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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-ama-relo	Bignoniaceae	NA		4		3																					7
Hevea brasiliensis (Willd. ex A.Juss.) Müll. Arg.	Serin-gueira	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	Chrysobalana-ceae	NA	3			5			15	43			1	2			7	5	2	2	7	1			7		100
Mangifera indica L.	Man-gueira	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-bra-sil	Fabaceae	NB					1		1																		2
Persea americana Mill.	Abaca-teiro	Lauraceae	E																					1	1			2
Podranea ricasoliana (Tanfani) Sprague	Sete-lé-guas	Bignoniaceae	E					1																				1
Poincianella pluviosa (DC.) L.P.Queiroz	Sibipi-runa	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

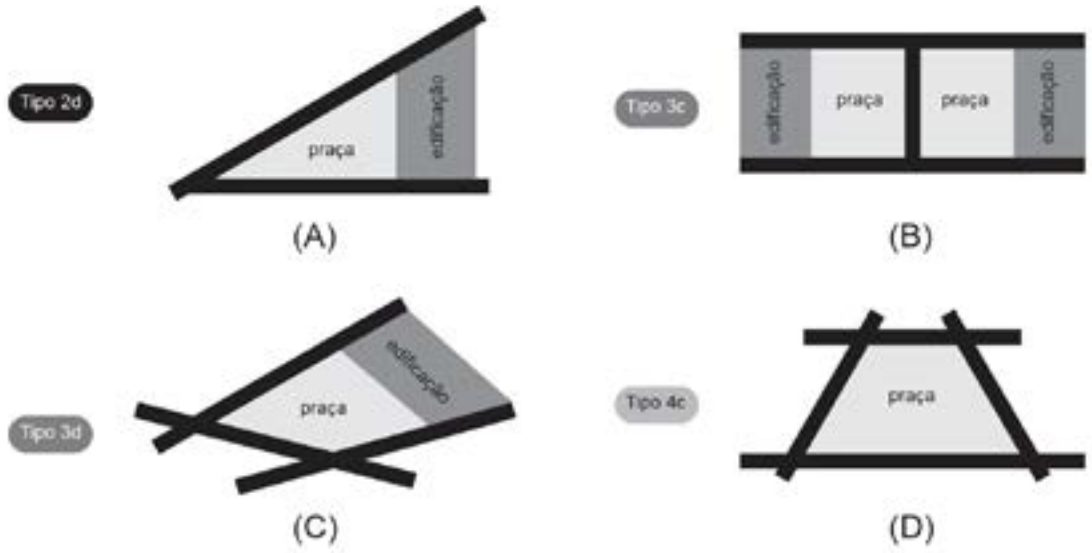
Source: the authors (2021).

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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