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EDITORIAL *LIFESTYLE*

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- Camila Aoki[3]
- Fernando Periotto[4]
- Alessandro Zabotto[5]

The reality of urban afforestation in Brazilian cities is alarming and impels us to actions beyond writing. However, the importance of this topic is constantly matured through the texts written by authors both Brazilian and foreign so that the practices can be improved as best as possible by the ones who carry out various actions involving green environments.

Unfortunately, trees and other types of vegetables are still not seen as living beings which inhabit our cities and yield hundreds of benefits in terms of people's health, comfort in general, shelter for fauna, scenic beauty, landscape connections, the pleasant mix with historical spaces, etc.

The municipal public administrations across the country, that is, the hands that actually "make" the afforestation for each urban state in Brazil, need to focus in a oriented and holistic way on the vastness of excellent works written in academic journals, manuals, books, e-books and other types of publications, so that they can reverse the chaotic situations in many of their neighborhoods.

In this special edition, important contributions on these issues are concerned from different and multidisciplinary areas, that is, themes from ecology, agronomy, and Arbor Theory, to point out the multidisciplinary aspects of urban afforestation, from its theoretical approaches to its practices in the municipal public administrations.

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Artigos

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ANALYSIS AND CLASSIFICATION OF SQUARES WITHIN THE URBAN FRAME OF THE CITY OF MANAUS - AMAZONAS

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Abstract: The squares are a strategic place to invest in the afforestation of a city, as they are less confronted with buildings and energy transmission networks, but mainly because they are a place of social interaction and recreational activities. Therefore, knowing its spatial configuration and its access by the surrounding population will allow for better planning by public agencies regarding the implementation, maintenance and floristic composition of the squares. Therefore, the main objective of the study was to analyze the design of squares within the urban frame of the city of Manaus - Amazonas, Brazil. Twenty-four squares were studied through mapping and visual analysis of satellite images from the Google Earth software. Subsequently, the classification according to the type of square proposed by De Angelis and De Angelis Neto (2000) was used. A total inventory of tree specimens (DBH > 10 cm) was carried out, being registered 513 trees distributed in 13 families, 31 genus and 35 species. Of the cataloged species, 51.4% (n=18 species) are classified as exotic to Brazil and 48.6% (n=17 species) are native to Brazil. However, of the 17 native species, 15 are native to the Amazon. The insertion of Manauaras squares in its urban frame is not standardized, so it was necessary to create four subtypes of squares to meet the specific reality of Manaus. It was found that the dominant type of classification of square, regarding insertion in the urban frame, is type 3 (54.2%), followed by type 2 (29.2%) and type 4 (16.6%).

Keywords: Afforestation; Urban forest; Urban frame.

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ANÁLISE E CLASSIFICAÇÃO DE PRAÇAS DENTRO DA MALHA URBANA DA CIDADE DE MANAUS - AMAZONAS

Resumo: As praças configuram-se como um local estratégico para investir na arborização de uma cidade, por serem locais de menor confronto com edificações e redes de transmissão de energia, mas principalmente por ser um local de convívio social e atividades lúdicas. Então, conhecer sua configuração espacial e o seu acesso pela população do entorno permitirá um melhor planejamento pelos órgãos públicos quanto à implementação, manutenção e composição florística das praças. Por isso, o objetivo principal do estudo foi analisar o desenho das praças dentro da malha urbana da cidade de Manaus - Amazonas. Foram estudadas 24 praças mediante o mapeamento e análise visual das imagens de satélite do software *Google Earth*. Posteriormente, foi utilizada a classificação quanto ao tipo de praça proposta por De Angelis e De Angelis Neto (2000). Foi realizado o inventário total dos espécimes arbóreos (DAP > 10 cm), sendo registradas 513 árvores distribuídas em 13 famílias, 31 gêneros e 35 espécies. Das espécies catalogadas, 51,4% (n=18 espécies) são classificadas como exóticas do Brasil e 48,6% (n=17 espécies) nativas do Brasil. No entanto, das 17 espécies nativas, 15 são nativas da Amazônia. A inserção das praças Manauaras, em sua trama urbana, não é padronizada, com isso foi necessário criar quatro subtipos de praças para atender a realidade específica de Manaus. Verificou-se que o tipo de classificação dominante de praça, quanto a inserção na malha urbana, é do tipo 3 (54,2%), seguido pelo tipo 2 (29,2%) e tipo 4 (16,6%).

Palavras-chave: Arborização; Floresta urbana; Malha urbana.

Manaus, the capital of Amazonas (AM) state, Brazil, is located in the equatorial zone, landlocked at the Amazonic biome and at the confluence of the rivers Negro and Solimões in the world greatest fresh water river basin (SALATI; VOSE, 1984). According to Köppen's classification, the city presents a type Afi weather, as Equatorial Hot and Humid; the average annual temperature is 26,7 °C (average minimum of 23,3 °C; average maximum of 31,4 °C); with average relative air humidity of around 80%; the average annual rainfall precipitation gets to 2,286mm, the rainfall density ranges every six months; with that the city presents only two seasons over the year (rainy/winter - between November and June; dry/summer - from July to October) (VELLOSO, 2002) and it has the greatest fauna and flora biodiversity of the world (TER STEGEE *et al.*, 2013).

Manaus covers an area of 11,401.1 km^2, with an estimated population in 2020, of 2,219,580 habitants and population density of 158.1 inhabit/km^2 (IBGE, 2020); it has 63 neighborhoods distributed in six urban zones (South-Center, South, East, North, West, West-Center) (PMM, 2010) and, officially it has 209 squares (SEMULSP, 2017). Manaus is the only city in the Brazilian North region that is among the 10 cities with the biggest participations in the Gross Domestic Product (GDP) of the country, being the sixth with a participation of 1.12% (IBGE, 2018).

Since its founding in 1669, Manaus has been going through changes in its cultural identity. Starting with the primitive concept given to the people and the place, by landlords and authorities (MESQUITA, 2019), going through the economic apogee with the Amazon Rubber Boom (1890 to 1910), that fostered the first great surge of urbanization, promoting the modernization, the beauty

and the refinement of the landscape (SANTOS, 2007; FROTA, 2013), like the creeks landfill, pavement of streets and construction of squares and planting of trees. This period has become known as *Belle-Époque* Manaus. However, such action erased everything that evoked the local peoples, fauna and flora.

Since the beginning of the twentieth century, Manaus already presented its architectural and landscape beauties. Mesquita (2005), in his findings, reports a search for the diversity of species chosen for the urban afforestation, however, as the only consideration was the structural beauty of the plant, there was the import of palm trees from other regions, which besides being inadequate, were costly for the sparse provincial revenues. Costa (2006) also emphasizes the authorities concern with road afforestation and specifically in squares and new streets, because they were beautifying constructions and sanitary demands of the time.

The squares constitute a strategic place for the planning of urban afforestation, since they are places with less comfort with urban buildings and electric networks. Another highlight is the size, which is usually small, enabling more distribution over the city and allowing proximity to green areas to a larger number of inhabitants. Article 99, item I, of the Brazilian Civil Code (2002) classifies the square as a public asset, defining its nature as a common property to the people.

The benefits brought by public squares derive from the vegetation that can be sheltered by them as well as from subjective aspects related to their existence, like the positive influence to the population's psychological aspect, provided from the contact with the green area and/or the use of the space for social interaction (MACEDO; ROBBA, 2002). Of all the public spaces, the squares are considered the most accessible to all because of the fact that they are located closer to residences, allowing more interaction for people in several age groups that can commute on foot, using their free time and also the interaction of population with the environment (GUEDES, 2009).

The square must be the main parameter for a performance evaluation of the public space, because the user of any social or educational level exerts an essential role in the usage stage and can be considered a thermometer for the efficiency of the setting (PAZ, 2008).

In this context it is determinant to review the role that the square has nowadays for the community in which it is inserted, because the public spaces in the context of the urban design must not be dissociated from the social matter. The study of the squares' design in the insertion of the urban frame will allow the diagnosis of these spaces, at the same time that it will provide information in the search of solutions face problems of integration of the urban space with human people and nature.

Objectives

- To analyze the design of squares in the urban frame of the city of Manaus/AM.
- To classify the squares on the insertion in the road frame.
- To evaluate the diversity of the vegetation planted in the city.

Methodology

The study was performed in 24 squares of the city of Manaus/AM (Chart 1).

Chart 1 – Location of the 24 squares studied by the District Zone of the city of Manaus/AM

District Zone	Square number	Official square name (popular square name)
South-center	1	Domingos Russo
	2	Conjunto Petros
	3	Nilton Lins
	4	Nossa Senhora de Nazaré
South	5	Francisco Queiroz
	6	Nossa Senhora do Perpétuo Socorro
	7	Heliodoro Balbi
	8	Cinco de Setembro
East	9	Colina do Aleixo
	10	Campo do Bahia
	11	Tiradentes
	12	Jorge Teixeira
North	13	Bíblia
	14	Conjunto Manoa
	15	Terminal da Cidade Nova
	16	Conjunto Ribeiro Júnior
West	17	Ismael Benigno
	18	São Jorge
	19	Duque de Caxias (Praça do 1º BIS)
	20	Abdul Rasac Hauache (CIGS)
West-center	21	Pró-menor Dom Bosco
	22	Praxiteles Antony
	23	Cavalaria
	24	Ulysses Azevedo Filho (Praça do Kissia I)

Source: the authors (2021)

The criteria to select the 24 squares at the urban zone were: the presence of arboreal individuals with a diameter at the breast height (DBH) ≥ 10 cm, the location by zones and the time of existence (old and new squares).

The inventory of the arboreal species, with DBH ≥ 10 cm, was performed through a total census. Botanical samples were collected and identified through the comparative to materials stored in the herbaria of the Federal Amazonas University (HUAM), National Institute of Amazon Research (INPA) and by parataxonomist.

By means of consultation to the data bank of Brazil's Flora 2020, conferences and updates were performed in the botanical nomenclature, botanical family and origin.

The classification of the squares in the road fabric of the city of Manaus/AM was performed

as of the mapping and visual analysis of satellite images from the *Google Earth* software. Each square's design was identified and vectorized manually, generating polygons that later were treated and measured by the Geographic Information System (QGIS) program. Afterward a table of traits with all the coordinates of the squares was elaborated with QGIS, generating a shapefile of points through their coordinates.

After the mapping and the determination of the design (layout) of the squares, their classification was done in terms of their insertion in the urban frame according to De Angelis and De Angelis Neto (2000), see Chart 2.

Chart 2 – Classification of squares in terms of the insertion in the urban frame

Type	Description	Subtype/description
1	only lane	1a/round
		1b/oval
2	two lanes	2a/two-tier round
		2b/interception of a straight lane with another lane that presents the semicircular layout
		2c/intersection of two lanes that form a 90º angle
3	three lanes	3a/triangular
		3b/two parallel lanes and one orthogonal to them, the fourth side of the square is occupied by buildings
4	four lanes	4a/quadrangular or rectangular
		4b/two-tier triangular
5	five lanes	rectangular or quadrangular, formed by four lanes parallel among themselves (two by two), with one extra fifth lane that crosses the square in half

Source: adapted from De Angelis and De Angelis Neto (2000).

The tabulation, the processing and analysis of the data observed and measured, in field, were evaluated by descriptive statistics and comparisons of the variables evaluated among the squares studied were done.

Results

Composition and floristic diversity

In the survey performed in the 24 squares in the city of Manaus, 513 arboreal individuals (DBH > 10 cm) were registered distributed in 13 families, 31 genres and 35 species (Table 1).

The most abundant families were: Fabaceae (n=150 individuals; 29.2%), Anarcadiaceae (n=114 individuals; 22.2%), and Chrysobalanaceae (n=100 individuals; 19.5%). These three families represent together approximately 71% of all the individuals studied. While the Lauraceae, Meliaceae, Rubiaceae and Sapotaceae families were the less abundant, each one of them with only two individuals (0.4%). The Fabaceae family presented the greatest richness, 10 species identified (Table 1).

A of the origin of the species, out of the 35 species listed in the 24 squares of Manaus, 51.4% (n=18 species) are classified as exotic of Brazil and 48.6% (n=17 species) are native from Brazil. Out of the 17 native species, 15 (88.2%) are native from the Amazon (Table 1). Among the

most abundant species (*L. tomentosa* - 100 individuals; *M. indica* - 99; *C. fairchildiana* - 69), two are native from the Amazonic biome (Table 1).

When we evaluate the floristic composition in each square, Praxiteles Antony has the greatest number of individuals (n=64) and exotic species (n=13). Out of the 24 squares, 14 (58.3%) have only exotic individuals planted (Table 1).

There is a predominance of exotic species in the urban afforestation in almost every city in Brazil (GONÇALVES; PAIVA, 2004). According to Neves *et al.* (2008), the Amazon has a great richness of arboreal species with potential to be used in the urban afforestation, however, rare are the native examples in public roads in the cities of the region, by virtue of the lack of information on the silvicultural aspects, mainly on the behavior of these species in public roads.

Milano (1984) recommends that each species should not exceed 15% of the total of individuals in the arboreal population, considering risks of plagues and diseases, with the possibility of compromising the longevity of species. According to Machado *et al.* (2006), the use of native species in the urban afforestation should be prioritized because they are less demanding in care and appear as more rustic, thus reducing investments.

Table 1 – Quantity of individuals of arboreal species (DBH > 10 cm) used in the afforestation of 24 squares of the six District Zones of Manaus/AM considering the origin of species (E - exotic; NB - native from Brazil; NA - native from the Amazonic Biome): 1 – Domingos Russo; 2 – Conjunto Petros; 3 – Nilton Lins; 4 – Nossa Senhora de Nazaré; 5 – Francisco Queiroz; 6 – Nossa Senhora do Perpétuo Socorro; 7 – Heliodoro Balbi (Praça da Polícia); 8 – Cinco de Setembro (Praça da Saudade); 9 – Colina do Aleixo; 10 – Campo do Bahia; 11 – Tiradentes; 12 – Jorge Teixeira; 13 – Bíblia; 14 – Conjunto Manoa; 15 – Terminal da Cidade Nova (Igreja de São Bento); 16 – Conjunto Ribeiro Júnior; 17 – Ismael Benigno; 18 – São Jorge; 19 – Duque de Caxias (Praça do 1o. BIS); 20 – Abdul Rasac Hauache (Praça do CIGS); 21 – Pró-menor Dom Bosco; 22 – Praxiteles Antony II; 23 – Cavalaria; 24 – Ulysses Azevedo Filho (Praça do Kíssia)

Species	Popular name	Botanical family	Origin	South-center				South				East				North				West				West-center				Σ Individuals
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
Adenanthera pavonina L.	Tento Vermelho	Fabaceae	E	3																								3
Alchornea discolor Poepp.	Supia-rana	Euphorbiaceae	NA																						1			1
Anacardium occidentale L.	Caju	Anacardiaceae	NA											1											6			7
Artocarpus altilis (Parkinson) Fosberg	Fruta-pão	Moraceae	E	1																								1
Artocarpus heterophyllus Lam.	Jaca	Moraceae	E											1											3			4
Cassia fistula L.	Chuva-de-ouro	Fabaceae	E					4						1												1		6
Ceiba pentandra (L.) Gaertn.	Sumaúma	Malvaceae	NA							1																		1
Cenostigma tocantinum Ducke	Pau-pretinho	Fabaceae	NA		5						2		3										7			3		20
Clitoria fairchildiana R.A.Howard	Palheteira	Fabaceae	NA						4	8		1					9	4						18	10	15		69

Cynometra bauhiniifolia Benth.	Jutairana	Fabaceae	NA																				4					4
Delonix regia (Bojer ex Hook.) Raf.	Flambo-yant	Fabaceae	E	1				2		6						3				1					2	6	1	22
Erythrina variegata L.	Eritrina	Fabaceae	E			1	3	1							1													6
Ficus benjamina L.	Ficus	Moraceae	E		5	2	21	4				2	2	4	2				3						1	1	1	48
Ficus elastica Roxb.	Ficus marrom	Moraceae	E			8												1				1	6					16
Genipa americana L.	Jenipapo	Rubiaceae	NA	1																					1			2
Guazuma ulmifolia Lam.	Mutamba	Malvaceae	NA	4																								4
Handroanthus serratifolius (Vahl) S.Grose	Ipê-amarelo	Bignoniaceae	NA		4		3																					7
Hevea brasiliensis (Willd. ex A.Juss.) Müll. Arg.	Seringueira	Euphorbiaceae	NA		1		2			11				1														15
Leucaena leucocephala (Lam.) de Wit	Leucena	Fabaceae	E	2	2																4				4			12
Licania cf. tomentosa (Benth.) Fritsch	Oiti	Chrysobalanaceae	NA	3			5			15	43			1	2			7	5	2	2	7	1			7		100
Mangifera indica L.	Mangueira	Anacardiaceae	E	7	10	4	2		1	2	1	4	3	1			2		3		3		3	7	22	3	21	99
Paubrasilia echinata (Lam.) Gagnon, H.C.Lima & G.P.Lewis	Pau-brasil	Fabaceae	NB					1		1																		2
Persea americana Mill.	Abacateiro	Lauraceae	E																					1	1			2
Podranea ricasoliana (Tanfani) Sprague	Sete-léguas	Bignoniaceae	E					1																				1
Poincianella pluviosa (DC.) L.P.Queiroz	Sibipiruna	Fabaceae	NB							4												2						6
Pouteria caimito (Ruiz & Pav.) Radlk.	Abiu	Sapotaceae	NA																						2			2
Psidium guajava L.	Goiabeira	Myrtaceae	E																						2			2

Spathodea campanulata P. Beauv.	Espatódea	Bignoniaceae	E																					1				1
Spondias mombin L.	Taperebá	Anacardiaceae	NA												3									5				8
Swietenia macrophylla King	Mogno	Meliaceae	NA				2																					2
Syzygium jambolanum (Lam.) DC.	Azeitona preta	Myrtaceae	E									3	1					1				1	1					7
Syzygium malaccense (L.) Merr. & L.M.Perry	Jambo	Myrtaceae	E		2	2	2							1		1					2		2		1		13
Terminalia catappa L.	Castanholeira	Combretaceae	E		1			1										1	8			3		3			17
Theobroma cacao L.	Cacau	Malvaceae	E																				2				2
Theobroma grandiflorum (Willd. ex Spreng.) K.Schum.	Cupuaçu	Malvaceae	NA																				1				1
Quantity of individuals in each square				22	30	17	40	14	5	48	46	10	9	13	6	3	12	12	13	11	9	10	23	12	75	34	39	513

Source: the authors (2021).

Classification of the squares in Manaus

After the analysis of the design (layout), the 24 squares of the city of Manaus/AM were classified in three types (Picture 1). Integrating the subtype 2a: the square Nossa Senhora de Nazaré, located in the South-center zone; integrating the subtype 2c: the squares Francisco Queiroz and Nossa Senhora do Perpétuo Socorro, located in the South zone; integrating the subtype 3a: the squares Domingos Russo and Nilton Lins, located in the South-center zone and the squares Colina do Aleixo, Bíblia and Pró-menor Dom Bosco, located in the East, North and West-center zones respectively; the squares Ismael Benigno, Duque de Caxias (1º BIS) and Abdul Rasac Hauache (CIGS), located in the West zone, Cavalaria and Ulysses Azevedo Filho (Conjunto Kissia I), located in the West-center zone, and Conjunto Manoa, located in the North zone; integrating subtype 4a: squares in Conjunto Petros, Cinco de Setembro and Praxiteles Antony, located in the South-center, South and West-center zones, respectively.

Picture 1 – Classification of the squares in Manaus/AM, according to De Angelis and De Angelis Neto (2000). (*) Squares with a new classification proposed by Cavalcanti and Cavalcanti

TIPO 2	2a	Nossa Senhora de Nazaré
	2c	Francisco Queiroz e Nossa Senora do Perpétuo Socorro
	*2d	Heliodoro Balbi, Campo da Bahia, Terminal da Cidade Nova e São Jorge
TIPO 3	3a	Domingos Russo, Nilton Lins, Colina do Aleixo, Bíblia e Pró-Menor Dom Bosco
	3b	Conjunto Manoa, Ismael Benigno, Duque de Caxias (1º BIS), Abdul Rasac Hauache (CIGS), Cavalaria e Ulysses Azevedo Filho (do Conjunto Kissia I)
	*3c	Conjunto Ribeiro Junior
	*3d	Jorge Teixeira
TIPO 4	4a	Conjunto Petros, Cinco de Setembro e Praxiteles Anthony
	*4c	Tiradentes

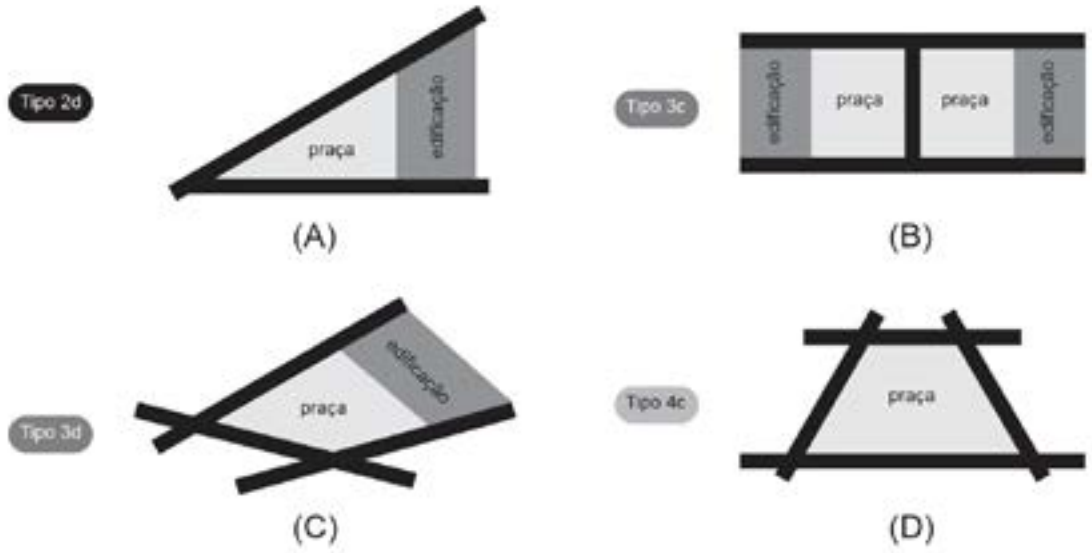
Source: the authors (2021).

The insertion of Manaus' squares, in its urban frame, is not standardized. It is perceived that the type of classification that is dominant is the type 3 (45.8%), which are squares conformed by three lanes, followed by type 2 (conformed by two lanes, 12.5%), and type 4 (conformed by four lanes, 12.5%), considering De Angelis and De Angelis Neto (2000). It is highlighted that the other squares (n=7) are not included in the calculation of this percentage because it was necessary to create new subtypes, considering their conformations did not correspond to any subtype listed in the referred classification. These new subtypes will be discussed in the next topic.

New subtypes in the classification of the squares in Manaus

In the study of the insertion of squares in the urban frame of Manaus/AM the classification proposed by De Angelis and De Angelis Neto (2000) was considered and through the specificity found, it was necessary to create four subtypes of squares to attend Manaus' reality (Picture 2).

Picture 2 – Scheme of the subtypes created by Cavalcanti and Cavalcanti (2021), as of the conformation of the lanes and geometrical shape of the squares in Manaus/AM: A - 2d; B - 3c; C - 3d; D - 4c



Source: the authors (2021)

The first subtype - **2d** (Picture 2A) was added to type 2. Description: triangular square, formed by two lanes that cross each other with an angle smaller than 90°, with one side taken by construction. It differs from other subtypes (2a, 2b and 2c, see Chart 1) because it presents buildings in one of the sides and in a triangular shape.

The second subtype - **3c** (Picture 2B) was added to type 3. Description: formed by two parallel lanes and one orthogonal to them, crossing the square. The other two sides are taken by constructions. It differs from the other subtypes (3a and 3b, see Chart 1) because it presents constructions on sides three and four and also because it is crossed by one lane.

The third subtype – **3d** (Picture 2C), was also added to type 3. Description: formed by three not parallel nor orthogonal lanes, with the fourth side taken by constructions. In this case, there is no parallelism among the lanes.

And the fourth subtype - **4c** (Picture 2D) was added to type 4. Description: formed by four lanes, two of them parallel and the other two not parallel, forming a trapezium. The distinction of this subtype from the others (4a and 4b, see Chart 2), happened because of two lanes not being parallel and presenting a geometric shape different from a square, rectangle or triangle.

The squares in Manaus that are not classified in these proposed subtypes are presented below. Subtype 2d is integrated by squares Heliodoro Balbi, Campo do Bahia, Praça do Terminal da Cidade Nova (Igreja São Bento) and São Jorge, located in the South, East, North and West zones, respectively. Square Conjunto Ribeiro Júnior, located in the North zone integrates subtype 3c and square Jorge Teixeira, located in the East zone integrates subtype 3d. Square Conjunto Tiradentes, located in the East zone, integrates subtype 4c. Including these ones in the classification of squares in Manaus, it is verified that the predominance continues to be type 3 (54.2%), followed by type 2 (29.2%) and type 4 (16.6%).

De Angelis and Castro (2004) highlight that the urban design is the appropriate way to treat and forward the evolution and renovation process of urban fragments. They state that the impor-

tance of public roads for the squares lays in the fact that their shapes can be defined by those, determining the different types of configuration and they highlight that the insertion of the squares in the urban frame lays in the fact that their outlines, defined by public roads, end um defining not only their shape, but also their functionality.

The square is a primordial urban icon for its surroundings' inhabitants as well as for the urban design of the city, bearing in mind that it also plays the role of green area, being an important vector of environmental comfort to people. Thus, the square is also related to the urban design, as well as in the shape of an intervention or creation of the urban landscape (MACEDO, 1986).

Conclusion

The design of squares in Manaus does not follow a spatial pattern. Their creation is set in obsolete or relegated spaces in the city's neighborhoods, mainly in the areas of minor purchasing power of the population.

Out of the 24 squares, most of them are type 3 (conformed by three lanes), followed by type 2 (two lanes) and type 4 (four lanes).

Because of Manaus' reality it was necessary to create four subtypes in the classification of the squares, 2d, 3c, 3d and 4c.

In the 24 squares 513 arboreal individuals were registered, distributed in 13 families, 31 genres and 35 species. The most abundant families were Fabaceae, Anacardiaceae and Chrysobalanaceae.

In the inventory of the squares, the number of exotic species in close to the native ones from Brazil, with a predominance of native species from the Amazon biome; representing a great advance in the thinking way of the public power for the work of balance between fauna and flora, as well as in the valorization of the population if regional species.

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PERCEPTION OF RESIDENTS IN MANAUS ON THE URBAN AFFORESTATION

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ABSTRACT: The municipal governments, through their Environmental Secretariats, seek to invest in afforestation through public policies, educational campaigns and seedling distribution. However, the actions are inefficient, as studies on afforestation are based on inventories of species planted in public places, few studies seek to understand the population on the subject of afforestation. It is believed that the work of environmental education is of paramount importance. This study aimed to analyze the perception of afforestation of residents from different areas of Manaus, Amazonas state through an interview in the city of Manaus. Most participants were women aged 18-28 years. Most residents have completed primary education. Residents understand what urban afforestation is and the benefits of planting trees can bring, but they are not aware of the most suitable species to be buried in the city.

KEYWORDS: Environmental education; Planning; Public roads.

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PERCEPÇÃO DOS MORADORES DE MANAUS SOBRE A ARBORIZAÇÃO URBANA

Resumo: As prefeituras municipais, por meio das suas Secretarias Ambientais, buscam investir na arborização mediante políticas públicas, campanhas educativas e distribuição de mudas. Contudo, as ações são ineficientes, pois os estudos sobre arborização baseiam-se em inventários das espécies plantadas nos logradouros, poucos trabalhos buscam o entendimento da população quanto ao assunto arborização. Acredita-se que o trabalho de educação ambiental é de suma importância. O presente estudo teve como objetivo de analisar a percepção sobre a arborização dos moradores de diferentes áreas de Manaus, estado do Amazonas. Através de entrevista na cidade de Manaus/AM. A maioria dos participantes foram mulheres na faixa etária de 18-28 anos. A maioria dos moradores com ensino básico completo. Os moradores tem entendimento do que é uma arborização urbana e dos benefícios que o plantio de árvores pode trazer, contudo não tem conhecimento das espécies mais adequadas a serem plantadas na cidade.

Palavras-chave: Educação Ambiental; Planejamento; Vias Públicas.

Amazonas state has 62 municipalities distributed in 1,559,161.7 km^2, which representing 53% of the Brazilian territory. The state's administrative headquarters are in Manaus, which has an area of 11,401.1 km^2, and 229.5 km^2 of these are in the urban perimeter (IBGE, 2020). In the last census performed by IBGE, in 2010, the estimation was a population of 1,802,014 inhabitants (IBGE, 2020).

In the last ten years, Manaus has been among the most populated cities in Brazil and has one of the highest yearly growing rates, however it has suffered a decrease in the last census, the city's population density is 158.1 inhabit/km^2 (IBGE, 2020).

The urbanization process of Manaus has been strongly stimulated since the colonial period to the exploitative-extractive agricultural economy, especially of rubber (SANTOS, 2007). However, Manaus pays a very high environmental price on behalf of the urban expansion that it has been suffering along the last 20 years (NOGUEIRA *et al.*, 2007), causing environmental problems increasingly common and significant (ALMEIDA *et al.*, 2011).

The invasion of Union land characterized the territorial expansion in the capital of Amazonas. Manaus is divided in six District Zones and has 63 neighborhoods (PMM, 2010). NOGUEIRA *et al.* (2007) state that in the 1970s, the occupation of Manaus was at the margins of the creeks in the South, South-center, West and West-center zones; also that with the creation of Manaus Free Zone, the migratory process was intensified, mainly with people coming from the countryside of the state; and at the end of the 1970s, the expansion of the urban perimeter started going towards the East zone; also that until the 1980s, Manaus had approximately 37 neighborhoods plus the Industrial District, however countless communities were created from irregular occupations and then the East and North zones started being effectively occupied.

The change in a city's physical and natural environment alters the landscape and the local weather. The analyses indicate an increase of the annual average temperature in Manaus of 3.17 ± 0,53 ˚C and directly modulated by the human occupation of the Region using deforestation and urbanism (OLIVEIRA *et al.*, 2006).

The changes in big cities range from the soil physical structure, like compression and water-

proofing, to the microclimate, due to the accumulation and the reflection of the heat on the built surfaces (AGUIRRE JUNIOR, 2010), resulting in the loss of quality of life of residents, pulling them away from a harmonious relationship with the natural environment (SHAMS *et al.*, 2009).

Urban green areas play a role of extreme importance for the quality of life in major cities, simultaneously acting over physical and mental health of the human being, mitigating the feeling of oppression amidst the big transformations in the cities, contributing for the air purification, the reduction of noise pollution, aesthetic harmony (GRAZIANO, 1994; GONÇALVES and PAIVA, 2004).

The main goal of this paper was to analyze the perception on afforestation of residents from different areas in Manaus, Amazonas, as well as, through the perception of people from Manaus, to know the benefits and problems related to urban afforestation, and to exhibit the Manaus people preference of afforestation standards.

METHODOLOGY

This study had a descriptive approach, of the qualitative and quantitative types, and was performed in the city of Manaus/AM, in the six district zones.

In each district zone, squares with arboreal vegetation were defined as reference points. 21 places were selected, in the South-center zone: Praça Domingos Russo, Conjunto Petros, Praça de Alimentação do Parque das Laranjeiras, Praça Nossa Senhora de Nazaré. In the South zone: Praça Francisco Queiroz, Praça Antônio Plácido de Souza, Praça Heliodoro Balbi, Praça da Saudade. In the East zone: Praça do Conjunto Colina do Aleixo, Campos Bahia, Praça Tiradentes. In the North zone: Praça Padre Pedro Vignola, Conjunto Ribeiro Jr. In the West zone: Praça Ismael Benigno, Praça Duque de Caxias, 1° BIS, Praça do CIGS. In the West-center zone: Praça do Pró-Menor Dom Bosco, Praça Santos Dumont, Cavalaria, Conjunto Kissia (Picture 1).

The technique of individual interview was used with an average duration of 30 minutes, applicating a form as an instrument, with open and closed questions, composed by two parts: socio-demographic data and data on afforestation.

The form was applied with four residents that live around the square and other four living 500 m from the court in North-South and East-West directions.

The inclusion criteria for the research were: to live around the square or 500 m from it; to be 18 years old or more, any gender and literate. And the exclusion criterion was to present an illness that precluded them from participating in the research.

The quantitative data were disposed in a data bank created in Microsoft Excel and analyzed by means of descriptive statistics.

The qualitative data was analyzed with the Content Analysis technique (BARDIN, 2004), employing the enunciation technique, according to the following organization: For the interpretation of the *corpus* constituent elements, the chosen method was the content analysis, using the pronunciation analytical technique with thematic transversality. The examination of information was sequenced in three chronological poles: *pre-analysis*: floating reading of the documents' material; *material exploration*: clippings encoding, aggregation and enumeration of the records' units; *results treatment and interpretation*: process of classification of elements in interest categories for analysis.

Picture 1 – Identification of data collect points in the city of Manaus/AM.
= Square as reference point; ■ = Form application point. Squares: 1ºBis, Campo do Bahia, Cavalaria, Conj. Petro, Conj. Kissia, Conj. Ribeiro Jr., Antônio Plácido de Souza, Conj. Colina do Aleixo, Domingos Russo, Heliodoro Balbi, Ismael Benigno, N. Sra. de Nazaré, Pe. Pedro Vignola, Conj. Tiradentes, Saudade, CIGS, Pq. das Laranjeiras, Francisco Queiroz, Pró-Menor Dom Bosco, Santos Dumont, Duque de Caxias

The technical and methodological phases of the content analysis are sequenced in three chronological poles: pre-analysis, material exploitation and results and interpretation treatment.

POLE I - PRE-ANALYSIS PHASE - Stage that organizes the analyzed material, with floating reading of the statements under the orientation of completeness, representativeness, homogeneity and pertinence, to constitute the *corpus*.

COMPLETENESS RULE: It refers to the contemplation of all *corpus* constitutive interviews.

REPRESENTATIVENESS RULE: It refers to the contemplation of all constitutive corpus interviews.

HOMOGENEITY RULE: Choosing precise criteria are complied, without escaping the theme (afforestation) and research objectives.

PERTINENCE RULE: The records archive adequates to the objectives prescribed by the analysis.

POLE II - MATERIAL EXPLORATION PHASE - It consists of elaborating the chosen operations in the texts in record units (semantic level: theme; linguistic group: word and sentence) for categorization and codification.

POLE III - RESULTS TREATMENT AND INTERPRETATION - Submitting the explored material to an interpretative and contextualized treatment in analysis categories and subcategories.

The ethical and legal aspects of the research comply with Resolution n. 466/2012 (CNS, 2012). Thus, all the interviewees' study objectives and voluntary participation nature were explained individually. The ones who accepted participating in the research were oriented to read the Informed Consent and sign it.

This research was submitted to the Research Ethics Committee of Amazonas Federal University/UFAM, in 2016. The favorable position was obtained by the Ethical Appreciation Presentation Certificate (CAAE) under n. 64336117.2.0000.5020

RESULTS

Interviewees' socio-demographic profile

Out of the total of participants (n=168), 94 were women (56%) and 74 were men (44%). The interviewees' age had its more extensive distribution in the age range between 18 and 28 years old, men had a percentage of 60.8% and women, 63.8% (Table 1).

Table 1 – Interviewees distribution according to gender and age range. Manaus, 2017

Age (years)	Men	Women
18-28	45 (60.8%)	60 (63.8%)
28-38	12 (16.2%)	13 (1.,8%)
38-48	8 (10.8%)	9 (9.6%)
48-58	5 (6.8%)	6 (6.4%)
58-68	2 (2.7%)	3 (3.2%)
68-78	2 (2.7%)	1 (1.1%)
78-88	-	2 (2.1%)
Total	**74**	**94**

On education, it is observed that most men and women have more that the primary education (Table 2), however the number of women (26.6%) that have completed higher education is almost three times higher than the men (12.2%). The participants' education level was advantageous for understanding the question son the perception of urban afforestation in the city.

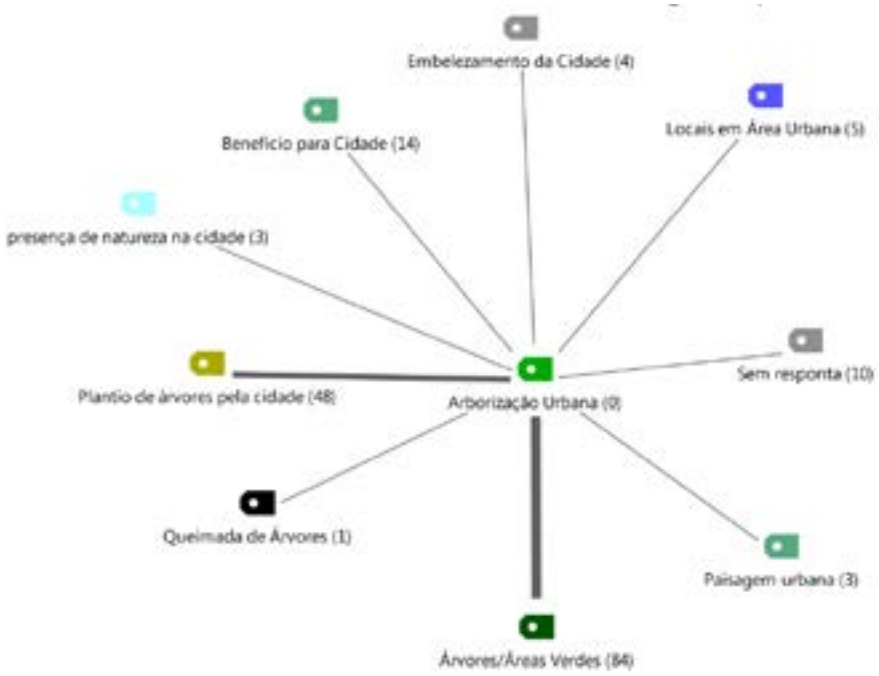
Table 2 – Interviewees distribution according to education. Manaus, 2017

Education	Men	Women
Never studied	-	2 (2.1%)
Completed elementary school	1 (1.4%)	2 (2.1%)
Did not complete elementary school	-	-
Completed high school	31 (41.9%)	25 (26.6%)
Did not complete high school	3 (4.1%)	2 (2.1%)
Completed higher education	9 (12.2%)	25 (26.6%)
Did not complete higher education	30 (40.5%)	38 (40.4%)
Total	**74**	**94**

Perception of residents in Manaus on the urban afforestation

When asked what is "urban afforestation", most interviewees answered that it was the group of trees and green areas in the city, 28% understood urban afforestation as the planting of trees that are put in the metropolitan area, which befits the afforestation concept (Picture 2); according to Oliveira (2005), who defines as "urban afforestation is every vegetal covering present in cities, constituted by trees that are in sidewalks, central seedbeds, parks and public squares".

Picture 2 – Conception on "urban afforestation" by residents of the city of Manaus, 2017

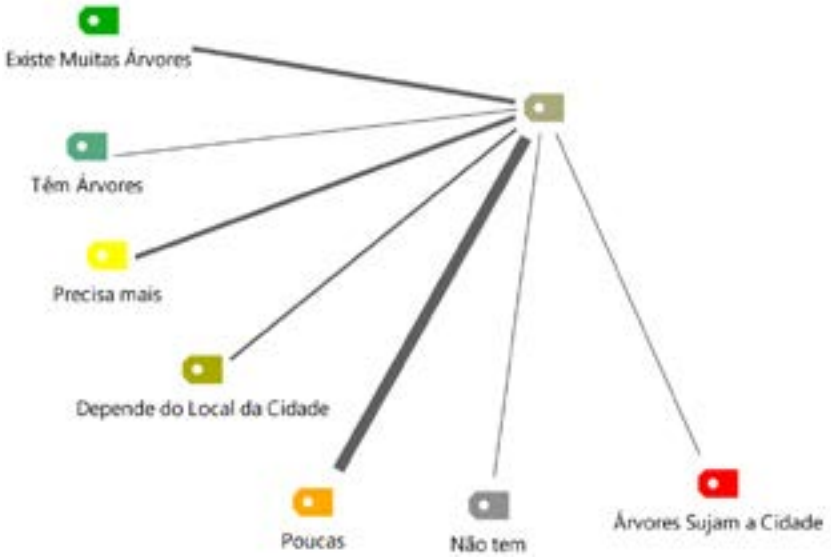


Other terms on urban afforestation were spoken by the interviewees, like: 8% understand afforestation as a way to bring benefits to the city; 3.4% see it as the presence of nature in the urban environment, others see it as the embellishment of the city (2.3%); and 8.3% did not have any knowledge of the term urban afforestation (Picture 2).

The interviewees believe that the afforestation of the city is precarious, because most answered that there are few trees. However, another part answered that there are a lot of trees. In studies performed by Lins Neto *et al.* (2016) in Manaus on 2014; the population also considered the afforestation precarious, with the worst assessments by residents of North and East zones.

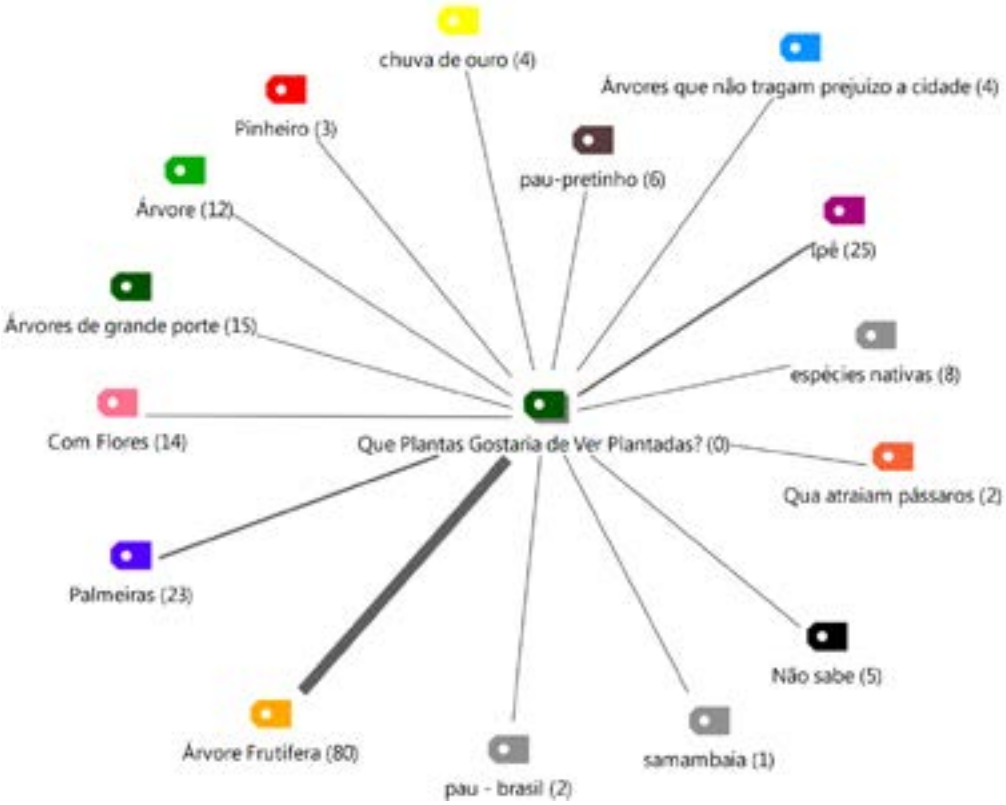
According to the city population's perception, the residents also notice the inadequate distribution of trees because there are places with a lack of green areas (Picture 3).

Picture 3 – Perception of Manaus' residents on the number of trees planted in the urban environment, 2017



On the species that the residents would like to see planted in Manaus (Picture 4), 47.6% answered that they would like fruitful species; 8.9% said big trees and 6% answered that any arboreal species could be implanted on the streets, with no preference; 13.7% had a choice on palm trees; 1.7% on pine trees; 2.3% on golden shower trees; and 0.5% on ferns. Other referenced species were ipê (14.8%) and pau-pretinho (4.5%), which are species indicated for the afforestation according to the Urban Afforestation Development Plan of Manaus (PMM, 2012).

Picture 4 – Plants indicated by Manaus's residents, preferably to plant on the urban environment, 2017

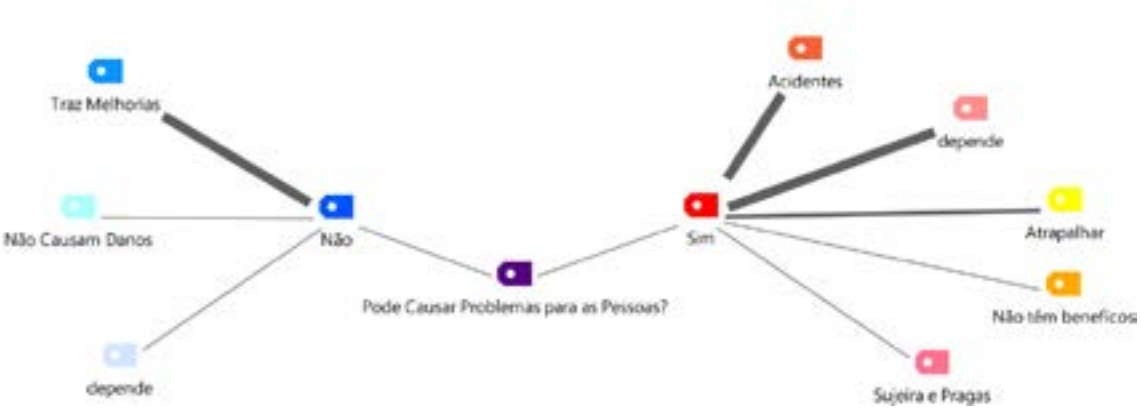


According to França *et al.* (2012), the use of inadequate species in the afforestation of the city brings several problems, such as deterioration of the sidewalks, streets, and houses. It may cause conflicts with the power grid, and the excessive plantation of some species diminishes the floristic diversity on the city's arboreal patrimony.

Manaus' residents present different opinions on the problems of the planted trees (Picture 5). A part of the residents answered that the trees do not cause problems, they only bring improvement, as said several times because they calm the weather in the city. Another part of the residents answered that the trees could cause problems, such as accidents and get it the way of traffic; some people justified that it depends on the species and the place where the tree was planted.

In the research performed in Manaus in 2014, the interviewees said the main risk in the urban afforestation is the "falling risk" and > 50% of the interviewees acknowledged the thermic comfort and shadow as a benefit from the trees (LINS NETO *et al.*, 2016).

Picture 5 – Manaus residents' perception on the problems caused by trees on the urban environment 2017



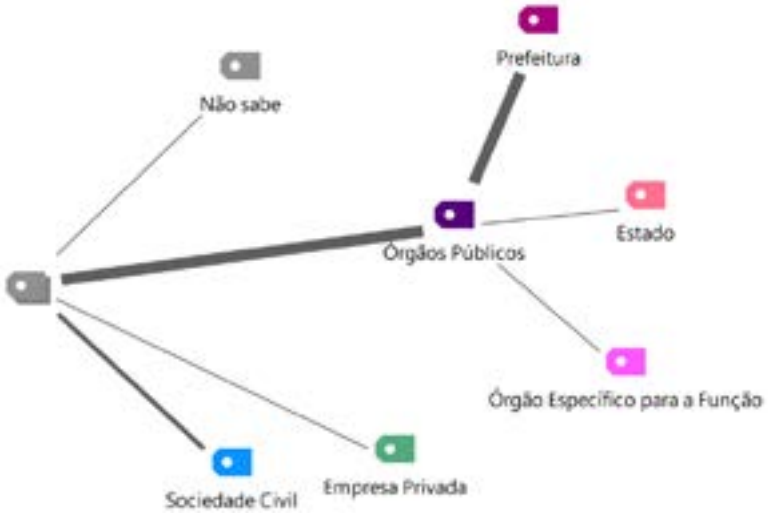
According to Ribeiro (2009), the size of the treetop must be considered before planting a tree, thus assuring that there is space and physical conditions available for its development, avoiding confrontations with buildings, vehicles, urban furnishing and pedestrians.

According to Rodrigues *et al*. (2010), an improper planting or species that are not adequate to the urban perimeter can occasion damages to the urban frame. One way to be aware the population on which species are indicated for the urban afforestation is by making campaigns on the theme.

Manaus residents clearly understand the public authority - city hall is responsible for the afforestation cares of the city. Only one part of the interviewees said it is a competence of the civil society (Picture 6).

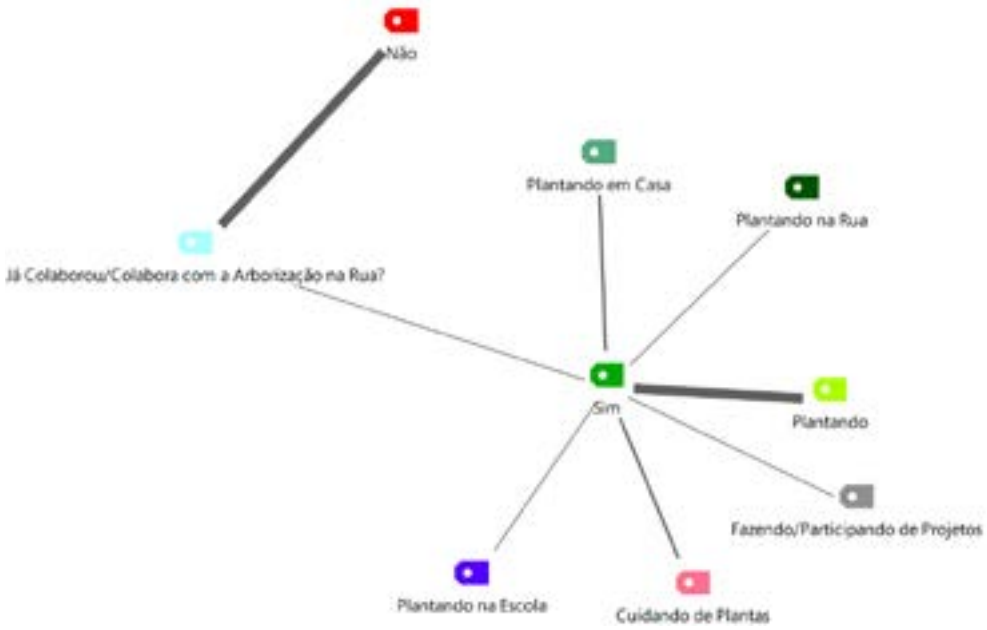
Indeed, the public authority is responsible for the city's afforestation, however the society must participate in this process by getting involved in actions that aim to improve and protect the trees in the urban space. According to Malavasi and Malavasi (2001), aside from executing the urban afforestation, city halls should also take care of its maintenance, because this competence lies on the development plans and laws related to using the soil in cities and metropolitan regions, which should observe the principles and limitations provided in Art. 2, single paragraph of the Forest Code that was added by Law 7.803/89.

Picture 6 – Residents understanding of the responsibility to care for the urban afforestation in Manaus, 2017



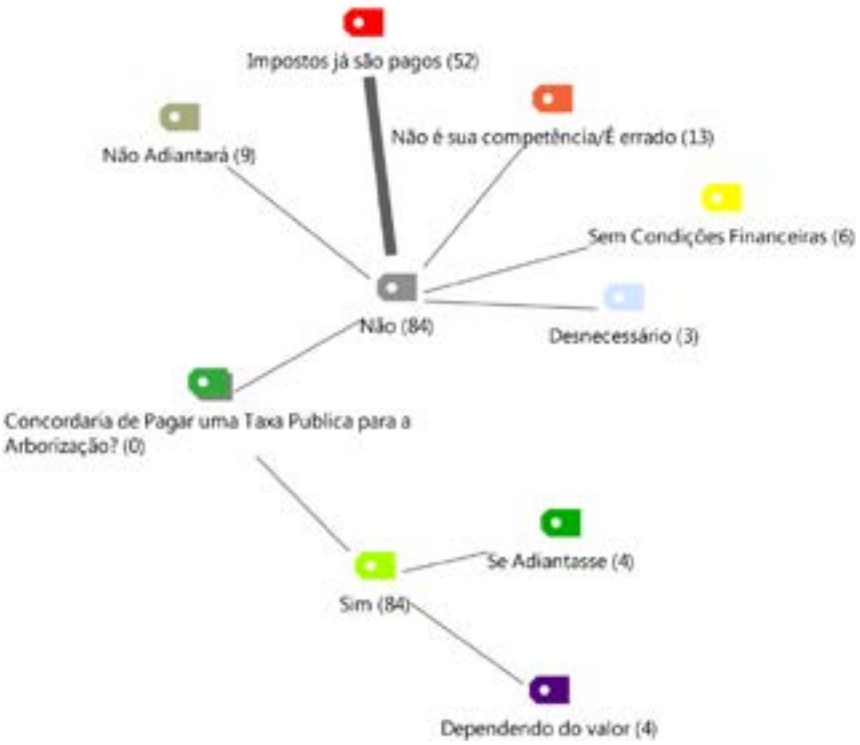
Although the residents know that the urban afforestation is Manaus' city hall duty, many people collaborate planting at home, on the street, at schools; other people answered that they help take care of the plants and participating in projects (Picture 7).

Picture 7 – Collaboration to urban afforestation by residents of Manaus, 2017



And finally, the interviewees were consulted about the possibility to contribute paying a public fee for the urban afforestation of Manaus (Picture 8). The opinions were different, 50% of the interviewees would not pay the price; most of them claimed that they already spend a lot of taxes; other reasons were that it is not the population's competence, it would not make a difference, and some pledged that they do not have financial conditions for that. The other 50% that would agree to pay the fee explained that they would do it depending on the value and and investment in the city's afforestation.

Picture 8 – Manaus residents' opinion about paying a financial fee to use in the urban afforestation, 2017



CONCLUSIONS

The population can notice the importance of afforestation in cities, and the benefits that it brings. However some answers were inconsistent, the majority can be explained by lack of information and orientation about the theme from the interviewees.

Most of the negative factors mentioned by the population were the bad distribution of the arboreal individuals throughout the city.

Urban afforestation needs planning so it does not bring problems for the city and its population; the species to be planted are crucial for for exploiting the afforestation. Manaus has a development plan that provides the species indicated for the city's afforestation.

The population must notice the significance of choosing individuals and adequate handling, so there is a real improvement in people's quality of life.

The city hall making campaigns about urban afforestation distributing pamphlets is a vital tool to instruct the population on using the urban afforestation correctly.

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BRAZILIAN NATIONAL URBAN FOREST POLICY

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Abstract: Despite the growing knowledge on the benefits of the Urban Trees, there is a gap related to the dimension related to the dimension of governance, normative instruments and public policies. In an attempt to improve this context, the Brazilian Society of Urban Forest instituted the Urban Forest National Policy Work Group (GTPNAU) inserted in the scope of the Standardization and Certification Brazilian Committee. GTPNAU had as its goal to elaborate a public policy proposal at national level, capable of offering guidelines and instruments, based on principles that acknowledge the urban forest as a public utility service. Another important expected result with the advance of the Brazilian National Urban Forest Policy consists on the understanding of Urban Trees as essential infrastructure for life in cities, on behalf of the several urban stakeholders, public managers, decision makers, real estate investors and companies that provide services; in order to correct the distortions in the urbanization process, that currently transform the green areas in urban cities in something that just a little piece of the population can enjoy which should be available for everyone.

Keywords: Urban Forest; National policy; Technical note.

A POLÍTICA NACIONAL DE ARBORIZAÇÃO URBANA

Resumo: Apesar do crescente conhecimento sobre os benefícios da vegetação arbórea urbana, observa-se uma lacuna, relacionada à dimensão da governança, instrumentos normativos e políticas públicas. Na tentativa de avançar melhorar esse contexto, a Sociedade Brasileira de Arborização Urbana instituiu o Grupo de Trabalho da Política Nacional de Arborização Urbana (GTPNAU) inserido no âmbito do Comitê Brasileiro de Normalização e Certificação. O GTPNAU teve por objetivo elaborar uma proposta de política pública em nível nacional, capaz de oferecer diretrizes e instrumentos, baseados em princípios que reconhecem a arborização urbana como um serviço de utilidade pública.

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Outro importante resultado que se espera obter com o avanço da Política Nacional de Arborização Urbana consiste na incorporação, por parte dos diversos stakeholders urbanos, gestores públicos, tomadores de decisão, investidores do setor imobiliário e empresas prestadoras de serviço, do entendimento das árvores urbanas como elementos de infraestrutura essencial para a vida nas cidades de modo a corrigir as distorções do processo de urbanização, que atualmente transforam o verde o urbano que deveria ser um direito de todos em um privilégio que poucos podem usufruir.

Palavras-chave: Arborização urbana; Política nacional; Nota técnica.

Technical Note

The reality observed in big and medium cities shows the reproduction of urban areas with low rates of arboreal vegetation. The few public policies in this area, allied to conflicts between urban and environmental legislations, contribute directly to the low quality of urban forest (CAICHE, 2020).

Despite the growing knowledge on the benefits of conservation, maintenance and insertion of arboreal vegetation in urban centers (SALBITANO, 2016), a scientific and technical gap is noted related to the dimension of governance, most specifically in the aspect related to the normative instruments and sectorial public policies of management and urban vegetation handling.

It is possible to verify in literatures from 1985 that at the 1st Urban Forest Conference held in Porto Alegre, Brazil (ENAU, 1985), the first record mentioning the necessity of establishing a normative instrument in a national range capable of ordering urban forest. Lately this theme has been present in other technical/scientific events like São Paulo Urban Forest Conference (Piracicaba, 2007), XVIII Brazilian Urban Forest Congress held in Rio de Janeiro (SBAU, 2014) and XXIII João Pessoa CBAU (SBAU, 2019), and in all cases the theme appeared in the events final documents, highlighting the importance of discussing the creation of an Urban Forest National Policy.

In the field of legal initiatives, there are the bills No. 2.897/2008, 396/2014 and 1.435/2019 that deal with the subject. What these three projects have in common is not the fact that they present a proposal of urban afforestation national policy, but that they amend Federal Law No. 10.257 from 2001 (City Statute) that makes Brazilian cities with more than 20,000 inhabitants being obligated to elaborate their urban with more than 20,000 inhabitants be obligated to elaborate their Urban Forest plans. However, these three initiatives currently have their proceeding closed.

In an attempt to improve this context, on May 6th of 2020 the Brazilian Society of Urban Forest instituted the Urban Forest National Policy Work Group (GTPNAU) inserted in the scope of the Standardization and Certification Brazilian Committee.

This group was coordinated by the forestry engineer Daniel Caiche and supported by professional from several areas: Luiz Octavio Lima Pedreira (Forestry Engineer - Secretary GTPNAU); Sergio Chaves (Landscape Architect - President SBAU); André Fraga (Environmental Engineer - Vice-president SBAU); Ricardo Martins (Agronomic Engineer - Technical Scientific Director SBAU); Maria Do Carmo Sanchotene (Biologist); Eliane Guaraldo (Architect and Planner); Flávio Pereira Telles (Forestry Engineer); Pedro Mendes (Agronomic Engineer); Giuliana Veslaco (Agronomic Engineer); Demóstenes Ferreira Silva filho (Agronomic Engineer); Roberto Rocha (Architect, Planner and Lawyer) e Adriana Reis (Forestry Engineer).

GTPNAU had as its goal to elaborate a public policy proposal at national level, capable of offering guidelines and instruments, based on principles that acknowledge the urban Forest as a public utility service, for managements and governments on their different spheres.

In order to achieve this goal, during 2020 and 2021, 24 meetings were held with the members of the group, counting on special guests such as Prof. Dr. Flávia Gizele Konig Brun, professor at Paraná Technological Federal University - Campus Dois Vizinhos/PR. The Forestry Engineer Claudio Renato Wojcikiewicz, member of Paraná State Interinstitutional Work Committee for Analysis of Urban Forest Plans, in addition to Cecília Michea, Cecilia Benavides and Leonardo Lira, members of *Red Árbol Urbano* from Chile.

As a result of this work, there is a first version composed by 43 articles, distributed in 5 main titles (General Dispositions, of the Urban Forest National Policy, of the Urban Forest Planning, of the Governance in Urban Forest and Final and Transitory Dispositions). This version established guidelines for the urban Forest planning on national scale, defined responsibilities and rights and brought innovative management instruments of the urban Forest.

This version was put in open consultation process on the Brazilian Urban Forest Society website. Lately meetings were held to incorporate suggestions and proceed the due adjustments of the proposal text. After that, the referral will follow to the National Congress so that the text can become a bill and follow the official proceeding.

It is expected that from the creation of the Urban Forest National Policy, the theme gets attention in the governmental agendas and that the arboriculture professionalization, as well as the increase of resources destined to the urban vegetation management materialize in improvement of quality of life in Brazilian cities.

Another important expected result with the advance of the Urban Forest National Policy consists on the understanding of incorporating of urban trees as essential infrastructures elements for life in cities, on behalf of the several urban stakeholders, public managers, decision makers, real estate investors and companies that provide services; in order to correct the distortions in the urbanization process, that currently transform the green an urban that should be everyone's right in a privilege that little can enjoy.

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LÁBREA: URBAN AFFORESTATION IN A CITY IN THE DEFORESTATION ARC

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Abstract: Lábrea, Amazonas, Brazil officially has 64.4% of its public streets lined with trees. However, there is no information available on the qualitative and quantitative aspects of this afforestation. The aim of the study was to inventory the urban afforestation of Lábrea to quantify and qualify the municipal road afforestation. The census of arboreal vegetation on the public roads covered parking lots and areas for pedestrian traffic (sidewalks and curbs) on the streets of the neighborhoods that make up the urban area, being recorded geolocated images of individuals. A total of 507 individuals were counted, distributed in 38 species and 15 botanical families, planting trees in the city's public streets. The species ficus (Moraceae, *Ficus benjamina*) and jambeiro (Myrtaceae, *Syzygium malaccense*) had the highest absolute density. Afforestation is concentrated in the Centro district (50 %). Disregarding the neighborhood, the most tree-lined street was October 22nd. The species are partially of native national origin (19 species, 50 %), of which 63% are Amazonian (12 species). In absolute terms, individuals are mostly of exotic origin (79 %). The individuals are in good structural condition, with type 1 phytosanitary status, located in sidewalks, conflicting or not with the electrical network (413 ind., 81 %) without conflicts with the pavement (402 ind., 79 %), outside the phenological period. Some common problems

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already reported also occur in the region. The low diversity of species in afforestation may indicate a certain loss in the quality of the urban physical and environmental structure.

Keywords: Floristic inventory; Urban afforestation; Southern Amazonas; Lábrea; Brazil.

LÁBREA: ARBORIZAÇÃO URBANA EM UMA CIDADE NO ARCO DO DESMATAMENTO

Resumo: Lábrea-AM, oficialmente, apresenta 64,4% de suas vias públicas arborizadas. No entanto, não existem informações disponíveis sobre os aspectos qualitativos e quantitativos desta arborização. O objetivo do trabalho foi inventariar a arborização urbana de Lábrea para quantificar e qualificar a arborização viária municipal. O censo da vegetação arbórea das vias públicas abrangeu estacionamentos e áreas destinadas ao trânsito de pedestres (calçadas e meio-fio) das ruas dos bairros que compõem a zona urbana, sendo registradas imagens geolocalizadas dos indivíduos. Foram contabilizados 507 indivíduos distribuídos em 38 espécies e 15 famílias botânicas, arborizando as vias públicas da cidade. As espécies ficus (Moraceae, *Ficus benjamina*) e jambeiro (Myrtaceae, *Syzygium malaccense*) apresentaram a maior densidade absoluta. A arborização está concentrada no bairro Centro (50 %). Desconsiderando o bairro, a rua mais arborizada foi 22 de outubro. As espécies são parcialmente de origem nativa nacional (19 espécies, 50 %), das quais 63 % são de ocorrência amazônica (12 espécies). Os indivíduos são majoritariamente de origem exótica (79 %). Os indivíduos estão em bom estado estrutural, com fitossanidade tipo 1, localizados em área de calçadas conflitando ou não com a rede elétrica (413 ind., 81 %), sem conflitar com o calçamento (402 ind., 79 %), fora de período fenológico. Alguns problemas comuns já reportados em outros trabalhos também ocorrem na região. A baixa diversidade de espécies na arborização pode indicar certo prejuízo na qualidade da estrutura física e ambiental urbana.

Palavras-chave: Inventário florístico; Arborização urbana; Sul do Amazonas; Lábrea; Brasil.

The afforestation can be defined as the group of planted trees that integrate the urban environment to the natural environment, influencing in the human being quality of life and making the urban areas more delightful (SIRVINSKAS, 1999). From the technical point of view, it can also be defined as the group of arboreal specimens that compose the vegetation localizes in urban area, established through an Afforestation Program that considers the characteristics of each region of the city (MANAUS, 2016).

In Brazil, the urban afforestation has been a concern of the environmentalists, once observed the benefits of this action to the society, among them: it relieves the climate issues through decreasing thermic ranges, improves the air quality, protects the soil against erosion, reduces the wind strength, decreases sound pollution, absorbs the atmosphere pollution, and acts as refuge to the fauna, thus promoting the expansion of biodiversity (SABADINI JUNIOR, 2017).

The Amazonic forest, worldwide known as shelter of great biodiversity, is in Brazil's North

region. Paradoxically, its cities, considering capitals and countryside cities, present the smallest percentage (36.7%) of wooded domiciles in the country (IBGE, 2010) and low richness and diversity of native species in the urban afforestation (VIEIRA; PANAGOPOULOS, 2020). The situation is worsened by the scientific ignorance on afforestation present in these cities or by the diminished scientific publicity of this information.

In this scenario, Amazonas stood out as one of the states with the smallest rates of scientific production related to the study on urban afforestation. This low representativeness was highlighted in studies about urban forests in cities located in the Brazilian Amazon, performed by Vieira and Panagopoulos (2020). These authors found only one scientific article available in international database or in specialized Brazilian magazine that referenced any city from Amazonas; Itacoatiara in this case.

Lábrea has the status of Centro Sub-regional of Purus. The city is at the right margin of Purus River. Its total area is composed by 53.99% of state and federal Units of Conservation (UCs); 22.93% of indigenous land; and 2.47% of settlements (WWF-BRASIL, 2017) that act as a green mosaic, resisting the advance of the expansion of the deforestation frontier. However, together with Boca do Acre and Apuí, also situated in the the Amazonas South Mesoregion, answer for 19.6% of the whole state's deforestation (AMARAL *et al.*, 2012).

Inserted in the deforestation arc, the South of Amazonas is an important and strategic region to stop the advance of deforestation in the Amazon, admittedly one of the main risk factors to the reduction of biodiversity in this biome. According to the Natural Environment Ministry, the most critical deforestation areas in Amazonas state are in Lábrea. Since 2008, Lábrea is in the "list of cities that deforest the Amazonic biome the most", as observed in MMA/Portaria n. 28, from January 24, 2008.

The pact "Agenda of commitments for the reduction of deforestation and burns, for the valorization of the forest and the local economy, and for the strengthening of citizenship", signed in 2009 by representatives of City, State and Federal Governments and other signatories (non-governmental entities and institutions of research and correlatives), brings, among its premises, the strengthening of the city environmental management, with governance and transparency, in accord to the guidelines of the National Environment Policy (BRASIL, 2009).

In this context, the city road afforestation, element that integrates green areas system, must receive special attention, once it can represent an expressive part of the total flora in one city (SENNA, 2002). Officially, Lábrea presents 64.4% of its public roads wooded (IBGE, 2017). However, there is no available information on qualitative and quantitative aspects of this afforestation.

The urban flora knowledge is part of a study program every city should be concerned to do, aiming at an afforestation plan that values landscape and ecological aspects, using mainly native species. In addition to benefits that directly influence the human being life, from the ecological point of view, urban afforestation is fundamental. Through it, the region's biological identity can be safeguarded, preserving or cultivating the vegetal species that appear in each specific region.

In the face of it, it is fundamental that citizens and governmental organs consider the whole natural capital of a city as part of the urban infrastructure, being managed in a planned and integrated way, in the same way that it happens with systems of sanitation, transport, energy etc. (SALVI *et al.*, 2011 *apud* GIRLING; KELLETT, 2005; WOLF, 2004). For this purpose, this research objectives were to inventory Lábrea's urban afforestation, aiming to quantify and qualify the municipal road afforestation.

Methodology

The census of arboreal vegetation in Lábrea's public roads contemplated streets in the following neighborhoods: Bairro da Fonte, Barra Limpa, Centro, Nossa Senhora de Fátima, Pantanal, São José e Vila Falcão. The study was performed between October 2019 and March 2020, being considered urban tree every individual of arboreal size planted in parking lots and areas destined to pedestrian transit (sidewalks and curbs), irrespective of a minimum DBH, since a lot of individuals would be excluded from the survey, as seen in a preliminary inventory.

The census was performed through visual analysis, filling an inventory form, with the following information: Date of data collection and responsible; Location of the tree (street, neighborhood); Characteristics of the tree (common name, size, total height, phytosanitary and structural state); Characteristics of the species (natural occurrence, presence of flowers and fruits, type of fruits). Characteristics of the space (type of road: sidewalk, curb, parking lot; power grid, paving situation). Measurement of circumference at breast height of 1.30 m and treetop diameter was performed using a measuring tape. Individuals were identified with the help of specific bibliography and consultation to professionals in the bothanical area. One geolocated photo was registered of each individual with the help of the mobile application Open Camera, a tools that allows photographic registry with location and photo direction information, ideal to elaborate reports, statements, reviews, among others. The height of the individuals was estimated with the help of a mobile application called Intelligent tools (Ferramentas inteligentes), with an estimated error of ± 10 cm.

The qualitative and quantitative evaluation was done with the due adaptations to the methodology described by Kramer and Krupek (2012).

For the qualitative evaluation of the afforestation and diagnosis of the trees, the information related to the tree and the space was analyzed, information obtained through visual analysis of the species inventoried in the census, such as: species, size, inclination, pruning, phytosanitary state, power grid, type of road, paving, among others.

For the quantitative evaluation, the quantity of occurring species of each species registered in the afforestation of public roads for each neighborhood inventoried was counted. About the ecological characterization of the afforestation, for data analysis, the following parameter were calculated: a) richness of species; b) abundance of species; c) *Shannon-Wiener* diversity index; d) Simpson dominance index; and e) Jaccard Similarity index.

Results and Discussion

507 individuals were counted, distributed in 38 species and 15 bothanical families, in the public roads of the city. Among the 15 families present, 46.7% was represented by only one species. The species ficus (Moraceae, *Ficus benjamina*) and jambeiro (Myrtaceae, *Syzygium malaccense*) presented the highest absolute density, having 152 and 131 inventoried individuals, respectively.

The inventory performed supports Vieira and Panagopoulos (2020) statement who, by studying Amazon's urban forests, related that *Ficus benjamina*, *Mangifera indica* and *Licania tomentosa* are the three most frequent species, representing almost 42% of the inventoried individuals. In this study only the species *Ficus benjamina* represented 30% of the inventoried individuals.

The urban afforestation in Brazil had its origin at the time of Colonial Brazil, with reported initiatives in Pernambuco and Rio de Janeiro (PAIVA; ALVES, 2002). In the North region of the

country, with the apogee of the Amazon rubber boom, Parisian characteristics were imported to the emerging cities, mainly in Belém and Manaus. Among these characteristics, the afforestation of public roads had emphasis with a merely aesthetic goal, following Haussmann's concept (GONÇALVES; PAIVA, 2013), where *Ficus benjamina* has been highlighted for being one of the most frequent species in the urban afforestation in several Brazilian cities.

Another interesting characteristic of the afforestation in Brazilian cities is the utilization of fruitful species, such as observed in this research. The second most frequent species was *Syzygium malaccense*. Even recognizing the possible negative impacts, surveys on urban afforestation have presented results that indicate the population preference for fruitful species, when there is a possibility to plant them (VIEIRA; PANAGOPOULOS, 2020) usually prevailing species that give juicy and palatable fruits to the human population, as the case of jambo tree and mango tree, contributing also to the diet and generating income to low-income families.

The total number of species (n=38) and families (n=15) can be considered low, comparing to similar studies. Kramer and Krupek (2012) obtained a total number of species (n=98) and families (n=43) higher than the ones found in this research, studying seven public squares in the city of Guarapuava-PR. Lima Neto *et al.* (2007) obtained a total number of 23 arboreal species identifying arboreal plants in six public squares and 12 avenues and central seedbeds in the city of Aracaju-SE. Pires *et al.* (2007) identified 35 families in a diagnosis done in the city of Goiandira-GO. And Lindenmaier and Santos (2008) found 45 families in the survey of 21 squares in the city of Cachoeira do Sul-RS.

The afforestation is centered in the central neighborhood, with 251 individuals of 12 families and 22 species (Table 1), distributed on the streets Getúlio Vargas (58 ind.), Coronel Luiz Gomes (38 ind.), 14 de maio (29 ind.), Camilo Morato (26 ind.), Vile Roy (25 ind.), Travessa Nazaré (16 ind.), 22 de Outubro (14 ind.), Travessa Padre Monteiro (13 ind.), Marechal Deodoro (11 ind.), Travessa Santo Antônio (10 ind.), Luiz Falcão (6 ind.) and 24 de Agosto (5 ind.). It is probably due to the fact that this neighborhood is the oldest in the city.

Table 1 – Inventory of the afforestation in the central neighborhood, Lábrea-AM

Family	N. of species	Common name	Scientific name	Number of individuals
Fabaceae	7	pau-pretinho	*Cenostigma tocantinum*	12
		acácia	*Acacia mangium*	3
		brasileirinho	*Erythrina variegate*	3
		canafístula	*Peltophorum dubium*	2
		cássia-do-sião	*Senna siamea*	1
		ingá-de-metro	*Inga edulis*	1
		marirana	*Senna silvestris*	1
Myrtaceae	3	jambeiro	*Syzygium malaccense*	42
		goiabeira	*Psidium guajava*	7
		azeitona roxa	*Syzygium cumini*	1
Bignoniaceae	2	ipê	*Handroanthus albus*	13
		ipê de jardim	*Tecoma stans*	2

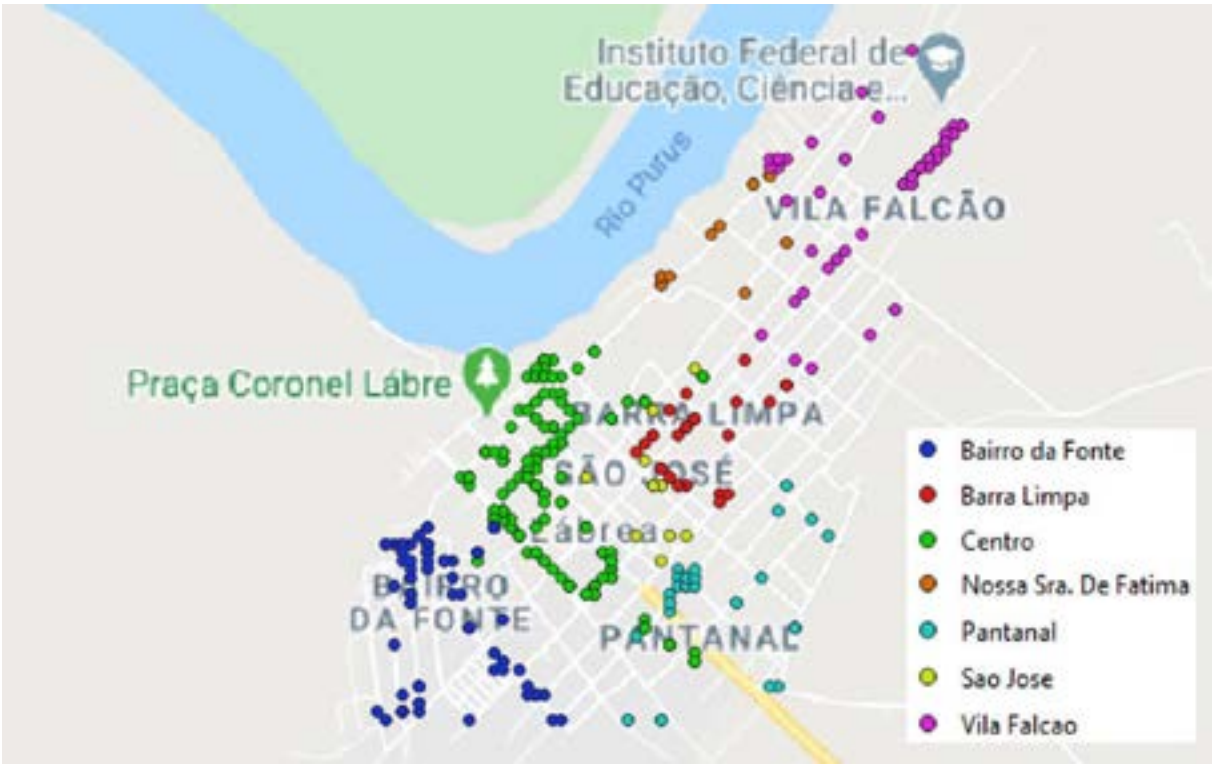
Family	N. of species	Common name	Scientific name	Number of individuals
Anacardiaceae	2	cajueiro	*Anacardium occidentale*	3
		mangueira	*Mangifera indica*	5
Moraceae	1	ficus	*Ficus benjamina*	129
Cupressaceae	1	pinheiro	*Thuja occidentalis*	10
Chrysobalanaceae	1	pajurá	*Couepia bracteosa*	6
Combretaceae	1	castanholeira	*Terminalia catappa*	6
Annonaceae	1	graviola	*Annona muricata*	1
Bixaceae	1	urucum	*Bixa orellana*	1
Malpighiaceae	1	lofântera	*Lophanthera lactescens*	1
Rubiaceae	1	noni	*Morinda citrifolia*	1
Total	**22**			**251**

Source: Research archive

Disregarding the neighborhood, the most afforested street was 22 de Outubro, with 84 individuals belonging to the seven bothanical families, out of which Fabaceae was more present with 43 representatives of different species (pata-de-vaca: *Bauhinia variegata*, 25; acácia: *Acacia mangium*, 12; pau-pretinho: *Cenostigma tocantinum*, 4; ingá-de-metro, *Inga edulis*, 1; pau-brasil: *Paubrasilia echinata*, 1). In Kramer and Krupek's (2012) paper, the family Fabaceae stood out for its richness of species (n=12). According to the author, this can be a consequence of the great diversity of this family among the flowering plants. Getúlio Vargas Avenue was the second most afforested, with 60 individuals belonging to eight bothanical families, from which Moraceae stands out with 45 individuals of ficus (*Ficus benjamina*).

The spatial distribution of the inventoried individuals can be observed in Picture 1.

Picture 1 - Spatial distribution of the individuals among the neighborhoods in Lábrea-AM



Source: Research archive

The urban afforestation species of the public roads in Lábrea are partially from national native origin (19 species; 50%), from which 12 species are of Amazonic occurrence (63% of native species identified in the study). However, the individuals are mostly from exotic origin (399 ind.; 79%), which supports the results of Vieira and Panagopoulos (2020), when they state that in the urban afforestation of cities in the Brazilian Amazon, the exotic species are more frequent that the native ones. Still according to these authors, the most abundant species are the ones largely used as ornamental and coming from planting made by organs responsible for the administration of these public places. And this is the main reason we see so many exemplars of these species. The even highlight that the adherence to the use of native species can represent the lack of concern with conservation and regional flora.

Mostly, they achieved adult size (337 ind., 66%), present plant health type 1 (483 ind.; 95%), are in good structural state (470 ind.; 93%), located in sidewalks area with conflict (133 ind.; 26%) or not (280 ind., 55%) with the power grid and root system with conflict (105 ind., 21%) or not (402 ind., 79%) with paving. During the survey period, the individuals were out of the phenological period, in other words, without flowers or fruits (445 ind., 88%; 417 ind.; 82%, respectively).

Six sick individuals were identified: four jambo trees (one located in the Fonte neighborhood, Camilo Morato Street and three located in Centro, 14 de Maio street) and two pau-pretinhos located in Centro, Coronel Luiz Gomes Street. Twelve individuals suffered drastic pruning: cajueiro, central neighborhood, 22 de Outubro street (1); ficus, Fonte neighborhood, Walter Pires street (1); jambeiro, Fonte neighborhood, José Martinês street (2) and Monsenhor Inacio street (2). Central neighborhood, Vile Roy street (2). Pantanal neighborhood, Deocleciano Sampaio street (1). São José neighborhood, Luiz Falcão street (1) and Travessa Santo Antonio (1); mangueira, Fonte neighborhood, Francisco Cidronio street (1). Two ficus individuals are under the "embrace" of Apuí

in Fonte neighborhood, Monsenhor Inácio street (Picture 2).

Picture 2 - Photographical registry geolocated using the Open Camera app. Ficus individual (*Ficus benjamina*) being embraced by apuí (*Ficus* sp.) in Fonte neighborhood, Monsenhor Inácio street

Source: Research archive

The qualitative parameters of the afforestation are summarized in Table 2.

Table 2 – Qualitative parameters of the individuals that compose the urban afforestation

Qualitative parameters	Neighborhoods							Total
	Centro	Bairro da Fonte	Vila Falcão	Pantanal	Barra Limpa	Fátima	São José	
Origin								
Exotic	206	70	46	25	29	16	7	399
Native	45	8	31	10	6	1	7	108
Size								
Adult	177	56	35	22	27	14	6	337
Young	74	22	42	13	8	3	8	170

Qualitative parameters	Neighborhoods							Total
	Centro	Bairro da Fonte	Vila Falcão	Pantanal	Barra Limpa	Fátima	São José	
Phytosanitary state								
Type 1	247	74	69	34	34	13	12	483
Type 2	4	4	8	1	1	4	2	24
Structural state								
Good	236	75	70	31	34	11	13	470
Reasonable	13	3	4	4	1	2	0	27
Bad	2	0	3	0	0	4	1	10
Type of road + conflict with power grid								
Curb								
Absent	80	0	4	0	0	2	0	86
Present	3	0	5	0	0	0	0	8
Sidewalk								
Absent	86	76	49	25	32	2	10	280
Present	82	2	19	10	3	13	4	133
Conflict with pavement								
Absent	172	78	61	33	34	12	12	402
Present	79	0	16	2	1	5	2	105
Phenology								
Flowers								
Absent	232	78	63	29	22	9	12	445
Present	19	0	14	6	13	8	2	62
Fruits								
Absent	226	67	59	33	16	9	7	417
Present	25	11	18	2	19	8	7	90

Source: Research archive

The quantitative parameters of the afforestation individuals are listed in table 3. The highest percentage of individuals covers the range from 0.1 to 250 cm of circumference at breast height (473 ind., 93.3%). Treetop diameter presented the highest number of individuals between 100.1 to 1000 cm (461 ind., 90.9%). With respect to height, the individuals as distributes between 200.1 to 2000 cm (457 ind., 90.1%), with the height of the first bifurcation ranging between 0.1 to 200 cm (463 ind., 91.3%). The data supports the recent intensification of afforestation actions on behalf of the municipal manager organ, initiated in 2000.

Table 3 - Quantitative parameters of the individuals that compose the urban afforestation

Quantitative parameters (cm)		Neighborhoods							
		Centro	Bairro da Fonte	Vila Falcão	Pantanal	Barra Limpa	Fátima	São José	**Total**
Circumference at breast height	0,1-50	51	15	56	10	10	3	10	155
	50,1-100	57	22	11	14	12	3	0	119
	100,1-150	78	27	6	6	5	9	3	134
	150,1-200	43	9	3	3	4	2	1	65
	200,1 - 250	16	4	1	1	3	0	0	25
	250,1 -300	3	0	0	0	1	0	0	4
	300,1 - 350	2	1	0	1	0	0	0	4
	350,1 - 400	0	0	0	0	0	0	0	0
	> 400,1	1	0	0	0	0	0	0	1
Treetop diameter	0,1 - 100	18	4	1	0	0	1	0	24
	100,1 - 200	19	7	12	8	1	3	0	50
	200,1 - 400	42	7	26	2	6	3	6	92
	400,1 - 600	86	25	21	9	6	2	3	152
	600,1 - 800	61	23	8	8	13	6	3	122
	800,1 - 1000	18	8	4	6	6	2	1	45
	> 1000,1	7	4	5	2	3	0	1	22
Height	0,1 - 100	4	1	0	0	0	0	0	5
	100,1 - 200	13	6	9	5	0	1	0	34
	200,1 - 400	29	10	15	4	5	4	7	74
	400,1 - 600	69	14	24	6	11	1	4	129
	600,1 - 800	81	10	14	4	6	6	0	121
	800,1 - 1000	24	15	2	2	8	2	0	53
	1000,1 - 2000	31	19	13	8	5	3	1	80
	> 2000,1	0	3	0	6	0	0	2	11
Height of 1st bifurcation	0,1 - 100	183	31	49	22	26	7	9	327
	100,1 - 200	54	30	27	8	6	7	4	136
	200,1 - 400	14	16	1	5	3	3	1	43
	> 400,1	0	1	0	0	0	0	0	1

Source: Research archive

In terms of ecological characteristics, it can be considered that the afforestation assessed does not have good condition in number, abundance and diversity of arboreal species. The families that presented more richness of species were Fabaceae (14 species), as identified in the study of Vieira and Panagopoulos (2020), followed by Myrtaceae, Malvaceae and Anacardiaceae (all rep-

resented by three species). In terms of neighborhoods, Centro and Vila Falcão presented more richness of species, with 22 and 17 species, respectively.

The two most abundant species (higher absolute density) are responsible for 56% of the total of occurring plants on the city's public roads [ficus (Moraceae, *Ficus benjamina*) and jambeiro (Myrtaceae, *Syzygium malaccense*)], and the other 44% are distributed in the other 36 species. In terms of neighborhoods, Centro, Bairro da Fonte and Vila Falcão presented more abundance, with 251, 78 and 77 individuals, respectively. The numeric predominance of few species are negative points related to the environmental, and mainly phytosanitary quality (KRAMER; KRUPEK, 2012). Still according to Kramer and Krupek (2012) apud Grey and Deneke (1978), there should be a maximum limit of 10 to 15%, for the frequency of individuals by species in a certain area. However, as happened in Kramer and Krupeck's work (2012), a few species appear with an elevated abundance, most of them with few representatives.

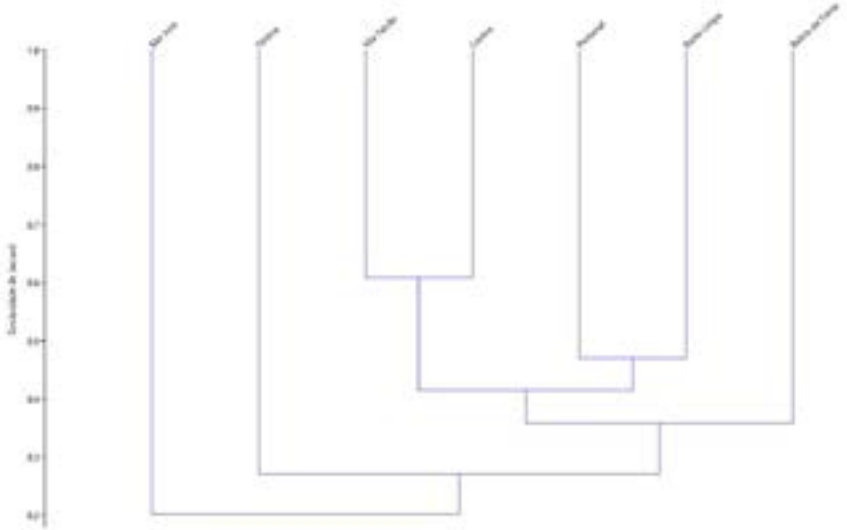
Shannon-Wiener diversity indexes by neighborhood were: Vila Falcão = 2,169; Pantanal =2,102; Barra Limpa = 1,905; Centro = 1,837; São José = 1,636; Bairro da Fonte = 1,465; Bairro de Fátima = 1,395.

Simpson dominance indexes by neighborhood were: Pantanal = 0,8278; Barra Limpa = 0,8196; Vila Falcão = 0,8221; São José = 0,7449; Centro = 0,6983; Bairro de Fátima = 0,6644; Bairro da Fonte = 0,6078.

About Jaccard similarity index, Cluster Analysis, showed low similarity among the areas studied, showing the formation of 3 groups, one big group formed by the species present in the neighborhoods Centro, Vila Falcão, Pantanal, Barra Limpa and Bairro da Fonte; another formed by Fátima neighborhood and another distinct group formed by São José neighborhood (Picture 3), what shows high differentiation among neighborhoods in terms of the species composition.

As observed by Kramer and Krupek (2012), there were high values of richness (Centro and Vila Falcão) and diversity (Vila Falcão and Pantanal), associated to a high frequency of few species (Centro), and it has put the road afforestation in ecological conditions still far from ideal.

Picture 3 - Jaccard Similarity Index Cluster Analysis of urban afforestation among neighborhoods



Source: Research archive

The floristic patterns of the afforestation are summarized in table 4.

Table 4 - Quantitative parameter of the individuals that compose the urban afforestation

Quantitative parameters	Neighborhoods						
	Centro	Bairro da Fonte	Vila Falcão	Pantanal	Barra Limpa	Fátima	São José
Richness	22	12	17	12	9	6	7
Abundance	251	78	77	35	35	17	14
Simpson dominance	0,6983	0,6078	0,8221	0,8278	0,8196	0,6644	0,7449
Shannon-Wiener diversity	1,837	1,465	2,169	2,102	1,905	1,395	1,636
Jaccard similarity	0,5941	0,5894	0,7655	0,8459	0,8671	0,7783	0,8406

Source: Research archive

Conclusion

The low diversity of species in Lábrea's afforestation can indicate a certain prejudice in the quality of the urban physical and environmental structure. Some common problems already related in studies also happen in the region, which are: the low quantity and abundance of species and elevated quantity of individuals of exotic origin species. In addition, such ecological characteristics were intermediary to related studies. To stimulate the use of native species of the region which, adapted to the environment where they appear, can help in the improvement of environmental and phytosanitary quality of the neighborhoods studied.

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URBAN THERMAL COMFORT: ANALYSIS OF THE IMPACT OF REVITALIZATION REVIVA CENTRO ON URBAN MICROCLIMATE OF CAMPO GRANDE

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Abstract: Green infrastructure is presented in several research as an urban strategy necessary to minimize the negative effects arising from the urbanization process and provide outdoor thermal comfort. The urban revitalization project "Reviva Centro", proposes the increase of vegetation along "14 de Julho" street, located in downtown Campo Grande, Mato Grosso do Sul, Brazil. In this sense, the aim of this study is to compare two scenarios, corresponding to the previous situations and after the implementation of the urban revitalization project. To compare the scenarios, the Envi-met program was used for 3D modeling and microclimatic simulation. The program simulates climatological interactions between surfaces, plants, and atmosphere, considering four fundamental variables of urban thermal comfort (temperature, relative humidity and wind speed and direction). The analysis and visualization of the results is based on the equivalent physiological temperature (PET), that classifies outdoor human thermal comfort conditions. Based on the results of the simulations, the increase in thermal comfort was provided in relation to cold and heat. At 8 am., an air temperature increases of 6 °C, decreasing the discomfort caused by the cold. At 16 hours the comfort gain is obtained by decreasing the air temperature, with a difference of 4.98 °C, optimizing thermal comfort in the scenario that represents the state after revitalization. The results presented in this research show the benefits of urban vegetation as a strategy to balance the urban microclimate and increase comfort for pedestrians.

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Keywords: Green Infrastructure; Thermal Comfort; Urban Revitalization; Envi-met; Physiological Equivalent Temperature (PET).

CONFORTO TÉRMICO URBANO: ANÁLISE DO IMPACTO DA REVITALIZAÇÃO REVIVA CENTRO NO MICROCLIMA URBANO EM CAMPO GRANDE

Resumo: A infraestrutura verde é apresentada em diversas pesquisas como uma estratégia urbana necessária para minimizar os efeitos negativos advindos do processo de urbanização e para proporcionar o conforto térmico urbano. O projeto de revitalização urbana "Reviva Centro", propõe o aumento da arborização ao longo da Rua 14 de julho, localizada no centro de Campo Grande, Mato Grosso do Sul, Brasil. Neste sentido, o objetivo desse estudo é comparar dois cenários, correspondentes às situações anterior e posterior a execução do projeto de revitalização urbana. Para comparar os cenários, recorreu-se ao programa Envi-met para modelagem 3D e simulação microclimática. O programa simula as interações climatológicas entre superfícies, plantas e atmosfera, considerando quatro variáveis fundamentais de conforto térmico urbano (temperatura, umidade relativa e velocidade e direção do vento). A análise e visualização dos resultados é feita com base na temperatura fisiológica equivalente (PET), que classifica o grau de estresse fisiológico humano ao ar livre. Com base nos resultados das simulações, um aumento do conforto térmico foi proporcionado em relação ao frio e ao calor. Às 8 horas da manhã, um aumento de temperatura do ar de 6°C, diminuindo o desconforto causado pelo frio. Às 16 horas o ganho de conforto é obtido pela diminuição da temperatura do ar, com uma diferença de 4,98°C, otimizando o conforto térmico no cenário que representa o estado posterior à revitalização. Os resultados apresentados nessa pesquisa evidenciam os benefícios da vegetação urbana como estratégia para equilibrar o microclima urbano e aumentar o conforto para os pedestres.

Palavras-chave: Infraestrutura verde; Conforto térmico; Revitalização urbana; Envi-met; Temperatura Fisiológica Equivalente (PET).

The urban thermal comfort is influenced by the relationship between the climatological variables and the urban environment characteristics. The climatological variables are temperature, relative humidity and velocity and direction of the wind. The urban environment characteristics are urban geometry, quantity of vegetation, water planes and surfaces materials (TSITOURA; MICHAILIDOU; TSOUTSOS, 2016; LAI *et al.*, 2019).

The green infrastructure is presented as a necessary strategy to minimize warming in cities caused by the urban heat islands (UHI) (OKE, 1987; KLEEREKOPER *et al.*, 2017; LIN *et al.*, 2017; POTCHTER *et al.*, 2018; ANTOSZEWSKI; ŚWIERK; KRZYŻANIAK, 2020; ELLIOTT; EON; BREADSELL, 2020). Through shading and evapotranspiration of the vegetation, it is possible to decrease the air temperature (DEMUZERE *et al.*, 2014) and increase the relative humidity, improving the human thermal comfort (LIU *et al.*, 2020), health (JAMEI *et al.*, 2016), well being and air quality

(CHAROENKIT; YIEMWATTANA, 2016; SANTAMOURIS; OSMOND, 2020). Thus, it is adherent to UN's Sustainable Development Goals, which are: SDG - 3 Good health and well-being; SDG - 11 Sustainable cities and communities and SDG - 13 Climate action, with incentives all over the world to promote urban green infrastructure (LIBERALESSO *et al.*, 2020).

The term green infrastructure is under study for more than two decades and it refers to ecological services that urban vegetation pays to the ecosystem in which it is inserted (BENTON-SHORT; KEELEY; ROWLAND, 2019), interconnected network of natural zones that maintain fresh air and ecological functions (BENEDICT; MCMAHON, 2006), such as vegetation, soil, bioengineering systems, for the improvement of the microclimate, air quality, habitat and better management of water (BOLUND; HUNHAMMAR, 1999).

Vegetation in the cities must respect the ecosystem involved, some native plants can be sensitive to urban modifications and pollution (MORAKINYO *et al.*, 2018), choosing low maintenance and not invasive species can be a more appropriate choice (TAN; JIM, 2017). Urban trees are an excellent tool for the microclimate improvement, tree planting on the streets must be studied so that their spacing does not obstruct the ventilation flow (YIN; LANG; XIAO, 2019). According to Erell (2017), the shading generated by the trees is more efficient when the treetops are bigger and with wide leaves, because this provides a bigger and more closed shading area. That is why the green infrastructure must be considered since its planning until maintenance needs (HUNTER *et al.*, 2019).

The temperature increases because of the capacity of a surface to liberate heat by convection and the afforestation reduces direct exposition to the sun and increases the air relative humidity, resulting in more comfort (ARAM *et al.*, 2019; CODER, 2011; LEE; JIM, 2019; MONTEIRO *et al.*, 2016).

To analyze thermal comfort at the individual's level, namely the physiological stress to maintain body temperature stable, it is necessary to understand the several indexes used to measure thermal comfort. PET (Physiological Equivalent Temperature) uses climatological variables, such as relative humidity, wind speed, temperature and solar radiation to result in thermal feeling. According to HOPPE (1999), PET is defined as the physiological temperature equivalent to the air temperature, the thermal balance of the human body to maintain central and skin temperature to the evaluated conditions. The use of urban vegetation impacts directly to the cooling of the urban environment, hence it influences the PET values in that analyzed environment (LUCCHESE, 2016; MORAKINYO *et al.*, 2019; WALTHER; GOESTCHEL, 2018).

For this investigation two scenarios were modeled: one of the state previous to the revitalization and other with the state posterior to the project's execution. The updated geographical data are taken under consideration so that it is possible to compare the results from the previous scenario to the scenario of the revitalization project.

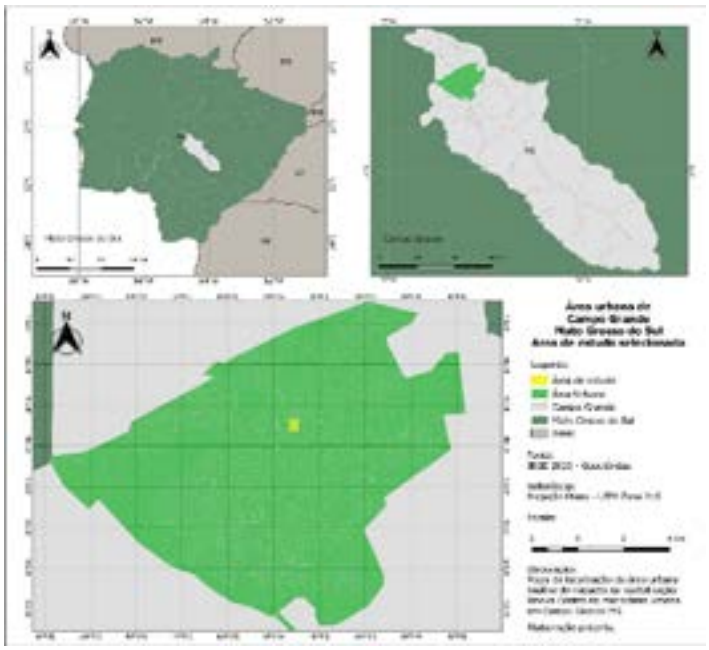
Material and methods

Study area

Campo Grande (20°28'13" S, 54°37'25" W, altitude of 600 m) is the capital of the state Mato Grosso do Sul, in the West Center region of Brazil. The estimated population for Campo Grande in

2021 is 916,001 inhabitants, according to IBGE (2021). The city has green spaces and important avenues afforested, for example Afonso Pena Avenue and Mato Grosso Avenue, both located in the central region. The part selected for the 3D modeling and computational simulation covers part of 14 of July Street, limiting to the intersections with Afonso Pena Avenue and Dom Aquino Street.

Picture 1 - Map of the study area location: Mato Grosso do Sul state, city of Campo Grande, urban perimeter of Campo Grande



Source: adapted from Souza (2017)

Computational simulations

In the analysis context of urban microclimate, one way to understand the relationship between the urban environment and the mechanisms of climatical regulation is the usage of computational simulation programs that decodify the urban nature.

These analysis studies of conditions to obtain urban thermal comfort can resort to methods of field measurement (REIS; LOPES, 2019)with positive effects on human thermal comfort. In this study, the cooling potential of all green spaces in Lisbon was estimated. For that, several mobile measurements of air temperature data were made in a single park (Gulbenkian's Garden, computational simulation (EVOLA *et al.*, 2017) or a combination of simulation and measurement to validate the results (TALEGHANI *et al.*, 2015).

Both scenarios are modeled using the *ENVI-met software*, with previous and posterior state to the revitalization project to compare results of air temperature, wind speed and air relative humidity; which are analyzed to obtain the gains related to the urban thermal comfort of each one of the respective scenarios.

Climate data

According to Souza, Paranhos Filho and Guaraldo (2020) the city of Campo Grande is placed in the transition zone between subtype Cf - Hot temperate climate completely humid and Aw -

Equatorial savannah with dry winter, according to Köppen's classification. The winter in Campo Grande starts on June 20 and ends on September 22, and it is considered the season with lower average values of annual temperature; average temperature data 1981-2010 (INMET, 2020).

The chosen season to evaluate the present study is winter, due to the gains that can be obtained in the balance of temperature range, in the cases the temperatures can be out of the range of thermal comfort feeling, in other words, uncomfortable in the heat as well as in the cold.

The computational simulation programs, in this case *Envi-met*, use as entry data for climatological variables, as air temperature, relative humidity (maximum and minimum), wind speed and direction. This group of information is called climatological file (FREDERICO *et al.*, 2020). For this study were considered data from hours measured for the period between 2008 and 2018 through data from INMET A702 Weather Station.

The meteorological data were extracted from the Hydro-Meteorological Information System (SIM) of INMET. These data were provided in *.xls* format archives, containing geographical coordinates, altitudes and climatological variables referring to the years from 2008 to 2018. The climate data resulting from the data treatment are presented in Table 1, are climatological variables from July, which represents the coldest month of the year in Campo Grande.

Table 1 - Climate data from 2008 to 2018

CLIMATE DATA JULY 2008 – 2018	
Wind speed in 10m high (m/s)	3,6
Wind direction (degrees)	67
Soil roughness	0,01
Air temperature, minimum (°C)	20,27
Air temperature, maximum (°C)	21,74
Air relative humidity, minimum (%)	55,13
Air relative humidity, maximum (%)	60,46

Source: Meteorological National Institute (INMET)

With the goal of evaluating the urban thermal comfort obtained with green infrastructure strategies presented in the project and executed in the urban revitalization, two scenarios were studied:

Scenario 1 almost does not present vegetation besides the central seedbed on Afonso Pena Avenue (main avenue of the city, it is famous for its seedbed with a lot of arboreal vegetation presence). 14 of July Street had a broader road, which implicated in narrower sidewalks, resulting in more presence of vehicles traffic.

Scenario 2 presents the result of the urban revitalization. As a consequence of the interventions, there was a reduction of the vehicles circulation and a substitution of the public road pavement, enlargement and substitution of the sidewalks pavement and an increase in the quantity of medium and big trees inserted along the extension of 14 of July Street (Picture 2).

Picture 2 - Photo of scenario 1 and photo of scenario 2

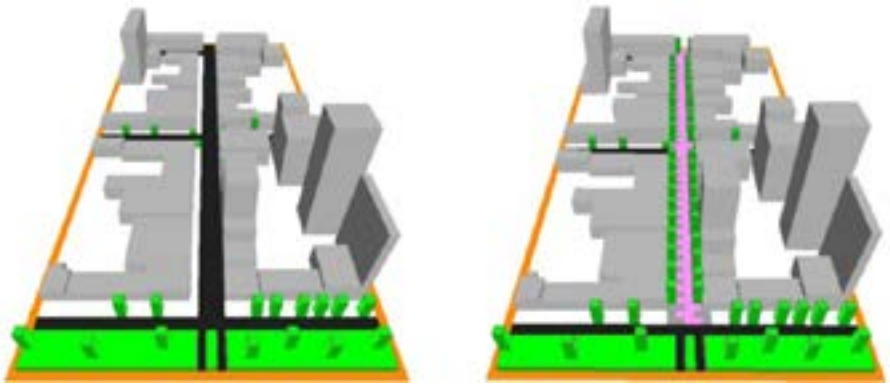
Source: Google Maps (2018) and photo from the author's archive (2021).

These scenarios were modeled in three dimensions with the tool *Spaces*, from ENVI-met program:

Scenario 1: Situation of 14 of July Street before the revitalization, broad street with three lanes and parking on the sides, narrow sidewalks and no trees (Picture 3).

Scenario 2: Current situation, after the execution of the revitalization project of 14 of July Street, narrowing and substitution of the street pavement, broadening and substitution of the sidewalks pavement (Picture 3).

Picture 3 - Scenario 1 (situation previous to the urban revitalization) and Scenario 2 (situation posterior to the urban revitalization) modeled with Spaces tool from ENVI-met 4.4.3



Microclimate simulation

In order to analyze the impact of the urban revitalization through a computational simulation, the software *Envi-met* 4.4.5 was used, according to the fundamental laws of fluid dynamics and thermodynamics (BRUSE; FLEER, 1998), considered an important tool for microclimate analysis of urban areas (TSOKA *et al.*, 2020).

After the analysis and extraction of the necessary data, the area modeling was elaborated on the *Spaces* tab. The vegetation and surface materials were adapted to the *ENVI-met* 4.4.3 software database and their nomenclatures were aligned, according to the model of Silva *et al.* (2019).

To determine the size of the trees, we collected information at the Landscape Project Memorial (FERNANDES, 2015). The arboreal species described at the memorial have between 8 and 12 meters high, for the simulation a 10m high tree was used from the program's data bank. For

the setting of the climatological file, the *ENVI-guide* function was used, the period chosen for the simulation was the month of July, considered the coldest of the year in Campo Grande (IBGE, 1981-2010). The data requested to run the simulations are the same presented on Table 1.

The simulations were calculated for a day in July of 2020, in a period of 48h, starting at 7 o'clock in the morning, close to the sunrise at this time of the year. According to the program's recommendations, it is necessary to calculate 48 hours in order to be able to extract the results referring to the second day of simulation (BRUSE, 2004).

To view the results of the variables of air temperature, wind speed, air relative humidity and PET, the data were extracted in the *Leonardo* tool of the *ENVI-met* 4.4.3 program. The atmospheric data generated by the computational simulation were inserted and the parameter analyzed from the choice of time defined to compare one scenario to the other.

Results and Discussion

Analyzing the results of air temperature for 8 am., the difference between the minimum temperatures presented is 5.7 °C. Scenario 1 presents the situation of minimum temperature (14.46 °C)showing more heat loss during the night (Table 2). In scenario 2, the presence of the vegetation causes a balance between gains and losses of heat, thus decreasing the daily temperature range.

The minimum air relative humidity happens in scenario 1 (53.03 °C) at 4 pm. (Table 2). In every time analyzed, the RH presents higher values in scenario 2, this is due to the evapotranspiration effect of the vegetation. It is worth to emphasize that in scenario 2 the region under analysis is closer to the salubrity situation indicated by the World Health Organization (WHO) for RH percentage, which is at least of 60%.

In order to evaluate the gain of thermal comfort it is necessary to take under consideration the values presented in the physiological equivalent temperature (PET) index, that establishes as comfortable, in other word, without physiological stress, values between 18 and 23 °C. As aforementioned, the green infrastructure inserted in the urban context of 14 of July Street, through the execution of REVIVA project, helps in the urban thermal comfort.

Table 2 - Results of the simulations for scenarios 1 and 2 in different times of the day

Scenarios	Times	Air temperature (°C)		Relative humidity (%)		Wind speed (m/s)		PET* (°C)	
	(24h)	min.	max.	min.	max.	min.	max.	min.	max.
1	8am.	14,46	21,13	40,26	66,43	0,00	13,29	8,00	37,00
2	8am.	20,16	21,27	57,24	63,34	0,00	12,56	15,00	40,00
1	1pm.	19,59	23,40	41,26	56,92	0,00	14,49	18,00	54,00
2	1pm.	19,98	23,75	51,54	59,01	0,00	12,98	17,00	55,00
1	4pm.	19,54	27,80	40,80	53,03	0,00	14,78	21,00	43,00
2	4pm.	20,05	22,82	53,53	58,26	0,00	13,54	15,00	41,00

By seeing the values presented at PET, scenario 1 presents minimum PET of 8 °C, while scenario 2, 15 °C; this means an increase of 7 °C, in terms of physiological stress degree, this dif-

ference soothes the stress caused by the cold. The second time that reflects the gain of thermal comfort obtained with the increase of the urban vegetation, was at 4pm., period when the accumulation of heat caused by the solar radiation results in the maximum value of temperature of the day. In this case the thermal comfort is reached by the decreasing of the maximum temperature. At 4pm. in the the scenario previous to the revitalization, the maximum temperature is of 27.80 °C, and in the scenario post revitalization this value gets to 22.82 °C, a difference of 4.98 °C (Table 2).

Comparing the results of graphic 4, we verify that a lower temperature range is observed for line if Scenario 2. With respect to the maximum temperatures between the two scenarios, the biggest difference happened at 4pm., which were approximately of 5 °C in the maximum temperature (Picture 4).

Considering that the month analyzed is in winter, it is also important to highlight the data of the minimum temperature presented at 8am., they went from 16.16 °C to 20.11 °C, which means that the benefit generated by the urban vegetation mitigated the thermal discomfort caused by the cold as well as the heat.

This contrast is due to the shading and evapotranspiration effects provided by the urban vegetation and, consequently, reflects directly on the minimum and maximum relative humidity results (Picture 5).

Picture 4 - Chart of air temperature on scenarios 1 and 2

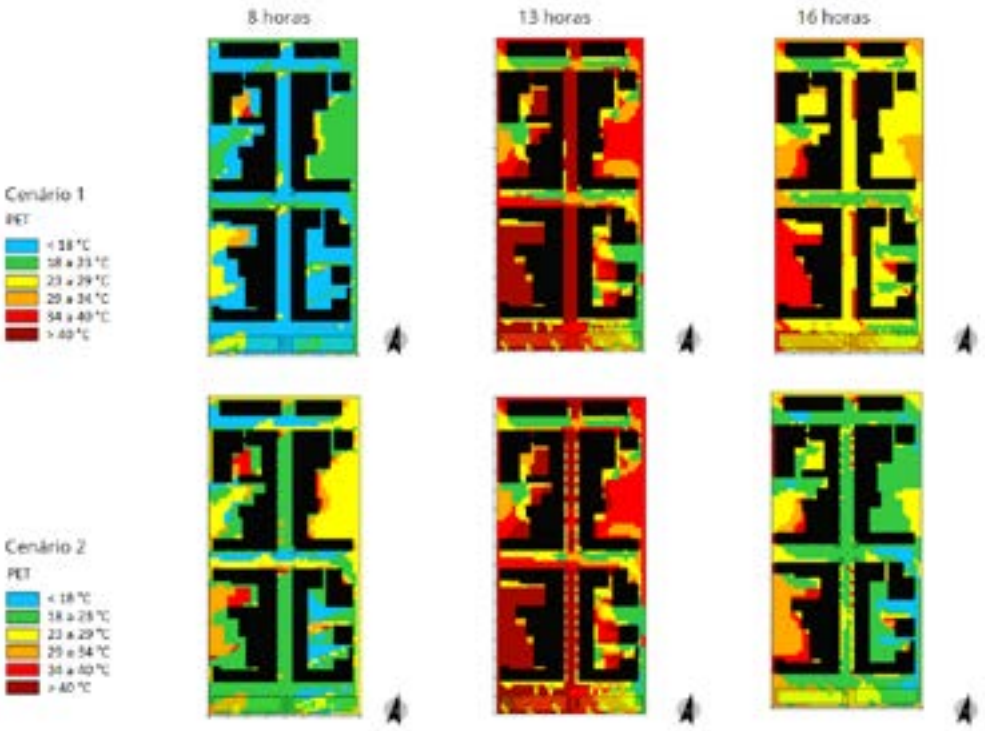
Picture 5 - Chart of air relative humidity on scenarios 1 and 2

With the increase of arboreal vegetation inserted along 14 of July Street, the balance scenario 2 presents in relation to the relative humidity values of scenario 1 is quite evident. The evapotranspiration effect allows to balance the air relative humidity values, the maximums and minimums come to a minor range.

With respect to all the times presented on Picture 5, the analysis of the air relative humidity indicated the increase of the minimums and maximums as of 12 o'clock, in scenario 2 (Picture 5). With the tool *ENVI-met BIOMET*, the program processes data resulting from the simulations and calculates the human thermal comfort index, in the study case in analysis, PET was chosen, which is organized in nine classes, with values between 18 °C and 23 °C, considering the human thermal comfort feeling.

The following maps showing 14 of July Street between Afonso Pena Avenue and Barão do Rio Branco Street highlight the differences between the two scenarios (Picture 6). The most even energy balance is visible with the minor temperature ranges and thermal neutrality feeling for most of the time in scenario 2. The road axis remains in thermal comfort situation in two of the times analyzed (8am. and 4pm.) and presents an improvement in comparison to scenario 1 at 1pm.

Picture 6 - PET results at the following times: 8am., 1pm. and 4pm.



Final considerations

With the *ENVI-met* 4.4.3 program a study was performed to quantify the thermal comfort optimization generated by the urban revitalization project "Reviva Centro" on 14 of July Street. The results present improvements in the parameters air temperature, wind speed, air relative humidity and human thermal comfort feeling, confirming that the green infrastructure is an efficient tool for the urban comfort improvement in micro-scale and that, being a part of the ecological structure, it contributes for the mitigation of urban heat islands.

The intervention with the increase of the urban vegetation for the winter scenario enhances the comfort at 8a.m. The PET thermal perception in scenario 1 is classified as mildly cold, but in scenario 2 the results show an improvement along the street evaluated and a green spot is noticed representing a comfortable thermal perception. At 1pm, when there is more exposition of the surfaces to solar radiation, trees promote a slight difference of comfort along the street, due to the shading that is projected where there is more circulation and permanence of people. The PET results for 4pm. indicate the increase of the thermal comfort. At this time the air temperature tends to be more elevated due to the increase of temperature of the urban surfaces. The difference between scenarios 1 and 2 is evident at the PET classification that goes from mildly hot, hot and very hot to an growth of the comfortable area.

The software allows an evaluation of the impact of the vegetation in hypothetical scenarios that simulate a real urban sample, this type of technology allows to observe the alterations of the climatological variables from one scenario to another and to understand how the wind and heat fluxes relate in an environment with and without vegetation. Modeling and simulating several scenarios can help urban planners in the choice of species and different spatial distributions on the planting of trees in the urban context, considering the local climate of each city.

It is also possible to highlight that the benefits obtained with the modification of the built environment go beyond the promotion of the thermal neutrality feeling, extending to the promotion of biodiversity, water management and improvement of the air quality.

Being able to use a part of the city as an experiment laboratory allows us to create models and test them through computational simulations that determine the success of the implementation of urban an environmental intervention projects in urban perimeters.

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URBAN GREEN EQUITY: OVERVIEW OF SCIENTIFIC RESEARCH FROM 1992 TO 2021

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Eliane Guaraldo[1]

Abstract: The growing concern with the impacts of climate change and the fast urbanization of cities has led international policies to guide changes in attitudes by governments and civil society, directing effective models of sustainable governance aimed at environmental health and equal access for society environmental benefits. In this study, we seek to understand the evolution of research and scientific production on a topic of great relevance today – green equity. Through scientometric analysis based on a systematic literature review, we analyzed articles published in the period between 1992 and 2021. We used the open source R-tool Biblioshiny, which processes information from academic databases to carry out the analyses. Through this methodology it was possible to identify the main fields of research and relate the results obtained with important historical milestones for sustainable development. We also seek to highlight the evolution of research lines and highlight the significant flows in the global collaboration network. We found that the theme of green equity was driven by international agendas such as the SDG and has been gaining more space in scientific production, linked to a greater variety of issues such as climate change, accessibility to green spaces, ecosystem services, green infrastructure and socioeconomic issues.

Keywords: Sustainable Development; Urban Governance; Climate Changes; Urban Forest; Biblioshiny.

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EQUIDADE VERDE URBANA: PANORAMA DA PESQUISA CIENTÍFICA NO PERÍODO DE 1992 A 2021

Resumo: A crescente preocupação com os impactos das mudanças climáticas e da rápida urbanização das cidades tem levado as políticas internacionais a orientar mudanças de atitude por parte dos governos e da sociedade civil, direcionando modelos eficazes de governança sustentável orientados à saúde ambiental e ao acesso igualitário da sociedade aos benefícios ambientais. Neste estudo buscamos compreender a evolução da pesquisa e da produção científica de um tema de grande relevância na atualidade – a equidade verde. Por meio de análise cienciométrica baseada em uma revisão sistemática de literatura, analisamos artigos publicados no período compreendido entre 1992 e 2021. Utilizamos a ferramenta-R de código aberto *Biblioshiny*, que processa as informações das bases de dados acadêmicos para a realização das análises. Por meio desta metodologia foi possível identificar os principais campos da pesquisa e relacionar os resultados obtidos com marcos históricos importantes para o desenvolvimento sustentável. Buscamos também destacar a evolução das linhas de pesquisa e evidenciar os fluxos significativos na rede de colaboração global. Descobrimos que o tema da equidade verde foi impulsionado por agendas internacionais como a ODS e vem ganhando cada vez mais espaço na produção cientifica, vinculado a uma maior variedade de questões como mudanças climáticas, acessibilidade a espaços verdes, serviços ecossistêmicos, infraestrutura verde e questões socioeconômicas.

Palavras-chave: Desenvolvimento Sustentável; Governança urbana; Mudanças climáticas; Floresta urbana; *Biblioshiny.*

Urban green equity is defined by Nesbitt as the equitative access to urban forests, which management aims to mediate the urban population's capacity of obtaining ecosystem services associated to them (NESBITT; MEITNER; GIRLING; SHEPPARD, 2019). The concept has a close relationship to discussions about sustainable urban growth approached by global organizations and agreements among world leaderships.

UN, the United Nations, in its last World Cities Report, from 2020, disclosed an alert on the criticality and concern with the fast urbanization of cities, where it is estimated that until 2050, 70% of the world population will be living in urban areas. This estimate directly implies on the cities' quality, impacting the life of billions of people and several ecosystems around the world.

The sustainable urban development happens when the occupation aims to privilege the common good and reduce inequalities in order to balance social needs. Thus, in addition to including the population in its diversity of age, gender, race or any other characteristics, it is also necessary to distribute infrastructure, public spaces, goods and urban services in an equitative way.

Still in the second half of last century, with Stockholm Conference (1972), Vienna Convention (1985), Montreal Protocol (1987), Brundtland Report - Sustainable Development (1987) and, finally, Agenda 21/ Rio 92 / Eco 92 (1992), cities' development was the focus of discussions and agreements among world leaders. In 2000 the Millennium Summit (UN) started the Millennium Declaration, in which the nations committed to join strengths to reduce extreme poverty in 15

years, through eight Millennium Development Goals (MDG). When this period finished, in 2015 UN launched the Agenda 2030, with an action plan of 17 Sustainable Development Goals (SDG) and 169 global goals, and one of them is the universal access to public spaces that are green and safe, inclusive and accessible, thus reinforcing the importance of the use and distribution of the multifunction ecosystem services derived from green spaces.

In this context, a growing concern with the impact of climate change and fast urbanization puts urban forests as strategic infrastructure, frequently included in global and regional initiatives. In addition to that the ecosystem services and their connection to the urban green have been acknowledged as essential components to sustainable cities (STEENBERG; MILLWARD; DUINKER; NOWAK *et al.*, 2015).

Although the healthy environment is a basic human right, studies in the field of environmental equity established that a variety of harmful uses of the land is disproportionately located in neighborhoods with low income and minority populations (KOO; BOYD; GUHATHAKURTA; BOTCHWEY, 2019).

As of this context, we seek to explore how the academic research in green equity has evolved in the last 30 years, verifying through bibliometric analysis its main approaches, directions and possible future unfoldings. This period allows the identification of lines of important researches, emerging topics, periodics and most influent authors and points which are the connections globally existing in the field of urban green equity.

Methodology

The literature systematic reviews provide reproducible and reliable evaluations of the current state and a research field (ROY, 2012). In this study, we chose the Scopus database for the search of documents and selection of relevant literature in articles related to urban green equity. We used as search term the expressions "*green equity*" OR "*green inequity*" OR "*Environmental justice*" AND *urban* AND *environmental* OR *green* OR *forestry* OR *greenspace* OR *greening* for the time gap from 1992 to 2021. Firstly, the term search selected 975 documents, from which, after the title analysis, we limited to 495 articles that presented more adherence to the theme.

After the definition of the text corpus, we proceeded to the science-meter analysis. In Scientometrics there are several tools and softwares with important functions for the viewing and exploring process of networks. We used *Biblioshiny*, an open code R-tool for a broad research of the scientific mapping that includes the main bibliometric analysis methods. With it, it is possible to import bibliographical data directly from *Scopus* and perform bibliometric analyses building data matrices for coupling, scientific collaboration analysis and keywords analysis. Thus, we conduct a structures analysis and present the research overview in green equity. We go from the production and relevance of articles associated to time frames, identification of research lines and emerging topics based on semantical evolution (which consists on the relationship among the main keywords, authors and periodics distributed in time and consolidated in a *Sankey* diagram) and, at last, the main connections and relevance of the countries in the global scenario, where the number of publications and collaboration networks were considered.

Results

Scientific production and global milestones in sustainability

The general data that we presented on table 1 show the main quantitative information obtained from the *text corpus* selected. In this, the 495 articles analyzed are concentrated in the last 30 years and were published in 167 different periodics. We also indicate the average values of publications, citations and annual growth.

Table 1 - General information about the text corpus data

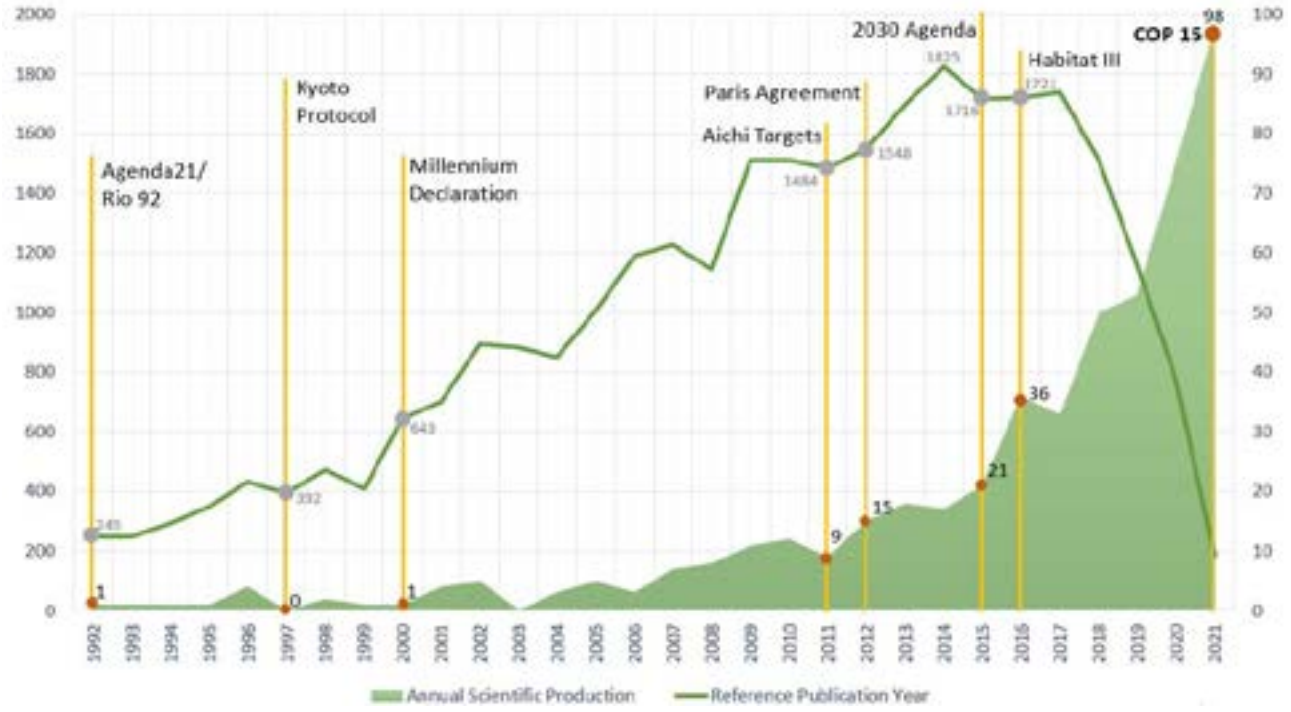
Period	1992 to 2021
Documents – Articles	495
Average years of publishing	4.79
Average of quotes by document	39.96
Average of quotes by year by document	6.137
Annual growth average rate	18,51%

Source: authors

According to the content analyzed, chart 1 (below) shows how this growth happened and which were the global milestones from 1992 to 2021. In it we see that the researches on the theme had numerically little significancy at the end of the twentieth century. This is probably due to the fact that the period is placed between the global agreements, such as Agenda 21, Kyoto Protocol and Millennium Declaration. Later, the growth happened in a gradual way until 2014, with a publishing average of 8.35 articles a year. In 2015, with Agenda 2030 and the creation of the Sustainable Development Goals, we see an elevated growth of the studies related to green equity, in which the average presented was of 48.5 articles a year. Considering the whole period researched, 1992 to 2021, the annual average growth rate was 18.51%.

The evolution of the number of quotes is similar to the growth of publications. This evolution was generally growing, pointing to a higher stability between 2009 and 2018, with a peak in 2014. For the publications posterior to 2018, we observed an accentuated decrease in the quantity of quotes, due to the time needed so that the new publications can become references in the area. However, we inferred that the theme has still not reached its maturity stage and, probably will continue to attract more researches as far as global actions intensify, as well as the theme disseminates through the countries.

Chart 1 - Publications and references associated to sustainability global milestones Font



Source: authors

Main research areas: keywords analysis

With the specific keywords analysis, it was possible to notice the main topics addressed in the researches as well as their development. Using *Biblioshiny*, we obtained a list of the 25 most used keywords by the authors. In Picture 1 we present this information in a word cloud shape, a visualization resource in which the themes relevance is categorized according to the font size, making the information clearer.

We noticed that the keyword "*environmental justice*", quoted 208 times, is highlighted. This happens because the term composes the pillars of the concept of green equity in its origin, even before the time period approached in the research. The second most frequent keyword is "*urban green space*" with 34 quotes, denoting an association between the green equity idea and the several urban places, spatializing the concept. Following, the word "*equity*", as a simple noun, appears 33 times, "*accessibility*" also 33 times, and "*urban planning*", 28 times. We understand that green equity is an expression that definitely starts to be associated to issues of space, urban space specifically and spatial distribution.

Picture 1 – Keywords Cloud

Source: authors

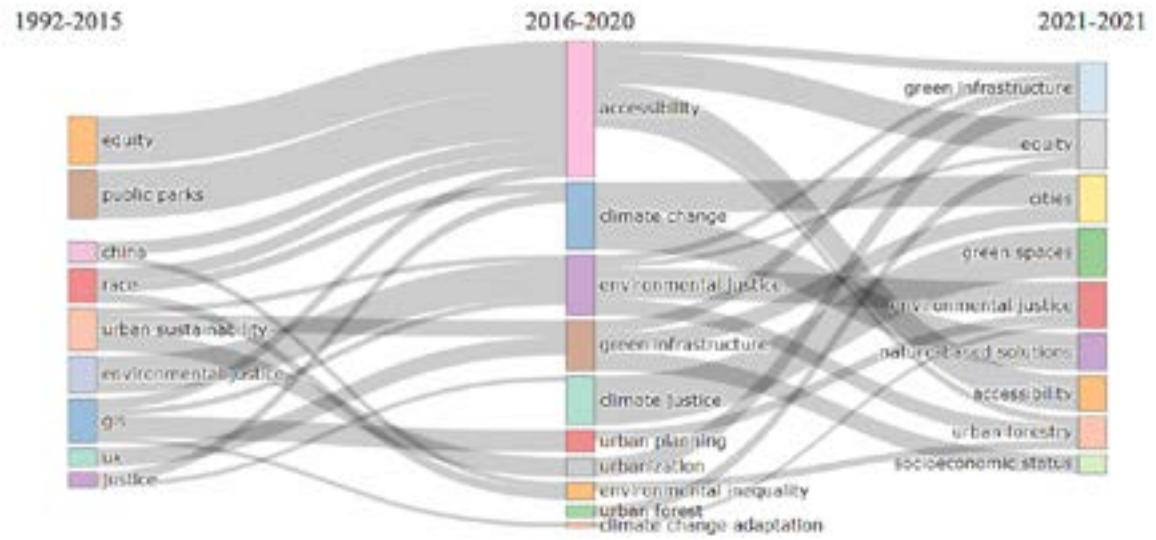
Still through keywords it is possible to notice which were the research directions, as Picture 2 shows. In this representation, the quantity of occurrences is viewed with the most frequent semantical associations over the period. This connection is represented by grey lines, which thickness is proportional to the quantity of occurrences.

The semantical evolution from 1992 to 2015 and from 2016 to 2020/2021 highlights that first the researches relate "*equity*" to "*environmental justice*", "*public pars*", "*race*", "*urban sustainability*" and "GIS" (*Geographic Information System*). After 2015, with an increase of the volume of scientific productions, there were also some additions to the diversity of themes, as "*accessibility*", "*climate change*", "*green infrastructure*", "*urban forest*" and "*urban planning*".

An aspect worthy of highlight is that the articles published in 2021 correspond to almost 20% of the total, what shows a very important growth in interest from the central theme and its associated terms. About these, the permanence of previous terms that have already been used and the appearance of new keywords more centered in green equity are noticed. They are: "*cities*", "green spaces" and "*socioeconomic status*".

The great increase verified in 2021, the last of the period studied in this research, is probably connected to the fact that the United Nations, through the *Food and Agriculture Organization of the United Nations*, declared the period of 2021 to 2030 the Decade on Ecosystem Restoration, with a broad focus that covers urban ecosystems.

Picture 2 - Semantical evolution Font



Source: authors

Main Periodics

The importance of evaluation of production in scientific magazines lays on the fact that in these the results of research are more readily disclosed and consumed, if compared to other ways of scientific knowledge publishing (DARKO, 2019). Thus, they are also more looked for by readers as information source and by authors as work publishing vehicle.

For the analysis of the text corpus selected, we point on table 2 the 10 main periodics, classified by number of publications. We can notice that the periodic *Landscape and Urban Planning* presents the greater number of publications and also the higher H-Index. H-Index operates with two metrics, productivity and quote impact of academic publications (ARIA; CUCCURULLO, 2017).

It was also possible to determine that the 10 periodics with greater number of publications are the same 10 with higher H-Index reported, only altering the classification.

Table 2 - Most influent periodics

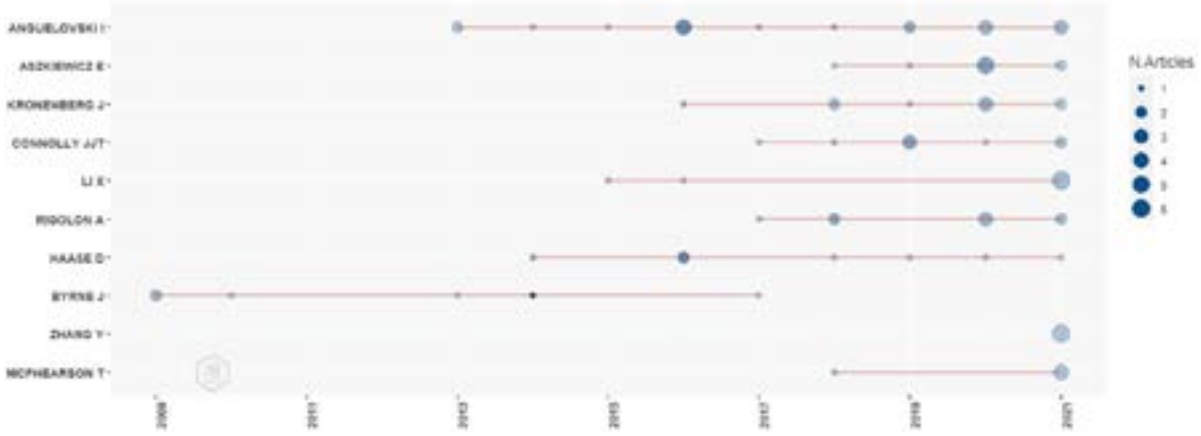
	Periodics	Articles	H-Index
1st	Landscape and Urban Planning	43	26
2nd	Urban Forestry and Urban Greening	34	17
3rd	Sustainability	27	8
4th	Local Environment	24	11
5th	International Journal of Environmental Research and Public Health	23	9
6th	Environmental Justice	21	6
7th	Cities	12	9
8th	Applied Geography	11	9
9th	Environmental Science and Policy	11	6
10th	Ecological Indicators	10	6

Source: authors

Main Authors

With respect to the classification of the 10 authors with more published articles (Picture 3), we observed that the production is centered near the last years of the research, with 89% of the articles, from a total of 84, published after 2015. From the authors, Anguelovski stands out with 18 articles published regularly since 2013 and as second most quoted author. And Byrne, even without recent publications, is the author that presents the higher number of quotes. We also highlight that, as showed in Picture 3, only in 2021, the year with most of the publications, authors like Li X, Zhang Y and McPhearson T published 6 and 4 articles, respectively. McPhearson's works approach themes like green infrastructure, ecosystemic services and access to parks in New York City, while Li X and Zhang Y treat mainly of equity in availability of green spaces and ecosystemic services associated to socio-economic and geographic factors, in addition to the perception and accessibility on green spaces and parks.

Picture 3 - Production of the main authors distributed over time



Source: authors

Scientific production of the countries and global collaboration network

With the data obtained, we identified the main productions by countries and the collaboration network existing. The list of countries and scientific production is on table 3. On the number of articles, the higher production is from the USA, followed by China, Germany, Spain, United Kingdom and Australia. We noticed that the greater amount of cooperation between countries is also concentrated among these first six countries.

Table 3 - Published articles and cooperation between countries

Classification	Countries	Published Articles	Cooperation
1	USA	486	82
2	China	157	24
3	Germany	71	38
4	Spain	63	28
5	United Kingdom	61	31
6	Australia	51	16
7	Canada	33	3
8	Netherlands	22	14

9	Poland	22	12
10	South Africa	18	8
11	Sweden	17	9
12	Brazil	16	5
13	Portugal	14	7
14	Belgium	12	9
15	Hungary	11	4
16	Norway	10	4
17	Italy	10	2
18	France	8	1
19	Korea	8	1
20	New Zealand	8	1
21	Colombia	7	2
22	Chile	6	1
23	Czech Republic	5	3
24	Estonia	4	1
25	Switzerland	4	1
26	Japan	2	2
27	Romania	2	1
28	Greece	1	2
29	Latvia	1	1

Source: authors

On Picture 4 it is possible to notice how these collaborations happen for two or more connections between countries. With the map it is possible to signal which were the main cooperation fluxes through the lines, where the thickness is related to the number of connections between the countries. The map also identifies in dark blue the country with the greater number of publications, USA, and fades the color saturation as the publications decrease.

On the map in Picture 4 we also notice that for the two countries with the higher number of publications, the existing fluxes are significant and diversified. In the case of the USA we verify that the cooperations happen in a larger quantity with Anglophone countries (mostly of English speakers), but still in a modest way with countries in the same continent, mainly the ones in South and Central America. And the fluxes with China happen in a more diversified way, where the most consistent relations are verified with the USA, countries in Europe and East Asia. Thus, we notice how Chinese researches are relevant not only in quantity but also in global connections when related to the academic study in green equity.

Picture 4 - Map of the collaboration network between countries with two or more cooperations

Source: authors

Final considerations

In this work we observed the specialties in green equity and its evolution in the studied literature, where it was possible to explore important aspects in the scientific approach and consolidate the study in a broad way, thus offering a panoramic view of the development of the theme in scientific research and its unfoldings until the current scenario.

It was possible to show how the research in green equity evolved since 1992. Initially associated to aspects of environmental justice, racial distinction, public parks and sustainability; green equity, mainly after the launching of the Sustainable Development Goals, by the United Nations in 2015, acquired more coverage and diversification in the studies, also associating to climate changes, accessibility to green spaces, ecosystemic services, green infrastructure and socio-economic issues.

Such questions, along with the increase of the publications, signal the importance of urban green equity in several axes of research and shows how such approaches converge with questions related to the quality of life, with connotations and unfoldings to interdisciplinary fields in Exact and Land, Human, Social and Health Sciences. Given the presented evidences, we understand that the researches will continue to grow and diversify over time, as the issues of equitative distribution and environmental justice gain global relevance and urgency, mainly in urban areas.

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THE SOCIAL CONSTRUCTION OF THE URBAN TREES LAW IN CHILE

Cecilia Michea Valenzuela*

I received an invitation from the Brazilian Society of Urban Arborization (SBAU) to present at the CBAU - CIAU 2021 Congress, under the title: "The Social Construction of the Urban Tree Law in Chile." I must say that from the beginning I have loved the idea of presenting our experience from this perspective of "Social Construction," because I believe that it transmits the essence of the work that we have done in Red Arbol Urbano, work that is supported by Communication Campaigns which in turn strengthen and position technical proposals, the expression of our conviction after the search to promote Green Cities.

Red Árbol Urbano arises as a response to the Abusive Culture of Tree Pruning, prevailing in the country. With whom this grouping begins, it is detected (and its seeks to counteract) that the ignorance of the environmental benefits of trees; and their needs in an urban context; limit people's empathy with them, as this distancing ultimately causes a deep fear of the tree.

The group was consolidated in 2018 through the Campaign "For a Wooded Chile" with the aim of making visible this environmental problem that arises from the deficient management of Urban Trees.

We are an independent, non-profit environmental organization that works pro bono.

Our objectives are to promote regulations and Environmental Education focused on the Valuation of the Tree, generating proposals and strategies from a management team of 3 professionals who are linked with different socio-environmental organizations that adhere to the objectives proposed by this team, in collaborative and multi-disciplinary work. Members:

Cecilia Michea | Designer, Graphic Representation | Valparaiso
Cecilia Benavides | Forestry Execution Engineer | The Angels
Leonardo Lira | Architect | Penco

* Autor correspondente

Designer, Graphic Representation. Bachelor's Degree in Design. University of Valparaíso, Chile. Diploma in Digital Marketing. Pontifical Catholic University of Chile. Red Árbol Urbano Coordinator (RAU), Chile. Email address: c.michea@uc.cl

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At first, one of the greatest challenges we had to overcome was projecting an image of integrity among the organizations and the team, despite being dispersed throughout the country. For which we have carried out a strategic and especially creative management of our digital channels in order to build a brand identity.

Alliances

From our vision, attracting attention to a topic so relevant to future generations, as ignored as it is persistent, requires structuring a collaborative work on a large scale, building long-lasting relationships at the national and international level. In this way we give consistency, we expand the arrival of a communicativel message that should sensitize, educate, unite and call for action, such as making visible how Urban Forestry can contribute to the creation of kinder and more sustainable cities.

Web

Centerpiece of our digital ecosystem is the website www.leydearboladourbano.com

All actions and dissemination redirect to this repository that records: Who We Are, Alliances, the Technical Proposals that we have developed, Activities and Library. Documenting our work has facilitated contact with other national and international organizations and authorities.

Communications

Our communicational work has always been serious, well founded, with respect, with a recognized discourse consistent with our activities, which has allowed us to approach different relevant actors to promote actions and advance our objectives. For us, the integral management of Urban Trees is a cross-cutting issue for the whole of society, therefore, it does not have a political color. We have tried to make contact with all the authorities that have shown interest, and for our part we have intended that this contact be the most representative of the current political trends in the country.

Technical work:

- "Proposal for an Urban Tree Law" submitted to the Ministry of Agriculture - MINAGRI (2018). The Ministry worked its initiative of law under the name of "Ley de Arbolito," from this proposal delivered by our group, which was not presented in parliament.

- "Catalog of tree species" (2019). Available on our website.

- "Proposal for a Municipal Ordinance on Green Infrastructure" (2020). Pending the completion of the law, this is a guide that we offer to the Municipalities for free. There are 74 municipalities in Chile and abroad that have requested it to date.

- "Draft Law on Urban Trees and Green Infrastructure" (2021). Donation Bill delivered by Red Arbol Urbano to the Senate of Chile, that enters on April 28, 2021, in a parliamentary motion sponsored by the Senators who are members of the Environmental Commission.

Conclusion

From our experience, having a quality product, defining digital strategies for Branding, Communication and Digital Marketing, which include the use of Social Networks, is an effective way to attract and co-create a "Community" around an environmental cause.

This seen from the strategy, but from the human relations it has been perhaps more important to consolidate ties in this "Pro-Tree Community," of which we appreciate their contributions to move together towards a "Wooded Chile," since it brings us closer to the objective greater than is pursued: Generate a cultural change that ensures social equity through the integral management of urban trees, where the involvement of citizens is essential to project and achieve the much-needed sustainable cities.