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Evaluation of Street Tree Inventories in a neighborhood in Rio Claro/SP - Brazil

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Abstract
Street trees impact the quality of life of human populations, providing aesthetic, social, ecological, and environmental benefits. Knowing and identifying urban tree species is important for good planning and management. The objective of this study was to assess street trees in the residential neighborhood Jardim das Palmeiras, in Rio Claro, SP, Brazil, through a quantitative and qualitative inventory. The following parameters were considered: scientific name, botanical family, common name, origin, typology, physiological condition, phytosanitary condition, location of the tree component on the sidewalk, permeable area, sidewalk condition, sidewalk survey, and interference with the power grid. Data on the species were also compared for the years 2011 and 2022. A total of 618 individuals were found, of which 588 could be identified by family and species. *Murraya paniculata* represented 27.7% of the total, and the Rutaceae family was most prominent, with 163 individuals. The inventory showed that 43% were shrubs/herbaceous, 76.94% were adult individuals, and 89.5% had a healthy phytosanitary condition. Due to the large number of shrubs, the percentage of conflicts with the power grid and the like was not significant. Although 58.8% of the sidewalk area was classified as poor for the species, that did not show correlation with the sidewalk survey. Comparison of the years 2011 and 2022 revealed a decline of 82 individuals. The street trees in the residential neighborhood Jardim das Palmeiras had low variability in family classification, irregular species frequency, and excessive planting of a single species, which is not recommended.
Keywords: urban green areas, urban forestry, urban infrastructure

1 INTRODUCTION

The scenario of rapid urban population growth, coupled with the increase in new technologies, has resulted in cities increasingly filled with large modern buildings in affluent areas, and small, densely-packed houses in socioeconomically vulnerable regions. There is a noticeable overuse of glass and particularly concrete, materials that retain heat and contribute to rising temperatures in urban centers (Farias, 2022).

The temperature increase resulting from the urbanization process, the loss of urban vegetation, increased soil impermeability, and channeling of water bodies that flow into municipalities favor the formation of heat islands. These are areas characterized by low relative humidity and high temperatures. The development of a heat island occurs due to lower water vapor availability in the air, reducing absolute humidity. In combination with higher air temperatures, this leads to a further decrease in relative humidity, proportional to air temperature (Vianna, 2018; Amorim, 2019). Another impact of high urbanization is increased pollution due to the release of harmful gases, such as carbon dioxide (CO_2) and ozone (O_3) from means of transportation, and especially due to the expansion of paved areas (Farias, 2022).

All these aspects have a negative impact on the environment, causing imbalance and degradation. Every year, many cities face problems of flooding, landslides, pollution in rivers and lakes, and others. These problems affect people's lives, leading to increased mental health issues (anxiety and depression), respiratory problems, infectious diseases, stress from noise pollution, and tragedies resulting in fatalities (Amato-Lourenço *et al.*, 2016; Abdala, 2022; Brito; Verli, 2022; Garcia, 2022).

Street trees, along with urban green spaces and green infrastructure, can contribute to better adaptation to and mitigation of changes caused by haphazard urbanization. Studies have shown that trees in urban areas provide various ecosystem services, such as noise reduction, pollution and temperature mitigation, improved disposition for physical activities and leisure, enhanced mental health, well-being, stress reduction, and even crime reduction (Locatelli *et al.*, 2017; Arratia *et al.*, 2020; Erlwein; Paulei, 2021; Sousa *et al.*, 2022).

Implementation of street tree projects on streets and avenues requires effective technical planning, involving the use of native species suitable for the planting location. Proper

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planting, maintenance, and renewal of tree species help avoid issues such as sidewalk disruption and conflicts with electrical infrastructure (Santos; Fabricante; Oliveira, 2018).

An initial survey to understand the local vegetation will assist in creating a proper street tree plan. This includes assessment of phytosanitary conditions, identification of conflicts, and evaluation of sidewalk conditions. Urban tree inventories enable proper management and ensure a high-quality process from implementation on (Zamproni *et al.*, 2018).

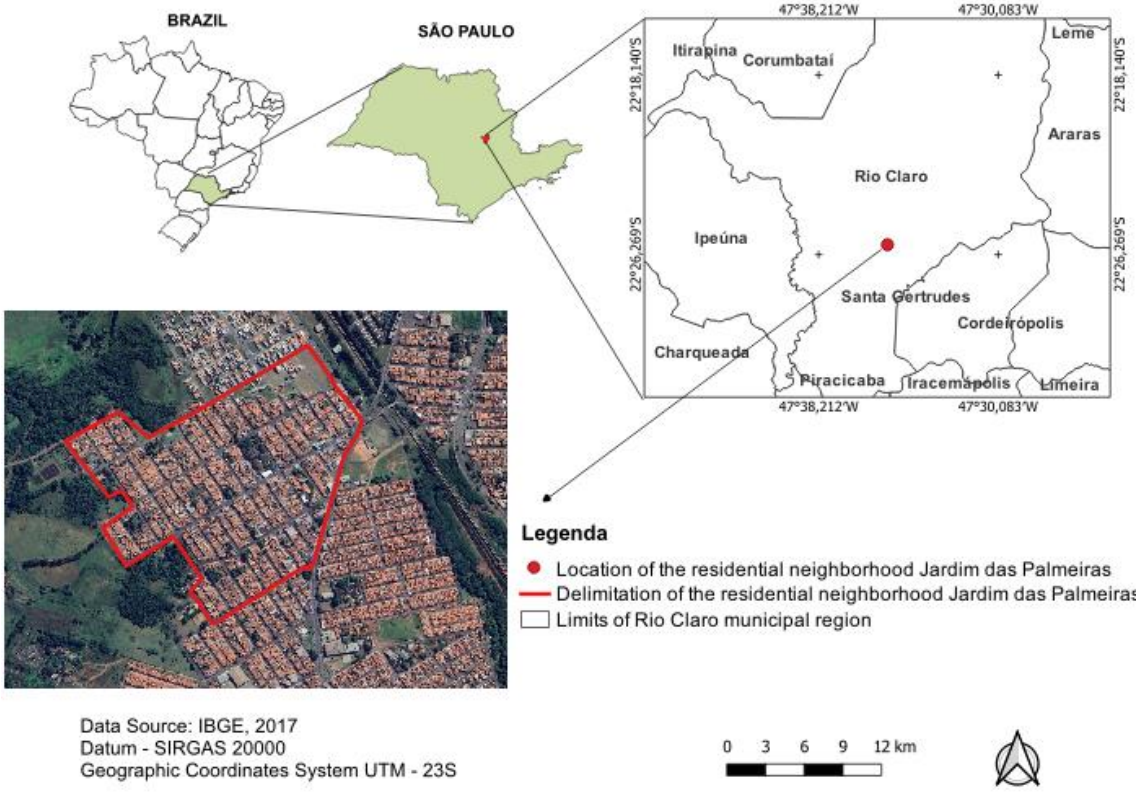
Thus, the aim of this study was to use a quantitative and qualitative inventory to evaluate street trees in the residential neighborhood Jardim das Palmeiras in the southern zone of the city of Rio Claro, São Paulo, Brazil.

2 Methodology

2.1 Characterization of the study area

The study area was the residential neighborhood Jardim das Palmeiras, in the southern zone of the city of Rio Claro, São Paulo. The city is in the east-central region of São Paulo, at 22° 24' 39" S and 47° 33' 39" W, 173 km from the capital city of São Paulo (Figure 1). The city has an estimated population of 201,418 people and is part of the Piracicaba Mesoregion, as well as the Campinas Intermediate Geographical Region (IBGE, 2010; 2022).

Figure 1 - Location Map of the residential neighborhood Jardim das Palmeiras in Rio Claro, SP, Brazil



Source: IBGE (2017) and Google Maps (2022).

2.2 Qualitative and Quantitative Survey

2.2.1 Delimitation of the Area

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The street tree survey was conducted from December 2021 to February 2022. We walked along the 16 streets and 6 avenues within the neighborhood with a total area of approximately 41.23 hectares (Figure 2).

Figure 2 - Streets and avenues included in the street tree survey in the residential neighborhood Jardim das Palmeiras in Rio Claro, SP, Brazil

Source: Google Maps (2022).

2.2.2 Evaluated Parameters

Twelve characteristics were observed during walks along the streets and avenues, and a spreadsheet was filled out (Table 1).

Table 1 - Parameters for evaluation of street trees in the residential neighborhood Jardim das Palmeiras in Rio Claro, SP, Brazil

Observation no.	Collected Information	Classification	Source of Information
1	Scientific name	-	Virtual Herbarium of the Reflora Program
2	Family	-	Virtual Herbarium of the Reflora Program
3	Common name	-	Popular knowledge
4	Origin	Native or exotic	Virtual Herbarium of the Reflora Program
5	Typology	Trees, shrubs/herbaceous plants, or palms	Virtual Herbarium of the Reflora Program
6	Physiological condition	Young or adult	Field research
7	Phytosanitary condition	Healthy, senescent, dead, or suppressed	Field research
8	Location of the tree component on the sidewalk	Adjacent to the curb, near the curb, in the middle of the sidewalk, or adjacent to the house	Field research
9	Permeable area	Good, average, poor, or very poor	Field research
10	Sidewalk upheaval caused by plant roots	Yes or no	Field research
11	Interference with electrical network and/or telephone lines	Yes or no	Field research

12	Sidewalk condition	No sidewalk, sidewalk in good condition, slightly damaged sidewalk, moderately damaged sidewalk, or extremely damaged sidewalk	Field research

Source: Research Data (2022) and FLORA E FUNGA DO BRASIL (2022)

For items 9 and 10, the following criteria were considered:

Item 9: a) Good: The location where the tree was planted was entirely composed of soil, allowing proper uptake of water and nutrients; b) Average: The location had a combination of concrete or sidewalk tiles/blocks (Portuguese pavimento) and a small uncovered area, allowing moderate uptake of water and nutrients; c) Poor: The location was mainly composed of concrete or sidewalk tiles/blocks (Portuguese pavimento) with a very minimal uncovered area, often almost the same diameter as the tree trunk/stipe, significantly hindering water and nutrient uptake; d) Very poor: The location was exclusively composed of covered areas with no permeable space for the tree, completely preventing water and nutrient uptake and resulting in cracks or even total destruction of the sidewalk.

Item 10: a) No sidewalk: There is no sidewalk in the area; b) Sidewalk in good condition: The sidewalk is undamaged; c) Slightly damaged sidewalk: The sidewalk has small surface cracks without significant safety issues; d) Moderately damaged sidewalk: The sidewalk has intermediate-sized cracks, potentially posing safety hazards; e) Extremely damaged sidewalk: The sidewalk has large cracks and upheaval, creating potential hazards for pedestrians, people with mobility difficulties, and wheelchair users, and it may obstruct wheelchair traffic.

2.3 Comparison of Trees in 2011 and in 2022

A comparison was made between the trees that appeared on the sidewalks in 2011 and the trees observed in the field survey in 2022. For 2011, the Google Maps Street View tool was used, which provides 360° horizontal and 290° vertical panoramic views, allowing users to see parts of some areas at ground level. In 2022, on-site visits were conducted. The numbers of individual trees per street and avenue in the 2011 and 2022 were placed in a spreadsheet, and the percentage of trees removed or added to public thoroughfares was calculated.

3 RESULTS AND DISCUSSION

3.1 General Analysis of the Street Tree Survey in the Residential Neighborhood Jardim das Palmeiras.

Through walks along the 16 streets and six avenues, 618 sidewalk plants were found, including trees, herbaceous plants, and palms. However, it was not possible to identify the species (scientific name, common name, and family) of 30 individuals. Therefore, the table below includes 588 identified plants (Table 2).

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Table 2 - List of species identified among the street trees/plants of the residential neighborhood Jardim das Palmeiras in Rio Claro, SP, Brazil

Scientific Name	Common Name	Family	Origin	FA	FR (%)
Murraya paniculata (L.) Jack	Murta-de-cheiro	Rutaceae	Exotic	163	27,7
Lagerstroemia speciosa Pers.	Resedá-gigante	Lythraceae	Exotic	36	6,1
Moquilea tomentosa Benth.	Goiti	Chrysobalanaceae	Native	34	5,8
Cenostigma pluviosum (DC.) Gagnon & G.P.Lewis var. pluviosum	Sibipiruna, Sebipira	Fabaceae	Native	28	4,8
Eugenia uniflora L.	Pitangueira	Myrtaceae	Native	24	4,1
Malpighia emarginata DC.	Aceroleira	Malpighiaceae	Exotic	20	3,4
Handroanthus albus (Cham.) Mattos	Ipê amarelo	Bignoniaceae	Native	18	3,1
Psidium guajava L.	Goiabeira	Myrtaceae	Native	17	2,9
Schinus molle L.	Aroeira-salsa	Anacardiaceae	Native	16	2,7
Lagerstroemia indica L.	Resedá	Lythraceae	Exotic	16	2,7
Phoenix roebelenii O'Brien	Palmeira Fênix	Arecaceae	Exotic	13	2,2
Bauhinia forficata Link	Pata-de-vaca	Fabaceae	Exotic	11	1,9
Tecoma stans (L.) Juss. ex Kunth	Ipê-de-jardim	Bignoniaceae	Exotic	11	1,9
Citrus aurantiifolia (Christm.) Swingle	Limoeiro	Rutaceae	Exotic	11	1,9
Cocos nucifera L.	Coqueiro	Arecaceae	Exotic	11	1,9
Terminalia catappa L.	Amendoeira-da-praia, Castanheira	Combretaceae	Exotic	11	1,9
Annona squamosa L.	Pinha	Annonaceae	Native	10	1,7
Ficus benjamina L.	Fícus-benjamim	Moraceae	Exotic	9	1,5
Pleroma granulosum (Desr.) D. Don	Quaresmeira	Melastomataceae	Native	9	1,5
Roystonea oleracea (Jacq.) O.F.Cook	Palmeira-imperial	Arecaceae	Exotic	8	1,4
Callistemon viminalis (Sol. ex Gaertn.) G.Don	Escova-de-garrafa	Myrtaceae	Exotic	7	1,2
Codiaeum variegatum (L.) Rumph. ex A.Juss.	Cróton	Euphorbiaceae	Exotic	7	1,2
Mangifera indica L.	Mangueira	Anacardiaceae	Exotic	7	1,2
Ligustrum lucidum W.T.Aiton	Alfeneiro	Oleaceae	Exotic	5	0,9
Dypsis lutescens (H.Wendl.) Beentje & J.Dransf.	Palmeira-areca	Arecaceae	Exotic	5	0,9
Syagrus romanzoffiana (Cham.) Glassman	Palmeira-jerivá	Arecaceae	Native	5	0,9
Pachira aquatica Aubl.	Monguba	Malvaceae	Native	5	0,9
Malvaviscus arboreus Cav.	Malvavisco	Malvaceae	Exotic	5	0,9
Eriobotrya japonica (Thunb.) Lindl.	Nespereira	Rosaceae	Exotic	4	0,7
Punica granatum L.	Romãzeira	Lythraceae	Exotic	4	0,7
Duranta erecta L.	Pingo-de-ouro	Verbenaceae	Exotic	4	0,7
Nerium oleander L.	Aloendro	Apocynaceae	Exotic	3	0,5
Ceiba speciosa (A.St.-Hil.) Ravenna	Paineira	Malvaceae	Native	3	0,5
Grevillea banksii R.Br.	Grevillea de Banks	Proteaceae	Exotic	3	0,5
Peltophorum dubium (Spreng.) Taub.	Canafístula	Fabaceae	Native	3	0,5
Bixa orellana L.	Colorau	Bixaceae	Native	3	0,5
Euphorbia umbellata	Leiteira	Euphorbiaceae	Exotic	2	0,3
Caesalpinia pulcherrima (L.) Sw.	Flamboyant-mirim	Fabaceae	Exotic	2	0,3
Dypsis decaryi (Jum.) Beentje & J.Dransf.	Palmeira-triângulo	Arecaceae	Exotic	2	0,3
Litchi chinensis Sonn.	Lichieira, Lecheira, Arbarinoia, Lichia, Uruvaia	Sapindaceae	Exotic	2	0,3
Psidium guineense Sw.	Goiabinha-do-campo	Myrtaceae	Native	2	0,3

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Annona muricata L.	Gravioleira	Annonaceae	Exotic	2	0,3
Caryota urens L.	Palmeira rabo-de-peixe	Arecaceae	Exotic	2	0,3
Schefflera actinophylla (Endl.) Harms	Árvore guarda-chuva	Araliaceae	Exotic	1	0,2
Dracaena marginata Lem.	Dracena-de-madagascar	Asparagaceae	Exotic	1	0,2
Sorbus vilmorinii	Sorveira de Vilmorin	Rosaceae	Exotic	1	0,2
Anacardium occidentale L.	Cajueiro	Anacardiaceae	Native	1	0,2
Agave attenuata Salm-Dyck	Agave	Asparagaceae	Exotic	1	0,2
Leucaena leucocephala (Lam.) de Wit	Leucena	Fabaceae	Exotic	1	0,2
Beaucarnea recurvata Lem.	Pata-de-elefante	Asparagaceae	Exotic	1	0,2
Ailanthus altissima (P. Mill.) Swingle)	Árvore-do-céu	Simaroubaceae	Exotic	1	0,2
Syzygium cumini (L.) Skeels	Jamelão	Myrtaceae	Exotic	1	0,2
Euphorbia tirucalli L.	Avelós	Euphorbiaceae	Exotic	1	0,2
Brugmansia suaveolens (Willd.) Sweet	Trombeta-de-anjo	Solanaceae	Exotic	1	0,2
Chamaecyparis lawsoniana (A. Murr.) Parl	Cedro	Cupressaceae	Exotic	1	0,2
Harpullia pendula	Tulipwood	Sapindaceae	Exotic	1	0,2
Persea americana Mill.	Acabateiro	Lauraceae	Exotic	1	0,2
Schefflera arboricola (Hayata) Merr.	Cheflera	Araliaceae	Exotic	1	0,2
Tamarindus indica L.	Tamarindeiro	Fabaceae	Exotic	1	0,2
Solanum paniculatum L.	Jurubeba	Solanaceae	Native	1	0,2
Pinus sp.	Pinheiro	Pinaceae	Exotic	1	0,2
Inga edulis Mart.	Ingá-de-metro	Fabaceae	Native	1	0,2
Allamanda cathartica L.	Alamanda	Apocynaceae	Native	1	0,2
Eugenia brasiliensis Lam.	Grumixameira	Myrtaceae	Native	1	0,2
Psidium cattleyanum Sabine	Araçazeiro	Myrtaceae	Native	1	0,2
Albizia amara (Roxb.)B.Boivin		Fabaceae	Exotic	1	0,2
Agave angustifolia Haw.	Piteira-do-caribe	Asparagaceae	Exotic	1	0,2
Handroanthus impetiginosus (Mart. ex DC.) Mattos	Ipê rosa	Bignoniaceae	Native	1	0,2
-	**-**	**-**	-	**588**	**100**

Source: Research Data (2022).

A substantial number of individuals of the species *Murraya paniculata* (L.) Jack 'Exotica', known as orange jessamine, were observed, accounting for almost 30% of the species in the residential neighborhood Jardim das Palmeiras. In the state of São Paulo, Law No. 1291 has prohibited the planting of this species since 2007 (São Paulo, 2007), as well as Law No. 15.953 since 2008 in the state of Paraná (Paraná, 2008).

This is due to the fact that *M. paniculata* is a host of the bacterium *Candidatus liberibacter*, which is spread by the vector insect *Diaphorina citri Kuwayama* (Asian citrus psyllid), a transmitter of citrus greening disease, also known as *Huanglongbing*, HLB, or simply citrus greening. This disease is responsible for severe damage to the citrus industry (Dias; Silva; Periotto, 2020).

When a limited variety of species is used for urban purposes, the result is higher susceptibility to pests and diseases. Therefore, opting for greater diversity in both species and families is recommended. That way, more flowers, fruit, and leaves can be available throughout the year, as each species has its own flowering, fruit-bearing, and leaf renewal period (Miranda;

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Carvalho, 2019).

Another significant result was the percentage of exotic species used for street trees/plants. Of the 68 species identified, 48 were exotic, a not uncommon scenario for street trees in Brazilian cities, where the trees planted are mainly exotic species, despite a rich diversity of native flora (Toscan *et al.*, 2010).

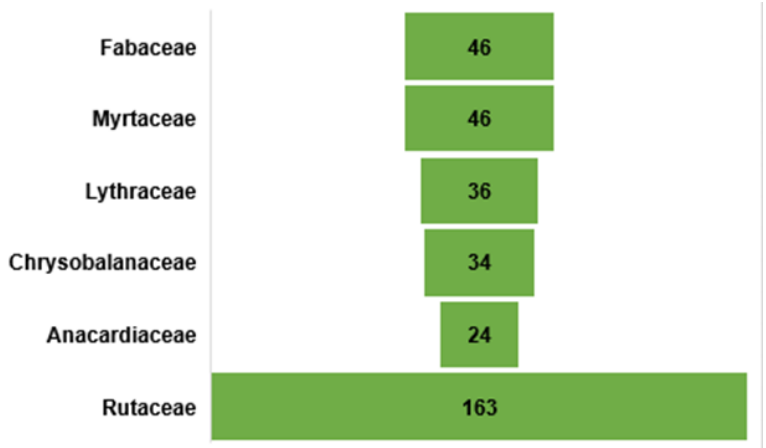
A survey in Frederico Westphalen, RS, inventoried 2,145 trees, and the exotic species *Lagerstroemia indica* was the most common, with 458 individuals; that species together with the species *Ligustrum lucidum* accounted for more than 40% of the total number of trees (Santos; Aragão Santana, 2019).

The same scenario occurred in a survey in Godoy Moreira, in the state of Paraná, where 76% of the species found were of exotic origin (Miranda *et al.*, 2015). In the Beira Rio neighborhood of Imperatriz, Maranhão, 71.79% of the species were exotic and 28.21% were native; species like *Licania tomentosa* and *Azadirachta indica* were most prominent (Lima, 2022).

Exotic species, when introduced into new areas, are capable of adapting and aggressively invading the habitats of native species, often causing irreversible environmental imbalances. Thus, they are the second leading cause of biodiversity loss on the planet (Blum *et al.*, 2008; Vianna; Jacobi, 2018).

Graph 1 shows the five most common families of tree/plant species of the 588 individuals identified in the inventory, which includes the Rutaceae family, particularly because of the large number of orange jessamine individuals in the neighborhood.

Graph 1 - The six families most frequently found in the street trees of the residential neighborhood Jardim das Palmeiras in Rio Claro, SP, Brazil



Source: Research Data (2022)

A total of 21 families and 284 individuals were found, with 163 belonging to Orange Jessamine (Murta) and 121 to tree species. These 284 individuals represent 48.3% of the total and are concentrated in just six families. The Rutaceae family had a single species, *M. paniculata*, which is considered a shrub, with the largest number of individuals at 27.5% (163) of the total. The Myrtaceae and Lythraceae families accounted for 7.8% (46) each, Fabaceae 6.1% (36), Arecaceae 5.7% (34), and Chrysobalanaceae 4% (24) of the total of 588 individuals identified. The cumulative number of individuals represented by a small number of families and species is a common phenomenon in Brazilian cities (Santos; Fabricante; Oliveira, 2018; Silva; Sousa, 2018;

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Vanzella *et al.*, 2021).

At least the desired minimum level of heterogeneity in street trees should be maintained using the 10/20/30 rule. This methodology suggests a maximum level of 10% of a single species, 20% related to a single genus, and 30% related to a single family (Santamour, 1990). These values, 10/20/30, are established with the intention of reducing the spread of pests and diseases in urban trees.

The typology of 609 individuals was identified, with the largest number being trees, at 49% (301), and shrubs, at 43% (262). Palms appeared in smaller number at 8% (46) (Table 3).

Table 3 - Percentage of individuals found in the residential neighborhood Jardim das Palmeiras in Rio Claro, SP, Brazil, according to typology classification

Typology	Number de individuals
Tree	301
Shrub	262
Palm	46
Total	**609**

Source: Research Data (2022)

The percentage values of trees and of shrubs are quite similar. However, it is important to use trees as street tree components, due to the greater ecosystem benefits they provide.

Trees enhance the aesthetic appeal of the urban environment and provide health benefits to residents, improving the overall quality of life. They also serve an ecological function by contributing to conservation of regional biodiversity, offering food and shelter for wildlife species. The benefits of urban trees are mostly in their canopies, where the photosynthesis process occurs; in addition, they absorb toxic gases, heavy metals, and dust, while releasing oxygen and water. Noise absorption is also proportional to the canopy volume, so larger trees and canopies provide greater benefits to the population (Scanavaca Júnior; Corrêa, 2021).

When more shrubs than medium/large trees are planted, we can say that there has been a "shrubification " process in the street tree population, which is not ideal; shrubs do not provide the same ecosystem services as trees. This "shrubification " process in cities is due to the misconception that medium and large trees can cause problems, including falling leaves and flowers, sidewalk damage, interference with utility lines, and others (Aguirre Junior; Lima, 2007).

A large part of the global population lives in urban centers continuously occupied by buildings and facilities for basic urban social functions, such as housing, work, leisure, and transportation. Urbanization conditions have inevitable consequences regarding climate change, and these modifications cannot all be mitigated with the use of shrubs. These modifications are related to changes in air circulation, solar radiation intensity, precipitation, temperature, relative humidity, and other factors that result in people's comfort or discomfort.

A considerable majority, 76.94%, of all individuals found in the inventory were found to be in the adult physiological state, and 89.5% of the plants appeared to be in good phytosanitary condition. This suggests that the municipal government and/or the population perform some maintenance on the plants. We found that 88% did not pose a conflict or interfere with the electrical network.

We observed that 18.28% of the individuals were located in the middle of the sidewalk or along the wall of residences. According to the Law of Accessibility no. 10,098, dated December

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19, 2000, the sidewalk needs to have 0.90 m clear space for wheelchair user mobility; trees located near walls can create various problems due to lack of space for root development (Brazil, 2000).

City sidewalks have considerable impact on street tree use because narrow sidewalks prevent the addition of medium and/or large species. Moreover, there must be space for the tree to have a permeable area around it. The quality of permeability at the sites of the 618 individuals in the neighborhood was analyzed (Table 4).

Table 4 - Number of individuals in the residential neighborhood Jardim das Palmeiras in Rio Claro, SP, Brazil, classified according to permeability status of the area of growth

Row Labels	Number of individuals
Poor	364
Good	124
Very Poor	87
Regular	42
Total Overall	**617**

Source: Research Data (2022)

We observed that 59% (365) of the sidewalks in the residential neighborhood Jardim das Palmeiras were classified as poor in terms of permeability. These areas were covered over and had little open ground, significantly hindering water uptake, nutrient uptake, and plant development.

Table 4 shows that 14% (87) had very poor permeability, and 6.8% (42) had average permeability. Only 20.1% (124) had good permeability, allowing for proper water and nutrient uptake. Indiscriminate urban soil sealing is one of the reasons for increased surface runoff and flooding. When surface runoff occurs intensely, most of the water flows on the streets. If the municipal drainage system does not function properly, floods can occur (Alves; Formiga, 2019).

Regarding sidewalk damage, of the 618 individuals inventoried, 511 (82%) had not lifted the sidewalk. The problem of lifting up the sidewalk may be related to permeability, as the 107 (18%) individuals lifting up the sidewalk were located in areas classified as having poor or very poor permeability. Such trees tend to send their roots to the surface in search of water for survival.

As for interference with the electrical and/or telephone network, of the 618 individuals inventoried, 546 did not show any conflicts or interference. Conflicts between trees and power lines, in most cases, involved medium to large-sized individuals. As the power lines are of conventional type, extensive pruning is required, leading to aesthetically deformed trees, morphologically altered trees, and physiologically weakened trees (Oliveira *et al.*, 2016).

3.2 Comparison of the trees existing in the residential neighborhood Jardim das Palmeiras in 2011 and in 2022

A comparison was made between 2011 and 2022 using the 618 street trees inventoried with the aim of observing changes in the presence of street trees in the neighborhood over the past 11 years (Table 5).

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Table 5 - Comparison between 2011 and 2022 regarding the number of individual street trees present on the sidewalks in the residential neighborhood Jardim das Palmeiras in Rio Claro, SP, Brazil

Location	2011	2022	Location (%)
Street2	5	2	-60.00 %
Street3	5	3	-40.00 %
Street4	17	10	-41.20 %
Street5	17	16	-5.90 %
Street6	34	33	-2.90 %
Street7	55	44	-20.00 %
Street8	56	51	-8.90 %
Street9	47	31	-34.00 %
Street10	46	26	-43.50 %
Street11	43	34	-20.90 %
Street12	62	54	-12.90 %
Street13	58	34	-41.40 %
Street14	57	53	-8.60 %
Street15	12	13	8.30 %
Street16	0	0	0.00 %
Avenue 1	7	5	-28.60 %
Avenue 3	18	44	144.40 %
Avenue 5	66	74	12.12 %
Avenue 7	60	58	-3.30 %
Avenue 9	26	25	-3.85 %
Avenue 11	9	8	-11.10 %

Source: Research Data (2022) and Google Street View (2011).

Street 16 did not exist in 2011, and in 2022, a field visit showed that no individuals of any type had been planted. The street with the most significant loss of individuals was Street 2, with a 60% decrease, which was due to the removal of palm trees. Similarly, Streets 3, 5, 9, and 12 and Avenue 11 had losses related to the number of shrub species.

Some streets continued to have more tree species than shrubs, but the difference decreased due to tree removal. Streets 4, 6, 7, 8, and 14 and Avenue 1 exhibited a decrease in number of species, with Street 4 showing the most significant loss (-41.20%).

Streets 10, 11, and 13 and Avenue 7 changed from streets with more shrubs to streets with more trees, but with a reduction in the total number of species, with Street 10 showing the most significant loss (-43.50%).

Avenue 9 had an equal number of trees and shrubs in 2011 but became an avenue with more shrubs in 2022 due to tree removal (-3.85%).

Avenue 3 had the most significant gain, an increase of 144.40% in 2022. The avenue had many shrubs in 2011 but now has more trees. However, this increase occurred in a single block, which will result in the removal of individuals in the future, due to poor planning (planting proximity) and issues with both vehicle traffic and pedestrian walkways.

Street 15, like Avenue 5, continued to have more shrub species than tree species, but the number of tree species increased in 2022.

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4 CONCLUSION

The street trees in the residential neighborhood Jardim das Palmeiras showed low variability in terms of family classification, irregular species frequency, and excessive planting of a single species, which is not recommended.

Murraya paniculata (L.) Jack was the most numerous species, with 163 individuals. However, this shrub species is not a tree, and it is prohibited in some states due to its negative impact on citriculture.

Considering all the trees, shrub/herbaceous species, and palm trees, 66% were exotic species. There were shortcomings in the planning of street trees; recommendations are to gradually and strategically replace exotic species and shrubs with medium-sized and large native species of the phytogeographic region along public thoroughfares.

Although the sidewalks in the neighborhood have poor permeability, they were not frequently lifted up, mainly due to the considerable presence of shrub species.

Comparative analysis between 2011 and 2022 revealed a decrease of 82 individuals in street trees in the neighborhood.

It is crucial to adopt technical criteria in the implementation of street trees, and the population should be educated regarding the importance of having medium-sized and large tree species, as well as regarding the problems associated with the introduction of exotic species.

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