

Floristic and Structural Analysis of Urban Tree Canopy: From Its Ecology to Its Social Issues

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Abstract

Currently, urban areas are the largest segment of the world's population, and they can reach up to 80% of it in some countries. Understanding green areas is of paramount importance to also understand the population's mental health and well-being, as well as to achieve ecological understanding and its impact on urban infrastructure. Thus, the aim of the present study is to carry out a survey on both urban afforestation structure and on its social impact on a Brazilian municipality. It also sought to understand the damages caused by these species to urban infrastructure in comparison to data collected in 2009, to assess forest coverage in this municipality and tree planting underutilized capacity. Accordingly, all the streets in this municipality's urban area, the botanical data of each tree and its damage to the city's infrastructure and phytosanitary conditions were surveyed (from 1 to 5). Data were compared to those from the 2009 census, and social issues were analyzed. In total, 5044 individuals belonging to 189 species were recorded. The most often found species were *Lagerstroemia indica* and *Murraya paniculata*. Out of the total number of trees, 458 trees scored at least one score "5" in one of the criteria, and this number represents 8.9% of the total of the trees. *L. indica* was the species accounting for the highest rates of phytosanitary and infrastructure issues. Data comparison evidenced that urban tree canopy lost 25% of its vegetation between the two measurements taken herein, but the number of species has increased. When it comes to damages, many trees started showing phytosanitary issues or damage to urban infrastructure.

Keywords

Urban Ecology, Urban Tree Canopy, Impact on Urban Infrastructure, Socorro-SP, Green Coverage

1. Introduction

Recently, increasingly integrative approaches between society and the environment have been observed in urban areas worldwide (Zhou et al., 2019; Byrne 2022). This perspective has gained unparalleled importance since more than half of the world's population currently lives in cities (BMJ, 2021) and it leads to immediate connection between people and green spaces (IPCC, 2021). Over 84% of the Brazilian population lives in urban areas (IBGE, 2022), and 93% of it is concentrated in the Southeastern region (IBGE, 2022), and yet, a significant portion of this population is living in large cities like São Paulo and Rio de Janeiro.

The planet's fast urbanization has put huge pressure on cities to make them provide high quality of life to their residents (Anestis & Stathakis, 2024). However, cities face major threats due to climate change and extreme events, such as drought, hazardous storms, surges and heatwaves (McPhearson et al., 2016). Cities also face a whole range of growing challenges because of the population growth, which outpaces infrastructure development in many parts of the world. The expansion of slums and informal settlements, demographic shifts, social inequality, economic fluctuations, pollution, and local climate and water system changes are serious issues, mainly in cities in poorer countries (Kurniawan et al., 2024).

Ecosystem services are among the ways to alleviate problems caused by cities (Pickett et al., 2016) because they benefit local and regional ecosystems available to urban residents (Haque & Sharifi, 2024; Ribeiro et al., 2024). However, ecosystem services are not merely benefits deriving from ecosystem functioning but associations between people and every ecosystem (Deng et al., 2023). Using green spaces constituting urban forest within cities, such as urban tree canopy, parks, squares, and green areas in general, also helps these ecosystem services (Rockström, 2015; Grimm et al., 2016). The study of urban forests is carried out by the science known as urban ecology.

Urban ecology provides many necessary tools to enhance the understanding on sustainability and resilience in cities (Datola, 2023). Sustainability is defined as the continuous process of ensuring balance among the economy and environmental and human well-being, both now and in the future (McPhearson et al., 2016). However, socioecological interactions in cities and in interconnected urban areas are quite complex (McPhearson et al., 2016), which makes such work intrinsically complex, as well.

Studies on urban ecology should help decision-makers in governmental entities by providing information and financial resources to help them navigate transformations taking place in their communities and take sustainable paths, in order to

achieve resilience in desirable transformed states (Pickett et al., 2014; Pickett et al., 2016). Cities are constantly seeking infrastructure to meet the demands for benefits, such as air temperature cooling, noise reduction, storm water absorption, and improvements in human physical and mental health (Herath & Bai, 2024; Zhao et al., 2024).

Properly using urban tree canopy is essential to accomplish such a task since its inappropriate use can lead to severe urban infrastructure and ecological issues (Sartori & Balderi, 2011), and distort people's perceptions about this matter (Gomes & Nascimento, 2022). Understanding the appropriate use of urban tree canopy is becoming increasingly necessary, because it helps determine the most suitable species for each location and the potential damages they can cause to urban infrastructure (Sartori et al., 2019). These challenges are even greater in impoverished neighborhoods, where investment in urban areas is as precarious as, or even more so than, investment in health, education and infrastructure, in general (Wolch et al., 2014; Mitullah, 2023; Chatterjee & Dutra, 2024).

Therefore, the aim of the present study was to survey trees in the urban tree canopy in Socorro municipality, São Paulo State. Its specific objectives were to understand the damages caused by tree species to urban infrastructure, to compare the present data to those collected in 2009, to assess forest coverage in Socorro municipality, to analyze differences in tree canopy concerning social aspects in this municipality and to assess tree panning underused capacity.

2. Materials and Methods

2.1. Study Site

The current study was conducted in Socorro municipality, Northeastern São Paulo State, near the Southern border of Minas Gerais State, at coordinates 22°32'41" S and 46°34'10" W, at altitude of 789 meters, on average (Figure 1). This municipality houses a population of 41 thousand people and its total area covers 448 Km², its HDI reaches 0.73, which is considered high (IBGE, 2022). The vegetation in this region is classified as mountainous seasonal semi-deciduous forest (Veloso et al., 1991), which is a phytophysiognomy of the Atlantic Forest Biome—one of the most biodiverse and threatened regions in the world given its large number of endemic and threatened animal and plants species (Myers et al., 2000, Laurance & Useche, 2009; Vale et al., 2018; de Lima et al., 2024). According to Köppen's classification, climate in this region is classified as humid temperate, Cfb, with mild and humid summer and dry winter. The dry season lasts from April to September and is one of the main determinants of seasonal semi-deciduous forests' occurrence in Socorro. Mean annual temperature is 18°C and mean annual rainfall reaches 1400 mm (its peak is 288.7 mm, in January and February, and its minimum rate is 25.06 mm, from March to September) (IBGE, 2022). Currently, the textile industry and tourism are the municipality's main economic sources, which makes proper urban infrastructure planning and adaptation, as well as urban tree canopy, crucial for the municipality (IBGE, 2022).

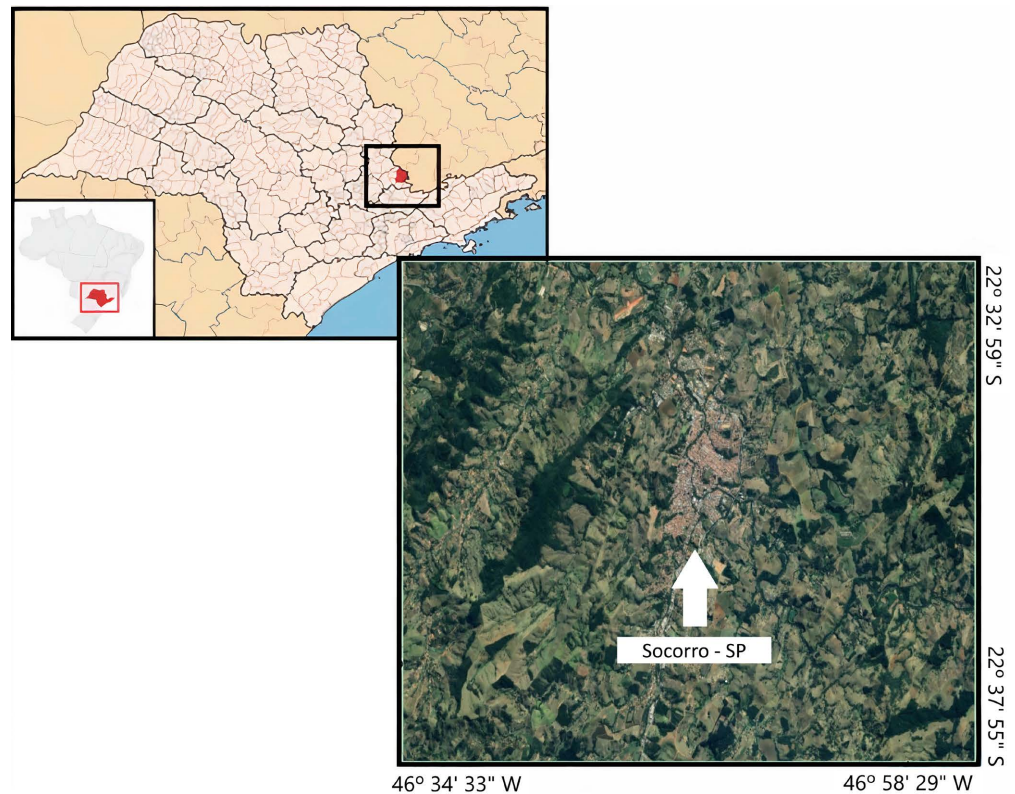


Figure 1. Location of the municipality of Socorro, in the northeastern state of São Paulo, Brazil.

2.2. Species Survey

The research project started in 2020 and counted on the collaboration of volunteers led by the Municipal Department of Environmental, which composed the “Arboriza Socorro” group (“Afforest Socorro” group). Its goal was to gather individuals interested in the city’s urban tree canopy aimed at helping the urban tree planning process. Conducting an urban tree canopy census in the city based on the survey methodology carried out in 2009 was one of the group’s initial actions (Sartori & Balderi, 2011).

The vegetation survey started in August 2021 and finished in November of this same year. All the streets and squares within the municipality’s urban limits were screened. All arboreal individuals presenting minimum height of 50 cm were recorded, and those in natural forests, parks, roads, riparian forests, reserves or private gardens were excluded from the survey.

The following information was recorded for each identified plant: species, diameter, height, location, phytosanitary condition, and aggression to public power wiring and pavement. Aggressions were visually classified, based on classification score ranging from 1 (no aggression) to 5 (extreme aggressive to pavement, houses, and/or public power wiring), according to Sartori and Balderi (2011). It was recommended to remove the individual and to replace it by a species that would cause less damage, in case of any detected extreme aggression caused by a tree. Adapting sidewalks and public power wiring, as observed in previous studies

(Sartori & Balderi, 2011; Sartori et al., 2021), was the best approach in case of individuals causing some damage but that would not grow any further. The classification of the damage was carried out exclusively by researcher RAS, due to their experience in conducting this type of analysis. This ensured that the entire evaluation was conducted by a single researcher, preventing the subjectivity of different evaluators from influencing the results.

Intermediate scores highlighted several aggression levels. Score 2 pointed out small aggression to pavement or slight contact with public power wiring; score 3 indicated clear aggression that did not cause any harm, but minor pavement lifting or gentle contact with wiring; and score 4 suggested pavement lifting, wall cracks and damage to public power wiring in non-threatening locations where tree removal or management was not so urgent. Results evidenced data related to the absolute number of individuals scoring “4” and “5” in each classification, as well as data associated with total number of individuals belonging to each species. This approach mitigates issues linked to species accounting for few individuals, because a maximum score could disproportionately affect the outcome.

Species were identified through comparison to previously identified exsiccates in *Flora do Brasil* (Flora do Brasil, 2020) and to those found at Fribourg Herbarium, PUC-Rio, as well as through consultations to taxonomic monographs, experts and classical studies. Species lacking arboreal or presenting shrubby habits were excluded and taxonomic synonymies were observed. Dead individuals were included in the counting. The APG IV (2016) system was used for taxon classification purposes. Species information was retrieved from the list of Brazilian flora species (Flora do Brasil, 2020) and from SpeciesLink (2020). *Flora do Brasil* website (Flora do Brasil, 2020) was also consulted to confirm species’ spelling and author names.

The flowchart represented in Figure 2 illustrates the path of the work’s development.

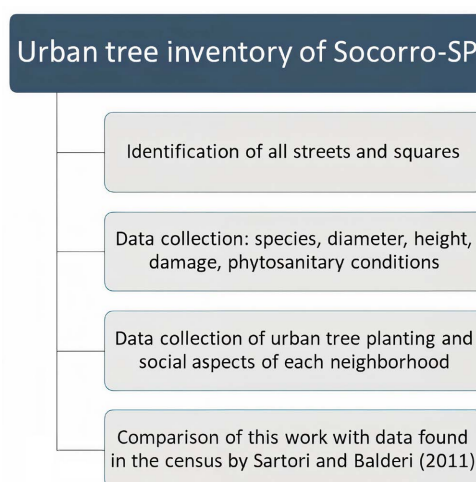


Figure 2. Steps for the development of the work.

2.3. Comparison

The data herein collected were compared to data collected in 2009 (Sartori & Balderi, 2011), including number of trees, species richness (number of species), phytosanitary conditions and damage classification to public power wiring and to pavement. In addition, neighborhoods were compared by taking into account the wealthiest and poorest neighborhoods in the municipality, and their relationship with vegetation. Neighborhood classification was based on data available in São Paulo Social Vulnerability Index (IPVS, 2010), which are provided by the state government. According to these data, most vulnerable neighborhoods are those with the most precarious structures, in other words, the poorest neighborhoods.

3. Results

3.1. Species Survey

The survey comprised 278 streets and squares. In total, 5044 individuals were recorded and they belonged to 189 species, 148 genera and 55 botanical families. *Lagerstroemia indica* was the most often found species, since it accounted for 25.4% of the total number of recorded trees. It was followed by *Murraya paniculata* (9.6%), *Handroanthus chrysotrichus* (7.9%), *Lagerstroemia speciosa* (4.2%) and *Eugenia uniflora* (3.2%). The top ten species represented 63% of the total number of recorded trees (Table 1).

Table 1. Species with more than 1% of the total relative abundance found in the urban tree population of Socorro, SP. N = Abundance; % percentage; Origin: Native or Exotic. Arranged in order of abundance.

Botany Family	Species	N	%	Origin
Lythraceae	<i>Lagerstroemia indica</i>	1282	25.4	Exotic
Rutaceae	<i>Murraya paniculata</i>	482	9.6	Exotic
Bignoniaceae	<i>Handroanthus chrysotrichus</i>	398	7.9	Native
Lythraceae	<i>Lagerstroemia speciosa</i>	211	4.2	Exotic
Myrtaceae	<i>Eugenia uniflora</i>	163	3.2	Native
Myrtaceae	<i>Callistemon viminalis</i>	152	3.0	Exotic
Fabaceae	<i>Cenostigma pluviosum</i>	133	2.6	Exotic
Arecaceae	<i>Roystonea oleracea</i>	117	2.3	Exotic
Melastomataceae	<i>Pleroma granulosum</i>	117	2.3	Native
Salicaceae	<i>Salix babylonica</i>	111	2.2	Exotic
Bignoniaceae	<i>Handroanthus heptaphyllus</i>	88	1.7	Native
Malvaceae	<i>Hibiscus rosa-sinensis</i>	80	1.6	Exotic
Malpighiaceae	<i>Malpighia emarginata</i>	76	1.5	Exotic
Fabaceae	<i>Senna macranthera</i>	61	1.2	Native
Oleaceae	<i>Ligustrum lucidum</i>	57	1.1	Exotic
Anacardiaceae	<i>Mangifera indica</i>	56	1.1	Exotic
Anacardiaceae	<i>Schinus molle</i>	54	1.1	Exotic
Fabaceae	<i>Bauhinia variegata</i>	54	1.1	Exotic
Arecaceae	<i>Syagrus romanzoffiana</i>	50	1.0	Native
Melastomataceae	<i>Pleroma mutabile</i>	50	1.0	Native

The most abundant genus was *Lagerstroemia* with 29.6% of the total number of trees, and it was followed by *Handroanthus* (9.8%) and *Murraya* (9.6%). The richest genus was *Eugenia*, with six species; it was followed by *Handroanthus* and *Machaerium*, (4 species, each).

The most abundant family was Lythraceae, with 30.2% of the total number of recorded trees; and it was followed by families Bignoniaceae (11.4%), Rutaceae (10.2%), Myrtaceae (8.5%), Fabaceae (8.4%) and Arecaceae (5.9%). The richest family was Fabaceae, with 32 species; which was followed by families Myrtaceae (18), Arecaceae (14) and Bignoniaceae (11). When it comes to species' origin, 73.3% of the individuals and 59% of the species were exotic. The remaining 26.4% of the individuals and 41% of the species were native (Table 1; Table A1).

With respect to dispersal, 47.6% of the species were zoochoric and 52.4% of them were non-zoochoric. In total, 32.7% of the individuals were zoochoric and 67.3% of them were non-zoochoric (Figure 3).

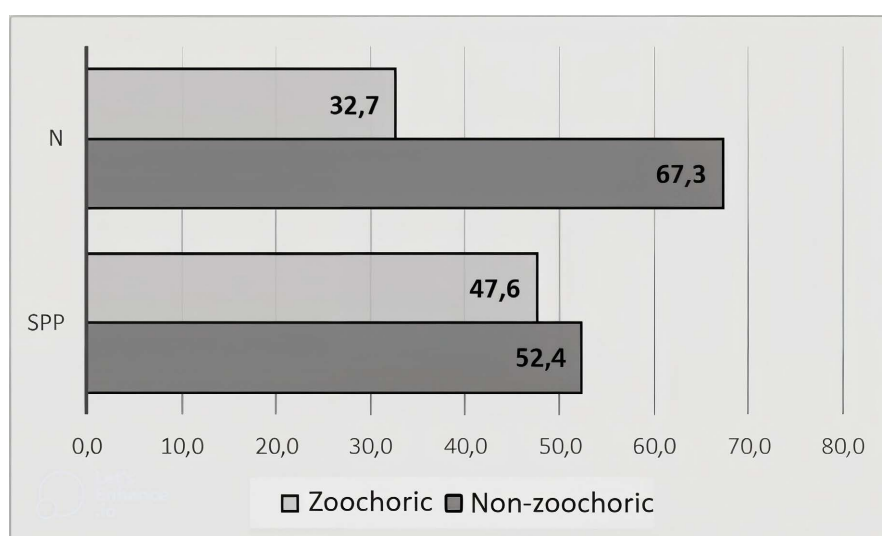


Figure 3. Relationship between zoochoric and non-zoochoric species (Spp) and individuals (N) found in the survey of urban vegetation in the municipality of Socorro, SP.

3.2. Damage Assessment

As for phytosanitary conditions, 67.6% of the individuals scored classification “1”, 12.0% of them scored “2”, 8.0% scored “3”, 4.8% scored “4” and 7.4% scored “5”. In absolute terms, the top five species presenting more problems with phytosanitary conditions were *Lagerstroemia indica*, *Murraya paniculata*, *Handroanthus chrysotrichus*, *Lagerstroemia speciosa*, and *Ligustrum lucidum*. These species accounted for 76% of the total number of trees scoring “5” and for 33.6% of those scoring “4”, and it represented 48.2% of the total number of recorded individuals.

In total, 426 trees out of this number scored “5” at least in one of the criteria, which corresponds to 8.4% of the total; 0.8% of the total recorded three scored “5”, 2% recorded two scores “5” and 6.1% were only scored once. It is worth

observing that these trees' removal after at least one total scoring was suggested (Table 2).

Table 2. Phyto-sanitary assessments, damage to wiring, and pavement data for species in the urban arborization of the municipality of Socorro, SP. Where: N—abundance data; %.

Classifications	Phyto		Wiring		Pavement	
	N	%	N	%	N	%
1	3411	67.6	4242	84.1	3978	78.9
2	612	12.1	359	7.1	649	12.9
3	404	8.0	233	4.6	209	4.1
4	242	4.8	128	2.5	57	1.1
5	375	7.4	82	1.6	151	3.0
Total	5044	100%	5044	100%	5044	100%

In relative terms, *Ligustrum lucidum*, *Triplaris americana*, *Caryota urens*, *Morus nigra*, and *Lagerstroemia speciosa* were the species presenting more problems as shown in Table 3.

Table 3. Species with the highest phytosanitary problems in absolute quantities (Phyto N) and relative percentages (Phyto %) in the urban arborization of Socorro-SP.

Species/Classifications	Phyto N						Phyto %				
	1	2	3	4	5	Total	1	2	3	4	5
<i>Lagerstroemia indica</i> (L.) Pers.	733	237	118	43	151	1282	57.2	18.5	9.2	3.4	11.8
<i>Murraya paniculata</i> (L.) Jack	309	44	33	48	48	482	64.1	9.1	6.8	10.0	10.0
<i>Handroanthus chrysotrichus</i> (Mart. ex A.DC.) Mattos.	341	25	9	4	19	398	85.7	6.3	2.3	1.0	4.8
<i>Lagerstroemia speciosa</i> (L.) Pers.	50	63	26	41	31	211	23.7	29.9	12.3	19.4	14.7
<i>Ligustrum lucidum</i> W. T. Aiton.	3	4	11	4	35	57	5.3	7.0	19.3	7.0	61.4
<i>Morus nigra</i> L.	21	0	9	7	7	44	47.7	0.0	20.5	15.9	15.9
<i>Caryota urens</i> L.	2	2	3	1	3	11	18.2	18.2	27.3	9.1	27.3
<i>Triplaris americana</i> L.	3	1	0	0	3	7	42.9	14.3	0.0	0.0	42.9

When it comes to public power wiring, 84.0% of individuals scored classification “1”, 7.1% scored “2”, 4.6% scored “3”, 2.6% scored “4” and 1.6% scored “5”. In absolute terms, *L. indica*, *M. paniculata*, *L. lucidum*, *M. nigra*, and *Cenostigma pluviosum* were the species accounting for more problems. These species accounted for 78% of the total number of trees scoring level “5” and for 52.3% of individuals scoring “4”, but they represented 39.6% of the total number of recorded individuals. In relative terms, these species were *L. lucidum*, *M. nigra*, *Delonix regia*, *Terminalia catappa*, and *Eriobotrya japonica* as shown in Table 4.

Table 4. Species with the greatest damage to wiring in absolute quantities (Wiring N) and relative percentages (Wiring %) in the urban arborization of Socorro-SP.

Species/Classifications	Wiring N						Wiring %				
	1	2	3	4	5	Total	1	2	3	4	5
<i>Lagerstroemia indica</i> (L.) Pers.	965	155	88	35	39	1282	75.3	12.1	6.9	2.7	3.0
<i>Murraya paniculata</i> (L.) Jack	432	15	13	8	14	482	89.6	3.1	2.7	1.7	2.9
<i>Ligustrum lucidum</i> W. T. Aiton.	45	0	3	3	6	57	78.9	0.0	5.3	5.3	10.5
<i>Morus nigra</i> L.	31	4	6	0	3	44	70.5	9.1	13.6	0.0	6.8
<i>Delonix regia</i> (Bojer ex Hook.) Raf.	14	2	2	0	2	20	70.0	10.0	10.0	0.0	10.0
<i>Terminalia catappa</i> L.	18	7	1	1	2	29	62.1	24.1	3.4	3.4	6.9
<i>Cenostigma pluviosum</i> (DC.) Gagnon & G. P. Lewis	96	8	6	21	2	133	72.2	6.0	4.5	15.8	1.5
<i>Eriobotrya japonica</i> (Thunb.) Lindl.	15	0	0	0	1	16	93.8	0.0	0.0	0.0	6.3

As for pavement, 78.9% of individuals scored classification “1”, 13.0% scored “2”, 4.1% scored “3”, 1.1% scored “4” and 3% scored “5”. *L. indica*, *L. lucidum*, *H. chrysotrichus*, *M. paniculata*, and *Callistemon viminalis* were the species showing the most significant issues. These species corresponded to 78.1% of the total number of trees scoring level “5” and to 68% of individuals scoring “4”, but they represented 47.0% of the total number of recorded individuals. In relative terms, *L. lucidum*, *Leucaena leucocephala*, *Schefflera actinophylla*, *Licania tomentosa*, and *Ceiba speciosa* were the species presenting more problems as shown in **Table 5**.

Table 5. Species causing the most damage to pavement in absolute quantities (Pavement N) and relative percentages (Pavement %) in the urban arborization of Socorro-SP.

Species/Classifications	Pavement N						Pavement %				
	1	2	3	4	5	Total	1	2	3	4	5
<i>Lagerstroemia indica</i> (L.) Pers.	783	329	85	23	62	1282	61.1	25.7	6.6	1.8	4.8
<i>Ligustrum lucidum</i> W. T. Aiton.	19	3	3	4	28	57	33.3	5.3	5.3	7.0	49.1
<i>Handroanthus chrysotrichus</i> (Mart. ex A.DC.) Mattos.	374	5	3	3	13	398	94.0	1.3	0.8	0.8	3.3
<i>Murraya paniculata</i> (L.) Jack	405	53	9	6	9	482	84.0	11.0	1.9	1.2	1.9
<i>Callistemon viminalis</i> (Sol. ex Gaertn.) G. Don	116	23	4	3	6	152	76.3	15.1	2.6	2.0	3.9
<i>Leucaena leucocephala</i> (Lam.) de Wit	5	0	0	0	1	6	83.3	0.0	0.0	0.0	16.7
<i>Schefflera actinophylla</i> (Endl.) Harms	5	1	0	0	1	7	71.4	14.3	0.0	0.0	14.3
<i>Licania tomentosa</i> (Benth.) Fritsch	8	2	0	0	1	11	72.7	18.2	0.0	0.0	9.1
<i>Ceiba speciosa</i> (A. St.-Hil.) Ravenna	9	0	2	0	1	12	75.0	0.0	16.7	0.0	8.3

3.3. Comparison between Surveys

The survey conducted in 2011 covered 275 locations in the investigated municipality, where 6829 trees belonging to 148 species were found. In 2021, 278 locations were surveyed, and 5044 trees belonging to 189 species were found. This

number represents 26% reduction in urban tree coverage in recent years. On the other hand, it represents 28% increase in the number of species. With respect to species' origin, exotic individuals represented 83.5% of the total number of individuals in 2011, and 68.2% of the species in this same year. Exotic individuals represented 73.3% of the total number of individuals in 2021, and 59% of the species as shown in **Table 4** and **Figure 4**.

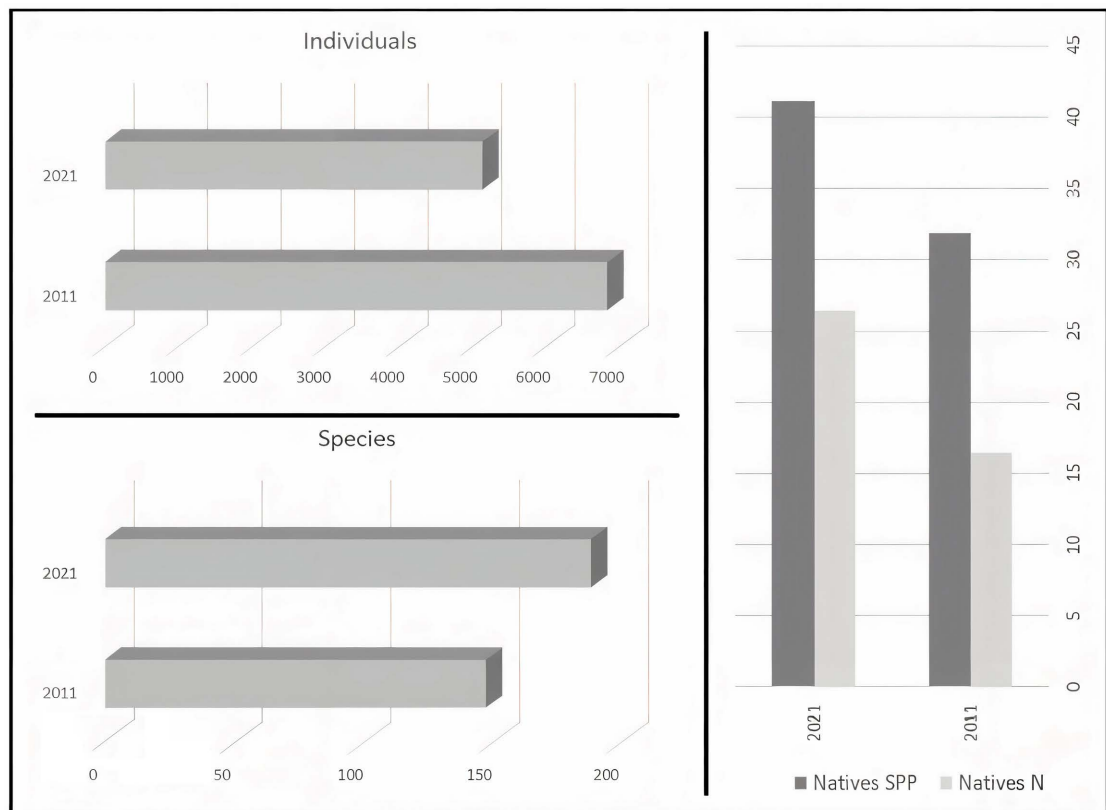


Figure 4. Comparison between the quantity of individuals, species, and the origin of individuals and species found in the two surveys of urban arborization in the municipality of Socorro-SP.

Only 18 species represented more than 1% of the total number of trees in 2011, but this number increased to 21 species in 2021. In total, 9 of these 21 species recorded reduction in number of individuals and 12 species recorded increase in this number. Among the species whose number had decreased in both censuses, some were no longer part of the most representative ones (with more than 1%), namely: *M. nigra*, *Ficus benjamina*, *Magnolia champaca*, *Caesalpinia pulcherrima*, and *Rhododendron simsii* as shown in **Table 6**.

Regarding the damages caused by trees, there were no records of trees scoring level “5” for causing any damage to pavement or public power wiring in 2011. Only four plants recorded level “4” for pavement and two plants recorded level “4”, for wiring. In 2021, there were 82 trees scoring level “5” for wiring and 131 scored level “4”. When it comes to pavement, 153 trees scored level “5” and 57 scored level “4” as shown in **Table 7**.

Table 6. Comparison between the most representative species, those with more than 1% of the total, between the surveys of 2011 and 2021 in the municipality of Socorro, SP. The data present the species, the position of the species in the survey, the number of individuals (N), and the percentage of gain or loss in relation to 2011 and 2021.

Species	2021		2011		%
	Position	N	Position	N	
<i>Lagerstroemia indica</i> (L.) Pers.	1	1282	1	1708	-24.9
<i>Murraya paniculata</i> (L.) Jack	2	482	2	1362	-64.6
<i>Handroanthus chrysotrichus</i> (Mart. ex A.DC.) Mattos.	3	398	3	308	29.2
<i>Lagerstroemia speciosa</i> (L.) Pers.	4	211	5	231	-8.7
<i>Eugenia uniflora</i> L.	5	163	9	155	5.2
<i>Callistemon viminalis</i> (Sol. ex Gaertn.) G. Don	6	152	7	169	-10.1
<i>Cenostigma pluviosum</i> (DC.) Gagnon & G. P. Lewis	7	133	4	239	-44.4
<i>Roystonea oleracea</i> (Jacq) O. F. Cook.	8	117	18	74	58.1
<i>Pleroma granulatum</i> (Desr.) D. Don	9	117	8	168	-30.4
<i>Salix babilonica</i> L.	10	111	40	25	344.0
<i>Handroanthus heptaphyllus</i> (Vell.) Mattos	11	88	12	102	-13.7
<i>Hibiscus rosa-sinensis</i> L.	12	80	6	179	-55.3
<i>Malpighia emarginata</i> DC.	13	76	32	32	137.5
<i>Senna macranthera</i> (DC. ex Collad.) H. S. Irwin & Barneby	14	61	19	57	7.0
<i>Ligustrum lucidum</i> W. T. Aiton.	15	57	11	113	-49.6
<i>Mangifera indica</i> L.	16	56	25	44	27.3
<i>Schinus molle</i> L.	17	54	24	45	20.0
<i>Bauhinia variegata</i> (L.) Benth.	18	54	10	113	-52.2
<i>Syagrus romanzoffiana</i> (Cham.) Glassman LC	19	50	29	36	39.0
<i>Pleroma mutabile</i> (Vell.) Triana	20	50	37	28	78.6
<i>Cupressus sempervirens</i> L.	21	47	79	6	683.3

Table 7. Data on phytosanitary evaluations, damage to wiring, and pavement-related data for species in the urban tree inventory of Socorro, SP. Where: N—abundance data; %.

Evaluation	Wiring					Pavement					Total
	1	2	3	4	5	1	2	3	4	5	
2011	6134	514	189	2	0	6393	351	91	4	0	6839
2021	4242	359	233	128	82	3978	649	209	57	151	5044

3.4. Comparison between Neighborhoods

The comparison between neighborhoods showed 27 neighborhoods classified based on vulnerability and 17 of them were classified as low vulnerability, namely: the wealthiest neighborhoods (nine were classified as medium vulnerability, and only one was classified as high vulnerability). In total, 89,038 meters were covered in these neighborhoods if one has in mind the mean distance of 18 m between one tree and the next one in the city. However, the distance between trees increased to

39 meters in the most vulnerable neighborhoods, and this same distance dropped to 14 m in the least vulnerable neighborhoods. The most vulnerable neighborhoods presented 36% of the street length and 17% of the trees, whereas the least vulnerable neighborhoods presented 64% of the street length and 83% of the trees as shown in **Table 8** and **Figure 5**.

Table 8. Comparative data between affluent and impoverished neighborhoods in the municipality of Socorro, SP, vulnerability, regarding the total street length (combined meters of streets_m), number of streets (total_streets), Number of trees per total meters of the area (trees_m = street_m/total trees), and number of Trees species.

N	Neighborhood	vulnerability	Streets_m	Total_streets	Trees_m	Total_species
1	Abadia	Median	2368.4	105	29.980	16
2	Gollo	Median	2694.5	62	43.459	15
3	Jd._araujo	Median	4363.9	170	25.670	32
4	Loteam_Santa_Cruz	High	5012.5	22	227.840	5
5	Mazzolini	Median	1334.8	27	49.437	5
6	Santa_Cruz	High	5532.8	63	100.596	19
7	Vila_Nova	Median	3052.6	83	37.686	27
8	Vila_Palmira	Median	3237.0	213	21.019	45
9	S.Vicente	Median	1365.5	46	29.684	14
10	Aparecidinha	Low	5436.9	408	13.491	53
11	Bela_Vista	Low	3419.7	244	14.015	47
12	Brun_Maria	Low	1099.7	84	13.092	22
13	Jd_Barbosa	Low	1443.4	89	26.730	28
14	Jd_Carvalho	Low	444.3	17	26.138	9
15	Jd_Saltinho	Low	3466.5	164	22.509	54
16	Jd_Teixeira	Low	2291.9	109	21.026	22
17	Jd_Jussara	Low	1187.7	129	9.816	25
18	Jd_Orlandi	Low	1758.3	128	14.531	31
19	Pompeia	Low	2001.6	208	9.623	17
20	F_Barbosa	Low	3150.2	463	7.001	45
21	Palma_real	Low	2099.9	157	16.153	29
22	Sam_Remoo	Low	390.9	18	21.717	3
23	Santa_Helena	Low	587.7	60	9.794	1
24	Santa_Rosa	Low	4452.8	477	10.653	77
25	Santa_Teresinha	Low	964.5	35	27.557	16
26	Centro	Low	23124.1	1341	22.648	95
27	Cubas	High	2756.4	31	88.917	15
Total			89038.3	4953.0	-	
Average			3297.7	183.4	34.8	
Standard deviation			4233.1	264.7	44.4	

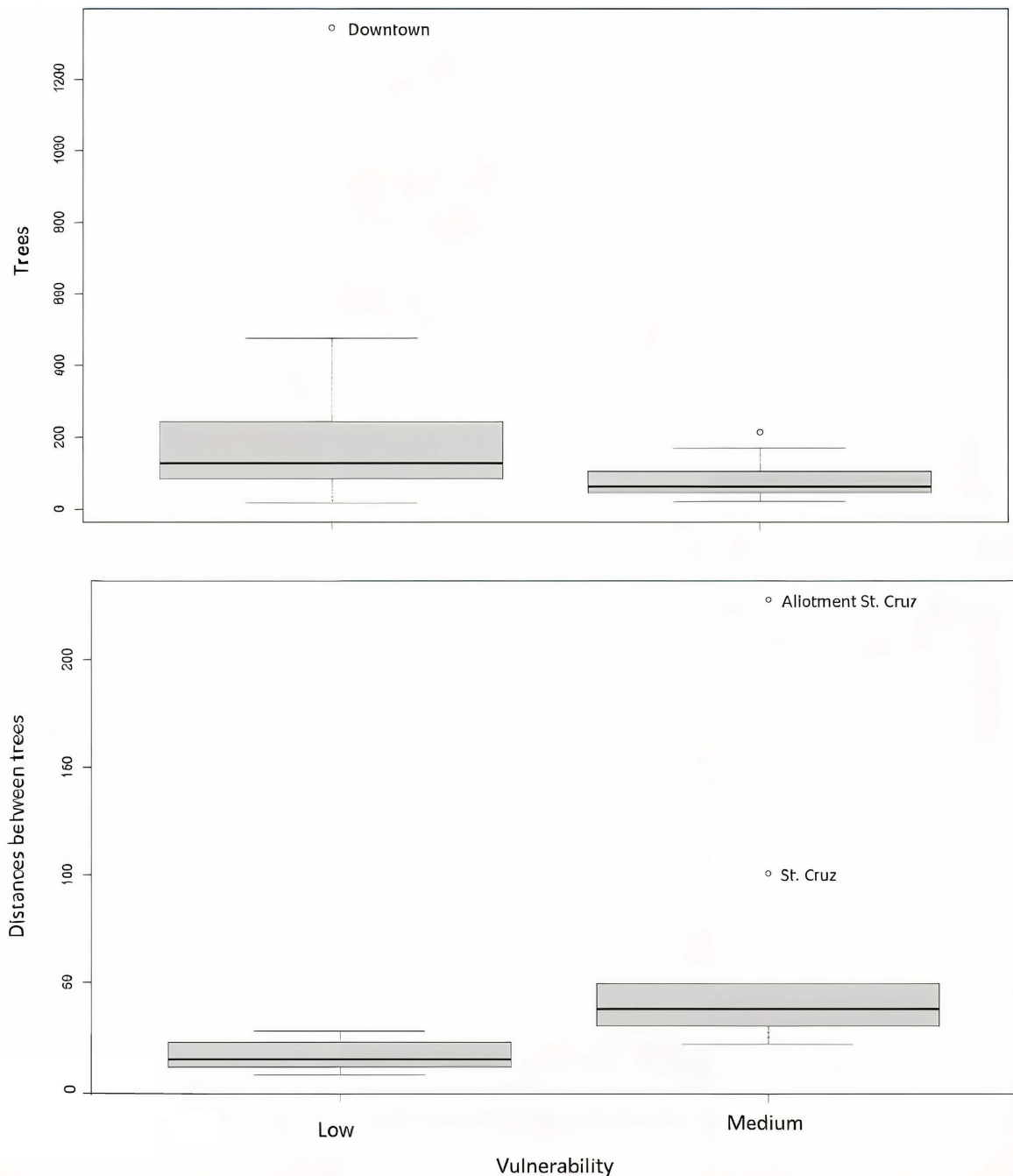


Figure 5. Comparative data between more and less socially vulnerable neighborhoods in the municipality of Socorro, SP, regarding the number of trees (above) and the distances between trees (below).

Discriminant analysis was carried out by taking into consideration the following parameters: total dimension of streets expressed in meters in a given neighborhood); total number of streets; mean distance between one tree and the next one in the neighborhood, based on the number of trees divided by the total metric of streets; and number of species. MANOVA analysis showed that all variables were significant in separating neighborhoods based on their vulnerability (high, medium or low) (Figure 6).

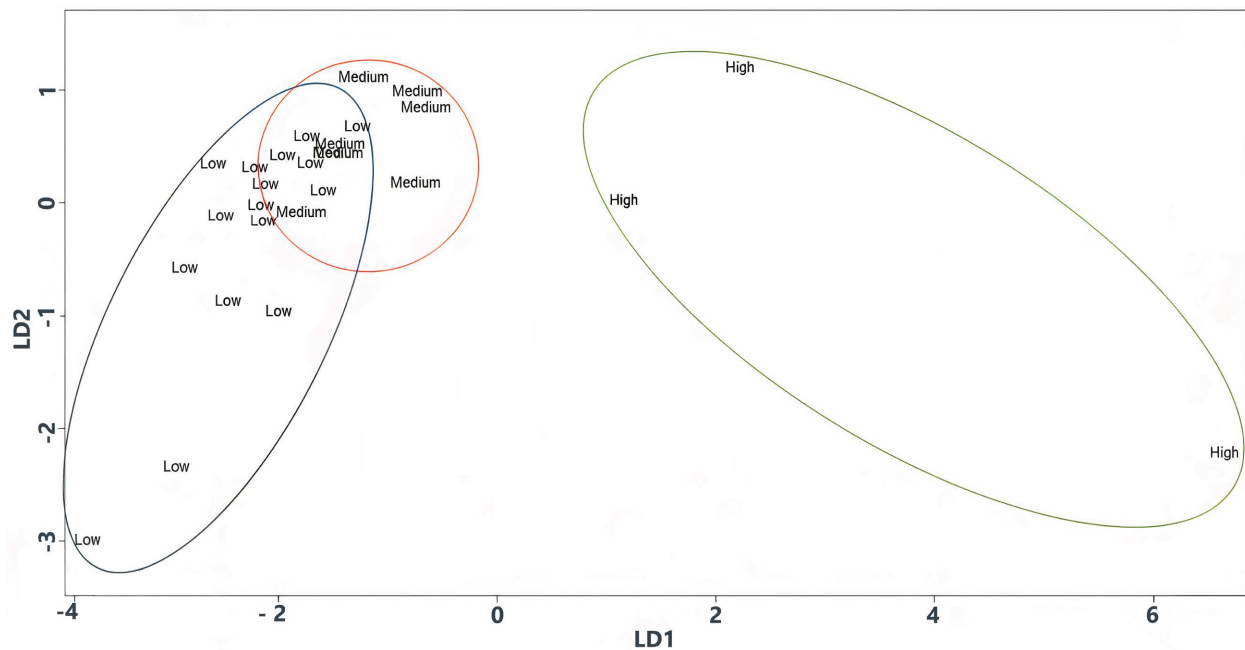


Figure 6. Discriminant analysis graph showing neighborhoods with high vulnerability, medium vulnerability, and low vulnerability regarding parameters of urban arborization in the municipality of Socorro, SP.

4. Discussion

The municipality of Socorro, although a small town in the interior of the state of São Paulo, faces urban tree planting challenges that are highly relevant and representative of the broader reality of urban arborization across Brazil. Similar processes to those observed in this study have been identified in major urban centers, such as Rio de Janeiro, the second-largest city in the country, as presented by [Ribeiro et al. \(2024\)](#). These phenomena reflect both the presence of municipal government incentives and the lack of investment. Administrations with less interest in urban tree planting can lead to a rapid decline in tree coverage, disproportionately affecting more vulnerable populations, who suffer from the lack of investment and neglect. Thus, we observed that tree coverage in the municipality of Socorro has significantly decreased over the past ten years.

Surveyed species did not differ from those of other surveys conducted in Brazilian municipalities, regardless of their distance. Rio de Janeiro ([Sartori et al., 2019, 2021](#)) and Araras-SP ([Martins & Correa, 2016](#)), in the Southeastern region; Jataí-GO ([Barros, 2010](#)), in the Midwestern region, Fortaleza-CE ([Moro & Castro, 2015](#)), in the Northeastern region and Altamira-PA ([Parry et al., 2012](#)), in the Northern region are examples of it—all these Brazilian municipalities virtually have the same species. Urban afforestation shows a monotony process and the use of exotic species ([Rufino et al., 2019; Abreu et al., 2023](#)). The current study recorded a relatively large number of species, but 90.7% of them were rare, and each of these species represented approximately 1% of the total number of individuals.

These uncommon afforestation species point out residents' actions towards

planting trees, although it is prohibited by law. This finding highlights the need for municipal action to develop rules on how, what and where to plant. Despite the legislation, people know they are unlikely to be fined and that, in the future, problems will be passed on to the municipal administration. Species planted in the wrong places can cause damages and lead to high municipal expenses since funds must be reallocated from environmental investments in order to mitigate environmental issues (Roman et al., 2021). Maringá municipality spent over 700 thousand reais (approximately 140 thousand dollars) to compensate damages caused by trees between 2005 and 2010.

The two most often found species in the municipality showed high density, although their number decreased in the last ten years. *Lagerstroemia indica* was the most often found species in 2009, although it experienced a 25% reduction, and *Murraya paniculata* recorded 65% reduction. Reduction in *M. paniculata* is understandable, because of Municipal Law 3323/2009, which prohibited this species' production, transport and trade (Socorro, 2009), since it hosts bacteria that can be transmitted to species belonging to genus *Citrus* and cause economic losses in the agricultural field (Ternes et al., 2023).

Species like *Handroanthus chrysothrichus* and *Eugenia uniflora* are native alternatives because they provide essential ecosystem services, such as fruit production for fauna (de Jesus et al., 2023) and flower production for bees (Barth et al., 2020), in addition to being important ornamental and landscaping species (Aguiar et al., 2022; dos Santos Silvério de Sá et al., 2021).

Regarding the origin of species, 73.3% of individuals and 59% of species are exotic, and this finding points out that using non-native species in the Atlantic Forest is still common (Rufino et al., 2019). Using native species is crucial due to their intrinsic relationship with the species forming the local ecosystem (Alves et al., 2023). It does not only prevent species' invasion (Moro et al., 2014), but also has individuals that are fully suitable and already adapted to the location; therefore, they help preventing the incidence of herbivores or other disease types (Pan et al., 2019). Lack of native species may be linked to lack of study on local vegetation or on the constant use of what is already common (Alves et al., 2023). This process still represents a colonial way of thinking, according to which, species were used based on landscapers' choice and on their origins. Many European landscapers started afforestation processes in Brazil in the 19th century, and many plants were selected to represent European squares in Brazilian squares, mainly those found in Parisian squares (Terra et al., 2021).

Using zoochoric species is essential for communities' ecological dynamics (Salcedo & Ceccon, 2020) because zoochory is one of the most critical existing interactions (Vizentin-Bugoni et al., 2021) and it enables animals, mainly birds, to use these trees as food resources (Oliveira et al., 2020).

With respect to damage assessment, many species presented phytosanitary issues regarding public power wiring or pavement. Over 7% of plants had severe phytosanitary issues and they were classified as level "5". However, in the initial

assessment, back in 2009, no plant had ever been classified as such, and this finding indicates that plants are aging, and many of them are the same ones assessed in the first survey, although it is not possible to precisely determine their age. Two factors in the process can boost phytosanitary issues: age and poorly performed pruning, since it makes it easier for pathogens to enter the plants (Martins et al., 2010, Das Graças Emerick et al., 2024). Accordingly, *L. indica* was the species widely used in the 1990s in the herein assessed municipality, but it has been lesser used in the last two decades; therefore, plants are older. This same species undergoes constant pruning, at least once a year, and it weakens its representatives (Martins et al., 2010, Das Graças Emerick et al., 2024).

Damage related to public power wiring should be carefully taken into consideration because it causes structural problems in cities that result in expenses for the municipality, besides leading to power outages and even to fire events (Santos et al., 2015). However, these problems can be mitigated by using suitable species and proper pruning. Yet, it is unlikely for trees to do not reach the wiring, since they easily exceed eight meters in height. Nevertheless, trees' drastic pruning to prevent them from touching the wires should be avoided (Dorigon & Pagliari 2013; Oliveira et al., 2023).

When it comes to pavement, using the correct species can help to avoid this problem (Dorigon & Pagliari 2013; Valença et al., 2024). Using species with large roots in small pavements, such as *Ligustrum lucidum*, *Ficus* sp., and *Licania tomentosa*, must take into consideration the fact that pavements in the assessed municipality rarely exceed 1.5 meters, and it may pose risk for future problems. However, they can be used in squares, flowerbeds and green areas. Oftentimes, adjusting the pavement helps minimizing problems (Martelli & de Moraes Cardoso, 2018).

As for structural damage, trees with large and dehiscent fruits increase people's prejudice towards urban afforestation (Basso & Corrêa, 2014). This is one of the processes to be avoided, because public acceptance of urban afforestation is one of the main factors contributing to its success (Basso & Corrêa, 2014).

The comparison between the two surveys showed that Socorro municipality has lost a significant part of its urban afforestation. In addition to losing 26% of its tree individuals, there is a large number of plants causing significant public power wiring, pavement and phytosanitary issues, and they were classified as level "5". In other words, these species must be removed to avoid future problems. Thus, it is essential to take into consideration that urban afforestation on public roads is a dynamic process, and that trees' constant surveillance, maintenance and replacement is always necessary (Basso & Corrêa, 2014).

The number of species has increased and it can be related to the fact that the population has started planting trees on the streets and this process led to diversification. Socorro municipality has standard species to plant on the streets, which account for minimal variation (Albertin et al., 2023). Yet, this municipality is undergoing a remodeling process, and many condominiums use plants considered

illustrative of European factors, such as *Salix babylonica* and *Cupressus sempervirens*.

Socorro municipality could house from 15 to 17 thousand trees in 2009 if one has in mind the mean spacing of six meters between trees. Currently, the municipality is covering about a third of its capacity. Based on these measurements, Santa Cruz neighborhood could house 808 trees; however, it only has 26. This is one of the poorest neighborhoods in the municipality, a fact that shows significant social discrepancy due to the number of trees, as reported by [Salmi et al. \(2023\)](#), [Heath \(2016\)](#) and [Brooks \(2020\)](#).

The smaller number of trees in urban afforestation is related to trees' removal in recent years and to lack of actions aimed at their replacement. Lack of public participation in this process is quite significant. However, increase in the number of species shows that the planted trees are part of a planting process driven by the population, although unplanned. Public participation in planting seedlings in urban areas is very interesting. However, this process can be extremely harmful in the future ([Paes et al., 2022](#)) because lack of planning can make planted trees invasive ([Abreu et al., 2023](#)) or cause damage to urban structures ([Sartori et al., 2021](#)). Public involvement in this process should be carried out in such a way to make sure that public authorities can control and actively participate in these actions by providing information and seedlings.

However, one of the facts that brought to light greater strangeness has already been seen in many other studies, namely: urban afforestation works as indicator of neighborhoods, even in a small municipality where there are no social issues like slums and where social differences are not very clear ([Salmi et al., 2023](#)). Lack of urban afforestation in these neighborhoods not only indicates lack of trees, and this is actually the consequence of several other factors, such as lack of municipal investment ([Sousa et al., 2022](#)).

The main issue is not the lack of afforestation faced by these neighborhoods, but lack of all the elements it represents. Urban afforestation reduces temperature ([Benz et al., 2021](#); [Hsu et al., 2021](#); [McDonald & Forte, 2021](#)) and noise pollution ([Oliveira et al., 2022](#)), sequesters carbon ([Brilli et al., 2022](#)), increases interaction with fauna ([Vizentin-Bugoni et al., 2021](#)), reduces health issues, mainly the psychological ones, in residents ([Cox et al., 2017](#); [Methorst et al., 2021](#); [Silva et al., 2019](#)), provides shade ([da Silva et al., 2023](#)), removes air pollution ([Arias et al., 2022](#)), facilitates water infiltration ([Lourenço et al., 2020](#)) and helps with climate issues ([Marçal et al., 2021](#)), among many other factors. Thus, the issue does not lie on who has the right to have a tree in front of their house, but on who has the right to get all social and ecological benefits they provide.

This work took a local approach, but it serves as a preliminary study for other projects that could be carried out within the same context, addressing the ecological and social issues presented by urban tree planting. In this way, we believe that this work could be expanded and presented more broadly to larger municipalities. Generally, studies focus solely on urban tree planting, taking into account only

the biological aspects, but the ecological aspects, such as the origin of species and types of dispersal, are often neglected. Furthermore, the entire social issue associated with urban tree planting is overlooked, an issue of utmost importance in both the Brazilian and global contexts. Thus, we highlight a problem presented by urban tree planting, and two questions arise: Why do only wealthier neighborhoods have the right to proper urban tree planting, and what has been done with native species, so important and yet so rarely used in urban planting? With these questions, we conclude and suggest that municipalities reconsider their environmental management.

5. Final Considerations

The present study allowed for the quantification of urban vegetation loss in Socorro municipality. The city lost approximately 25% of its trees recorded in 2009. This finding shows how lack of municipal investment in urban afforestation can lead to considerable loss of trees in the urban area within 10 years or so.

Species increase results from general planting by the population, which may soon cause problems, because many of the planted trees did not follow any criteria or get any technical assistance. This process could lead to higher expenses for the municipal administration to remove, maintain and even compensate these trees in the future.

Trees also show problems regarding public power wiring, as well as phytosanitary and pavement issues, due to their aging and improper pruning.

Despite being a small municipality in the hinterlands of the country's wealthiest state, social differences still reflect on urban afforestation. Poorer neighborhoods lack urban afforestation, and have lower species diversity and wider spacing between trees than the wealthier neighborhoods because of lack of proximity between the municipal administration and these neighborhoods.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Annex

Table A1. Species found in the survey of the urban arborization in Socorro-SP ordered by percentage of occurrence with data from: Botanical family; Scientific name of species; Common names; ori = Origin (Nativ or exotic); N° = Number of individuals; and % = Total percentage of individuals.

Botany family	Scientific names	Common names	Ori	N°	%
Lythraceae	<i>Lagerstroemia indica</i> L.	Resedá	e	1708	23.64
Rutaceae	<i>Murraya paniculata</i> (L.) Jack	Murta	e	1362	18.85
Bignoniaceae	<i>Handroanthus chrysotrichus</i> (Mart. ex DC.) Mattos	Ipê-amarelo	n	308	4.26
Fabaceae	<i>Poincianella pluviosa</i> (DC.) L.P.Queiroz	Sibipiruna	e	239	3.31
Lythraceae	<i>Lagerstroemia speciosa</i> (L.) Pers.	Resedá-gigante	e	231	3.20
Malvaceae	<i>Hibisco rosa-sinensis</i> L.	Hibisco	e	179	2.48
Myrtaceae	<i>Callistemon imperialis</i> (Sol. Ex Gaertn.) G. Don ex Loud.	Escova-de-garrafa	e	169	2.34
Melastomataceae	<i>Tibouchina granulosa</i> (Desr.) Cogn.	Quaresmeira	n	168	2.32
Myrtaceae	<i>Eugenia uniflora</i> L.	Pitanga	n	155	2.15
Fabaceae	<i>Bauhinia divaricata</i> L.	Pata-de-vaca	e	113	1.56
Oleraceae	<i>Ligustrum lucidum</i> W.T.Aiton	Alfineiro	e	113	1.56
Bignoniaceae	<i>Handroanthus impetiginosus</i> Mattos	Ipê-roxo	n	102	1.41
Moraceae	<i>Morus nigra</i> L.	Amora	e	94	1.30
Moraceae	<i>Ficus benjamina</i> L.	Ficus-benjamina	e	92	1.27
Magnoliaceae	<i>Magnolia champaca</i> (L.) Baill. ex Pierre.	Magnolia-amarela	e	89	1.23
Fabaceae	<i>Caesalpinia pulcherrima</i> (L.) Sw.	Flamboianzinho	e	78	1.08
Ericaceae	<i>Rhododendron simsii</i> Planch.	Azaléia	e	77	1.07
Arecaceae	<i>Roystonea oleracea</i> (NJ Jacquin) OF Cook	Palmeira-imperial	e	74	1.02
Fabaceae	<i>Cassia leptophylla</i> Vogel	Falso-Barbatimão	e	57	0.79
Verbenaceae	<i>Duranta vestita</i> Cham.	Pingo-de-ouro	e	56	0.77
Myrtaceae	<i>Psidium guajava</i> L.	Goiaba	n	51	0.71
Combretaceae	<i>Terminalia catappa</i> L.	Chapéu-de-sol	e	47	0.65
Anacardiaceae	<i>Schinus mole</i> L.	Aroeira-salvo	e	45	0.62
Fabaceae	<i>Cassia javanica</i> Linn.	Cassia-rosea	e	45	0.62
Anacardiaceae	<i>Mangifera indica</i> L.	Manga	e	44	0.61
Apocynaceae	<i>Nerium oliander</i> L.	Loandro	e	41	0.57
Lythraceae	<i>Punica granatum</i> L.	Romã	e	40	0.55
Fabaceae	<i>Delonix regia</i> (Bojer ex Hook.) Raf.	Flamboyant	e	39	0.54
Arecaceae	<i>Syagrus romanzoffiana</i> (Cham.) Glassman	Jerivá	n	36	0.50
Mortas				36	0.50
Arecaceae	<i>Archontophoenix cunninghamiana</i> H. Wendl. & Drude	Seafórtia	e	34	0.47
Malpighiaceae	<i>Malpighia emarginata</i> DC.	Acerola	e	32	0.44
Bignoniaceae	<i>Tabebuia roseoalba</i> (Ridl.) Sandwith	Ipê-branco	n	30	0.42
Arecaceae	<i>Dypsis lutescens</i> (H. Wendl.) Beentje & J. Dransf	Areca-bambu	e	28	0.39
Melastomataceae	<i>Brunfelsia uniflora</i> (Pohl) D. Don	Manacá-de-jardim	e	28	0.39
Melastomataceae	<i>Tibouchina candolleana</i> (Mart. ex DC.) Cogn.	Manacá-da-serra	n	28	0.39

Continued

Sapindaceae	<i>Koelreuteria bipinnata</i> Franch	Árvore-da-China	e	28	0.39
Rosaceae	<i>Eriobotrya japonica</i> (Thunb.) Lindl.	Nêspera	e	27	0.37
Rosaceae	<i>Prunus serrulata</i> Lindl.	Cerejeira-do-Japão	e	27	0.37
Bignoniaceae	<i>Jacaranda mimosifolia</i> D.Don.	Jacarandá-mimoso	e	24	0.33
Fabaceae	<i>Machaerium villosum</i> Vogel	Jacarandá-paulista	n	23	0.32
Bignoniaceae	<i>Spathodea nilotica</i> Seem	Espatódea	e	22	0.30
Rutaceae	<i>Citrus limon</i> (L.) Osbeck	Limão	e	22	0.30
Nyctaginaceae	<i>Bougainvillea glabra</i> Choisy	Primavera	n	20	0.28
Cupressaceae	<i>Cupressus lusitanica</i> Mill.	Cedro	e	18	0.25
Fabaceae	<i>Calliandra houstoniana</i> (Mill.) Standl.	Caliandra	e	18	0.25
Anacardiaceae	<i>Schinus terebinthifolius</i> Raddi	Aroeira-pimenteira	n	17	0.24
Apocynaceae	<i>Plumeria rubra</i> L.	Jasmim-manga	e	17	0.24
Araliaceae	<i>Schefflera actinophylla</i> (Endl.) Harms	Chifre-de-veado	e	17	0.24
Fabaceae	<i>Cassia fistula</i> Linn.	Cássia-chuva-de-ouro	e	17	0.24
Lauraceae	<i>Persea americana</i> Mill.	Abacate	e	16	0.22
Arecaceae	<i>Euterpe edulis</i> Mart.	Palmito-Jussara	n	14	0.19
Arecaceae	<i>Lytocaryum weddellianum</i> (H.Wendl.) Tol.	Coco-vedeliano	e	14	0.19
Euphorbiaceae	<i>Euphorbia pulcherrima</i> Willd.	Poinsettia	e	14	0.19
Myrtaceae	<i>Psidium cattleianum</i> Sabine	Araçá	n	13	0.18
Myrtaceae	<i>Eugenia uvalha</i> Cambess.	Uvaia	n	12	0.17
Crhysobalonaceae	<i>Licania tomentosa</i> (Benth.) Fritsch	Oiti	e	11	0.15
Fabaceae	<i>Tipuana tipu</i> (Benth.) Kuntze	Tipuana	e	11	0.15
Rutaceae	<i>Citrus reticulata</i> Blanco	Mexerica	e	11	0.15
Cupressaceae	<i>Thuja occidentalis</i> L.	Tuia	e	10	0.14
Polygonaceae	<i>Triplaris americana</i> L.	Pau-de-formiga	e	10	0.14
Malvaceae	<i>Ceiba erianthos</i> (Cav.) K.Schum.	Paineira	n	9	0.12
Proteaceae	<i>Grevillea robusta</i> A. Cunn. Ex. R. Br.	Grevilha	e	9	0.12
Arecaceae	<i>Acrocomia aculeata</i> (Jacq.) Lodd. ex Mart.	Macaúba	e	8	0.11
Arecaceae	<i>Cariota urens</i> L.	Cariota	e	8	0.11
Arecaceae	<i>Copernicia prunifera</i> (Mill.) H.E.Moore	Carnaúba	e	8	0.11
Bignoniaceae	<i>Handroanthus serratifolius</i> (A.H.Gentry) S.Grose	Ipê-amarelo	n	8	0.11
Cupressaceae	<i>Juniperus chinensis</i> L.	Zimbros	e	8	0.11
Fabaceae	<i>Anadenanthera colubrina</i> (Vell.) Brenan	Angico-branco	n	8	0.11
Fabaceae	<i>Peltophorum dubium</i> (Spreng.) Taub.	Canafistula	n	8	0.11
Fabaceae	<i>Platycamus regnellii</i> Benth.	Pau-pereira	n	8	0.11
Oxalidaceae	<i>Averrhoa carambola</i> L.	Carambola	e	8	0.11
Podocarpaceae	<i>Podocarpus macrophyllus</i> (Thumb.) D. Don	Podocarpus	e	8	0.11
Rubiaceae	<i>Coffea arabica</i> L.	Café	e	8	0.11
Fabaceae	<i>Caesalpinia echinata</i> Lam.	Pau-Brasil	e	7	0.10
Magnoliaceae	<i>Magnolia grandiflora</i> L.	Magnólia	e	7	0.10

Continued

Rhamnaceae	<i>Hovenia dulcis</i> Thunb.	Uva-japonesa	e	7	0.10
Araliaceae	<i>Schefflera arboricola</i> Hayata	Cheflera	e	6	0.08
Casuarinaceae	<i>Casuarina equisetifolia</i> Forst. & Forst.	Casuarina	e	6	0.08
Cupressaceae	<i>Cupressus sempervirens</i> L.	Cipreste-italiano	e	6	0.08
Euphorbiaceae	<i>Euphorbia cotinifolia</i> L.	Leiteiro-vermelho	e	6	0.08
Euphorbiaceae	<i>Joannesia princeps</i> Vell.	Boleira	e	6	0.08
Fabaceae	<i>Erythrina crista-galli</i> L.	Murungu	n	6	0.08
Pinaceae	<i>Pinus elliottii</i> L.	Pinus	e	6	0.08
Bigoniaceae	<i>Handroanthus heptaphyllus</i> Mattos	Ipê-de-folhas-pequenas	e	5	0.07
Ebenaceae	<i>Diospyros kaki</i> L.	Caqui	e	5	0.07
Griselinaceae	<i>Pittosporum tobira</i> (Thunb.) Aiton fil.	Pitosporo	e	5	0.07
Myrsinaceae	<i>Myrsine guianensis</i> (Aubl.) Kuntze	Capororoca	n	5	0.07
Sapindaceae	<i>Sapindus saponaria</i> L.	Saboeiro	e	5	0.07
Agavaceae	<i>Yucca elephantoides</i> Regel	Pata-de-elefante	e	4	0.06
Annonaceae	<i>Annona squamosa</i> L.	Fruta-do-conde	e	4	0.06
Apocynaceae	<i>Thevitia thevetioides</i> Adans	Chapéu-de-Napoleão	e	4	0.06
Araucariaceae	<i>Araucaria angustifolia</i> (Bertol.) Kuntze	Pinheiro-do-paraná	n	4	0.06
Bigoniaceae	<i>Tecoma stans</i> (L.) Juss. ex Kunth	Falso-ipê	e	4	0.06
Fabaceae	<i>Inga vera</i> Willd.	Ingá-do-brejo	n	4	0.06
Fabaceae	<i>Libidibia ferrea</i> (Mart. ex Tul.) L.P.Queiroz	Pau-ferro	n	4	0.06
Lecythidaceae	<i>Cariniana legalis</i> (Mart.) Kuntze	Jequitibá	n	4	0.06
Lythraceae	<i>Lafoensia pacari</i> A.St.-Hil.	Dedaleiro	n	4	0.06
Myrtaceae	<i>Myrcia</i> sp.	Guamixama	e	4	0.06
Myrtaceae	<i>Myrcia splendens</i> (Sw.) DC.	Guamirim	n	4	0.06
Myrtaceae	<i>Myrciaria cauliflora</i> Berg.	Jaboticaba	n	4	0.06
Myrtaceae	<i>Syzygium cumini</i> (L.) Skeels	Jambolão	e	4	0.06
Araucariaceae	<i>Araucaria columnaris</i> Hook.	Araucária-excelsa	e	3	0.04
Bixaceae	<i>Bixa orellana</i> L.	Urucum	e	3	0.04
Euphorbiaceae	<i>Sapium glandulosum</i> (L.) Morong	Leiteiro	n	3	0.04
Fabaceae	<i>Inga marginata</i> Willd.	Ingá	n	3	0.04
Fabaceae	<i>Leucaena leucocephala</i> (Lam.) de Wit	Leocena	e	3	0.04
Fabaceae	<i>Samanea tubulosa</i> (Benth.) Barneby & J.W.Grimes	Alforobo	e	3	0.04
Malvaceae	<i>Pachira aquatica</i> Aubl.	Castanha-do-Maranhão	e	3	0.04
Rubiaceae	<i>Gardenia jasminoides</i> J. Ellis	Gardenia	e	3	0.04
Rutaceae	<i>Balfourodendron riedelianum</i> (Engl.) Engl.	Pau-marfim	n	3	0.04
Salicaceae	<i>Casearia sylvestris</i> Sw.	Erva-de-lagarto	n	3	0.04
Sapindaceae	<i>Litchi chinensis</i> Sonn.	Lichia	e	3	0.04
Cannabaceae	<i>Trema micrantha</i> (L.) Blume	Trema	n	2	0.03
Euphorbiaceae	<i>Euphorbia leucocephala</i> Lotsy	Neve-da-montanha	e	2	0.03
Fabaceae	<i>Acacia podalyriifolia</i> A. Cunningham ex G. Don.	Acácia	e	2	0.03

Fabaceae	<i>Bauhinia forficata</i> Link	Pata-de-vaca	n	2	0.03
Fabaceae	<i>Gleditsia triacanthos</i> L.	Espinheiro-da-virginia	e	2	0.03
Fabaceae	<i>Pterocarpus violaceus</i> Vogel	Aldrago	e	2	0.03
Lauraceae	<i>Ocotea pulchella</i> (Nees & Mart.) Mez	Canela-preta	n	2	0.03
Lecythidaceae	<i>Cariniana estrellensis</i> (Raddi) Kuntze	Jequitibá-rosa	n	2	0.03
Malpighiaceae	<i>Byrsonima</i> sp.	Murici	e	2	0.03
Meliaceae	<i>Cedrela fissilis</i> Vell.	Cedro-rosa	n	2	0.03
Myrtaceae	<i>Syzygium jambos</i> (L.) Alston	Jambo	e	2	0.03
Rosaceae	<i>Prunus persica</i> (L.) Batsch	Pêssego	e	2	0.03
Sapindaceae	<i>Acer forrestii</i> Diels	Ácer-negundo	e	2	0.03
Apocynaceae	<i>Allamanda cathartica</i> L.	Alamanda	e	1	0.01
Araliaceae	<i>Dizygotheca elegantissima</i> (Veitcyh. Ex Mast.) Vig & Guill.	Falsa-aralia	e	1	0.01
Arecaceae	<i>Phoenix roebelenii</i> O'Brien	Fênix	e	1	0.01
Cycadaceae	<i>Cyca revoluta</i> Miq.	Cica	e	1	0.01
Dilleneaceae	<i>Dillenia indica</i> Linn.	Árvore-do-dinheiro	e	1	0.01
Fabaceae	<i>Anadenanthera peregrina</i> (L.) Speg.	Angico-vermelho	n	1	0.01
Fabaceae	<i>Andira anthelmia</i> (Vell.) Benth.	Angelim-amargoso	n	1	0.01
Fabaceae	<i>Hymenaea courbaril</i> L.	Jatobá	n	1	0.01
Fabaceae	<i>Leucochloron incuriale</i> (Vell.) Barneby & J.W.Grimes	Chico-Pires	n	1	0.01
Fabaceae	<i>Machaerium hirtum</i> (Vell.) Stellfeld	Jacarandá	n	1	0.01
Fabaceae	<i>Pithecellobium dulce</i> (Roxb.) Benth.	Grumachil	e	1	0.01
Fabaceae	<i>Schizolobium parahyba</i> (Vell.) Blake	Guapuruvú	n	1	0.01
Fabaceae	<i>Senna didymobotrya</i> (Fresen.) HS Irwin & Barneby	Cássia-africana	e	1	0.01
Malvaceae	<i>Luehea grandiflora</i> Mart. & Zucc.	Açoita-cavalo	n	1	0.01
Moraceae	<i>Ficus insipida</i> Willd.	Figueira-do brejo	n	1	0.01
Moraceae	<i>Ficus microcarpa</i> L.	Fícus	e	1	0.01
Moraceae	<i>Maclura tinctoria</i> (L.) D.Don ex Steud.	Maclura	n	1	0.01
Muntingiaceae	<i>Muntingia calabura</i> L.	Calabura	n	1	0.01
Myrtaceae	<i>Eucalyptus</i> sp.	Eucalipto	e	1	0.01
Myrtaceae	<i>Psidium</i> sp.	Guamixama	e	1	0.01
Oleraceae	<i>Jasminum primulinum</i> Hemsl.	Jasmim-amarelo	e	1	0.01
Sapindaceae	<i>Acer rubrum</i> L.	Acer-vermelho	e	1	0.01
Vitaceae	<i>Leea coccinea</i> Bojer.	Léia	e	1	0.01
Total				6829	100