigma tocantinum Ducke	Pau-preto	Fabaceae	2	NBA
Crescentia amazonica Ducke	Cuieira	Bignoniaceae	2	NBA
Deguelia spruceana (Benth.) A.M.G.Azevedo & R.A.Camargo	Faxeiro	Fabaceae	2	NBA
Lophanthera lactescens Ducke	Lanterneira	Malpighiaceae	2	NBA
Protium heptaphyllum (Aubl.) Marchand	Breu-branco	Burseraceae	2	NBA
Albizia julibrissin Durazz.	Acácia-constantinopla	Fabaceae	1	Ex
Anacardium spruceanum Benth. ex Engl.	Cajuí	Anacardiaceae	1	NBA
Calliandra surinamensis Benth.	Caliandra	Fabaceae	1	NBA
Caryocar villosum (Aubl.) Pers.	Pequizeiro	Caryocaraceae	1	NBA
Cassia leiandra Benth.	Mari	Fabaceae	1	NBA
Copaifera martii Hayne	Copaibarana	Fabaceae	1	NBA
Couroupita guianensis Aubl.	Abricó-de-macaco	Lecythidaceae	1	NBA
Delonix regia (Bojer ex Hook.) Raf.	Flamboyant	Fabaceae	1	Ex
Eucalyptus sp.	Eucalipto	Myrtaceae	1	Ex
Heptapleurum actinophyllum (Endl.) Lowry & G.M. Plunkett	Árvore-guarda-chuva	Araliaceae	1	Ex
Hymenaea courbaril L.	Jatobá	Fabaceae	1	NBA
Pachira aquatica Aubl.	Munguba	Malvaceae	1	NBA
Pouteria sp.	Abiurana	Sapotaceae	1	NB
Pterodon emarginatus Vogel	Sapupira	Fabaceae	1	NB
Senna siamea (Lam.) H.S.Irwin & Barneby	Cássia-de-cião	Fabaceae	1	Ex
Sterculia apetala (Jacq.) H.Karst.	Cacipá	Malvaceae	1	NBA
Sterculia pruriens (Aubl.) K.Schum.	Axixá	Malvaceae	1	NBA
Syzygium cumini (L.) Skeels	Azeitoneira	Myrtaceae	1	Ex
Tamarindus indica L.	Tamarindo	Fabaceae	1	Ex
Ziziphus mauritiana Lam.	Cereja-indiana	Rhamnaceae	1	Ex

Legend: N - Number of trees; O - Origin of species; Ex - Exotic; NB - Native to Brazil; NBA - Native to Brazil and native to the Amazon Biome. Source: the authors (2024).

Among the 19 species that make up the Fabaceae family, two of them accounted for 58.16%, with *Clitoria fairchildiana* (palheteira) and *Bowdichia virgilioides* (sucupira) being the most numerous, with 29 and 28 individuals per species, respectively. When considering the number of tree individuals, the most prominent families were: Anacardiaceae, with 219 trees (31.65%); followed by Bignoniaceae, with 124 (17.84%); Fabaceae, with 98 trees (14.10%); and Meliaceae, with 90 (12.95%).

The remaining families included fewer than 37 tree individuals each. The prominence of the Anacardiaceae family is linked to the quantity of *Mangifera indica* (mango tree) trees, which had the highest number of specimens among the identified species, representing over 85% of the tree specimens in this family, and 27.16% of all the trees evaluated. Along with *M. indica*, the species *A. indica* appears as the second most representative in terms of the number of trees, with 85 individuals, accounting for 12.21% of the entire census.

Regarding the squares, the Parque da Cidade (22), São Sebastião (13), Jati (11), and Rodrigues dos Santos (11) stood out for having the highest number of species. The species *M. indica* was predominant in São Sebastião

square (35 individuals – 59.32%) and Jati square (4 – 20.0%), *Handroanthus impetiginosus* (17 individuals – 16.50%) and *Spondias mombin* (15 individuals – 14.56%) in Parque da Cidade square, and *Terminalia catappa* in Rodrigues dos Santos square (10 individuals – 40.0%).

Regarding the origin of the species, 65.45% are native to Brazil, while 34.55% are exotic to the country. Among the Brazilian native species, the majority, 54.54%, belong to the Amazon region. When examining the species with the highest number of individuals, it is noted that the exotic species (54.60%) are more common than the natives (45.40%).

The most common exotic species in the squares were *M. indica*, with 188 individuals, and *A. indica*, with 85 individuals, totaling 72.11% of the exotic trees. On the other hand, the native species showed a more diversified distribution, with seven predominant species: *H. serratifolius* (ipê-amarelo) (17,55%), *H. impetiginosus* (ipê-rosa) (12,54%), *M. tomentosa* (oiti) (11,60%), *C. fairchildiana* (palheteira) (9,09%), *B. virgilioides* (sucupira) (8,78%), *Handroanthus* sp. (ipê) (8,15%) and *S. mombin* (taperebazeiro) (5,64%), totaling 73.35% of the native arboreal individuals.

Phytosociology

The absolute frequency indicated that the most common species in the evaluated squares were: *M. indica* (78.95%), *M. tomentosa* (43.74%), *H. serratifolius* (39.47%), and *A. indica* (36.84%) (Table 2). Together, these species represent 37.25% of all species found (Table 2), with relative frequencies of 14.71, 8.33, 7.35, and 6.86%, respectively. It is worth noting that *M. indica*, *A. indica*, and *H. serratifolius* also showed high values of density, with 10.51, 4.72, and 3.11 individuals per hectare, respectively. These three species accounted for 47.41% of the individuals that make up the arboreal community of the squares.

Table 2. Importance value index, frequency, density, dominance, absolute and relative values, of the top ten tree species in the squares of Santarém - PA.

Tabela 2. Índice de valor de importância, frequência, densidade, dominância, absolutas e relativas, das dez principais espécies arbóreas das praças de Santarém - PA.

Scientific name	N	AF	FR	AD	RD	ADo	RDo	CVI	IVI
Mangifera indica L.	188	78.95	14.71	10.51	27.16	7.85	48.48	75.63	90.34
Azadirachta indica A.Juss.	85	36.84	6.86	4.72	12.21	0.57	3.54	15.76	22.62
Handroanthus serratifolius (Vahl) S.Grose	56	39.47	7.35	3.11	8.05	0.43	2.68	10.73	18.08
Handroanthus impetiginosus (Mart. ex DC.) Mattos	40	21.05	3.92	2.22	5.75	0.09	0.57	6.32	10.24
Moquilea tomentosa Benth	37	44.74	8.33	2.06	5.32	0.19	1.16	6.47	14.81
Clitoria fairchildiana R.A.Howard	29	18.42	3.43	1.61	4.17	0.84	5.20	9.37	12.80
Bowdichia virgilioides Kunth	28	31.58	5.88	1.56	4.02	0.89	5.48	9.50	15.38
Ficus benjamina L.	27	34.21	6.37	1.50	3.88	0.60	3.69	7.57	13.94
Handroanthus spp.	26	23.68	4.41	1.45	3.74	0.20	1.24	4.98	9.39
Terminalia catappa L.	21	13.16	2.45	1.17	3.02	0.47	2.93	5.94	8.40
Syzygium jambos (L.) Alston	20	23.68	4.41	1.11	2.87	0.37	2.26	5.13	9.54
Spondias mombin L.	18	10.53	1.96	1.00	2.59	1.67	10.32	1.91	14.87
Pinus sp.	10	2.63	0.49	0.56	1.44	0.15	0.92	2.35	2.84

Legend: N - Number of individuals; AF - Absolute frequency; RF - Relative frequency; AD - Absolute density; RD - Relative density; ADo - absolute dominance; RDo - relative dominance; CVI - cover value index; IVI - importance value index. Source: the authors (2024).

The Jati square (345.68 ind/ha - 14.73%), the Câmara de Santarém square (168.87 ind/ha - 7.20%), and the Dom Thiago square (120.09 ind/ha - 5.12%) presented the highest tree densities among the evaluated squares.

The species with the greatest canopy area dominance were *M. indica* (7.85 m^2/ha) and *S. mombin* (1.67 m^2/ha). These species accounted for 58.80% of the relative dominance of all species, with representativeness of 48.48% and 10.32% respectively. The dominance of *M. indica* (exotic) was 4.7 times higher than that of the second most dominant species, *S. mombin* (native). *M. indica* also stands out in terms of the CVI, contributing 75.63% to these indices followed by *A. indica* (15.76%), *S. mobim* (12.91%), and *H. serratifolius* (10.73%), with the other species contributing less than 10% of the CVI.

Among the species with the highest Importance Value Index (IVI), *M. indica* obtained the highest importance value, at 90.34%, followed by *A. indica*, with 22.62%, and *H. serratifolius*, with 18.08%. The other species did not exceed 16% of IVI.

Diversity index

The squares in Santarém achieved an overall Shannon-Wiener diversity index (H') of 2.85 and an average of 1.18. Among the set of squares, H' values ranged from 0 to 2.85. The diversity and equity values for all squares are presented in Table 3.

Table 3. Diversity and evenness indices for the tree component of the squares in Santarém - PA.
Tabela 3. Índices de diversidade e equidade para o componente arbóreo das praças de Santarém - PA.

Square	No. Families	No. Species	No. Trees	No. Ex	No. NB	H'	J'
Parque da Cidade	12	22	103	12	91	2.849	0.909
Jati	8	11	20	9	11	2.233	0.931
Rodrigues dos Santos	8	11	25	18	7	1.979	0.825
Vila Arigó	5	8	17	12	5	1.905	0.916
Centenário	6	7	16	5	11	1.895	0.974
Cristo Libertador	6	8	16	6	9	1.859	0.894
Mon Senhor Gregório	6	7	26	14	12	1.831	0.941
Francisco V. Albuquerque	4	6	15	4	11	1.679	0.937
Flores	5	6	17	5	12	1.611	0.899
Maria Antonieta	6	6	36	27	9	1.586	0.885
Três Poderes	5	5	6	4	2	1.561	0.970
Mararu	5	6	13	1	12	1.519	0.848
São Sebastião	8	13	59	49	10	1.508	0.588
Juventude	5	6	30	23	7	1.506	0.841
Santa Rita de Cássia	5	5	11	6	5	1.468	0.912
Elder de Jesus	3	5	11	4	7	1.367	0.849
Menino Jesus	2	4	5	0	5	1.332	0.961
Olavo Bilac	4	4	6	2	4	1.243	0.896
Santíssimo	4	5	15	3	12	1.205	0.749
Tiradentes	5	5	33	19	14	1.155	0.718
Da Saudade	4	4	9	10	6	1.143	0.825
Nova República	3	4	14	5	9	1.116	0.805
Valdomiro Burmann	4	4	8	8	0	1.074	0.774
D.E.R	3	3	15	4	5	1.061	0.966
Barão de Santarém	5	6	42	31	11	1.025	0.572
São José Operário	3	3	8	4	4	0.974	0.887
Liberdade	2	2	2	0	2	0.963	1.000
Praça de Eventos	6	6	57	51	6	0.815	0.455
Fortaleza do Tapajós	2	3	9	1	8	0.684	0.622
Pescador	3	4	17	15	2	0.660	0.476
São Cristóvão	2	2	5	5	0	0.637	0.918
Mimi Paixão	2	2	4	3	1	0.562	0.811
Vera Paz	2	2	4	3	1	0.562	0.811
Manoel Morais	2	2	7	7	0	0.410	0.592
Câmara de Santarém	1	1	2	2	0	0.000	0.000
Dom Thiago	1	1	3	3	0	0.000	0.000
Eliete da Silva Lira	0	0	0	0	0	0.000	0.000
Urumari	0	0	0	0	0	0.000	0.000
General	**22**	**55**	**686**	**375**	**311**	**2.846**	**0.710**

Legend: No. Families – Number of botanical families; No. Species – Number of species; No. Trees – Number of trees; No Ex – Number of exotic trees; No. nB – Number of native trees from Brazil; H'– Shannon-Weaver Diversity; J' – Pielou's Evenness. Source: the authors (2024).

The squares with the greatest diversity were Parque da Cidade (2.85) and Jati (2.23), which have their floristic composition predominantly made up of native species, in respective proportions of 90.91% and 54.55%. Out of the 24 squares with a diversity between 1 and 2, 18 of them have a percentage of natives exceeding 50%.

DISCUSSION

In the city of Santarém, the Fabaceae family stood out in the squares' tree population, both in terms of the frequency and abundance of species. This predominance can be associated, in the context of this research, with the fact that various species belonging to this family have notably showy flowers, which favors a preference for their planting (TABLE 1). The same pattern is observed in other Brazilian cities, such as Crato-CE and Macapá-AP (SANTOS et al., 2012; GOMES et al., 2016). The species *C. fairchildiana*, which corresponds to 29.59% of the family, and *B. virgilioides*, which represents 28.57%, were the main contributors in Santarém to this position of the Fabaceae. *C. fairchildiana* has desirable characteristics for urban tree planting, such as a wide and leafy canopy, which has driven its use in the urban forests of Brazilian cities (RIBEIRO *et al.*, 2021).

The Anacardiaceae family usually does not show prominence in tree inventories in Brazilian cities, not even ranking among the top five families in terms of species diversity, as evidenced by various research studies (KRAMER; KRUPEK, 2012; SANTOS *et al.,* 2012; GOMES *et al.,* 2016). However, its superior notability in the Northern region of Brazil. This prominence is directly attributed to the presence of individuals of *M. indica*, a species highly valued in this region due to the exuberance of its canopy and the sweet taste of its fleshy fruits (SILVA, 2018). These characteristics are preferred by the population, which plays a fundamental role in urban tree planting in this region of the country (BIONDI; PEDROSA-MACEDO, 2008; SILVA, 2018).

The percentage of exotic species found for Santarém, at 34.55%, can be considered low as it represents less than 50% of the total species, differing from other cities in the Northern region, such as Paragominas-PA (41.18%) and other Brazilian cities, such as Guarapuava-PR (47.96%) and Picos-PI (51%) (KRAMER; KRUPEK, 2012; REIS et al., 2018; SILVA et al., 2018). It is common to see an inversion of the predominance of exotic species when comparing species diversity and the number of individuals per species in other Brazilian cities (KRAMER; KRUPEK, 2012; GOMES et al., 2016). In various square inventories, *M. indica* and *A. indica* were also found among the most abundant exotic species in terms of number of individuals (SILVA; BIONDI; BATISTA, 2018).

A significant part of the introduction of exotic species into urban greening, whether on streets, squares, or parks, is due to the initiative of the population (BIONDI; PEDROSA-MACEDO, 2008). In this sense, according to the authors, it is important for public authorities to adopt awareness-raising measures regarding the use of exotic species and to develop management practices aimed at mitigating their spread in urban areas.

The species *M. indica*, *M. tomentosa*, *H. serratifolius*, and *A. indica* had occurrences over 35% in the evaluated squares and are also frequent in the road greening of Santarém, according to studies carried out by Baumann et al. (2019) and the Santarém City Hall (2023). Among them, the species *M. indica*, *A. indica*, and *H. serratifolius* had a higher density of individuals. However, *A. indica* is considered a problematic species because it is exotic and has allelopathic potential in relation to insects and other plants, as well as rapid growth and propagation, which can inhibit the development of native species (LEÃO *et al.*, 2011).

In terms of canopy dominance of the evaluated species, *M. indica* showed a dominance 4.7 times greater than the second most dominant species, the native *S. mombin*. This pattern of dominance of exotic species over natives is common in urban areas, due to the high dispersal capacity, hardiness, and absence of natural predators of the exotic species, which gives them a competitive advantage over native species (FABRICANTE et al., 2017). Although other native species stand out in terms of frequency and density of individuals, such as *M. tomentosa*, *H. serratifolius*, and *A. indica*, they do not show high dominance since dominance was measured by the canopy area of the trees. Thus, species with larger canopies, even without prominence in the previous parameters, offer a greater area of occupation in the evaluated squares, justifying, therefore, the position of *S. mombin* in this parameter.

Among the evaluated species with the highest CVI, *Spondias mombin* stands out, which, although it has a lower density compared to other species, excels in CVI due to its species' characteristic wide canopy. However, it is crucial to emphasize that, despite this feature, *S. mombin* is not the ideal choice for urban tree planting in equatorial regions. This is because of its deciduous nature, resulting in the complete loss of its shading capacity during the summer, when tree cover is most needed (GUIMARÃES *et al.*, 2021).

The significant importance attributed to the species *M. indica* and *A. indica* may reflect issues in the planning of urban tree planting in Santarém. Both species have characteristics that are less desirable for this purpose, as they have aggressive surface roots, large and fleshy fruits (in the case of *M. indica*), as well as allelopathy, rapid propagation, and toxic fruits, in the case of *A. indica*. (SILVA *et al.*, 2018; BAUMANN *et al.*, 2019). These characteristics can cause problems for urban infrastructure and other plant species, compromising biodiversity and the functioning of the urban ecosystem.

When analyzing the average H' found in some squares in Brazil (Table 1), it is notable that the squares of Santarém stand out positively in comparison with four of the weighted studies. Using these squares as a standard of reference, the general H' value found in Santarém, which is 2.85, can be characterized as significantly high.

Table 4. Mean values of the Shannon-Wiener index in Brazilian squares.
Tabela 4. Valores médios do índice de Shannon-Wiener em algumas praças brasileiras.

Locality	No. square	No. trees	H' general	Source
Santarém, PA	38	686	2,85	This research
Guarapuava, PR	7	1.143	2,66	Kramer e Krupek (2012)
Iporá, GO	5	198	2,53	Bernardes *et al.* (2019)
Gurupi, TO	3	261	2,37	Santos *et al.* (2012)
Natal, RN	10	498	1,13	Silva e Almeida (2016)

Legend: No. square – Number of squares; No. trees – Number of trees. Source: the authors (2024).

In order to evaluate the floristic community diversity of Santarém's squares, the index H' found in this research was also compared with the diversity thresholds established by Floriano (2014) for native forests in Brazil. According to these criteria, H' values between 1.5 and 3.5 are considered indicative of medium diversity. Therefore, it can be reaffirmed that the floristic community of Santarém's squares exhibits medium diversity, also presenting an equitable distribution of species, with an evenness of 0.71.

When evaluating the individual H' index of each square, it is observed that Parque da Cidade square (2.85) and Jati (2.23) obtained the highest levels of diversity, being close to the overall H'. These values exceed the H' indices of seven of the cities mentioned in Table 5. In addition, another 12 squares, along with these two, present medium levels of diversity, according to Floriano's (2014) definition.

On the other hand, of the remaining 24 squares, 11 were categorized with low species diversity, presenting an H' index of less than 1.5. Nine of the squares within this group demonstrated very low diversity (H' < 1.0). Four squares, in turn, had an H' equal to zero, either due to the presence of only one tree species, as in the Câmara de Santarém and Dom Thiago squares, or to the total absence of trees, as in the Eliete da Silva Lira and Urumari squares.

Diversity influences the phytosanitary security of tree individuals, since the lower the diversity of an environment, the greater the risks of predation or disease tend to be. Moreover, high homogeneity of species makes the environment less attractive to visitors (SILVA, 2012). Therefore, planting new species within squares to gain diversity is interesting, as long as it occurs in a planned way both in the choice of species and in the sizing of quantities.

The inclusion of a variety of plants in urban areas brings benefits to the environment, such as offering different opportunities for interaction with local fauna and reducing the monotony of space, providing a more pleasant experience for visitors (WOOD, 2018). Silva (2012) emphasizes that urban green areas with greater plant diversity are less likely to suffer phytosanitary problems. In addition, plant diversity allows for more dynamic landscapes throughout the year, thanks to different flowering and foliage cycles.

CONCLUSIONS

The analyses carried out led to the conclusion that:

- The floral composition of the squares in Santarém is predominanttly made up for tree species that are exotic to the brazilian flora.
- The exotic species *Mangifera indica* e *Azadirachta indica* were identified as the most representative in most of the phytosociological variables analyzed, with the exception the frequency and dominance variables for *A. indica*. In these cases, the native species *Moquilea tomentosa* and *Spondias mobim* also stood out.
- The Parque da Cidade (H'=2,85) and Jati (H'=2,23) squares, had the highest floristic diversity in Santarém. This diversity contributes to the ecological richness of these areas, promoting a more balaced healthy environment.

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REFERENCES

ALVARES, C. A.; STAPE, J. L.; SENTELHAS, P. C.; GONÇALVES, J. D. M.; SPAROVEK, G. Köppen's climate classification map for Brazil. **Meteorologische Zeitschrift**, Stuttgart, v. 22, n. 6, p. 711-728, 2013.

BAUMANN, S. S. R. T.; SANTA BRÍGIDA, C. A.; SILVA, J. B. S.; LIMA, P. S.; RABELO, L. K. L.; PIRES, E. C.; MAESTRI, M. P.; AQUINO, M. G. C. Espécies arbóreas tóxicas presentes na arborização urbana do município de Santarém, Pará. **Revista Ibero-Americana de Ciências Ambientais**, Aracaju, v. 10, n. 3, p. 342-351, 2019.

BERNARDES, A. M. A.; MOURA, T. M.; DINIZ, V. S. S.; DIAS, M. A.; MARQUES, M. Levantamento florístico e fitossociológico do componente arbóreo de praças públicas do município de Iporá, Goiás. **Revista Verde de Agroecologia e Desenvolvimento Sustentável**, Pombal, v. 14, n. 3, p. 436-442, 2019.

BIONDI, D. Floresta urbana: conceitos e terminologias. In: BIONDI, D. (Ed). **Floresta Urbana**. Curitiba: a autora, 2015a. pp. 11-27.

BIONDI, D.; PEDROSA-MACEDO, J. H. Plantas invasoras encontradas na área urbana de Curitiba (PR). **Floresta**, Piracicaba, v. 38, n. 1, 2008.

BOBROWSKI, R.; FERREIRA, R. L. C.; BIONDI, D. Descrição fitossociológica da arborização de ruas por meio de diferentes formas de expressão da dominância e da densidade. **Ciência Florestal**, Santa Maria, v. 26, n. 4, p. 1167-1178, 2016.

CORRÊA, P. B.; CORRÊA, J. A. D. J. Análise da temperatura de superfície da área urbana de Santarém através de imagens termais do Landsat 5. **Revista Geonorte**, Manaus, v. 3, n. 5, p. 714-722, 2012.

FABRICANTE, J. R.; SANTOS, J. P. B.; ARAÚJO, K. C. T.; COTARELLI, V. M. Utilização de espécies exóticas na arborização e a facilitação para o estabelecimento de casos de invasão biológica. **Revista Biotemas**, Florianópolis, v. 30, n. 1, p. 55-63, 2017.

FLORIANO, E. P. **Fitossociologia florestal**. São Gabriel: UNIPAMPA, 2009. 142 p.

GOMES, E. M. C.; RODRIGUES, D. M. S.; SANTOS, J. T.; BARBOSA, E. J. Análise quali-quantitativa da arborização de uma praça urbana do Norte do Brasil. **Nativa**, Sinop, v. 4, n. 3, p. 179-186, 2016.

GUIMARÃES, T. P.; MANESCHY, R. Q.; OLIVEIRA, I. K. S.; CASTRO, A. A.; OLIVEIRA, P. D.; COSTA, K. C. G. Composição botânica na área de influência da copa de *Spondias mombin* L. disperso em pastagens no assentamento Belo Horizonte I, São Domingos do Araguaia-PA. **Brazilian Journal of Animal and Environmental Research**, Curitiba, v. 4, n. 3, p. 4729-4739, 2021.

KRAMER, J. A.; KRUPEK, R. A. Caracterização florística e ecológica da arborização de praças públicas do município de Guarapuava, PR. **Árvore**, Viçosa, v. 36, n. 4, p. 647-658, 2012.

LEÃO, T. C.; ALMEIDA, W. R.; DECHOUM, M. D. E. S.; ZILLER, S. R. **Espécies exóticas invasoras no Nordeste do Brasil**: contextualização, manejo e políticas públicas. Recife: Centro de Pesquisas Ambientais do Nordeste e Instituto Hórus de Desenvolvimento e Conservação Ambiental, 2011. 99 p.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA (IBGE). **Estimativas da população residente no Brasil e Unidades da Federação com data de referência em 31º de dezembro de 2022**. Rio de Janeiro, 2022. Disponível em: <http://biblioteca.ibge.gov.br/visualizacao/livros/liv97868.pdf>. Acesso em: 29 ago. 2023.

MARTINI, A.; BIONDI, D. Microclima e conforto térmico de um fragmento de floresta urbana em Curitiba, PR. **Floresta e Ambiente**, Seropédica, v. 22, p. 182-193, 2015.

SILVA, I. R.; OLIVEIRA, A. T. S.; SILVA, L. B. O.; BAIA, R. S.; CORREA, T. B. C.; MARTINS, W. B. R. Diagnóstico visual e fitossociologia na arborização de praças em Paragominas, Pará. **Revista da Sociedade Brasileira de Arborização Urbana**, Curitiba, v. 13, n. 1, p. 1-13, 2018.

RIBEIRO, F. I. O.; SILVA, A. V. S.; QUEIROZ, L. O.; SILVA, S. B.; XAVIER, W. K. S.; LIMA, E. S.; CANTUÁRIA, P. C.; SOARES, A. C. S. Diagnóstico quali-quantitativo da arborização da praça Jaci Barata "Zagury", Macapá, Amapá, Brasil. **Brazilian Journal of Development**, Curitiba, v. 7, n. 1, p. 9116-9136, 2021.

SANTARÉM. **Manual de Orientação Técnica da Arborização Urbana de Santarém, Pará**. Santarém: Prefeitura Municipal de Santarém, 2023. 48 p.

SANTOS, A. C. B.; SILVA, M. A. P.; SOUZA, R. K. D. Levantamento florístico das espécies utilizadas na arborização de praças no município de Crato, CE. **Cadernos de Cultura e Ciência**, Pimenta, v. 10, n. 1, p. 13-18, 2012.

SILVA, C. D. D.; ALMEIDA, L. M. Composição florística e fitossociológica das praças do bairro de Neópolis, Natal – RN. **Carpe Diem: Revista Científica e Cultural do UNIFACEX**, Natal, v. 14, n. 2, p. 86-103, 2016.

SILVA, D. A.; BIONDI, D.; BATISTA, A. C. Avaliação qualitativa da arborização com *Mangifera indica* nas ruas de Belém – PA. **Acta Biológica Catarinense**, Joinville, v. 5, n. 1, p. 34-45, 2018.

SILVA, L. S.; OLIVEIRA, Y. R.; SILVA, P. H.; PIMENTEL, R. M. M.; ABREU, M. C. Inventário das plantas arbustivo-arbóreas utilizadas na arborização urbana em praças públicas. **Journal of Environmental Analysis and Progress**, v. 3, n. 2, p. 241-249, 2018

SILVA, R. N. Caracterização e análise quali-quantitativa da arborização em praças da área central da cidade de Arapiraca, AL. **Revista da Sociedade Brasileira de Arborização Urbana**, Piracicaba, v. 7, n. 2, p. 102-115, 2012.

WOOD, A.; HARSANT, M.; DALLIMER, M.; CHAVEZ, A.; MCEACHAN, R. R. C.; HASSALL, C. Not all green space is created equal: Biodiversity predicts psychological restorative benefits from urban green space. **Frontiers in Psychology**, Suíça, v. 9, p. 2320, 2018.