CIÊNCIAeNATURA

UFSM

Ci. e Nat., Santa Maria v.42, e80, p. 1-22, 2020

DOI:10.5902/2179460X42355

ISSN 2179-460X

Environment Submissão 02/02/20 Aprovação 06/05/20 Publicação 11/09/20

How to qualify the vegetation in public squares to help the management of urban ecosystem services?

Como qualificar a vegetação nas praças para contribuir com a gestão dos serviços ecossistêmicos urbanos?

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ABSTRACT

We adopted procedures to analyze the floristic composition of public squares in Irati, Paraná, in order to diversify the provision of methods to generate information for public management. We found that describing the ratio of taxa may not be efficient for presenting problems regarding species diversification. Species diversity analysis should be divided into tree quantity and canopy area to determine the benefits that could be lost from removing exotic species. Using the procedure that considers crown area is more effective for estimating the cover value of the species. The diameter distribution, total height, and crown area curves can help management decisions about new plantings and prioritize risk assessment. The results of spatial indices can complement the information about data distribution.

Keywords: Green areas; Urban ecology; Urban forest management; Urban forestry

RESUMO

Procedimentos de análise da composição florística das praças em Irati, Paraná, foram adotados para diversificar o fornecimento de informações ao processo de gestão pública. Constatou-se que a descrição da proporção de táxons pode não ser adequada para indicar problemas com a diversificação de espécies. A análise da diversidade de espécies deve ser decomposta quanto à quantidade de árvores e área de copa, para ponderar as possíveis perdas de benefícios com a remoção de espécies exóticas. O uso do procedimento considerando a área de copa é mais interessante para estimar o valor de cobertura das espécies. As curvas de distribuição diamétrica, de atura total e de área copa demonstram-se úteis para auxiliar decisões de manejo sobre novos plantios e priorização de avaliação de risco. Os resultados dos índices espaciais podem complementar as informações sobre a distribuição dos dados.

Palavras-chave: Áreas verdes; Ecologia urbana; Gestão da floresta urbana; Silvicultura urbana

1 INTRODUCTION

The process of managing urban ecosystem services should take into account the environmental features of a place, including trees, as well as socio-cultural behaviors that intertwine, depend on and qualify the services provided by a particular

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green infrastructure or the group of them in the city (CZÚCZ et al., 2018; VAN OUDENVEN et al., 2018). The importance of different urban green infrastructures has been highlighted in the promotion of ecosystem services to adapt cities to climate change, maintaining and promoting the quality of life of the inhabitants (LINDLEY et al., 2018; WANG; SHEN; XIANG, 2018). This is relevant in a global and mainly Brazilian context, as more than 84% of the Brazilian population lives in cities (IBGE, 2019).

Considering public squares as part of the urban green infrastructure, qualified technical procedures for the floristic composition maintenance are important to ensure the provision of required ecosystem services, as vegetation maintenance practices can affect their quality and quantity (KABISCH, 2015; KIM, 2016). This should be highlighted because public squares are spaces of socio-cultural interest that can be used for different purposes such as holding events, fairs and popular meetings (VIEZZER, 2015; SILVA; CARVALHO, 2017), helping to provide the quality of life and well-being to the whole urban population (VUJCIC; TOMICEVIC-DUBLJEVIC, 2018). Likewise, public squares have environmental importance for the cities and their population (GIDDINGS; CHARLTON; HORNE. 2011; VIEZZER, 2015), because they help to maintain the soil permeability, reducing runoff and helping to regulate the microclimate (VIEZZER, 2015; MARTINI et al., 2017).

In order to maximize the provision of ecosystem services, care must be taken with the built structures and proper management of existing or implanted vegetation (VIEZZER, 2015). These actions should be performed through the public management process, which should be led by floristic inventories and phytosociological studies, among other information (ROMANI et al., 2012). The floristic inventories of public squares have been carried out to acquire specific information, where quantitative variables such as number of trees, total height and trunk diameter are commonly collected (JESUS et al. , 2015; GOMES et al., 2016) and / or qualitative ones, such as the general condition of trees and the need for maintenance practices (SCHALLENBERGER et al., 2010; ROMANI et al., 2012). However, the tree canopy area is the most important variable for generating information from the urban floristic inventories, as it is related to the main part of the tree for the provision of benefits (BOBROWSKI; BIONDI, 2012; NOWAK; AEVERMANN, 2019).

Nevertheless, there is still a lack of improved technical understanding and guidance on how to characterize the floristic composition and tree structure of public squares, given the fact that this kind of urban forest typology sometimes has a composition similar to a forest remnant, with dense and stratified canopy, or sometimes present a composition similar to the sidewalks afforestation with sparse trees, without intertwining crowns (CARCERERI; BIONDI; BATISTA, 2016).

Generally, in Brazilian papers about forest inventory and analysis of tree composition of squares, we can find different procedures, with varied purposes, not guided by a standardized technical sequence that allows comparisons, in order to determine the quality of what exists and to guide, in an improved way, the management practices.

In the papers about public squares of Brazilian cities like in Mariano et al. (2008), Souza et al. (2011), Kramer and Krupek (2012), Romani et al. (2012), Araújo et al. (2015), Freitas et al. (2015), Bezerra et al. (2016), Brito et al. (2012), Dantas et al. (2016) and Gomes et al. (2016), there are discussions concerned to species nativity and proportion of taxa, without qualifying the information collected by describing the coverage value of species, as they evaluate different sampled areas. In the papers of Mariano et al. (2008), Souza et al. (2011) and Brito et al. (2012) authors carried out the analysis by the quantitative description of species, without details about tree structure, diversity or risks. In Kramer and Krupek (2012), Romani et al. (2012) and Dantas et al. (2016) they estimated diversity indices to characterize the quality of species composition. In Romani et al. (2012) and Freitas et al. (2015) tree inventory guided qualitative and quantitative analysis using different technical procedures. Few studies reported information about distribution classes of data, such as DBH, height and canopy area, which is basic information to guide the management process, to analyze and propose management priorities such as new plantings or risk evaluation of large trees.

Thus, the adoption of diversified procedures for analyzing data of floristic inventories of public squares becomes essential for good planning, since it will be useful for management practices and public policies, and also as a subsidy to identify problems and outline goals to solve them sustainably (REDING et al., 2010; JESUS et al., 2015).

Within a proposal of detailed and comprehensive analysis of the floristic census of public squares in the city of Irati, Paraná, the objective of this research was to analyze different procedures of data analysis and description, observing significant differences and variations that may compromise or assist the management process of these public spaces and the provision of ecosystem services.

2 MATERIAL AND METHODS

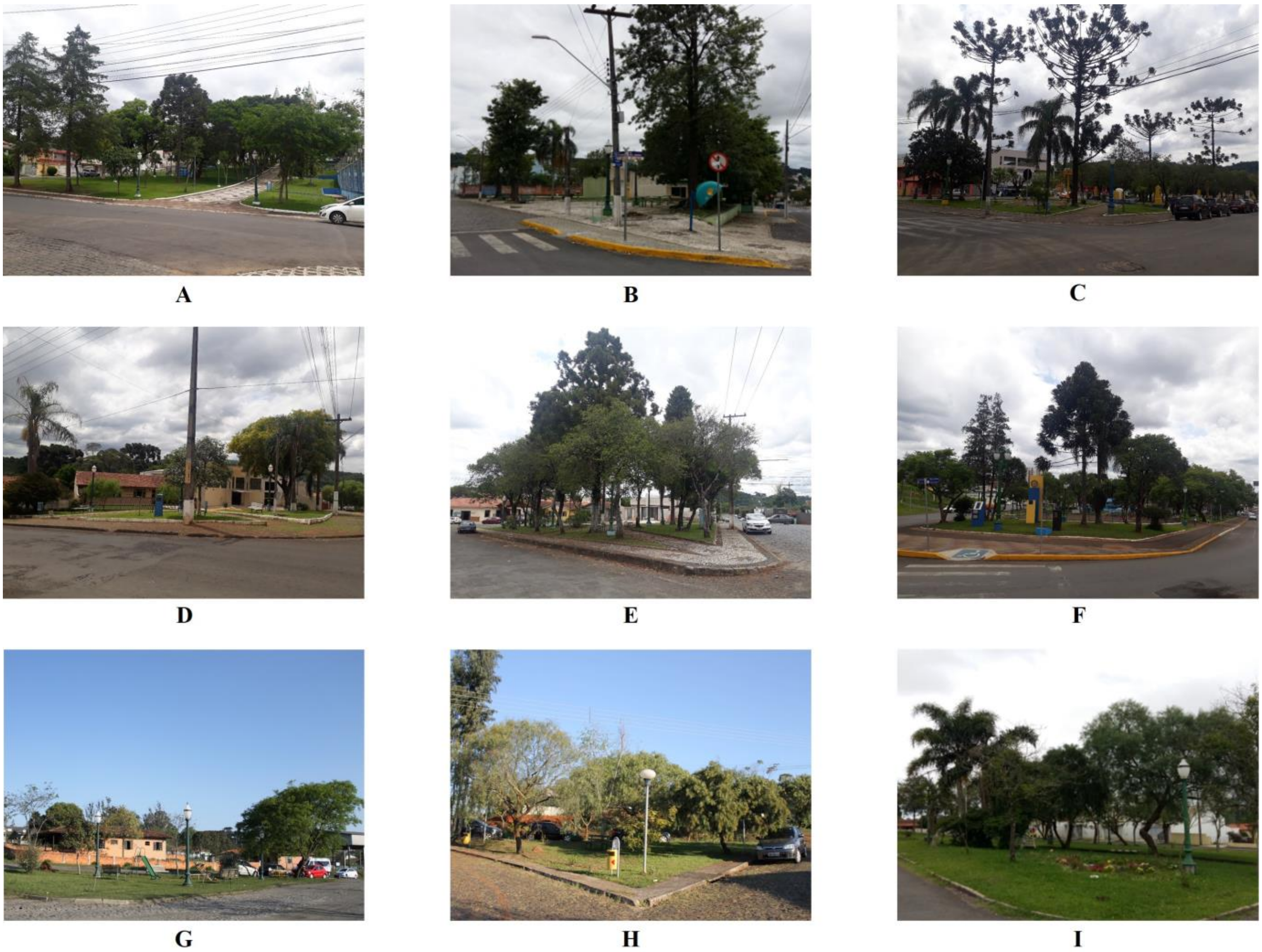
This research was carried out with data from the public squares of Irati, a city inserted in the Mixed Ombrophilous Forest ecosystem, in the Atlantic Forest Biome. The municipality is in the south-central part on the second plateau of Paraná State, 150 km from the capital Curitiba and at the central coordinate 25º 27 '56 "S and 50º 37' 51" O. The total population estimated is 60,727 inhabitants (IBGE, 2019), but 79.94% of the them live in the urban area (IPARDES, 2019). The city is divided into 20 neighborhoods, with different dimensions and infrastructure conditions (SCHIRMER et al., 2019).

The floristic census was performed from August 2016 to February 2017, in the nine public squares of the city (Figure 1). Information on circumference at 1.30 m above ground (CAP) was collected from each tree, with measuring tape. To estimate the average crown diameter (m), we measured four crown projection radii towards each cardinal point, with a tape measure. Total height was estimated by a Blume-Leiss hypsometer.

Tree species identification was done in loco, due to a previous floristic survey carried out in most of the squares (SCHALLENBERGER et al., 2010). For divergent or unrecognized species, botanical material was collected for a checking process at the Herbarium of the Midwest State University, Campus Irati.

In each square we determined the areas of the pervious surfaces, from measurements using measuring tape. The total area of each square was obtained from image-delimited polygons in Google Earth Pro 6.0.

Figure 1 – Floristic composition and structure of public squares in Irati, Paraná, where: Etelvina Andrade Gomes Square (A), Magdalena Giacomello Anciutti Square (B), Bandeira Square (C), Eduardo Letchacoski Square (D), Rafael Batista de Oliveira Square (E), Edgard Andrade Gomes Square (F), Riozinho Square (G), Alto da Glória Square (H) and Lagoa Square (I)



Source: authors

From the floristic composition we evaluated the distribution of trees among family, genus and species taxa for all data. Regarding the nativity, species were classified as native and exotic to the Mixed Ombrophilous Forest ecosystem, through the Reflora database (2019), and we obtained the proportion of each group for the total data and per public square. Regarding the invasive character, the proportion of species and trees was evaluated according to the list presented in Ordinance 59/2015 of the Environmental Institute of Paraná (IAP, 2019). To characterize the intensity of the presence of native species in each square, we proposed the species nativity index (ratio between the number of native species and the total number of species) and the tree nativity index (ratio between the number of native tree species and the total number of trees).

Species diversity was analyzed by the proportion of species in relation to the total area of each square (DIV1), to allow comparative analysis among them, since these urban infrastructures had different total areas. This procedure was adopted because diversity indices such as Margalef, Pielou and Shannon-Wienner are influenced by the sampled area (MAGURRAN, 2011). To estimate the diversity per public square, the following equation was used:

$$DIV = \frac{NS}{TA} \times 1000$$

Where:

DIV – Species diversity per 1,000 m² of public square;

NS – Total number of species in the square;

TA – Total area of the square (m²).

The diversity estimated was recalculated by removing the invasive species (diversity without invasive alien species - DIV2) and the exotic species (diversity with native species only - DIV3). This procedure was adopted because publications concerning the floristic analysis of the urban forest usually does not present details about this information, which may mask the quality of the diversity estimated.

To support management decisions aimed at removing trees from invasive or all exotic species, the impact of this decision on the existing floristic composition was evaluated. For this, using the chi-square test we compared the total number of trees in each square, the number of trees without invasive species and the number of native trees. Also, the total crown area of each square, the crown area without invasive species and the crown area of native species were compared.

Phytosociological analysis was performed in a spreadsheet to determine the cover value (CV) of the species, using the transverse trunk area at 1.30m (ROMANI et al., 2012) and crown area (BOBROWSKI et al., 2016) as variables that describe dominance. With this information, the cover values (CV) were compared using the chi-square test in order to verify if there was any difference in species distribution in the coverage ranking.

The floristic composition structure was analyzed by data distribution in diameter classes (0.05 m of amplitude), total height (5.0 m of amplitude) and crown area (50.0 m^2 of amplitude), for the total population and per public square. This kind of information is useful to present the distribution pattern of trees and species in relation to size, in relation to influences of management practices such as pruning and in relation to population sustainability over time (BOBROWSKI; BIONDI, 2012; BOBROWSKI; BIONDI ; FIGUEIREDO FILHO, 2012).

The area of the pervious surfaces, in relation to the total area of each square, was used as a variable to determine the effective contribution to soil permeability in percentage terms. With information about the crown area of each square, we classified them according to different typologies related to the presence of trees, the crown cover and the proportion of impervious surfaces (Table 1):

Frame 1 – Classification of public squares according to Viezzer (2015)

Square type	Presence of trees	Crown cover	Impervious surface
Desert-square	No	0%	> 30%
Garden-square	Yes	< 10%	> 30%
Wooded-square	Yes	> 10%	> 30%
Field-square	No	0%	< 30%
Savannah-square	Yes	< 10%	< 30%

Forest-square	Yes	> 10%	< 30%

Source: authors

Based on the population data for the urban area (IBGE, 2019; IPARDES, 2019) and the papers of Lima Neto and Souza (2009) and Biondi and Lima Neto (2012) we estimated the spatial indices indicated below. This information was useful to show the importance of tree composition in each square, as well as to improve the comparative process and the analysis of the distribution of squares within the city. The spatial indices were:

Square Area Index per Inhabitant (SAI)

$$SAI = \frac{\sum SA}{NH}$$

Where:

SAI –Square Area Index per Inhabitant;

SA – Square total area;

NH – Number of inhabitants.

Tree Density Index (TDI)

$$TDI = \frac{N}{TA} \times 100$$

Where:

TDI – Tree Density Index per Square (N/m²);

N – Number of trees;

TA – Total area of the square (m²).

Tree Shading Index (TSI)

$$TSI = \frac{TCA}{TA} \times 100$$

Where:

TSI – Tree Shading Index (m²/m²);

TCA – Total crown area per square (m²);

TA – Total area of the square (m²).

3 RESULTS AND DISCUSSION

Among the 45 species sampled in the nine public squares of Irati, the ten species with the largest number of trees represented 67.88%, as follows: Ligustrum lucidum (alfeneiro), Syagrus romanzoffiana (jerivá), Handroanthus chrysotrichus (ipê-amarelo-miúdo), Lagerstroemia indica (extremosa), Tipuana tipu (tipuana), Araucaria angustifolia (araucária), Handroanthus heptaphyllus (ipê-roxo), Cryptomeria japonica ‘Elegans’ (criptoméria), Lafoensia pacari (dedaleiro) e Grevillea robusta (grevílea).

The composition among botanical families followed the order Fabaceae (15.56%), Arecaceae, Bignoniaceae and Myrtaceae (11.11%), Cupressaceae (8.89%) and other families (2.22%). The genera with the largest number of species were Handroanthus with four species (8.89%), Chamaecyparis with two species (4.44%) and Cryptomeria with two species (4.44%). Among species, L. lucidum (16.32%), S. romanzoffiana (11.14%) and H. chrysotrichus (9.59%) presented the highest proportions of trees in the floristic composition.

Papers related to the survey of trees in the urban forest, including trees in public squares, usually consider the proportion of taxa proposed by Santamour Junior (1990). For this author, the floristic composition should present less than 30% of species of the same family, less than 20% of species of the same genera and less than 10% of trees for each species, to promote a diversified composition and avoid problems with pests and diseases. Although, this recommendation has no solid basis for these limits. It happens because some species, even at low frequency in the composition, may be prone to problems with pests and diseases, which reflects their low adaptation to the local planting conditions (RAUPP; CUMMING; RAUPP, 2006). Therefore, besides species diversity, the current concern for the management of trees in public squares and sidewalks should be their adaptability to the conditions of urban environmental stress (RAUPP; CUMMING; RAUPP, 2006; SJÖMAN; HIRONS; BASSUK, 2018).

Of the ten main species mentioned above, G. robusta presents symptoms of dieback in the two public squares where it is planted, showing loss of vigor and poor general condition. The species L. lucidum, L. indica and T. tipu are shown to be adapted to the urban stress conditions of the city and are commonly planted in southern Brazil cities (BACKES; IRGANG, 2004; DELESPINASSE et al., 2011). However, as observed in Curitiba by Leal, Bujokas and Biondi (2006), these species can lose their vigor and decline in condition due to the proliferation of different species of mistletoe, which are hemiparasites that spread over tree canopies and may compromise the development and growth of these species.

When considering the species nativity index (SNI) and the tree nativity index (TNI) for the total data (Table 2), it can be observed that the exotic species predominate in the tree composition of squares. If only the species nativity index (SNI) is considered, the composition quality may be overestimated. As observed for Bandeira Square, species nativity is above 50% of the total, but when considering the tree nativity index (TNI) this value is below 50%. In the process of managing the composition diversity, not only the number of species matters, but also the number of trees. This must be considered to provide better-planned management practices, especially given the need to remove invasive alien species. Even with the problem they pose to local ecosystems, they can offer environmental benefits such as microclimate regulation that is one of the most important services provided for cities.

Despite being the square with the fourth-largest number of species (Table 2), Rafael B. de Oliveira Square presented the highest species diversity per 1,000 square meters (Table 3), and all of them presented higher diversity values than the value determined for the total data. However, it is not yet possible to say whether these results would be appropriate or not for tree compositions in public squares, as there is no suitable knowledge about diversity levels for urban trees (SJÖMAN; ÖSTBERG; BÜHLER, 2012). The advantage of this simple procedure for demonstrating species diversity is that weighting the number of species per square meter allows comparisons between sites with different total areas, which is common among squares in Brazilian cities. These comparisons are really important in the process of planning actions to diversify the species composition and replacement of invasive exotic species over time.

If management practices were applied to these squares there would be no significant change in diversity (Table 3), whether only invasive alien species were removed (χ^2 = 1.7750; DF = 8; p-value = 0.9872), as if only native species were kept (χ^2 = 13.1270; DF = 8; p-value = 0.1076). A public manager, when facing a result like this, could easily decide on a project for the removal of exotic ones, in order to promote a campaign of valuing native species from the local ecosystem, as recommended by related studies (REZENDE; SANTOS, 2010; BATISTA et al., 2013; OLIVEIRA et al., 2019).

Table 2 - Data variability and distribution among squares in the city of Irati, Paraná, in relation to the number of trees (NT), number of species (NS), total area in m² (TA), pervious surface area in m² (PA), crown area coverage in m² (CA), species nativity index (SNI), tree nativity index (TNI), tree density index in number of trees per 100m² of square (TDI) and tree shading index in % of total area (TSI)

Square Name	NT	NS	TA	PA	CA	SNI	TNI	TDI	TSI
Etelvina A. Gomes	49	33	11,039.29	5,327.04	7,472.7	42.42	36.24	0.60	7.69
Magdalena G. Anciutti	13	3	1,017.11	82.96	602.28	33.33	5.38	0.29	9.21
Bandeira	33	8	2,261.54	1,324.73	1,694.95	52.50	45.45	0.35	4.95
Eduardo Letchacoski	6	3	679.29	318.00	329.11	56.67	56.67	0.44	8.45
Rafael B. de Oliveira	21	7	659.57	277.48	595.74	28.57	4.76	.06	0.32

Edgard A. Gomes	13	20	7,663.78	3,534.00	4,241.48	30.00	38.94	0.26	5.34
Riozinho	4	3	424.84	364.00	159.28	56.67	75.00	0.71	7.49
Alto da Glória	4	2	225.77	167.91	103.66	50.00	75.00	0.89	5.91
Lagoa	43	4	1,733.00	863.61	1,228.78	75.00	97.67	0.23	0.90
Total	386	45	25,704.19	12,259.73	16,427.98	35.56	43.52	0.18	63.91

Source: authors

Table 3 - Data variability and distribution among squares in the city of Irati, Paraná, in relation to the total species diversity (DIV1), diversity without invasive alien species (DIV2), diversity with native species only (DIV3), total number of trees (NT1), number of trees without invasive alien species (NT2), number of trees of native species (NT3), total crown area (CA1), crown area without invasive alien species (CA2) and crown area of native species (CA3)

Square Name	DIV1	DIV2	DIV3	NT1	NT2	NT3	CA1	CA2	CA3
Etelvina A. Gomes	2.99	2.72	1.36	149	140	54	7,472.70	7,244.86	2,117.03
Magdalena G. Anciutti	2.95	1.97	0,.98	13	6	2	602.28	295.71	59.54
Bandeira	3.54	2.21	2.21	33	15	15	1,694.95	1,046.57	1,046.57
Eduardo Letchacoski	4.42	4.42	2.94	6	6	4	329.11	329.11	122.09
Rafael B. de Oliveira	10.61	7.58	4.55	21	9	1	595.74	191.63	26.89
Edgard A. Gomes	2.61	2.22	0.78	113	88	44	4,241.48	2,992.43	1,202.68
Riozinho	7.06	7.06	4.71	4	4	3	159.28	159.28	32.60
Alto da Glória	8.86	8.86	4.43	4	4	3	103.66	103.66	92.91
Lagoa	2.31	2.31	1.15	43	43	42	1,228.78	1,228.78	1,193.00
Total	1.75	1.48	0.66	386	315	168	16,427.98	13,592.03	5893.31

Source: authors

When analyzing the effect of tree removal over the number of trees, it was found that there would be a significant difference if only the invasive ones were removed (χ^2 = 26.5192; DF = 8; p-value = 8.56^{-4}), as well as if only native species were kept (χ^2 = 142.0666; DF = 8; p-value = 8.82^{-27}). This effect would also happen if the canopy area was considered, with a significant reduction if only the invasive species were removed (χ^2 = 1052.9716; DF = 8; p-value = 5.48^{-222}), as well as keeping only the native species (χ^2 = 7528,9602; DF = 8; p-value = 0.000). Therefore, discussions that permeate the need for punctual or gradual management of invasive or exotic species should consider the losses and the effects promoted by this activity. Each tree, if in good structural and physiological conditions, tends to contribute with the provision of a variety of environmental services, especially in cities where there is a scarcity of trees to work around the adverse effects of urbanization.

No significant difference was found between the methods to describe the species coverage value (χ^2 = 16.9533; DF = 44; p-value = 0.9999), however some changes in the species ranking are interesting (Table 4). The species with the highest cover values (CV), in both methods, presents the largest number of trees sampled in Irati squares. On the other hand, T. tipu, which is the fifth species with the largest number of trees, ranks third in the CV ranking determined by the cross-sectional area and second place by the CV determined by the crown area.

In the phytosociological analysis applied to urban forest typologies, determining the importance of species by crown area, as a descriptive factor of dominance is more interesting than using the cross-sectional area or the abundance of species in the sample (BOBROWSKI; FERREIRA; BIONDI, 2016). This recommendation is due to the crown that is the main means by which trees offer benefits, and because the trunk represents only the location and not the actual space occupied by the tree.

Table 4 – Results for the phytosociological analysis of Irati squares, where it is indicated the number of trees (N), the coverage value by cross-sectional area (CSA) and by the crown area (TCA), and the origin of species, native (N) and exotic (E)

Tree Species	N	CSA	TCA	Origin
Anadenanthera colubrina	2	5,5	0,66	N
Araucaria angustifoli	18	13,31	15,06	E
Bauhinia variegata	7	2,92	3,28	N
Butia eriospatha	3	3,87	1,17	E

Callistemon viminalis	1	0,28	0,32	E
Camellia japonica	2	0,54	0,59	N
Campomanesia xanthocarpa	1	0,26	0,29	N
Chamaecyparis lawsoniana var. ellwoodii	5	1,38	1,75	E
Chamaecyparis obtusa	4	1,29	1,39	E
Citrus volkameriana	1	0,27	0,29	N
Cryptomeria japonica ‘Elegans’	16	8,72	6,05	N
Cryptomeria japonica	1	0,92	0,73	N
Cupressus lusitanica	9	5,54	4,59	E
Eriobotrya japonica	2	1,22	1,14	E
Eugenia pyriformis	1	0,26	0,29	E
Grevillea robusta	13	10,29	7,89	E
Handroanthus albus	11	3,84	4,87	E
Handroanthus chrysotrichus	37	11,69	14,08	E
Handroanthus heptaphyllus	16	6,46	8,46	N
Handroanthus impetiginosus	1	0,4	0,44	E
Jacaranda mimosifolia	6	4,89	5,22	N
Koelreuteria paniculata	3	1,64	2,02	E
Lafoensia pacari	15	4,26	4,46	N
Lagerstroemia indica	21	6,35	7,46	N
Libidibia ferrea var. leiostachya	5	2,04	3,07	E
Ligustrum lucidum	63	30,32	31,22	E
Livistona chinensis	6	4,19	2,32	N
Luehea divaricata	3	0,82	0,85	E
Magnolia grandiflora	3	0,44	0,6	E
Morus nigra	1	0,26	0,26	E
Muellera campestris	1	0,82	0,94	N
Nerium oleander	2	0,64	0,89	E
Peltophorum dubium	11	10,43	14,45	N
Phoenix roebelenii	1	0,32	0,34	E
Pinus taeda	1	2,28	2,02	N
Psidium cattleianum	2	0,56	0,57	N
Psidium guajava	2	0,54	0,56	E
Salix babylonica	1	0,29	0,33	E
Sapium glandulosum	1	0,27	0,28	E
Schinus molle	13	6,09	7,63	E
Schizolobium parahyba	1	1,00	0,74	E
Syagrus romanzoffiana	43	24,34	17,69	E
Tipuana tipu	20	15,14	20,18	E
Vitex megapotamica	2	0,54	0,58	E
Yucca elephantipes	8	2,65	2,17	E
Total	386	200	200	

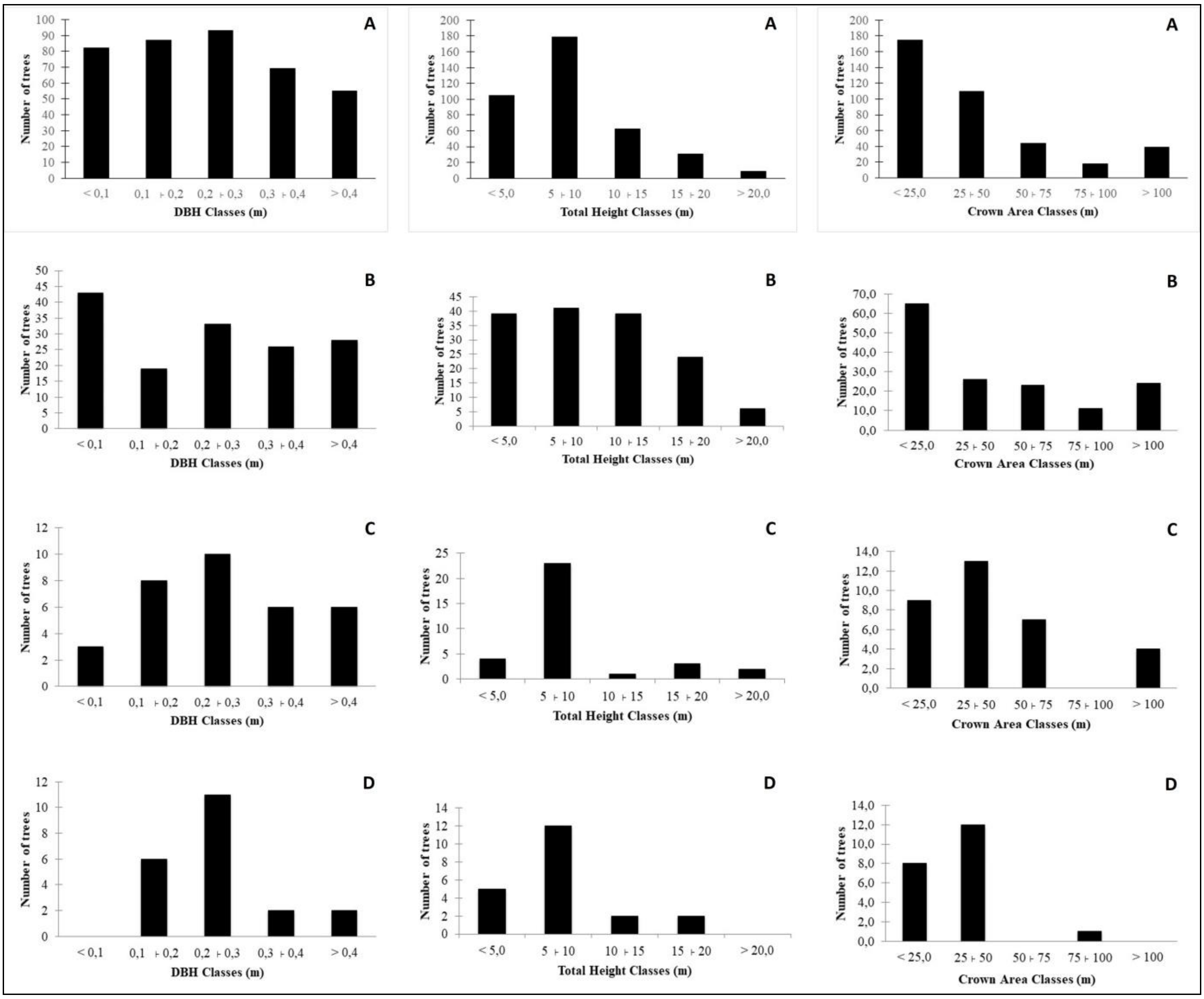
Source: authors

Squares in Irati city presented variations and differences in DBH, total height and crown area classes (Figure 2). The distribution curves for the total data are not equivalent and cannot represent the characteristics of each square, since that for the same variable we can see a difference in the distribution pattern among squares. This is related to the characteristics of the square's creation and to the previous management practices.

The Etelvina Andrade Gomes Square (Figure 2-B) has characteristics of a mature tree composition, stabilized for a square since the data are distributed in all DBH classes, total height, and crown area. This reflects a composition with trees of different sizes and species of different sizes. From the distribution curves, there are two points of special attention that demonstrate the sustainability of the floristic composition in this place. The first is that there is a significant number of trees in the first classes, which represents, in this case, the existence of young trees to replace the positive effects produced by the older ones over time. Given the number of trees in the upper classes, the second point is that risk assessment actions should be prioritized for these trees in order to work around problems and promote management practices or to remove those trees with irreparable structural defects.

For Bandeira Square (Figure 2-C), despite the distribution of data in all DBH, total height and crown area classes, there is a small number of trees considering the total square area (Table 2). In this case, the largest number of trees in the first classes indicates, primarily, the composition with small species (S. molle) and with mature L. lucidum trees damaged by repeated topping pruning, an activity that alters the natural dimension of height and area of tree crowns.

Figure 2 – Data distribution in DBH, total height and crown area classes for the total sampled data (A), Etelvina Andrade Gomes Square (B), Bandeira Square (C) and Rafael Batista de Oliveira Square (D)



Source: authors

As for Rafael B. de Oliveira Square (Figure 2-D), the absence of trees in the first DBH class is a point of concern, as the sustainability of the composition is not guaranteed. Besides being a small square, the tree composition is mature and stable in growth, since the local crown coverage exceeds 90% of the total area, with a tree shading index of 90.32 (Table 2). The highest number of trees in the first classes of crown area distribution is due to the narrow canopy of the species C. japonica and the competition among trees, given the dense canopy cover. In order to improve the sustainability of the floristic composition in this square, the planning for replacement of trees, due to bad general conditions, must be carried out together with the planting of new seedlings, given the lack of space for the insertion of new trees.

Regarding the total area of the pervious surfaces, Riozinho Square presented a permeable soil proportion of 85.68% (Table 2), which is the highest value. For most squares, the pervious surfaces are close to 50% of the total area, which is somewhat positive because this kind of urban forest typology plays a role of environmental interest (the effects of trees and the permeable area) and social interest (pathways for pedestrians, accesses and different kind of structures).

According to the proposal of Viezzer (2015), seven squares would be classified as wooded-square and two classified as forest-square (Riozinho Square and Alto da Glória Square). It is an interesting procedure to show the appearance of squares associated with different composition patterns in different ecosystems. Although, when analyzing the tree cover in these squares (Figure 1) we found that the classification cannot be suitable for the case since the squares Riozinho and Alto da Glória are those with the smallest proportions of crown area (Table 2).

In these two cases, the greater capacity to offer environmental benefits, as predicted by Viezzer (2015), would be limited, and it is necessary to distinguish and detail the information. The higher proportion of pervious surfaces of these squares would have a greater effect on the reduction of runoff at the moment of evaluation. However, the lower proportion of crown area may compromise the offer of other environmental services when compared to squares that, even with greater impervious surfaces, are covered by higher crown volume.

From the spatial indices estimated, we obtained a square area index per inhabitant (IAPH) of 0.53m² / inhabitant, with marked distinctions in the distribution of squares, since only seven of the twenty neighborhoods of the city have squares. According to Biondi and Lima Neto (2012), this is a very low value for IAPH because it expresses the small contribution of these places with the availability of crown area and green spaces to the population.

The downtown has the largest number of squares, with the largest total area and tree crown cover (Etelvina Andrade Gomes Square, Edgard Andrade Gomes

Square, Bandeira Square, and Magdalena Giacomello Anciutti Square). The Rio Bonito neighborhood has two squares (Rafael Batista de Oliveira and Eduardo Letchacoski) and the neighborhoods Riozinho, Lagoa and Alto da Lagoa with one square each. For the city of Irati, public squares are important spaces for the promotion of environmental and social services, as there is only one park in the city, in the Rio Bonito neighborhood.

Although there was a strong correlation (> 0.98) between the variables number of trees, total square area and crown area of the square (Table 2), the correlation between the TDI and TSI indices was very low (0.10). The TDI and TSI values varied widely due to the heterogeneity of composition and the total area of the squares. But it can be useful for weighting management decisions supported by information about the distribution of data in DBH classes and crown area, mainly.

For Lima Neto and Souza (2011), the tree shade index (TSI) should be greater than 30% for places with commercial use and 50% for places with residential use. Of the city squares, only Magdalena Giacomello Anciutti, Edgard Andrade Gomes and Bandeira Square are located in commercial areas. Therefore, by the aforementioned recommendation, the squares Eduardo Letchacoski, Riozinho and Alto da Gloria (Table 2) would not comply with that. On the other hand, it should be considered that for squares such as Magdalena G. Anciutti, the quality of the TSI index is masked, as trees have structural problems and disfigured crowns (Figure 1).

4 CONCLUSIONS

It was found that the description of taxa proportion may not be suitable to show problems with species diversification, as species with a small number of trees in the floristic composition may have problems with pests and diseases.

Species diversity analysis should be broken down into tree quantity and canopy area to weigh the possible loss of benefits from the removal of exotic species.

The use of the crown area to determine the cover value is more interesting and better represents the importance of species in the tree composition of squares.

The DBH, total height, and crown area graphical distribution are useful to assist management decisions, especially regarding the need to prioritize new plantings and tree risk assessment procedures.

The results of the spatial indices can complement the information on the data class distribution, considering that they weight the information by a unit of area.

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