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Review Paper

Tree species used in urban forestry in Brazil: a scientometric review

Daniela Baldez Vidal-Couto[1], *Carolina Reis de Brito*[2,7], *Isis Leite Medeiros Mascarenhas Andrade*[3,8], *Amanda Freitas Cerqueira*[3,9], *Igor Pires Reis*[2,10], *Sergio Luiz Valente Tomasini*[4], *Ândrea Carla Dalmolin*[5] & *Marcelo Schramm Mielke*[2,6,11]

Abstract

We conducted a scientometric review based on urban floristic inventories published in Brazilian scientific journals between 2000 and 2020 to determine the diversity and conservation status of trees used in urban forestry in Brazil. The floristic inventories were divided according to five Brazilian geographic regions. Tree species were divided into native and exotic species. We identified 71 floristic inventories of urban forestry, most of which were concentrated in the South and Southeast regions. In total, 473 species and 125 botanical families were identified. The largest number of species and families was found in the Southeast region, but most species/inventories were found in the North and Central-West regions. The ratio of native to exotic tree species was approximately 1:1; however, when the five most commonly used species were analyzed, the ratio of native to exotic species was less than 0.6, regardless of the geographic region. Regarding vulnerability, most of the species included in this study were not assessed for threat (86%), whereas only 1.7% of the species were vulnerable and 1% were endangered. We emphasize the urgent need to increase the number of tree species included in the IUCN Red List Categories and Criteria in urban forestry programs in Brazil.
Key words: biodiversity; native trees; tropical trees; urban forest inventories.

Resumo

Realizamos uma revisão cienciométrica baseada em inventários florísticos urbanos publicados em revistas científicas brasileiras entre 2000 e 2020 visando determinar a diversidade e o estado de conservação de árvores utilizadas na arborização urbana no Brasil. Os inventários florísticos foram divididos de acordo com cinco regiões geográficas brasileiras. As espécies arbóreas foram divididas em nativas e exóticas. Identificamos 71 inventários florísticos de arborização urbana, a maioria concentrada nas regiões Sul e Sudeste. No total, foram identificadas 473 espécies e 125 famílias botânicas. O maior número de espécies e famílias foi encontrado na região Sudeste, mas a maioria das espécies/inventários foi encontrada nas regiões Norte e Centro-Oeste. A proporção de espécies arbóreas nativas e exóticas foi de aproximadamente 1:1; no entanto, quando analisadas as cinco espécies mais utilizadas, a proporção de espécies nativas para exóticas foi inferior a 0,6, independentemente da região geográfica. Em relação à vulnerabilidade, a maioria das espécies incluídas neste estudo não foram avaliadas como ameaçadas (86%), enquanto apenas 1,7% das espécies estavam vulneráveis e 1% estavam ameaçadas. Enfatizamos a necessidade urgente de aumentar o número de espécies arbóreas incluídas nas categorias e critérios da Lista Vermelha da IUCN em programas de arborização urbana no Brasil.
Palavras-chave: biodiversidade; árvores nativas; árvores tropicais; inventários florestais urbanos.

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[1] Universidade Estadual de Santa Cruz, Prog. Pós-graduação em Produção Vegetal, Ilhéus, BA, Brazil. ORCID: <https://orcid.org/0000-0001-5462-6904>.
[2] Universidade Estadual de Santa Cruz, Lab. Ecologia Aplicada, Ilhéus, BA, Brazil.
[3] Universidade Federal do Sul da Bahia, Prog. Pós-graduação em Biossistemas, Ilhéus, BA, Brazil.
[4] Universidade Federal do Rio Grande do Sul, Depto. Horticultura e Silvicultura, Faculdade de Agronomia, Porto Alegre, RS, Brazil. ORCID: <https://orcid.org/0000-0002-3431-5145>.
[5] Universidade Federal do Sul da Bahia, Centro de Formação em Ciências Agroflorestais, Ilhéus, BA, Brazil. ORCID: <https://orcid.org/0000-0002-4372-0492>.
[6] Universidade Estadual de Santa Cruz, Depto. Ciências Biológicas, Ilhéus, BA, Brazil. ORCID: <https://orcid.org/0000-0001-6930-2902>.
[7] ORCID: <https://orcid.org/0000-0002-7557-8072>. [8] ORCID: <https://orcid.org/0000-0001-9655-3088>.
[9] ORCID: <https://orcid.org/0000-0002-3929-0901>. [10] ORCID: <https://orcid.org/0000-0002-0697-9788>.
[11] Author for correspondence: msmielke@uesc.br

Introduction

Urban forests benefit city life and the environment in several ways, such as improving the quality of life, mitigating heat, managing stormwater, and diminishing the consequences of global warming (Abreu-Harbich *et al*. 2014; Nitoslawski *et al*. 2019; Pretzsch *et al*. 2021; Hopkins *et al*. 2022), and possibly improving food security (Brito & Borelli 2020). However, urban forests also have some disadvantages such as the risk to urban infrastructure and safety and implementation and maintenance costs; nevertheless, the extensive list of its benefits can overcome the disadvantages with proper planning and management (Jim *et al*. 2018; Roman *et al*. 2021; Vega *et al*. 2021). Among the most important aspects for good planning and management of trees in urban environments is the choice of species, which depends on several factors, such as tree size, crown shape, type of fruit, deciduousness, and type of roots, in addition to aesthetic and cultural factors (Standish *et al*. 2013). In this sense, the inclusion of native species in the planning of urban spaces can be a way to reconcile the knowledge of local populations about these species, thus associating cultural aspects with biodiversity conservation (Romão *et al*. 2015; Almas & Conway 2016; Soares *et al*. 2021). This fact is particularly important in the case of Brazil, a country with high biodiversity and a large number of endangered flora species (BGCI 2021).

In Brazil, exotic trees were initially used in urban planning with the arrival of European colonizers (Kury *et al*. 2013). The first region to be impacted by this practice was the Northeast, with records available of *Citrus* planting in Pernambuco in the 17th century (Matthes 1994). Much of the Brazilian city aesthetics is a reflection of colonial history. A good example of this phenomenon is the Rio de Janeiro urban renovation carried out at the beginning of the 20th century, which was strongly inspired by the renovation of Paris in the 19th century (Silva 2019). During the renovation, in addition to the foreign influence in architecture, many plants were imported mostly from Asia. *Terminalia catappa* L., *Casuarina equisetifolia* L., *Ligustrum japonicum* Thunb., *Tamarindus indica* L., *Mangifera indica* L., and many other exotic trees were used in the early 20th century, and are still found in the city (Ferreira 2021; Santos *et al*. 2010). Therefore, the introduction of Burle Marx of native species in his gardens in the '40s was revolutionary (Sá Carneiro 2019). This novel use of native species as ornamental plants has allowed the conservation of genetic diversity and is recommended for restoring and conserving biodiversity in urban landscapes (Romão *et al*. 2015; Standish *et al*. 2013).

The use of native species in urban "green areas" is of great importance, particularly in Brazil, which is estimated to be the most biodiverse country, with around 10–20% of all the plant diversity in the world (Lima *et al*. 2022; Romão *et al*. 2015). The country has two major hotspots, the Cerrado and Atlantic Forest, which is one of the most vulnerable hotspots for climate change (Bellard *et al*. 2014). Moreover, Brazil has four other highly diverse biomes: the Pantanal, Pampas, Caatinga, and Amazon Forest - the largest tropical forest in the world (Esquivel-Muelbert *et al*. 2019). However, the expansion of cities and agricultural rural areas has caused the species native to these biomes to lose their habitat. Therefore, the introduction of native and particularly endemic species is an excellent conservation strategy in urban areas in Brazil (Standish *et al*. 2013).

Although the use of native species contributes to the conservation of local biodiversity, the use of exotic species can jeopardize these conservation efforts. Invasive alien species, which can potentially compete with other native species, irreversibly affect the local diversity (Godoy *et al*. 2011). For example, in North America, the introduction of the *Schinus molle* L. and *Schinus terebinthifolia* Raddi (both native from South America) for ornamental use threatens native plants and costs the government of the United States of America (USA) millions of dollars in control measures (Bañuelas *et al*. 2019; Osland & Feher 2020). In Brazil, *Leucaena leucocephala* (Lam.) de Wit is a non-native and invasive species that excludes native species due to its rapid growth and sexual maturity, capacity for sexual and asexual reproduction, and resistance to stress (Melo-Silva *et al*. 2014). Additionally, the native fauna may become dependent on exotic species. One of the most well-known cases is the Australian endemic and threatened species Carnaby's Cockatoos (*Calyptorhynchus latirostris* Carnaby), which developed food dependence on exotic Gnangara pine (*Pinus pinaster* Ailton) (Dwyer 2021; Stock *et al*. 2013). An important aspect of planning for urban conservation management and measuring conservation status is knowing which trees were used and which are recommended for urban forestry.

The systematic literature review provides a synthesis of a given area of knowledge by gathering evidence to answer pre-defined research questions. This involves identifying all primary research relevant to the defined review question, critically evaluating this research, and summarizing the results. Furthermore, systematic reviews synthesize data from different studies to produce a new result or integrated conclusion. The steps involved in the systematic review include study selection, critical evaluation, and data extraction conducted by independent reviewers to reduce the risk of subjective interpretation as well as inaccuracies due to random errors that affect the review results. The process of systematization distinguishes systematic reviews from traditional and descriptive literature reviews (Aromataris & Pearson 2014). One approach within the systematic review is scientometric analysis, which quantitatively determines the scientific production, sheds light on the relevance of the research, and explores trends in the different areas of knowledge (Vanti 2002; Chen & Song 2019). Scientometric studies provide information on the state of the art of a given topic to assess its stagnation or gaps, visualize regions where the subjects are concentrated, and determine the allocation of financial resources for future research (Hood & Wilson 2001).

To assess the diversity and conservation status of native and exotic trees used in urban forestry in Brazil, we performed a scientometric review based on urban floristic inventories published in scientific Brazilian journals between 2000 and 2020. We sought to answer the following questions: (a) What is the geographic distribution of urban forest inventories in Brazil? (b) Which are the most used tree species for urban forestry in Brazil? (c) What are the relationships between the native and exotic species? (d) What is the degree of threat posed by the tree species used in urban forestry in Brazil?

Material and Methods

A scientometric survey was conducted on all papers published in the Journal of the Brazilian Society of Urban Forestry (Revista Brasileira de Arborização Urbana (RevSBAU) (ISSN 1980-7694). This journal has been publishing articles on urban forestry in Portuguese, Spanish, and English since 2006 and is the main journal of urban forestry in Brazil. As other Brazilian journals also publish articles on urban forestry, we complemented our survey by searching for articles in the SciELO database (<https://www.scielo.br/>). The word "inventário" (inventory, in Portuguese) was used as the search query in the RevSBAU database (<https://revistas.ufpr.br/revsbau/search>). We used the words "arborização urbana inventário" (inventory urban arboriculture, in Portuguese) as the search query in the SciELO database, resulting in 10 articles. The survey in the SciELO database covered the period between 2000 and 2020. Following the database search, the papers were screened and selected for a systematic review. Duplicates were deleted. Only publications in Brazilian journals that carried out inventories in Brazilian municipalities were selected, and theses and dissertations were excluded. After screening, the titles and abstracts were analyzed, and articles that did not meet the criteria were excluded. Finally, the remaining articles were read and selected according to the established criteria for inclusion into the final database.

The articles differed in spatial scales, with a focus on streets, squares, neighborhoods, or cities. Based on geographic location, the articles were separated into the five Brazilian geographical regions (South, Southeast, Central-West, North, and Northeast). The regional characteristics were based on the Brazilian Institute of Geography and Statistics (IBGE 2010). All the species mentioned in the articles and the complete inventories were selected for this systematic review. The species were divided into four morphotypes: trees (woody species 4.00 m and taller), shrubs (woody species 3.99 m and shorter), palms (species from the Arecaceae family), and herbs (non-woody plants). Only trees were analyzed in this systematic review. Five articles with no references to trees were excluded from the analysis. In total, 71 articles, reviews, and technical notes were selected for this study (see Tab. S1, available on supplementary material <https://doi.org/10.6084/m9.figshare.23906154.v1>).

Approximately 30% of the inventories did not include all the species found at the study locations; the articles contained only a determinate number of the most common species (*e.g.*, ten most common species). Many species were listed with outdated scientific names, which needed to be reviewed. Moreover, some species were unidentified or identified only by the genera or botanical family names. A nomenclature review was conducted according to the information available in Flora and Funga of Brazil 2022 and World Flora Online

(Flora e Funga do Brasil 2022; WFO 2022), to obtain the correct species name. We then divided the species with the corrected names into native and exotic species according to Flora and Funga of Brazil (2022). A vulnerability survey was carried out for all species according to the IUCN Red List Categories and Criteria (Flora e Funga do Brasil 2022).

Results

Although the aim was to include all urban forest inventories starting from 2000, the oldest relevant article was published in 2004 (Fig. 1). The vast majority of inventories on urban trees in Brazil were published in the journal RevSBAU (62 articles), followed by the journals Ciência Florestal (ISSN:1980-5098) (five articles), Revista Árvore (ISSN 0100-6762) (three articles), and Revista Brasileira de Horticultura Ornamental (ISSN:2447-536X) (one article). Based on the methodology used in our study, 71 inventories were found between 2004 and 2020 reporting the presence of tree species in urban forestry in the five geographic regions of Brazil. The largest number of inventories were found in the South region, followed by the Southeast, North, Northeast, and Central-West regions (Figs. 2-3).

In total, 125 botanical families and 473 species of trees were reported in the analyzed inventories. The largest number of families was reported in the Southeast region, followed by the South, North, Central-West, and Northeast regions (Fig. 4a). The largest number of species was reported in the South-east region, followed by the North, South, Central-West, and Northeast regions (Fig. 4b). However, the ratio between the number of species per inventory was higher in the North (31 species/inventory) and Central-West (20 species/inventory) regions (Fig. 5). The ratio between the number of species per inventory was approximately three times higher in the North than in the South (9), Southeast (12), and Northeast (9) regions.

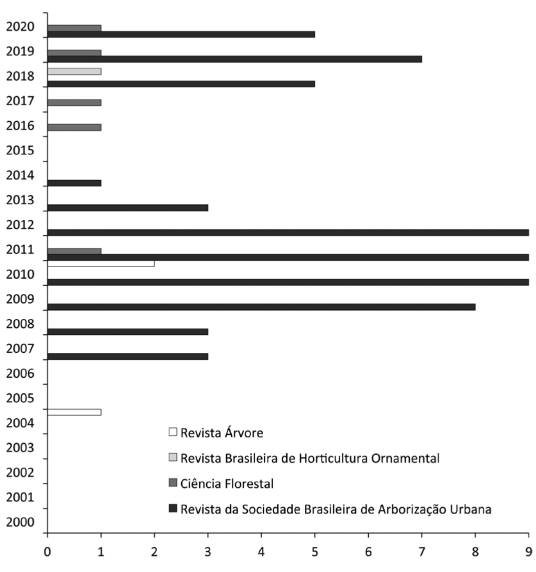

Figure 1 – Articles with urban forestry inventories in Brazil published by a journal from 2000.

Similarly, the ratio between the number of species per inventory and the ratio between native and exotic species was higher in the North region (2.3), where 153 native and 66 exotic species were reported (Fig. 6). For the other regions, the proportion of native and exotic species was very close to 1, with the Northeast region showing the lowest ratio. The numbers of native and exotic species reported in the South, Southeast, and Central-West regions were 107 native and 96 exotic, 127 native and 112 exotic, and 74 native and 64 exotic species, respectively. Despite this result, the vast majority of species reported in the inventories analyzed in this study were native to Brazil (309 species) and 164 were exotic species (Tab. S2, available on supplementary material <https://doi.org/10.6084/m9.figshare.23906154.v1>).

With the exception of the North region, the numbers of native and exotic species were very similar in the analyzed inventories; however, the five most cited species were mostly exotic trees (Tab. 1). Moreover, except for the North region, the species with the highest occurrences in all other regions were always exotic, with *F. benjamina*, *M. indica*, and *T. catappa* being the most prominent reported species, except in the South region. Among the five geographic regions, the Central-west region had the largest number of species pertaining to the six highest occurring species, while *Murraya paniculata* (L.) Jack, *F. benjamina*, *Psidium guajava* L., *S. molle*, and *T. catappa* are the fourth most cited species.

Among the five most cited tree species in the four geographic regions that correspond to tropical Brazil (Fig. 7), *F. benjamina* (exotic), *M. tomentosa* (native), and *T. catappa* (exotic) were common in the North, Northeast, Central-West, and Southeast regions. *M. indica* (exotic) was common in the North, Northeast, and Central-West regions.

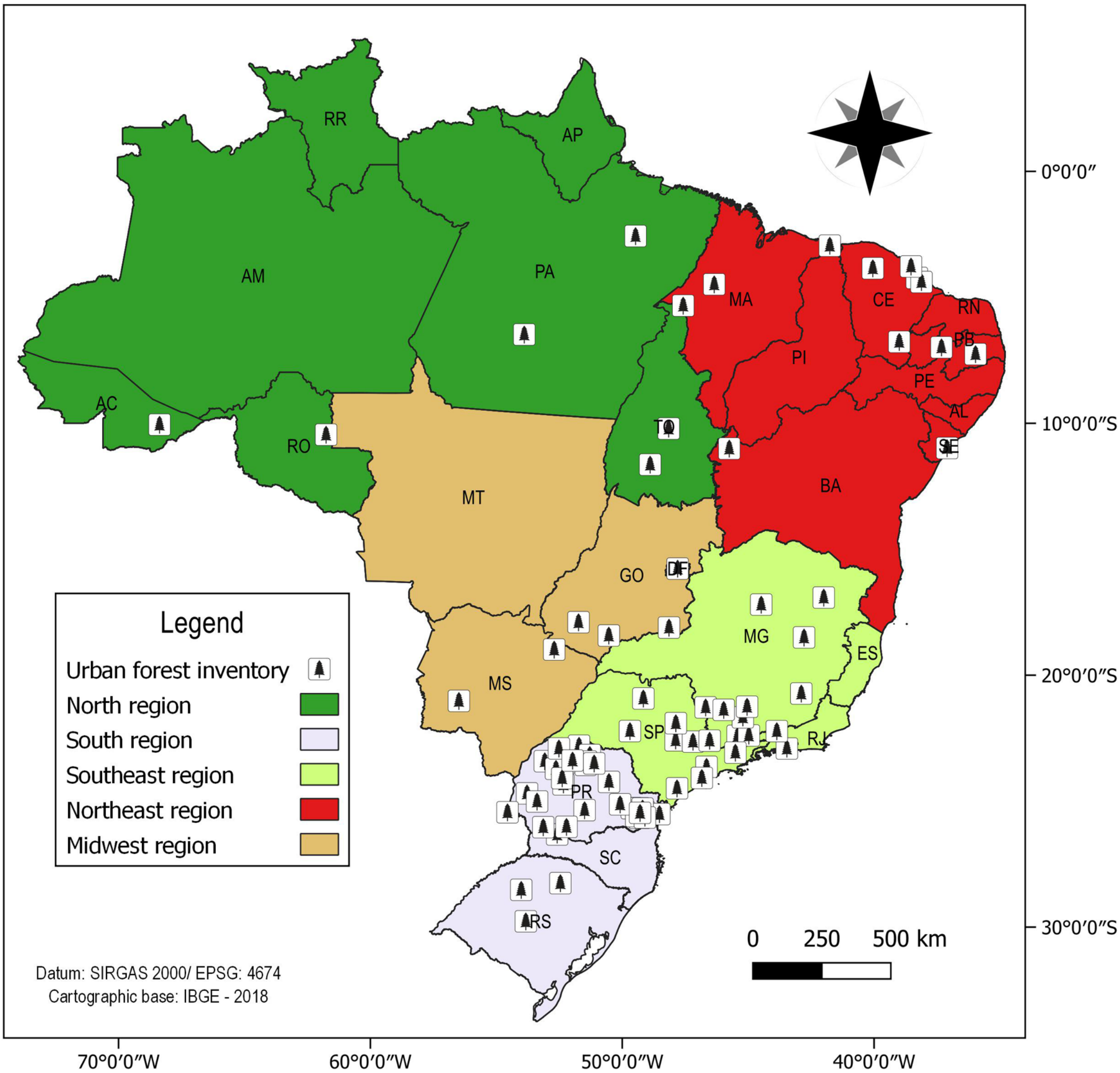

Figure 2 – Brazilian map indicating the 71 urban forest inventories used in this study.

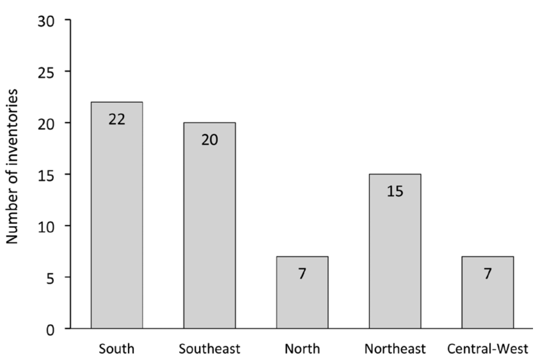

Figure 3 – Number of inventories published on urban silviculture in the five geographic regions of Brazil between 2004 and 2020.

Regarding the degree of vulnerability, the vast majority of species reported in the inventories belonged to the category "species not assessed for threat" (408 species), followed by "least concern" (48 species), "vulnerable" (8 species), "endangered" (5 species), and "near threatened" (4 species) (Tab. S2, available on supplementary material <https://doi.org/10.6084/m9.figshare.23906154.v1>). Therefore, the vast majority of the species assessed in this study, including natives and exotics, belonged to the category not assessed for threat (86%), whereas only 1.7% and 1% of the species were in the vulnerable and endangered categories, respectively. The species indicated as vulnerable were *Apuleia leiocarpa* (Vogel) J. F.Macbr., *Bertholletia excels* Bonpl., *Cedrela fissilis* Vell., *Cedrela odorata* L., *Dalbergia nigra* (Vell.) Alemão *ex* Benth., *Melanoxylon brauna* Schott, *Plinia edulis* (Vell.) Sobral, and *Swietenia macrophylla* King. Among these, the most frequently cited were *C. fissilis* (21 inventories) and *S. macrophylla* (6 inventories). The species indicated as endangered were *Araucaria angustifolia* (Bertol.) Kuntze, *Cariniana legalis* (Mart.) Kuntze, *Handroanthus arianeae* (A.H. Gentry) S. Grose, *Ocotea odorifera* (Vell.) Rohwer, and *Ocotea porosa* (Nees and Mart.) Barroso. Among these, the most frequently cited were *A. angustifolia* (18 inventories) followed by *C. legalis* (2 inventories). All species listed in the vulnerable and endangered categories are native to Brazil.

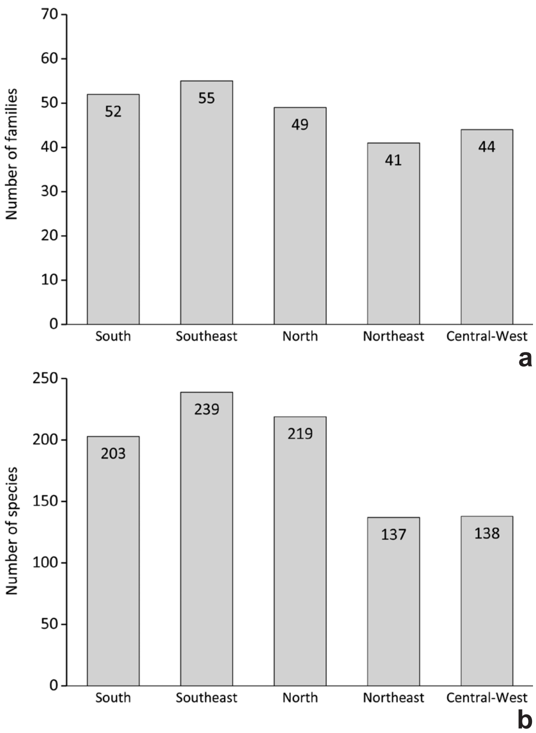

Figure 4 – a-b. Numbers reported in the 71 inventories published on urban silviculture in the five geographic regions of Brazil between 2004 and 2020 – a. botanical families; b. tree species.

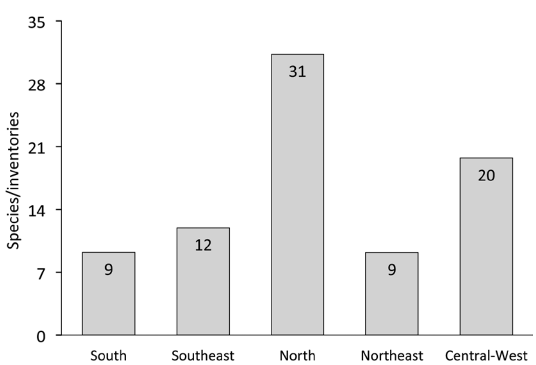

Figure 5 – Ratio between the number of tree species and number of inventories published on urban silviculture in the five geographic regions of Brazil between 2004 and 2020.

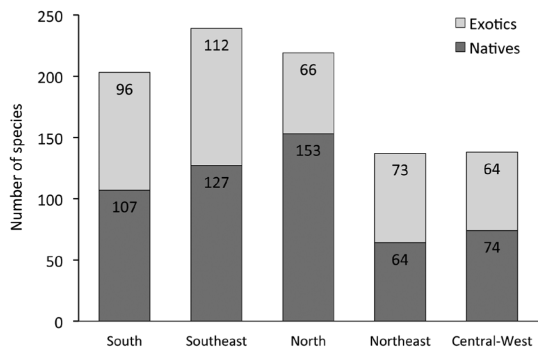

Figure 6 – Number of native and exotic species reported in the 71 inventories published on urban silviculture in the five geographic regions of Brazil between 2004 and 2020. Values in parentheses correspond to the native/exotic species ratio.

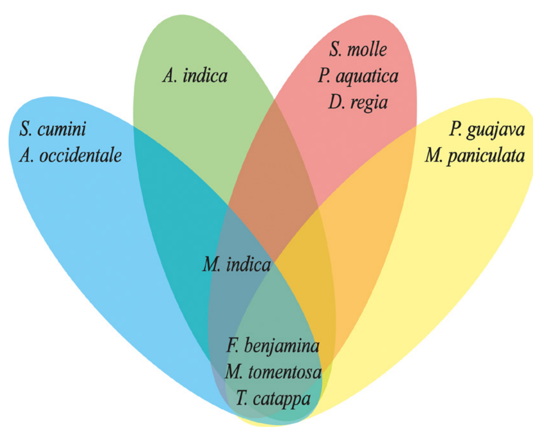

Figure 7 – Venn diagram representing the most used tree species in urban forestry in the four regions of tropical Brazil: North (orange), Northeast (green), Central-West (red) and Southeast (yellow).

Table 1 – List of the five most cited tree species reported in 71 inventories on urban silviculture in the five geographic regions of Brazil published between 2004 and 2020.

Region	Rank	Species	Family	Origin	Inventories
South	1	*Melia azedarach* L.	Meliaceae	Exotic	17/22
	2	*Tipuana tipu* (Benth.) Kuntze)	Fabaceae	Exotic	16/22
	3	*Handroanthus chrysotrichus* (Mart: *ex* DC.) Mattos	Bignoniaceae	Native	15/22
	4	*Cenostigma pluviosum* var. *peltophoroides* (Benth.) Gagnon & G.P. Lewis	Fabaceae	Native	14/22
	5	*Jacaranda mimosifolia* D. Don	Bignoniaceae	Exotic	13/22
	5	*Grevillea robusta* A. Cunn. *ex* R. Br.	Proteaceae	Exotic	13/22
	5	*Handroanthus heptaphyllus* (Vell.) Mattos	Bignoniaceae	Native	13/22
	5	*Hovenia dulcis* Thunb.	Rhamnaceae	Exotic	13/22
Southeast	1	*Ficus benjamina* L.	Moraceae	Exotic	17/20
	2	*Moquilea tomentosa* Benth.	Chrysobalanaceae	Native	16/20
	3	*Murraya paniculata* (L.) Jack	Rutaceae	Exotic	15/20
	4	*Psidium guajava* L.	Myrtaceae	Exotic	15/20
	5	*Terminalia catappa* L.	Combretaceae	Exotic	15/20
North	1	*Terminalia catappa* L.	Combretaceae	Exotic	7/7
	2	*Mangifera indica* L.	Anacardiaceae	Exotic	7/7
	3	*Ficus benjamina* L.	Moraceae	Exotic	7/7
	4	*Anacardium occidentale* L.	Anacardiaceae	Native	6/7
	5	*Moquilea tomentosa* Benth.	Chrysobalanaceae	Native	6/7
	5	*Syzygium cumini* (L.)Skeels	Myrtaceae	Exotic	6/7
Northeast	1	*Mangifera indica* L.	Anacardiaceae	Exotic	13/15
	2	*Ficus benjamina* L.	Moraceae	Exotic	13/15
	3	*Terminalia catappa* L.	Combretaceae	Exotic	12/15
	4	*Azadirachta indica* A.Juss	Meliaceae	Exotic	12/15
	5	*Moquilea tomentosa* Benth.	Chrysobalanaceae	Native	12/15
Central-West	1	*Pachira aquatic* Aubl	Malvaceae	Native	6/7
	2	*Moquilea tomentosa* Benth.	Chrysobalanaceae	Native	6/7
	3	*Mangifera indica* L.	Anacardiaceae	Exotic	6/7
	4	*Delonix regia* (Bojer *ex* Hook.) Raf	Fabaceae	Exotic	5/7
	5	*Murraya paniculata* (L.) Jack	Rutaceae	Exotic	5/7
	5	*Ficus benjamina* L.	Moraceae	Exotic	5/7
	5	*Psidium guajava* L.	Myrtaceae	Exotic	5/7
	5	*Schinus molle* L.	Anacardiaceae	Native	5/7
	5	*Terminalia catappa* L.	Combretaceae	Exotic	5/7

Discussion

The creation of inventories of urban forestry should be the first step to establishing planning and management guidelines for existing species in public areas. Knowing which species are present in a particular urban area, as well as their physical and sanitary conditions, can help indicate the need to plant new individuals (Zambonato *et al*. 2021). Trees must be permanently monitored and maintained in the urban environment given their relevance for the ecosystem (Pretzsch *et al*. 2021).

One of the many reasons the largest number of inventories is located in the South, Southeast, and Northeast regions is partnerships between municipal governments, research centers, and universities. Silva *et al*. (2020) analyzed the technical content of 49 Master Plans for Urban Afforestation (PDAU) in Brazil through a meta-analysis and reported that the South region had the highest number of PDAUs (22), followed by the Southeast (15) and Northeast (6). In addition, the southern states of Brazil and their researchers are pioneers in urban afforestation research. The southern region of Brazil is also cited in a review aimed at understanding urban forest research in Latin America and the Caribbean for a more diverse and global analysis of urban forestry (Barona *et al*. 2020). The study by Barona *et al*. (2020) showed that most surveys were conducted in Brazil (42%), followed by Mexico (17%), Chile (15%), and Argentina (9%). Furthermore, according to these authors, the city with the highest number of studies is Curitiba, the capital of the state of Paraná, one of the three main states of the southern region of Brazil. The different climate of the southern region compared with the climate in other regions of Brazil is an important factor that influences the distribution of the tree species cited in the inventories. The southern region of Brazil has a mild or medium mesothermal climate, classified as Cfa and Cfb according to Koppen-Geiger (IBGE 2010). Moreover, the vegetation from other regions of Brazil, which have a predominantly tropical climate, has different characteristics.

Brazil has six biomes that are important natural resources and sources of rich diversity in natural species. The diversity, composition, and relative abundance of native species compared to that of non-native species can affect the population of pollinators and dispersers (Freitas *et al*. 2020b). Brazilian biodiversity is known worldwide, and the Cerrado and Atlantic Forest biomes are outstanding biodiversity hotspots (Bellard *et al*. 2014). Despite the country's rich biodiversity, the most planted species tend to always be the same. The ease of purchasing exotic species for use in urban landscaping is closely related to the production of seedlings in nurseries, where exotic species usually predominate. The most popular ornamental plants for easy propagation and cultivation in the world plant market can be called "global commercial plants" (Cardim 2022). These species are more attractive than native species due to the easily obtainable information on propagation techniques, fertilization, pest and disease control, and pruning management. With regard to native species, information on propagation, cultivation, and management techniques is scarce, and they are considered weeds that grow in abundance, which makes them unappealing for use in classical European gardens (Romão *et al*. 2015).

The cited species in inventories in tropical Brazil are *F. benjamina*, *M. indica*, and *T. catappa*. *F. benjamina*, which is native to India, is a tropical tree species widely planted in urban afforestation due to its rustic appearance with evergreen shiny green foliage and the ease of pruning its canopy into different shapes. However, it has aggressive and superficial roots that can damage sidewalks, public roads, and water distribution networks. In addition, species of the genus *Ficus* are susceptible to attacks of *Liothrips adisi* zur Strassen, which causes the leaves to curl and fall into people's eyes as they pass under the canopy, resulting in burning and irritation that can become a public health problem. (Matos & Queiroz 2009). *M. indica* is a fruit tree native to South Asia, India, and the Malay archipelago, although the species has since spread to other parts of the world, including the Americas (Genú & Pinto 2002). This tree species can reach heights of up to 30 m and has a rounded symmetrical canopy with a taproot system that can penetrate deep into the soil for survival during periods of drought. The fruit is drupe-like, from a few grams to 2 kg in weight, with a range of shapes, such as reniform, ovate, oblong, rounded, or heart-shaped, and it is much liked by humans and animals (Genú & Pinto 2002). Mango is considered invasive in the riparian areas of the semi-arid region of Northeast Brazil (Leão *et al*. 2011). *T. catappa* is a large tree that reaches up to 30 m in height and is easily recognized due to its largely obovate leaves (Ribeiro *et al*. 2012). It is native to the tropical regions of Peninsular Malaysia, Southeast Asia, and the Andaman Islands (CABI 2019). This species is invasive in coastal ecosystems in Brazil and forms population masses capable of excluding native species through competition for resources and interference (Fabricante *et al*. 2021).

M. tomentosa, the most reported native tree species in inventories in tropical Brazil, is native to the Atlantic Forest biome (Sothers & Prance 2020). It is a fast-growing tree, reaching more than 20 m in height, with shallow and vigorous roots. Its fruit is fleshy and edible to fauna and human populations (Gonçalves & Paiva 2017). The botanist Auguste François Marie Glaziou started using this species in his projects (second half of the 19th century) inspired by English gardens, where Brazilian plants were used in the squares and streets of Rio de Janeiro (Freitas *et al*. 2020a).

H. chrysotrichus is a tree species native to subtropical Brazil and to the Cerrado, Atlantic Forest, and Pampa biomes (Lohmann 2020). This species is slow growing and can reach up to 10 m in height. It has a high landscape value owing to its golden yellow flowers. It has deciduous leaves with a rounded crown, a slightly tortuous trunk, and an irregular shape, where the main stem is not clearly evident (Toledo Filho 1988). However, it does not exhibit natural pruning and requires frequent pruning (Matos & Queiroz 2009).

Urban trees enable people to have contact with nature (Vega *et al*. 2021). Moreover, urban trees are often the first contact with native biodiversity for people living in cities (Moro & Castro 2015). Some exotic species adapt very well outside of their natural habitat and spread in a disorderly fashion, thus becoming invasive species and altering the native fauna and flora of the invaded environment. In contrast, many native plant species do not become a bioinvasive risk and provide better ecological quality to urban environments. In addition, they act as *ex-situ* conservation pools for native species (Moro & Castro 2015). Thus, the planting of native tree species in cities ensures the maintenance of parent trees that can provide seeds for nurseries and play an important role in creating environmental awareness.

Similarly, exotic trees can also be beneficial if planted prudently in cities. However, the excessive use of exotic species in urban environments poses a high risk for forest areas close to cities due to the possible dissemination of seeds or other propagating material (Santos *et al*. 2010). In addition, the excessive use of a few exotic species in urban forestry often creates more awareness among people about tree species from other countries than it does about native species (Moro & Castro 2015). This can be negated by emphasizing the Brazilian native species with high ornamental and landscape potential; however, basic research into understanding and evaluating the growth and development of native species in forest nurseries and urban conditions is needed and is currently lacking.

Although 20% of the total native tree species in Brazil fall into one of the IUCN Red List Categories and Criteria (BGCI 2021), our results showed that most of the species used in urban forestry in Brazil are not threatened with extinction. The risks of the decline of the native species population can be minimized by identifying key threats, such as urban and commercial development, invasive species, and climate change (BGCI 2021). Several of these threats are related to urban issues and can be mitigated through urban forestry planning with attention to these species. For example, *S. macrophylla* has been used in urban forestry because of its foliage and shade. This species, owing to its excellent aesthetic and the physical and mechanical characteristics of its wood (Guimarães Neto *et al*. 2004; André *et al*. 2008), has been extensively exploited, thus causing a sharp decline in its population in areas of natural occurrence (Degen *et al*. 2013; Alcalá *et al*. 2014). Some important means to guarantee the conservation of the species that fall under the vulnerable to extinction categories include their usage in urban forestry with education and training and through creating awareness among local communities to expand knowledge about the local flora. Brazil contains the largest number of tree species worldwide (8,847 in total), with 4,226 endemic species (BGCI 2021). Therefore, the use of native species in urban forestry instills in people a sense of belonging and marvel at the biodiversity of Brazilian flora, which brings awareness to the importance of conserving native tree species.

Based on the methodology used in this study, we identified 71 floristic inventories on the presence of tree species in urban forestry in Brazil, most of which were concentrated in the South (22) and Southeast (20) regions. In total, 473 species and 125 botanical families were identified. The largest number of species and families was found in the Southeast region, but the largest number of species/inventories was found in the North and Central-West regions. In the analyzed inventories, there was a ratio of approximately 1:1 between native and exotic tree species. However, when only the five most used species in urban forestry were analyzed, the ratio of native to exotic species was always lower than 0.6, regardless of the geographic region. *F. benjamina*, *M. indica*, and *T. catappa* were the most frequently reported exotic species in the analyzed inventories. The most frequently reported native species were *M. tomentosa* (Southeast, Northeast, North, and Central-West) and *H. chrysotrichus* (South). The vast majority of tree species accessed in this study, including native and exotic species, were not assessed for threat (86%), while only 1.7% of the species were in the vulnerable category and 1% in the endangered category. Popular knowledge about native flora is important for the conservation of endangered species. Hence, we emphasize the urgent need to increase the number of tree species included in the IUCN Red List Categories and Criteria in urban forestry programs in Brazil.

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Data availability statement

In accordance with Open Science communication practices, the authors inform that all data are available within the manuscript.

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