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LEVANTAMENTO FLORÍSTICO E CENSO DAS PRAÇAS PÚBLICAS DA ZONA SUL DE NATAL / RN, BRASIL

FLORISTIC SURVEY AND CENSUS OF THE PUBLIC SQUARES OF SOUTHERN NATAL / RN, BRAZIL

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RESUMO

Praças públicas são áreas verdes urbanas que promovem a valorização da natureza, oferecendo oportunidades de lazer, interação com a comunidade e hábitos saudáveis. A vegetação em praças públicas promove sombreamento e influencia a estética dos espaços públicos atuando na saúde mental e física da população. Pode apresentar elementos selecionados apenas pelo seu valor ornamental ou ainda conter elementos da vegetação nativa remanescente, ajudando a conectar a biota nativa de fragmentos de vegetação no entorno das cidades. Com o objetivo de compreender a composição e qualidade da cobertura arbórea das praças públicas de uma das capitais do Brasil, Natal, realizamos um levantamento florístico e censo. A origem exótica e nativa das espécies foi distinguida e índices e valores foram calculados e compilados para melhor compreender a composição, distribuição espacial, semelhança com áreas verdes urbanas adjacentes e qualidade dos espaços verdes para a população. A maioria das espécies pesquisadas são de origem exótica e nossos resultados apontam para a necessidade de expansão da cobertura arbórea e investimento em melhor planejamento paisagístico, administração e manutenção de praças públicas. Nossos resultados integram um conhecimento global da situação atual e da relevância do planejamento da vegetação urbana, com representatividade relevante para o Brasil e a América do Sul.
Palavras-chave: Inventário; Áreas verdes; Arborização urbana.

ABSTRACT

Public squares are urban green areas that promote the appreciation of nature, offering opportunities to recreation, community interaction and healthy habits. The vegetation in public squares promotes shading and influences aesthetics of public spaces acting on the population mental and physical health. It may present elements selected only for their ornamental value or even contain elements of the remaining native vegetation, helping to connect the native biota of vegetation fragments surrounding cities. With the aim to understand the composition and quality of the tree cover of public squares of one of the main cities in Brazil, Natal, we performed a floristic survey and census. The exotic and native origin of species was distinguished. Indexes and values were calculated and compiled to better understand the composition, spatial distribution, similarity to adjacent green urban areas and quality of green spaces for the population. Most species surveyed are of exotic origin and our results support the need to expand the tree cover and to invest in a better landscape planning, administration, and maintenance of public squares. Our results integrate a global knowledge of the current situation and of the relevance of the planning of urban vegetation, with relevant representativeness for Brazil and South America.
Keywords: Inventory, Green areas; Urban Forest.

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INTRODUCTION

Urban vegetation provides essential environmental services, such as the reduction of solar radiation in urban spaces (OLIVEIRA et al., 2011), the retention of air pollution particles (NOWAK et al., 2014; GUERRERO-LEIVA et al., 2016), soil protection and stabilization (BAE; RYU, 2015; SARAH et al., 2015) and the protection of water resources (COVILLE; ENDRENY; NOWAK, 2020). Furthermore, urban green areas promote the valorization of nature, opportunities for recreation and community interaction, and the development of healthy practices (SECRETARIAT OF CONVENTION ON BIOLOGICAL DIVERSITY, 2012). Interaction with forested spaces can reduce psychological precursors of violence, such as irritability, in addition to reducing anxiety and stress, and increasing relaxation, what can provide benefits to the general quality of life of the urban population (TIAN et al., 2011). Thus, the planning of urban vegetation is necessary based not only on its aesthetic values but on the ecosystem services it provides to improve the quality of life (DUARTE et al., 2018).

Distinguished from free spaces, urban green areas include vegetated squares, urban parks, and public gardens, among others (LIMA et al., 1994; RUBIRA, 2016). With dimensions ranging from 100 m² to 40468,6 m², the squares contribute to the culture and history of cities due to the social interaction they provide among all layers of society (GOMES, 2007). The specific function of the squares is to encourage community life, acting as central meeting point for people and even comprising local commerce (REDIN et al., 2010). The vegetation in the squares acts mainly to shade areas, increasing humidity, preventing direct sunlight on surfaces and also the reflection of the heat caused by direct insolation of asphalt and concrete (OLIVEIRA et al., 2013). Furthermore, it can act positively on mental health of the population, through the aesthetics and environmental comfort provided by a well-planed landscape (BARGOS; MATIAS, 2011).

Plant elements in public squares are selected primarily to compose an aesthetic landscape. However, plant selection and landscape planning in those spaces can also act as a form of ex situ conservation and promote environmental education for the population. In addition, the inclusion of elements of the native vegetation may serve to connect fragments of the biota of the surroundings. Nevertheless, in most of Brazilian squares, exotic species dominate (SECRETARIAT OF CONVENTION ON BIOLOGICAL DIVERSITY, 2012). In Brazil, the planning of urban landscaping in green areas, streets and squares, is historically carried out empirically and out of a technical-scientific context (DA SILVA; DE ALMEIDA, 2016; DA SILVA et al., 2018). Few Brazilian cities have specific legislation to regulate well-structured landscape planning, qualified for urban environmental quality (IBGE, 2010). Poorly planned urban landscaping can cause several problems in cities, such as arboreal conflict with electrical networks and the appearance of signs and cracks in the sidewalks, caused by the exposure of roots (DA SILVA et al., 2018). However, most people, including city planners and policymakers, generally consider urban green space and other natural components in residential areas as luxuries and not necessities (SOGA; GASTON, 2016). The vast majority of Brazilian cities does not even have monitoring over urban green areas and cannot have formal knowledge of their floristic composition (DUARTE et al., 2018). Knowing the floristic composition of urban areas is essential to obtain qualitative and quantitative information to help decisions about pruning, removal, planting or phytosanitary treatments (SANTOS et al., 2015).

In the state of Rio Grande do Norte (RN), located in the extreme northeast of Brazil, there is still much to understand about urban green spaces as a whole. Recent work in this area has focused on the morphological characterization of native plants for ornamental use, the economic impact of the use of native and exotic species in urban landscaping in Natal-RN, the environmental perception of residents on urban green areas, and feasibility of implementing a Botanical Garden in the city of Natal (MACEDO unpublished data; DIESEL unpublished data). These works highlight that the native local flora has potential for the use in landscaping, what would increase species richness to urban areas (MACEDO, unpublished data). And although a quantitative study is still missing, it is estimated that native species are underrepresented in public or private areas (VERSIEUX et al., 2016). Overall, little is formally known about the real floristic composition of the green planted areas in Natal (the capital of the state), including roadbeds and squares, and even less is documented from other municipalities in the state.

Aware that green areas are beneficial for the quality of life of the urban population and for the remaining native biota, this study aims to expand the knowledge about the urban flora of Natal-RN and, thus, provide subsidies for its planning, maintenance, and development. Specifically, we present a formal diagnosis of the floristic composition of public squares in one of the major regions of the city, including a list and a species census and an analysis of the proportion of native and exotic plants. In addition, we access data on the green coverage of public squares, the proportion of green areas per inhabitant, and their quality for the population. We also discuss the relevance of these data to support the adequate planning of urban spaces. We highlight that the scenario described and discussed for Natal, although local is similar to several cities and regions in Brazil as well as in South America and other regions of the world. This diagnostic can be used to integrate a global understanding of the current situation and of the relevance of the planning of urban vegetation.

MATERIAL AND METHODS

Study area

Natal is in the northern coastal region of Brazil and is the capital of the state of Rio Grande do Norte (latitude: 5° 47' 40'' S; longitude: 35° 12' 40'' O) (Fig. 1). The city has 803,739 inhabitants and 167,264 km² of area, 44.7% of which are urban green areas (IBGE, 2018). For administrative purposes, the city is divided into four zones: north, west, south, and east. The city's native vegetation consists of fragments of the Atlantic Forest, with sand dune systems and mangroves (DE ARAÚJO et al., 2015). Natal has 248 public squares distributed throughout the city; the south zone is home to most of them (90 in total) (SEMURB, 2020 b).

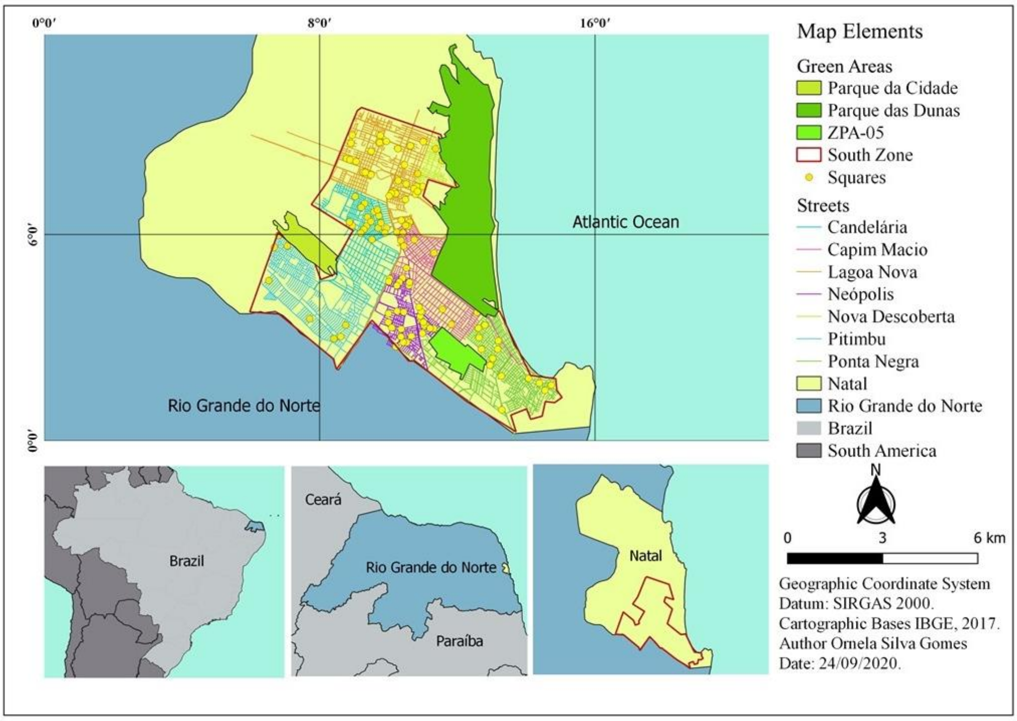

Figure 1. Praças da zona sul de Natal e áreas adjacentes Natal- RN, Brazil, 2020.
Figura 1. Squares in southern Natal and adjacent areas, Natal-RN, Brazil, 2020.

The south zone of Natal is divided into seven neighborhoods: Lagoa Nova, Nova Descoberta, Candelária, Capim Macio, Pitimbu, Neópolis, and Ponta Negra. This zone includes major preservation areas, including the Parque Estadual Dunas de Natal, the Parque da Cidade do Natal Dom Nivaldo Monte, and one of the ten Environmental Protection Zones in the city (ZPA-5). The Parque da Cidade do Natal Dom Nivaldo Monte (5° 51' 4.08" S and 35° 13' 40.85" W), an area of 136.54 ha, was created with the main objective of preserving the underground springs and the preservation ecosystem of the sand dune (PREFEITURA DE NATAL, 2018). The Parque Estadual Dunas de Natal (05º 48' 45'' S and 35º 11' 35'' W) is the first Protected Area implemented in Rio Grande do Norte for the conservation of natural ecosystems (PREFEITURA DE NATAL, 2018). The ZPA-05 does not include a park but, as well as all the other ten Environmental Protection Zones in the city, it is a place of preservation and conservation of natural resources and includes a dunes/lagoons system area (PREFEITURA DE NATAL, 2018).

Collection of qualitative and quantitative data

The field research was carried out in all public squares in the southern zone of Natal where qualitative and quantitative measures were recorded for all trees. We included the squares listed by the administration of the city (in a shapefile file provided by SEMURB – Secretaria Municipal de Urbanismo; including address, name, law of creation, and the regulatory situation). In each public square, we recorded all existing tree species and the number of individuals per species. Palm trees were also registered due to the relevant local representativeness. Vouchers for all species were collected and included in the Herbarium of the Federal University of Rio Grande do Norte (UFRN).

After compiling a list of species, we checked the Reflora database (http://reflora.jbrj.gov.br) to distinguish the origin of plants in two categories: (1) Native, including species native to the Atlantic Forest domain (where Natal is located) (2) Exotic, including species that are neither native to the Atlantic Forest domain nor native to Brazil. Brazilian species that are not from Atlantic Forest domain were considered exotics for the local vegetation.

To measure the absolute frequency of species and families in each neighborhood, we used $AF = \frac{pi}{P} \times 100$, where pi is the number of public squares with the occurrence of a certain species or family and P is the total number of public squares sampled.

Analysis of green areas by inhabitant and quality of public squares

We measured the approximate area of each square using the Google Earth polygon tool (GOOGLE EARTH, 2020), as some of them were not properly delimited. We measured the richness of species per area (including trees and palms; SR/ m²) for each square. To estimate the amount of public area per inhabitant in each neighborhood we used the total green area index: $IAVT = \frac{\Sigma \text{ total area squares}}{\text{number of inhabitants}}$ (CAVALHEIRO; NUCCI, 1998; HARDER, RIBEIRO, TAVARES, 2006). To access a possible relationship of the income with the vegetation maintained in public squares we used both the number of inhabitants per neighborhood and the monthly income, which was estimated through the mean number of minimum wages per neighborhood (data provided by the administration of Natal; SEMURB, 2020b).

To access the quality of public squares in each neighborhood we used the index of usable green areas: $IAVU = \frac{\Sigma \text{ of the areas } (m^2) \text{ of the squares completely usable}}{\text{number of inhabitants}}$ (CAVALHEIRO; NUCCI, 1998; HARDER, RIBEIRO, TAVARES, 2006). For the calculation of IAVU, public squares were distinguished in three categories: (1) fully usable, (2) partially usable, and (3) without conditions of use. The main criteria for establishing these classes were the presence of benches (only considered present when functional, even when with minor damages), lawns, flowerbeds, shrubs, cleanliness, and buildings in good condition; the presence of each item counted 1 point to compose grades from 0 to 6; we consider grades 0-1 as public squares without conditions of use (WCU), 2-3 partially usable (PU), 4-5 fully usable (U).

Relationship between variables

To investigate the relationship between the number of individuals, species richness, the proportion of native species, the monthly income, and the values of IAVT and IAVU found in each neighborhood, we calculated the Pearson's correlation using the free software BioEstat version 5.0 (AYRES et al., 2007). A correlation is considered significant when the p-value is less than 0.05 ($p < 0.05$).

Floristic relationship between squares and adjacent urban forests

To estimate a possible role for public squares as ecological corridors between the areas of remnants of surrounding native vegetation, we compared the floristic composition of public squares in the southern area of Natal with three adjacent urban green areas: (1) Parque Estadual Dunas de Natal (2) Parque da Cidade do Natal Dom Nivaldo Monte, and (3) ZPA-05. To acquire a list of species from each of these areas, we accessed herbarium collections on the online database Jabot (http://rb.jbrj.gov.br/v2/consulta.php). In each search we filtered collections of trees and palm made in those localities (a final species list for each area is available in Table B in Gomes; Calvente 2022).

The list was also complemented and checked with data produced and published by Roque et al. (2020) and by Diesel (unpublished data). Then, a presence (1) and absence (0) matrix was used to calculate the relationship between the areas using the Unweighted Pair Group Method using arithmetic averages (UPMGA) implemented in PAUP (Phylogenetic Analysis Using Parsimony) test version 4.0 (SWOFFORD, 1989).

Tree cover in sampled squares

To estimate the proportion of tree cover in the public squares of Natal, we randomly selected three squares from each size category defined in this study (small, medium, and large), resulting in a 10% sample (nine) of the 90 public squares. The size categories were: (1) small, including squares with 2,500 m² or smaller; (2) medium, including squares between 2,500 and 5,000m²; and (3) large, including squares over 5000 m².

In each of these nine public squares sampled at random, we recorded: (1) the number of trees and palms per area; and (2) breast height circumference (BHC). We considered as trees all woody species with a trunk with breast height circumference (BHC) greater than six centimeters (RIEGELHAUPT; LEAL, 2005), and at least 1.3 m tall (based on standard methodology for studies using diameter at breast height - DBH - in Brazil; RIEGELHAUPT;

LEAL, 2005). In the case of trees that branched below the breast height, each branch was measured and the DBH of the branches was calculated, using the equivalent diameter calculation (Deq=$\sqrt{\sum (DBH^2)}$) according to the methodology of Souza et al. (2016).

Furthermore, we estimated the density of individuals, in each squared sampled, through an inversion of the formula of the total density per area $TDA = \frac{A}{N}$ (originally $TDA = \frac{N}{A}$), where A is the area of the square (m²) and N is the total number of individuals in the square. Also we measured the vegetation occupation through the addition of the basal areas of all individuals (TBA – total basal area) in each of these squares. The basal area of each individual is given by the formula $G=\frac{\pi \times DBH^2}{40000}$ (m²). Finally, to estimate the proportion of each sampled square covered by the total basal area of trees in that square, we calculated the percentage of TBA in relation to the square's area.

RESULTS AND DISCUSSION

Floristic composition, natives and exotics

We accounted in total 79 species and 4,007 individuals of 28 botanical families in all 90 public squares in the south zone of Natal-RN (Table 1). We registered for *Cocos nucifera* the highest number of individuals (n=688, 17% of individuals, present in 65.56% of the squares) and for Mangifera indica (n=407, 10% of individuals, present in 72.22% of the squares) the highest absolute frequency of individuals (Table C in GOMES, CALVENTE 2022). The exotics represented 59.49% of all documented species while natives represented 40.51%. Among the exotic species, *Cocos nucifera*, *Mangifera indica*, *Azadirachta indica*, and *Eucalyptus* sp. had the greater number of individuals (688, 407, 199, and 180, respectively; Table 1). The most representative natives were *Anacardium occidentale*, *Tabebuia aurea*, and *Handroanthus impetiginosus* (with 511, 130, and 125, respectively). Regarding the number of individuals inventoried in all the squares, 69% belong to exotic species while 31% of individuals belong to native species.

Tabela 1. Lista de famílias, espécies e número de indivíduos (IN) nas praças da zona sul de Natal-RN, 2020.

Table 1. List of families, species and individuals number (IN) found in the squares of the southern zone of Natal- RN, 2020.

Family	Cientific Name	IN
Anacardiaceae	*Anacardium occidentale* Linnaeus	511
Anacardiaceae	*Mangifera indica* Linnaeus	407
Anacardiaceae	*Spondias mombin* Linnaeus	10
Anacardiaceae	*Astronium urundeuva* Allemão	24
Anacardiaceae	*Spondias purpurea* Linnaeus	4
Annonaceae	*Annona squamosa* Linnaeus	16
Annonaceae	*Annona muricata* Linnaeus	4

Araliaceae	*Schefflera actinophylla* (Endl.) Harms	9
Araucaceae	*Araucaria columnaris* (J. R. Forst) Hook	4
Arecaceae	*Cocos nucifera* Linnaeus	688
Arecaceae	*Dypsis decaryi* (Jum.) Beentje & J.Dransf.	1
Arecaceae	*Syagrus cearensis* Noblick	27
Arecaceae	*Copernicia alba* Morong	17
Arecaceae	*Phoenix* sp**.**	9
Arecaceae	*Caryota mitis* Lour.	5
Arecaceae	*Roystonea oleracea* (Jacq.) O.F.Cook	62
Arecaceae	*Dypsis lutescens* (H.Wendl.) Beentje & J.Dransf.	56
Bignoniaceae	*Spathodea campanulata* P.Beauv.	5
Bignoniaceae	*Handroanthus impetiginosus* (Mart. ex DC.) Mattos	125
Bignoniaceae	*Tabebuia aurea* (S. M.) Benth. & Hook.f. ex S.Moore	130
Bignoniaceae	*Handroanthus chrysotrichus* (Mart. ex DC.) Mattos	10
Boraginaceae	*Cordia myxa* Linnaeus	1
Burseraceae	*Commiphora leptophloeos* (Mart.) J.B.Gillett	1
Chrysobalanaceae	*Licania tomentosa* (Benth.) Fritsch	121
Chrysobalanaceae	*Microdesmia rigida* (Benth.) Sothers & Prance	6
Chrysobalanaceae	*Chrysobalanus icaco* Linnaeus	1
Combretaceae	*Terminalia catappa* Linnaeus	170
Casuarinaceae	*Casuarina equisetifolia* Linnaeus	68
Fabaceae	*Pithecellobium dulce* (Roxb.) Benth.	115
Fabaceae	*Luetzelburgia purpurea* D.B.O.S.Cartoso, L.P.Queiroz & H.C.Lima	2
Fabaceae	*Mimosa caesalpiniifolia* Benth.	1
Fabaceae	*Prosopis sp*	24
Fabaceae	*Inga sp*	1
Fabaceae	*Paubrasilia echinata* (Lam.) Gagnon, H.C.Lima ...	72
Fabaceae	*Clitoria fairchildiana* R.A.Howard	106
Fabaceae	*Delonix regia* (Bojer ex Hook.) Raf.	44
Fabaceae	*Cassia fistula* Linnaeus	2
Fabaceae	*Cenostigma pyramidale* (Tul.) E. Gagnon & G.P. Lewis	4
Fabaceae	*Bauhinia monandra Kurz*	2
Fabaceae	*Senna siamea* (Lam.) H.S.Irwin & Barneby	129
Fabaceae	*Tamarindus indica* Linnaeus	34
Fabaceae	*Leucaena leucocephala* (Lam.) de Wit	16
Fabaceae	*Libidibia ferrea*(Mart. ex Tul.) L.P.Queiroz	25
Fabaceae	*Gliricidia sepium* (Jacq.) Kunth ex Walp.	27
Fabaceae	*Copaifera duckei* Dwyer	1
Fabaceae	*Hymenaea courbaril* Linnaeus	5
Fabaceae	*Albizia sp.*	21
Fabaceae	*Adenanthera pavonina* Linnaeus	111
Fabaceae	*Enterolobium contortisiliquum* (Vell.) Morong	4
Fabaceae	*Calliandra* sp	2
Lamiaceae	*Vitex gardneriana* Schauer	7
Malpighiaceae	*Byrsonima verbascifolia* (L.) DC.	1
Malvaceae	*Pachira aquatica* Aubl.	18
Malvaceae	*Talipariti tiliaceum* (L.) Fryxell	109
Malvaceae	*Sterculia apetala* (Jacq.) H.Karst.	3
Malvaceae	*Pseudobombax marginatum* (A.St.-Hil., Juss. & Cambess.) A.Robyns	1
Meliaceae	*Azadirachta indica* A. Juss	199
Meliaceae	*Swietenia macrophylla* King	3
Moraceae	*Ficus benjamina* Linnaeus	50
Moraceae	*Artocarpus heterophyllus* Lam.	1
Moreae	*Morus sp.*	4
Moringaceae	*Moringa oleífera* Lam	12

Myrtaceae	*Psidium guajava* Linnaeus	16
Myrtaceae	*Eucalyptus sp.*	180
Myrtaceae	*Syzygium cumini* (L.) Skeels	88
Myrtaceae	*Syzygium jambos* (L.) Alston	15
Myrtaceae	*Callistemon acuminatus* Cheel	1
Opiliaceae	*Agonandra brasiliensis subsp. brasiliensis* Miers ex Benth. & Hook.f.	1
Polygonaceae	*Triplaris gardneriana* Wedd.	1
Rhamnaceae	*Ziziphus joazeiro* Mart	3
Rubiaceae	*Genipa americana* Linnaeus	3
Rutaceae	*Citrus x limon (L.)* Osbeck	31
Rutaceae	*Pilocarpus jaborandi* Holmes	1
Sapindaceae	*Talisia esculenta* (Cambess.) Radlk.	3
Sapindaceae	*Filicium decipiens (*Wight & Arn.) Thwaites	2
Sapotaceae	*Pouteria sp*	2
Sapotaceae	*Sapindus saponaria* Linnaeus	6
Sapotaceae	*Chrysophyllum sp*	1
Urticaceae	*Cecropia pachystachya* Trécul	10

Our results indicate a higher use of exotics in public squares of Natal. This contradicts the recommendations registered by the administration of Natal-RN, which indicates prioritizing native species (SEMURB, 2021). Native species are safer in terms of bioinvasive risk and can improve the ecological quality of urban environments and, at the same time, offer aesthetic benefits (MORO et al., 2014; MORO; CASTRO, 2015; BURIVALOVA et al., 2015). However, exotic species are probably prioritized for landscaping and urban planning. Most of them are naturalized species with edible fruits, such as coconut and mango trees with locally cultural and sustained use. It is also possible that the local population in Natal is actively planting and propagating these species because of the interest in their fruits. Nevertheless, *M. indica* is not recommended for urban forestry due to its roots that may damage sidewalks, its fruits may cause damage to vehicles, clogging culverts, attract vectors, promote dirt and bad odor after fruit deterioration (DA SILVA; DE ALMEIDA, 2016). Furthermore, *Cocos nucifera* (Arecaceae) presented a considerable number of individuals probably because of its wide used in landscaping (MOHAN et al., 2019).

The predominance of exotic species in most urban centers may occur due to the lack of technical knowledge about the potential of native species (GONG; CHEN; YU, 2013; VERSIEUX et al., 2016). The preference for introducing exotics can occur due to several factors, such as rapid growth and overvalued beauty (CUPERTINO; EISENLHOR, 2013). In the northeast of Brazil, *Azadirachta indica* is used mainly for ornamental and commercial purposes. Rapid growth and high seed production, however, are indicative of invasive potential and it may cause possible environmental problems in the future (MORO; WESTERKAMP; MARTINS, 2013). We believe the common use of this species in urban areas should be carefully evaluated.

Anacardiaceae, Fabaceae, Arecaceae and Myrtaceae were the most represented families in this study. Anacardiaceae had the highest number of individuals (956 individuals), though only 6% of species belonged to this family. Fabaceae was the family with the greatest species richness (28%) and it was also represented by a high number of individuals (759). For Arecaceae, we registered 10% of the species and 863 individuals (Figure E in GOMES; CALVENTE, 2022). Indeed Fabaceae is one of the most used families in urban forestry (PAZINI et al., 2020; MONALISA-FRANCISCO; RAMOS, 2019; SARTORI et al., 2019). This preference is possibly due to many species with ornamental potential, rapid growth, and resilience. A high number of individuals were registered for *Adenanthera pavonina*, *Clitoria fairchildiana*, *Pithecellobium dulce* (, and *Senna siamea*. Although Fabaceae is more frequent (92%; Table Appendix F in GOMES; CALVENTE, 2022;), Anacardiaceae (80% frequency) had a larger number of individuals, in particular of *M. indica* and *A. occidentale*, both used as a source for edible fruits.

Vegetation cover

The neighborhood with the lowest index of total green areas was Nova Descoberta, which presents only 0.14 m² / inhabitants. This neighborhood is also the least populated. Ponta Negra had the largest green area with 4.10 m² / inhabitants. Globally, including all neighborhoods in southern Natal, the proportion of green areas was 2.42 m² / inhabitant (Table D in GOMES; CALVENTE, 2022;). This low proportion registered here indicates the need for the implementation of larger wooded areas. Furthermore, each square presented less than one tree per m^2 (I / m²) (Table A in GOMES; CALVENTE, 2022;). The highest value for the index of total green areas (IAVT) calculated for Ponta Negra is much less than the minimum (15 m² per inhabitant) recommended by the Brazilian Society for Urban Arborization (SBAU, 1996), although we are disregarding in this evaluation other green areas such as public parks and protection areas. Public parks and protection areas in southern Natal are not imbed in neighborhoods and are not structured for everyday activities, so the squares are the major source of green areas available to fill the everyday needs of the population. Even though Ponta Negra had a much larger green area compared to other neighborhoods, it presented the lowest value of useful areas (IAVU), due to the little or no maintenance and absence of built elements.

The IAVU of all the studied neighborhoods presented values below 2 m² / inhabitants. The smallest usable area was found in the Ponta Negra neighborhood, with only 0.01 m² / inhabitant. The neighborhood with the highest IAVU was Pitimbu (1.66 m² / inhabitant), where the values of IAVT and IAVU remained balanced and did not decrease like the others. The Candelária neighborhood was the only one that did not present fully usable areas (Table A in

GOMES; CALVENTE, 2022). Globally for southern Natal, the usable green areas calculated are 0.81 m² per inhabitant (Table D in GOMES; CALVENTE, 2022;).

Nova Descoberta had low IAVT and IAVU values, possibly because there are few official public squares there and also a few (35) individuals compared to other neighborhoods. The size of the green area there is disproportionate to the size of the population. There and in other neighborhoods, we observed the existence of squares that were not registered by SEMURB and, for this reason, are not considered official squares. We decided not include those in this study due to methodological restrictions. Although we have not done exhaustive searches of squares that were not inventoried in each neighborhood, our general observations indicate that they are not so many. Nevertheless, we recommend a review in the inventory of public squares in southern Natal, since it is possible that for some places, such as Nova Descoberta, there is a higher number of squares implemented but not registered formally, what could result in larger IAVT and IAVU values. Another issue was problems with the delimitation of the squares as seen in Pitimbu, for example. The absence of proper built delimitation caused inaccuracy in the delimitation of surrounding roads, sidewalks, private properties and the squares area what also may deserve administration intervention. Squares in this neighborhood are visited by local population and there is considerable care to the squares given by them.

Quality of public squares

Of all squares, 37% were considered without conditions of use, 38% of them are partially usable, and only 25% are completely usable (Figure I, GOMES; CALVENTE, 2022). Regarding the quality of the public squares for the population, most squares were classified as partially usable, although some of them had damaged benches and structures (personal observation). For example, in the Eucaliptos Square (Candelária), the square with the highest total basal area recorded due to the presence of many mature trees, part of the benches needed to be restored and some of the trees needed thinning and phytosanitary treatment (personal observation). Many other squares also needed maintenance and investments in infrastructure (personal observation). The Dinarte Mariz Square, for example, did not have benches or structures built for leisure. We noticed that there is not a frequency of cleaning and maintenance in most of them (personal observation).

In general, we observed much lower percentage of useful areas than the initial proportion accounted for green areas alone. This is because many of the public squares did not offer attractive elements for the population, and some that did, were not in good condition of use (personal observation). Some lacked benches, space for physical activities, flower beds, and had damaged building elements. It's worth mentioning that the southern area of Natal is still an expanding zone of the city and that other areas in the city visually seem to include better maintained public squares (personal observation).

A notable benefit of urban green spaces is the opportunity offered to citizens to connect with nature, witness ecological processes in action, and allow the population to have the potential to become more scientifically informed and to deliberate on conservationist initiatives and policies (LEPCZYK et al., 2017). For this, the areas must be attractive, giving accessibility to all age groups, attracting children, youth, adults, and the elderly. The installation or renovation of sports courts, especially in the poorest areas, may seem a good investment for the public squares studied, as they are extremely useful and attractive for the population.

Relationship between variables

We calculated significant positive correlation between the number of individuals and species richness (r = 0.90), the number of individuals and IAVT (r = 0.83), and the proportion of native individuals and the proportion of native species (r = 0.80). Significant negative correlation were obtained between species richness and the proportion of native species (r = -0.78) (Table 2).

Tabela 2. Valores de correlação de Pearson (r) (**p <0.05**) entre as variáveis apresentadas para os bairros. NI = Número de indivíduos; Richness = riqueza de espécies
Table 2. Pearson's correlation values (r) (**p <0.05**) between variables presented for neighborhoods. NI = Number of Individuals; Richness = Species richness

Relation	r	p
NI x Richness	**0.90**	**0.0059**
NI x Native Individuals	-0.66	0.1057
NI x Native Species	-0.69	0.0831
NI x Income	0.22	0.6286
NI x IAVT	**0.83**	**0.0217**
NI x IAVU	0.01	0.9784
Richness x Native Species	**-0.78**	**0.0375**
Richness x Native Individuals	-0.58	0.1688
Richness x Income	0.37	0.4140
Richness x IAVT	0.70	0.0782
Richness x IAVU	0.19	0.6832
Native Species x Native Individuals	**0.80**	**0.0292**
Native Species x Income	-0.64	0.1212
Native Species x IAVT	-0.62	0.1408
Native Species x IAVU	-0.55	0.1988
Native Individuals x Income	-0.29	0.5287
Native Individuals x IAVT	-0.46	0.2987
Native Individuals x IAVU	-0.56	0.1865
Income x IAVT	0.06	0.8949
Income x IAVU	0.07	0.8858
IAVT x IAVU	0.13	0.7747

In general, we highlight that in the neighborhoods where the natives are more representative, there are fewer tree individuals and fewer species than in the neighborhoods that, on the contrary, have a higher proportion of exotics, individuals and species. The Ponta Negra neighborhood had the highest number of individuals (793), 46.28% of which were of native origin. The greatest species richness was obtained in Lagoa Nova (57 species) and Ponta Negra (48 species), while the lowest richness was obtained in Nova Descoberta. Despite this, the highest percentage of individuals of native origin (60%) was found in Nova Descoberta. The highest percentage of exotic species was registered in Neópolis (80.91%) and Pitimbu (74.43%). Nova Descoberta had the lowest monthly income (2.07), while the Capim Macio neighborhood had the highest (4.71) (GOMES; CALVENTE, 2022; Appendix D). Nova Descoberta neighborhood was one of such cases that stood out with a high number of native individuals, despite presenting the lowest species richness.

A closer proximity of Nova Descoberta with the territorial limits of Parque Estadual Dunas de Natal may have influenced these results. In this case, remnants of native vegetation may have been left untouched in public squares or the closer proximity may have allowed dispersion of propagules between both green areas. For example, *Handroanthus impetiginosus* was the most frequent species in this neighborhood; a native ornamental species also found inside the park. Nevertheless, the total green areas and usable areas per inhabitant were also lower where the native species predominate, although not statistically significant. We believe this highlights a pattern in which it seems exotics are preferred in neighborhoods with greater investments in public spaces. In fact, neighborhoods with higher income also had higher proportions of exotics, although not statistically significant. It seems, possibly, urbanization in neighborhoods with higher incomes targeted the implementation of exotics, while in neighborhoods with lower incomes the lower proportion of exotics may be associated with the lower spending on squares urbanism. In those places, naturally occurring species may have been left to compose an urban environment without much intervention.

This may corroborate what has been described as the “luxury effect” in which the highest rates of biodiversity are directly related to the lifestyle and socioeconomic status of the population, since families with more unrestricted income are more likely to invest in the appearance of their living surroundings (GROVE; LOCKE; O'NEIL-DUNNE, 2014; ESCOBEDO et al., 2015). The positive correlation between the number of individuals, richness, and IAVT also corroborates this trend in Natal, where neighborhoods with the greatest amount of green areas per inhabitant have a more exuberant and species-rich public squares vegetation.

Floristic relationship between squares and adjacent urban forests

The compiled list of species for comparison between areas had a total of 178 tree species (GOMES; CALVENTE, 2022; Appendix B). We listed 79 species for the squares in this study, 97 species were registered for Parque Estadual Dunas de Natal, 38 species were registered for Parque da Cidade do Natal Dom Nivaldo Monte, and five species were registered for ZPA-05. *Anacardium occidentale* was the only one found in all areas. *Hymenaea courbaril*, *Mimosa caesalpiniifolia*, *Paubrasilia echinate* (both from the Fabaceae family; native), and *Cecropia pachystachya* (Urticaceae; native) were shared by the squares, Parque da Cidade do Natal Dom Nivaldo Monte, and Parque Estadual Dunas de Natal. *Mangifera indica*, *Astronium urundeuva, Spondias mombin* and *Spondias purpurea* were shared by ZPA-05 and the squares.

The shortest calculated distance was found between Parque da Cidade do Natal Dom Nivaldo Monte and ZPA-05 (12%). Among the other areas, the calculated distance was greater. The greatest distance was found between Parque Estadual Dunas de Natal (32%) and other areas (Figure J in GOMES; CALVENTE, 2022). Overall, we highlight a low similarity of species between them, reinforcing the poor representation of the local native vegetation in the city squares. *Anacardium occidentale,* the only species that was found in all areas is widely spread in the native vegetation, in particular in dune systems. In squares, this species is maintained due to the ease of cultivation in the region and the appreciation of its fruits. The greatest similarity found between the floras of the Parque da Cidade and the ZPA-05 is possibly because these areas share a large number of species absent in both areas. Despite the predominance of shrub-tree vegetation characteristic of Restinga and dune systems in the areas of the Parque da Cidade do Natal Dom Nivaldo Monte, Parque Estadual Dunas de Natal and ZPA-05 (SEMURB, 2020a), certainly several native tree species occurring there can also be implemented in the landscaping of local squares, for its beauty and ease of cultivation and maintenance.

Future studies must focus on the selection and publication of a list of native species for urban use. Also, it is important to disseminate the appreciation of native species and its use among the teams responsible for planning the squares and among the population in general. In this way, the identity of the local vegetation can also be registered in the city squares, increasing the population's environmental awareness and the ecological role of the squares.

Public squares size, density and basal area

Almost half of the number of squares studied (44%, 40 squares) was categorized as small squares. Medium-sized squares represented 29% (26 squares) and large squares 27% (24 squares) (Figure G in GOMES; CALVENTE, 2022;). The smallest square is Teresinha F. Gouveia Square (Lagoa Nova) with 334 m² and the largest was Henrique Carloni Square (Ponta Negra) with 24308 m² (Table A in GOMES; CALVENTE, 2022;). The highest density of individuals per area was found in the Dinarte Mariz Square (51,38 m²/ individuals); considered a small public square. The second-highest density was found in the Eucaliptos Square (45,56); considered a large square (Table H in GOMES; CALVENTE, 2022;). The largest total basal area was found in the large square Eucaliptos Square reaching a value of 15.81m². Ayrton

Senna Square (middle square) obtained the second largest plant occupation, reaching 7.50 m² of total basal area. Finally, the proportion of the squares occupied by total basal area is less than one percent in all sampled squares and, on average, small squares have a higher proportion of occupation by total basal area (Table H in GOMES; CALVENTE, 2022;).

CONCLUSION

Main results of this work indicate that the trees and palms found in public squares in southern Natal are predominantly of exotic origin. Overall, the proportion of green areas per inhabitant is small as well as the proportion of trees in public square areas. Furthermore, we conclude that only 25% of the 90 squares are properly usable. The vegetation in the public squares in the study area represents poorly the native surrounding vegetation what can be enhanced to increase the population's environmental awareness and the ecological role of the squares. Our results support the need to expand the tree cover and to invest in better landscape planning, administration and maintenance. We hope that the data presented here supports the adequate planning and choice of species in the future and integrates a base of knowledge for the implementation of ecological corridors to aid in the preservation of the local biota as well as for the expansion of good quality public green areas for the population in the city.

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