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Assessment of urban forestry in Aquidauana (MS, Brazil)

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Abstract

Objective: The aim of the present study was to assess urban forestry in the city of Aquidauana (state of Mato Grosso do Sul, Brazil) to contribute to the establishment of a municipal urban afforestation plan.
Methodology: Eight quadrants measuring 200 × 500 m were sampled, totaling 23 km of walkways, 59 streets in seven neighborhoods and 1280 trees, corresponding to a sampling intensity of 6.4% (95% precision; 10% error limit). Information was obtained on species, origin, spatial variables and plant health.
Originality/Relevance: We present important qualitative and quantitative aspects for the planning and management of urban forests in the city, which may be insufficiently considered by the local public administration.
Results: The number of trees per kilometer of walkway is below the recommended figure. We recorded 101 species distributed among 36 families. A high number of native species was found, but exotic species predominated in both number and abundance, especially *Moquilea tomentosa* (60%). Regarding the spatial component, 46% of the trees were located under power lines and 60% of these trees had some conflict with the grid. Approximately 17% of the trees were closer to the curb than the recommended distance. Among the trees sampled, most (60%) did not present any type of conflict with infrastructure. Tree health merits attention, as less than 10% of the population was categorized as being in an optimum state.
Management contributions: We recommend the implantation of legal norms for tree management, including the offer of tree-trimming courses for those involved in this practice in the city, as well as the planting of native species and the adoption of environmental education programs.

Keywords: Urban trees, qualitative-quantitative inventory, floristic survey.

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Diagnóstico da arborização urbana de Aquidauana (MS, Brasil)

Resumo

Objetivo: O objetivo deste estudo foi realizar um diagnóstico da arborização viária da cidade de Aquidauana (MS) de forma a subsidiar a construção Plano de Arborização Urbana do município.
Metodologia: Foram amostrados oito quadrantes de 200 × 500 m, totalizando 23 km de passeio, 59 ruas em sete bairros e 1280 árvores, totalizando 6,4% de intensidade amostral (precisão de 95%; 10% de limite de erro). Informações a respeito das espécies, origem, parâmetros espaciais e condições fitossanitárias foram obtidas.
Originalidade/Relevância: Apresentamos aspectos qualitativos e quantitativos importantes para o planejamento e gestão da arborização urbana do município, os quais podem estar sendo insuficientemente considerados pela administração pública local.
Resultados: O número de árvores por quilômetro de passeio está abaixo do recomendado. Registramos 101 espécies, as quais distribuem-se em 36 famílias. Foi observado um elevado número de espécies nativas, contudo, espécies exóticas predominam em número e abundância, em especial, *Moquilea tomentosa* (60%). Considerando o componente espacial, 46% das árvores estão localizadas sob a rede elétrica, destas, 60% destas apresentam algum conflito com a rede. Cerca de 17% das árvores apresentam distância de meio-fio inferior às recomendações. Dentre as árvores amostradas, a maioria (60%) não apresenta qualquer tipo de conflito com a infraestrutura. O estado fitossanitário das árvores requer atenção, uma vez que menos de 10% da população foi enquadrada em “ótimo estado”.
Contribuições sociais/para a gestão: Recomendamos implantação de normas legais para manejo das árvores, incluindo a oferta de cursos de poda aos envolvidos nessa prática no município, plantio de espécies nativas e adoção de programas de educação ambiental.

Palavras-chaves: Árvores urbanas, inventário quali-quantitativo, levantamento florístico.

Diagnóstico de forestación urbana en Aquidauana (MS, Brasil)

Resumen

Objetivo: El objetivo de este estudio fue realizar un diagnóstico de la forestación de calles en la ciudad de Aquidauana (MS) para subsidiar la construcción del Plan de Forestación Urbana del municipio.
Metodología: Se muestrearon ocho cuadrantes de 200 × 500 m, totalizando 23 km de acera, 59 calles en siete barrios y 1280 árboles, totalizando 6,4% de intensidad de muestreo (95% de precisión; 10% de límite de error). Se obtuvo información sobre especies, origem, parámetros espaciales y condiciones fitosanitarias.
Originalidad/Relevancia: Presentamos importantes aspectos cualitativos y cuantitativos para la planificación y gestión de la forestación urbana en el municipio, que pueden ser insuficientemente considerados por la administración pública local.
Resultados: El número de árboles por kilómetro de pasarela está por debajo del recomendado. Registramos 101 especies, las cuales se distribuyen en 36 familias. Se observó un alto número de especies nativas, sin embargo, las especies exóticas predominan en número y abundancia, especialmente *Moquilea tomentosa* (60%). Considerando el componente espacial, el 46% de los árboles se encuentran bajo la red eléctrica, de los cuales el 60% tiene algún conflicto con la red. Alrededor del 17% de los árboles tienen una distancia al borde inferior a las recomendaciones. Entre los árboles muestreados, la mayoría (60%) no presenta ningún tipo de conflicto con la infraestructura. El estado fitosanitario de los árboles requiere atención, ya que menos del 10% de la población se clasificó en “excelente estado”.

Aportes sociales/de gestión: Se recomienda implementar normas legales para el manejo de los árboles, incluyendo la oferta de cursos de poda a los involucrados en esta práctica en el municipio, la siembra de especies nativas y la adopción de programas de educación ambiental.

Palabras clave: Arbolado urbano, inventario cuali-cuantitativo, levantamiento florístico.

Introduction

The urban forest is all trees in a system of free spaces of a city, such as free areas for public and mainly collective use as well as private free areas and areas that follow the road system (PDAU/CG, 2010). The urban forest composes the landscape of the city and is a structuring element of urban spaces, providing numerous benefits, such as the filtering of pollution and particles from the air (Nowak et al., 2006; Terzaghi et al., 2013), the regulation of the microclimate (Basso & Corrêa, 2014; Martini et al., 2017; Rocha, 2018) and noise reduction (Maleki & Hosseini, 2011; Ow & Ghosh, 2017; Dias de Oliveira, 2018) as well as exerting an influence on the water balance by assisting in the drainage of water and diminishing the impact of rain (Nicodemo & Primavesi, 2009; Alves & Formiga, 2019). The urban forest also assists in the maintenance of biodiversity (Livesley et al., 2016), embellishes streets and public spaces and has cultural and recreational value (Bolund & Hunhammar, 1999; Backes & Irgang, 2004; Nicodemo & Primavesi 2009; Ferrini et al., 2014). Thus, trees in the urban setting constitute a potential mechanism for quality of life and social wellbeing (WHO/EUROPE, 2016).

Despite the numerous benefits, a lack of planning of the urban forest can lead to problems with regards to the electrical power network, telephone lines, sidewalks, the water supply and sewage system as well as problems related to public health, causing numerous expenses for the public authorities, such as maintenance, replacement and removal services (Milano & Dalcin, 2000). Thus, there is a need for strategic planning of these areas and the authorities require information to assist in decision making when considering the quality and wellbeing of the population in terms of these problems as well as the lessening the impact of storms (Shams et al., 2009).

Nearly 85% of the Brazilian population live in urban areas. This is also the percentage of the urban population in the state of Mato Grosso do Sul according to the most recent census conducted by the IBGE [Brazilian Institute of Geography and Statistics] in 2010. Cities have been growing, most often in a very rapid and disorderly way without adequate planning, which causes a set of problems that significantly interfere with the lives of the residents (Pivetta & Silva Filho, 2002). The planning of urban forests is fundamental to urban development and requires knowledge on the existing scenario through a qualitative-quantitative inventory (Coletto et al., 2008)

Published qualitative-quantitative inventories exist for 13 municipalities in the state: Anastácio (Rabelo et al., 2020), Bonito (Zamproni et al., 2018), Cassilândia (Guilherme et al., 2018), Chapadão do Sul (Pelegrim et al., 2012, Guilherme et al., 2018), Costa Rica (Guilherme et al., 2018), Corumbá (Lopo, 2014), Coxim (Mota & Almeida, 2011), Dourados (PDAU/Dourados, 2019), Miranda (PDAU/Miranda, 2020), Paranaíba (Guilherme et al., 2018), Três Lagoas (Santos, 2014), the capital Campo Grande (PDAU/CG, 2010; Pestana et al., 2011) and Aquidauana (restricted to the city center) (Sá et al., 2021). The aim of the present study was to perform a qualitative-quantitative assessment of the urban forest along streets in different neighborhoods of the municipality of Aquidauana to assist in the establishment of a municipal urban afforestation plan.

Methods

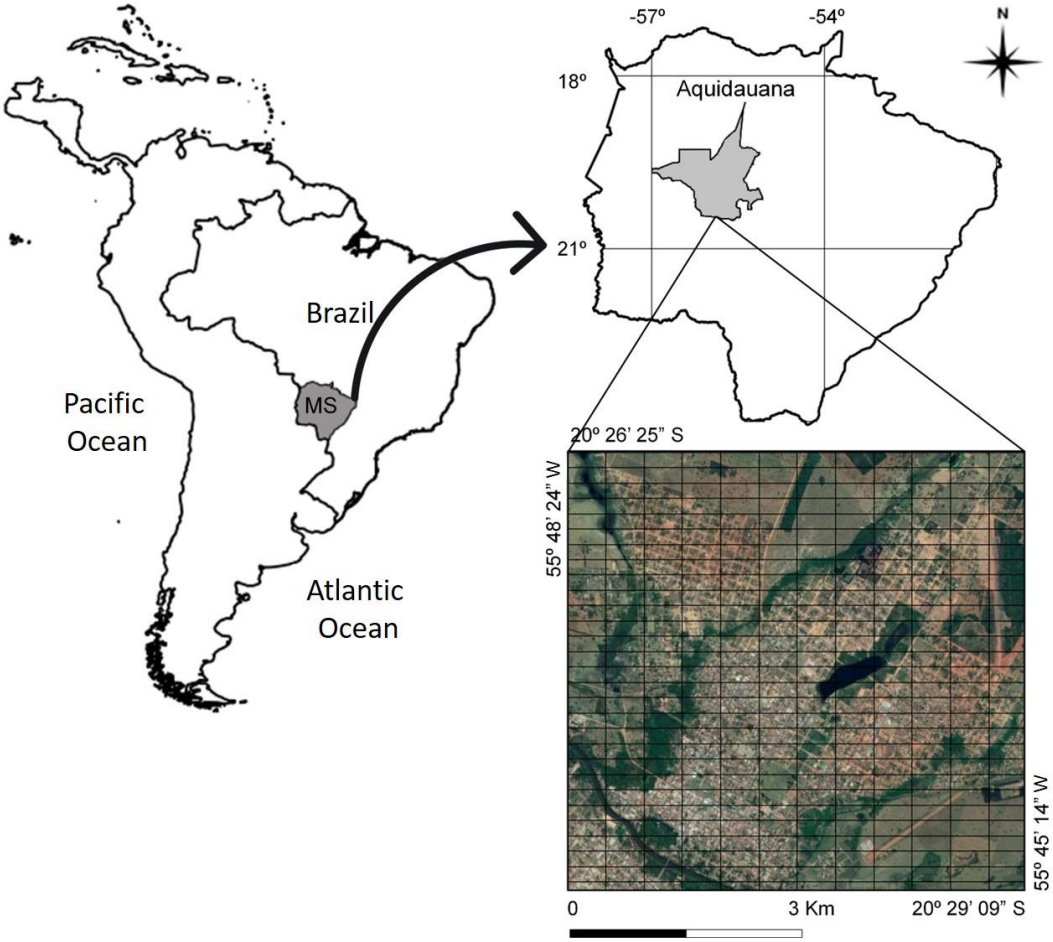
The municipality of Aquidauana is located in the central portion of the state of Mato Grosso do Sul (MS) in the *Cerrado* (savanna)-*Pantanal* (wetland) ecotone (Figure 1). The city has a total area of 16,957.75 km², with an estimated population of 45,614 residents and demographic density of 2.69 residents/km², according to the most recent census (IBGE, 2010). The urban area has a total area of approximately 20 km² and an estimated population of 36,000

residents. Classified as Aw tropical (Peel et al., 2007), the climate is warm and wet in summer with a rainy season spanning from October to April and dry in winter (May to September). Average annual precipitation is 1200 mm and maximum and minimum temperatures are 33° and 19°C, respectively (Schiavo et al., 2010). According to data from INMET (National Meteorology Institute [s.d.]), Aquidauana is among the ten hottest municipalities in the Midwest region of Brazil, together with Coxim, Três Lagoas and Paranaíba in the state of MS.

Due to the vast urban area, the decision was made to perform sampling with the random selection of quadrants. The entire area of the city was divided into quadrants measuring 200 x 500 m, which were numbered and randomly selected by lots. According to Milano & Soares (1990), this format and size were the most efficient among those tested by the authors. Only quadrants with more than 50% of the total extension of tree-lined streets were considered potential samples, defining a sample population of 126 units (Figure 1). After analysis, these units were randomly selected to define what quadrants would be used for the survey. The sampling was limited to tree-lined streets. Public squares and other green areas were not considered. Data collection was performed between December 2018 and August 2019.

Figure 1

Location of study area (quadrants measuring 200 x 500m) in municipality of Aquidauana, state of Mato Grosso do Sul (MS), Brazil.



Source: The authors

To determine the sufficiency of the sample considering precision of 95% probability and a 10% limit of error, the following formula was used with the aim of homogenizing differences in observed density in the data:

$$Ncalculated = \frac{t^2 * s^2}{E^2 + \frac{t^2 * s^2}{N}}$$

in which s^2 = variance of the variable of interest (number of trees per kilometer of tree-lined street); t = the tabular value for n-1 degrees of freedom and p probability level; E^2 = $(LE\%.X)^2$, with LE = limit of percentual error and X = mean of the variable; N = total number of potential units; $\frac{t^2 * s^2}{N}$ = correction factor for the finite population.

All trees in the selected quadrants were counted, identified and classified with regards to the following:

1. Area of natural occurrence: Native or exotic; all species that originally occur in the state of Mato Grosso do Sul were considered native in this survey; for such, we followed Flora of Brazil (2020) and Lorenzi (1992, 1998, 2009);
2. Size: Total height of the tree in meters and circumference at breast height (CBH) in centimeters;
3. Distance from building: distance from tree to wall or alignment of the property in meters;
4. Distance from the curb: distance from the tree to the curb in meters;
5. Distance from corners/intersections, greater or not than five meters (in accordance with legislation);
6. Presence of electrical grid: existence or not of low- and/or high-tension wires;
7. Conflicts with infrastructure: damage to sidewalks, walls, benches and conflicts with passages, signage, lighting and buildings;
8. Phytosanitary quality: presence of termites, parasites, fungi, injuries, inclination, necrosis and poorly performed pruning as well as death of vegetative portion of the plant, if occurred.

The identification of species was performed in the field whenever possible with the assistance of identification manuals (Lorenzi, 1992; 1998; 2009; Pott & Pott, 1994; Silva Junior, 2005; Ramos et al., 2008; Silva Junior & Pereira, 2009) or subsequently through the aid of virtual herbaria. Descriptive statistics was used for the data analysis.

Results and Discussion

The qualitative-quantitative assessment of Aquidauana was performed in eight previously selected quadrants totaling approximately 23 km of roadway, including 59 streets in seven neighborhoods. The number of quadrants was sufficient for a 95% confidence level and 10% rate of error, corresponding to 6.4% of the sample intensity.

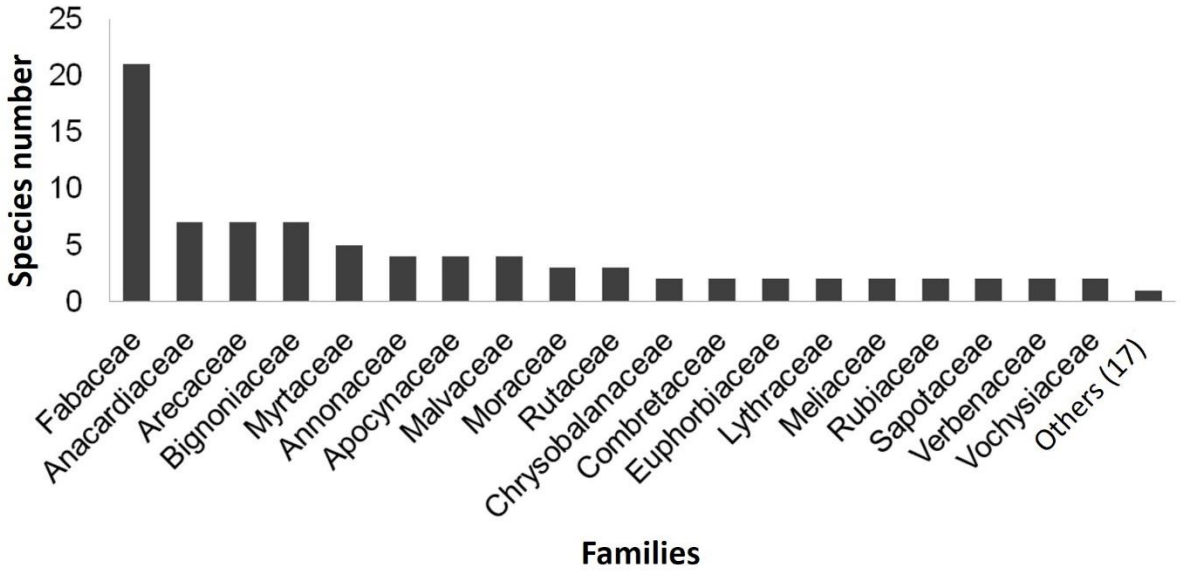
A total of 1280 trees belonging to 101 species (two of which were undetermined, Appendix 1) were surveyed. This richness is lower than that recorded for the municipalities of Campo Grande (161 species, PDAU/CG, 2010) and Dourados (150 species, PDAU/Dourados, 2019), but higher than that recorded for other municipalities in the state, such as Bonito (61 species, Zamproni et. al., 2018), Cassilândia (48 species, Guilherme et al., 2018), Chapadão do Sul (54 species, Guilherme et al., 2018), Costa Rica (47 species, Guilherme et al., 2018), Coxim (17 species, but only one neighborhood sampled by Mota & Almeida, 2011), Paranaíba (45 species, Guilherme et al., 2018) and Três Lagoas (44 species, Santos, 2014). High species richness may be the result of continual, random planting performed by the local population (Rocha et al., 2004) or the maintenance of native plants species during the urbanization process, as seen in some quadrants sampled.

The species are distributed among 36 families, the most representative of which in terms of richness is Fabaceae (20.8% of species), followed by Bignoniaceae (7.8%) Anacardiaceae (6.9%) and Arecaceae (5.9%) (Figure 2). Fabaceae is considered the largest family in Brazil, with 2100 species and 188 genera, 31 of which are endemic, found in all Brazilian biomes

(Barroso et al., 1991; Lima, 2000). The substantial planting of species of this family is very common in Brazil, including municipalities of Mato Grosso do Sul (Pelegrim et al., 2012; Santos, 2014) and other states (Silva et al., 2018; Santos et al., 2019; Sousa et al., 2019).

Figure 2

Relative contribution of botanical families with species richness of the urban forest of Aquidauana, MS



Source: The authors.

Our data point to an average density of 55.74 trees/km of public streets in Aquidauana. This is higher than the density found in the municipality of Campo Grande (50 trees/km (PDAU/CG, 2010), which is currently considered the most arborized state capital in the country. Milano (1998) considers one tree every 12 m to be adequate for a good urban forest. This translates to 120 trees/km. Thus, the density found for Aquidauana is far below the recommended value and it is necessary to invest in the planting of seedlings in the municipality.

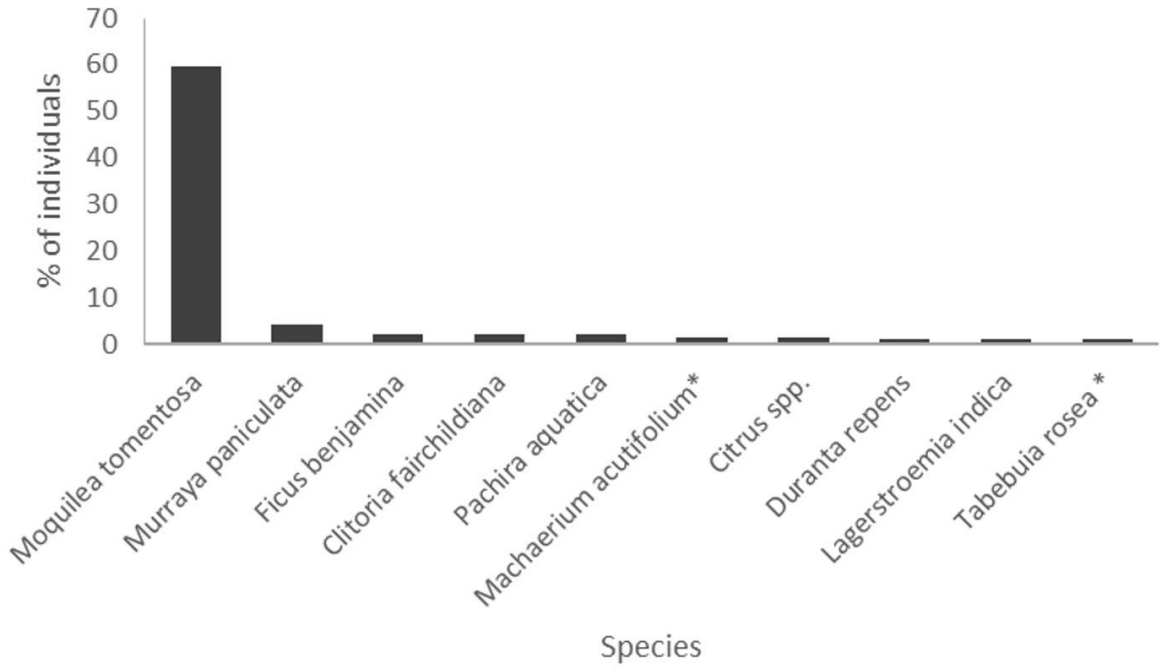
Considering the origin of the species used along the public streets of Aquidauana, we found 49 exotic species and 46 that are native to Mato Grosso do Sul. The use of native plants for urban afforestation has several advantages, as the plants are adapted to the local soils and climatic conditions, generally require less irrigation and fertilization than non-native plants and are often more resistant to insects and diseases, which makes them less likely to require pesticides (Slattery et al., 2003). Moreover, the use of native plants can assist in the maintenance of associated diversity (*e.g.,* pollinators and seed dispersers) (Brun et al., 2007).

Native species are often represented by one or few individuals, whereas exotic species predominate in number. Only one of the ten most abundant species is native to the state (Appendix 1, Figure 3): *Machaerium acutifolium* (1.5% of the individuals). The most abundant species by far is *Moquilea tomentosa* (60%), which is common in municipalities of Mato Grosso do Sul (Pelegrim et al., 2012; Santos, 2014; Guilherme et al., 2018; Zamproni et al., 2018) and other states (Brandão et al., 2011; Silva et al., 2012; Santos et al., 2019; Sousa et al.; 2019). This is a native tree of the Atlantic Forest of Brazil, occurring from the state of Pernambuco to the northern portion of the state of Espírito Santo and Rio Doce Valley in the state of Minas Gerais (Lorenzi, 2002). The selection of this species for the urban forest may be related to the fact that the tree has leaves throughout the year, with an ample, leafy canopy, is appropriate for topiary pruning and is efficient at reducing the temperature (Basso & Correa, 2014). However, the percentage of *M. tomentosa* in the urban forest of Aquidauana is much higher than that recommended by Grey and Deneke (1978), who indicate a frequency of less than 15%, and that recommended by Santamour Júnior (2002), who indicate that the frequency should not surpass 10% of a single species, 20% of a single genus and 30% of a single plant family. This recommendation is based on the fact that homogeneity in an urban forest implies a high chance of the propagation of diseases and parasites, a high loss of individuals as well as the fact that the predominance of few species in the urban forest of a city has a set of consequences for biodiversity of the urban ecosystem, as plant diversity is of the utmost importance to the

expansion and fixation of the fauna (Brun et al., 2007), the maintenance of the biological equilibrium and pest control (Milano, 1988). Thus, no further planting of this species should be performed and investments should be made in the planting of seedlings of native species.

Figure 3

*Ten most abundant species in urban forest along public streets in Aquidauana, Mato Grosso do Sul. * Species native to state.*



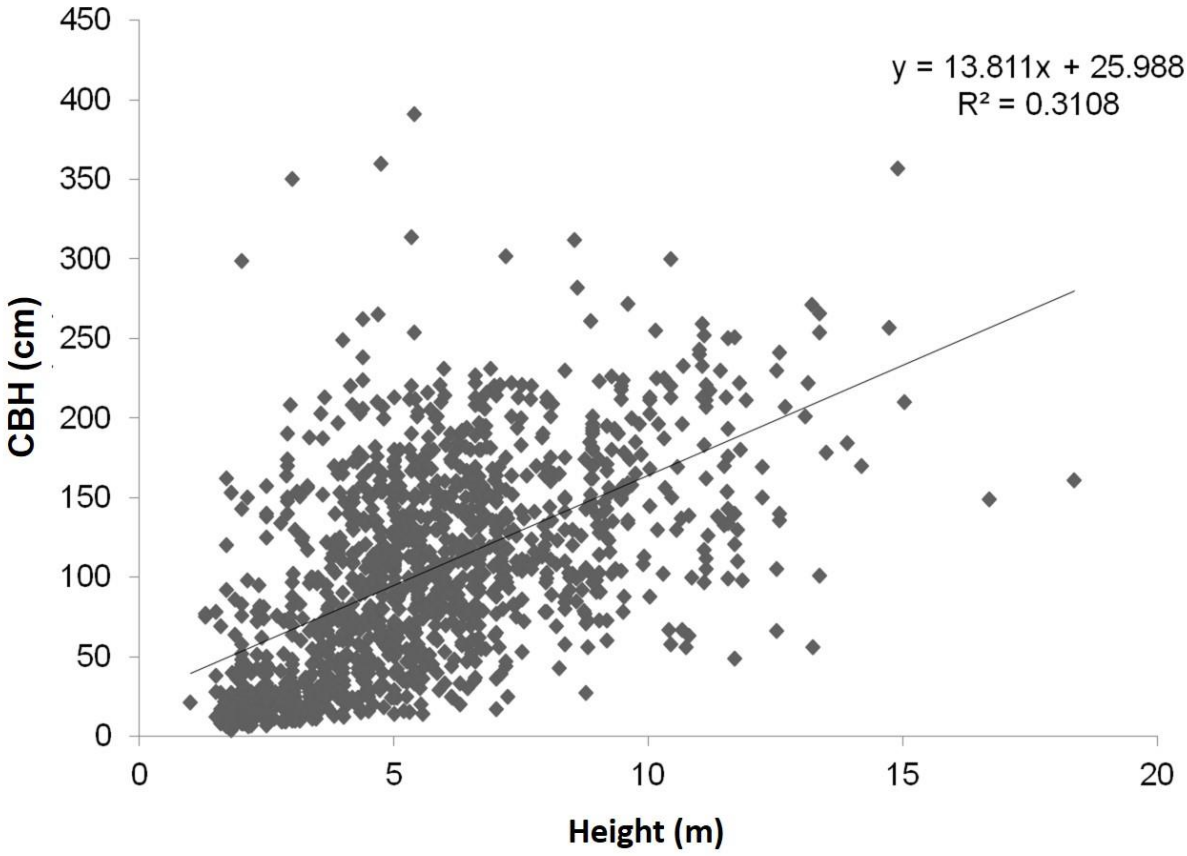
Source: The authors.

The average height of the trees was 5.1 ± 1.1 m and the circumference at breast height was 68.3 ± 26.2 cm. The trees with the tallest average height were *Albizia niopoides* (18.4 m) and *Licania humilis* (13.1 m), which also had the highest CCH values (Appendix I). *Moquilea tomentosa*, which was the most abundant species in the study, had an average height of 6.2 ± 2.4 m and CCH of 126.5 (± 56.8 cm). Taller trees generally have a larger CCH. However, it is

also possible to have trees with a large CCH and very short height, which are individuals submitted to drastic pruning, leading to the suppression of a considerable part of the canopy (Figure 4). Drastic pruning should be avoided and only employed in emergency situations preceded by a technical assessment. Approximately 17% of the trees had a CCH less than 30 cm and more than 65% of these trees were less than 3 m in height, corresponding to young trees. The Institute of the Environment of the state of Mato Grosso do Sul permitted the cutting of trees with a CHH ≥ 30 cm (SEMADE Resolution 09/2015) (IMASUL, 2015). However, this single aspect in not valid for the urban environment and other criteria, such as height and plant health, should be observed to prior to the cutting and/or removal of trees from the urban environment.

Figure 4

Ratio between height (m) and circumference at breast height (CBH) of trees along public streets of Aquidauana, Mato Grosso do Sul.



Source: The authors.

With regards to the spatial parameter, 46% of the tress are located under power lines and 60% of these trees have some conflict with the electrical grid. Around 17% of the trees are less than the recommended distance from the curb (greater than 30-40 cm, according to Santiago, 1980) to avoid physical damage by vehicles and 15% are less than 5 cm from the curb. If we consider the minimal distance of 1 m proposed by Milano (1984), the frequency of trees in an irregular situation rises to 34.7%. More than 12% of the individuals are less than 1 m from the building or wall, which could cause cracks in constructions (Silva Filho et al., 2002),

promote excessive shade (Gonçalves & Paiva, 2004) and facilitate the entrance of thieves on the property (Monico, 2001). Moreover, 5% of the trees are less than 5 m from corners, which is in disagreement with technical recommendations and exerts a negative impact on traffic.

Among the trees sampled, most (60%) have no conflict with infrastructure (walkway, signage, lighting or buildings). Conflict with the walkway due the growth of roots and consequent raising or breaking of the sidewalk or impediment of the passage of pedestrians was the most common conflict, with 9% of the individuals in this situation, which is largely the result of insufficient free space for the adequate growth of trees; more than 15% did not have even a 10 cm radius of free area around the plant. The species most in conflict with the walkway are *Moquilea tomentosa*, *Clitoria fairchildiana*, *Citrus* spp. and *Murraya paniculata*, the first two of which mainly due to the growth of roots and the subsequent two due to impeding the passage of pedestrians. Thus, the implantation of legal norms for the management of trees is needed, including the offer of pruning courses to those involved in this practice in the municipality. Aquidauana has a recent Municipal Afforestation Code (Complementary Law nº 88/2020) that disciplines actions of suppression, transplanting and pruning plant species in public spaces. Besides this recent legal instrument, two other municipal laws on urban afforestation are the Soil Use and Parceling Law (Lei n°796/1979) and the complementary law that creates the directing plan (Complementary Law n°09/2008). These two instruments address free space for growth, insertion and free span for occupation of the soil. However, both are in need of revision and updating. The updating of the directing plan including an ample discussion with the community and the creation of the municipal urban afforestation plan (envisaged in Article 4 of the Municipal Afforestation Code) are actions of extreme importance to the maintenance of the urban forest of Aquidauana.

The planting of seedlings should be coordinated by the authorities and property owners should be counselled in terms of care and management. In the state of São Paulo, 6.91% of plantlets suffer some degree of vandalism (breaking, injury or mechanical removal) and 1.37%

are stolen to be resold (Sirvinskas, 2020). The vandalism and robbery of seedlings are important aspects that afforestation administrators should take into consideration and warn the public, as the care of trees is the joint responsibility of the state and population.

The phytosanitary state of the trees requires attention, as less than 10% of the individuals are in an optimal state without the presence of termites, parasites, fungi, injuries, inclination, necrosis and poorly performed pruning and more than 30% have a combination of four or more of these problems. Poorly performed pruning is the main problem of the urban forest along public streets of Aquidauana (85.3% of the trees), followed by injuries (67.7%) and necrosis (57.9%). Poorly performed pruning has a tendency to increase as residents do so by themselves or hire third parties with no technical training for these activities, at times impatient with the public power or due to a lack of knowledge. Among the poorly performed pruning – although not counted in the present study – the occurrence of drastic pruning is noteworthy, which often results from the inadequate choice of species to be used and the lack of adequate management without the proper conduction of the canopy of the trees, for example. The high occurrence of necrosis is often the consequence of this poorly performed pruning, which is a gateway for pathogens.

Regarding injuries, environmental education work is needed with the public for the mitigation of the problem and to avoid vandalism, which should include raising the awareness of the population regarding the benefits provided by urban afforestation, the problems triggered by poor management practices and information on the current norms of the municipality.

Conclusion

With this study, we found that the afforestation of public streets in the municipality of Aquidauana has a considerable diversity of species, but many native species are represented by few individuals, promoting the homogenization of urban forest, with a predominance of *M.*

tomentosa. The number of specimens is below the recommended quantity and there is a need for planting, which should prioritize native species. The main problems of the urban forest are conflicts with the electrical grid, poorly performed pruning and the presence of necrosis on the trees. These problems are interlinked and require mitigation measures, such as the adequate planning of the planting and management of trees, the implementation of legal norms, the offer of pruning courses for all agents involved in this practice in the municipality and the adoption of environmental education programs that address this issue.

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Appendix 1

Species recorded in urban forest of road system in Aquidauana (MS, Brazil) with respective common names, origin, number of individuals sampled and average (standard deviation) height and circumference at breast height (CBH).

Family	Species	Common name	Origin			Individuals number	Height (m)		CAP (cm)	
			MS	Brazil	Exotic		Mean	Standard deviation	Mean	Standard deviation
Anacardiaceae	*Anacardium humile*	Cajuzinho-do-cerrado	X			1	2.6	-	11.0	-
Anacardiaceae	*Anacardium occidentale*	Cajueiro	X			4	5.0	1.8	38.3	25,5
Anacardiaceae	*Astronium fraxinifolium*	Gonçalo-alves	X			6	5.2	1.9	51.3	38,5
Anacardiaceae	*Mangifera indica*	Mangueira			X	12	6.2	2.3	90.0	44,0
Anacardiaceae	*Myracrodruon urundeuva*	Aroeira	X			9	7.7	3.1	83.7	51,3
Anacardiaceae	*Schinus terebinthifolia*	Aroeira-vermelha	X			1	5.4	-	52.0	-
Anacardiaceae	*Spondias purpurea*	Seriguela			X	11	4.6	2.1	89.2	57,2
Annonaceae	*Annona coriacea*	Araticum	X			1	4.0	-	14.0	-
Annonaceae	*Annona crassiflora*	Marolo	X			1	3.2	-	15.0	-
Annonaceae	*Annona muricata*	Graviola			X	2	3.2	1.2	34.5	12,0
Annonaceae	*Annona* spp.	Ata				3	4.3	0.9	36.0	23,5
Apocynaceae	*Nerium oleander*	Espirradeira			X	1	2.5	-	15.0	-
Apocynaceae	*Plumeria pudica*	Jasmim-da-venezuela			X	2	2.1	0.1		
Apocynaceae	*Plumeria rubra*	Jasmim-manga			X	1	1.6	-	17.0	-
Apocynaceae	*Thevetia peruviana*	Chapéu-de-napoleão	X			3	2.6	0.3	31.7	13,8
Arecaceae	*Acrocomia aculeata*	Bocaiuva	X			8	7.2	2.8	67.3	22,1
Arecaceae	*Cocos nucifera*	Coqueiro		?	?	1	6.6	-	60.0	-
Arecaceae	*Dypsis lutescens*	Areca-bambu			X	1	2.4	-	27.0	-
Arecaceae	*Phoenix roebelenii*	Palmeira-fênix			X	4	2.8	0.2	43.5	5,7

Family	Species	Common name	Origin			Individuals number	Height (m)		CAP (cm)	
			MS	Brazil	Exotic		Mean	Standard deviation	Mean	Standard deviation
Arecaceae	*Roystonea regia*	Palmeira-imperial			X	4	5.1	2.6	56.8	35,4
Arecaceae	*Syagrus romanzoffiana*	Jerivá	X			5	5.1	1.8	57.0	13,0
Arecaceae	Undetermined	-				1	2.5	-	16.0	-
Bignoniaceae	*Handroanthus chrysotrichus*	Ipê-amarelo-cascudo		X		9	3.0	1.1	18.0	9,4
Bignoniaceae	*Handroanthus heptaphyllus*	Ipê-rosa	X			2	2.2	0.3	12	7,7
Bignoniaceae	*Handroanthus impetiginosus*	Ipê-roxo	X			8	7.4	3.1	57.3	28,8
Bignoniaceae	*Jacaranda cuspidifolia*	Caroba	X			4	6.5	2.7	70.8	58,6
Bignoniaceae	*Spathodea campanulata*	Espatódia			X	2	8.8	3.3	143.0	90,5
Bignoniaceae	*Tabebuia aurea*	Paratudo	X			6	4.5	2.1	76.5	67,1
Bignoniaceae	*Tabebuia rosea*	Ipê-rosa			X	11	5.9	3.2	64.3	55,9
Bignoniaceae	*Tabebuia roseo-alba*	Ipê-branco	X			7	2.8	0.9	21.3	16,1
Bixaceae	*Bixa orellana*	Urucum	X			3	3.0	1.2	22.0	2,0
Boraginaceae	*Cordia glabrata*	Louro-preto	X			4	8.6	3.8	91.0	47,5
Calophyllaceae	*Kielmeyera coriacea*	Pau-santo	X			2	3.7	0.4	13.5	2,1
Caricaceae	*Carica papaya*	Mamão			X	4	2.8	0.7	21.3	11,5
Caryocaraceae	*Caryocar brasiliense*	Pequi	X			4	9.9	1.0	170.3	61,3
Chrysobalanaceae	*Licania humilis*	Marmelo-do-campo	X			1	13.1	-	201.0	-
Chrysobalanaceae	*Licania tomentosa*	Oiti		X		764	6.2	2.4	126.5	56,8
Combretaceae	*Terminalia argentea*	Capitão-do-mato	X			1	9.2	-	116.0	-
Combretaceae	*Terminalia catappa*	Sete-copas			X	4	7.5	3.6	131.0	40,4
Cupressaceae	*Cupressus macrocarpa*	Cipreste			X	1	4.0	-	49.0	-
Dilleniaceae	*Curatella americana*	Lixeira	X			2	7.4	2.3	125.0	19,8
Euphorbiaceae	*Croton urucurana*	Sangra-d'água	X			1	6.4	-	47.0	-

Family	Species	Common name	Origin			Individuals number	Height (m)		CAP (cm)	
			MS	Brazil	Exotic		Mean	Standard deviation	Mean	Standard deviation
Euphorbiaceae	*Jatropha gossypiifolia*	Pião-roxo	X			3	4.5	0.9	14.0	-
Fabaceae	*Adenanthera pavonina*	Falso-pau-brasil			X	1	1.3	-	75.0	-
Fabaceae	*Albizia niopoides*	Farinha-seca	X			1	18.4	-	161.0	-
Fabaceae	*Amburana cearensis*	Amburana	X			1	7.3	-	222.0	-
Fabaceae	*Andira cujabensis*	Morcegueira	X			1	11.6	-	154.0	-
Fabaceae	*Bauhinia curvula*	Pata-de-vaca	X			2	4.7	0.2	17.0	1,4
Fabaceae	*Bauhinia variegata*	Pata-de-vaca			X	9	3.1	1.1	49.3	26,1
Fabaceae	*Cenostigma pluviosum*	Sibipiruna	X			4	8.1	1.1	156.5	34,7
Fabaceae	*Caesalpinia pulcherrima*	Flamboyanzinho			X	6	3.6	1.5	22.0	6,7
Fabaceae	*Cassia fistula*	Chuva-de-ouro			X	3	6.5	2.0	40.7	34,0
Fabaceae	*Senna spectabilis*	Cassia-amarela	X			1	8.7	-	126.0	-
Fabaceae	*Clitoria fairchildiana*	Sombreiro		X		27	6.3	1.9	133.3	43,0
Fabaceae	*Delonix regia*	Flamboyant			X	5	3.7	1.6	84.8	42,6
Fabaceae	*Dimorphandra mollis*	Falso-barbatimão	X			2	9.2	0.2	113.0	31,1
Fabaceae	*Dipteryx alata*	Cumbaru	X			9	6.2	2.9	50.0	37,0
Fabaceae	*Erythrina falcata*	Mulungu	X			1	5.5	-	87.0	-
Fabaceae	*Hymenaea stigonocarpa*	Jatobá	X			4	5.5	2.2	51.3	50,3
Fabaceae	*Inga laurina*	Ingá-branco	X			8	6.9	3.6	167.8	108,6
Fabaceae	*Leucaena leucocephala*	Leucena			X	2	4.7	0.4	45.0	26,9
Fabaceae	*Machaerium acutifolium*	Jacarandá-do-campo	X			20	5.3	2.4	35.0	30,0
Fabaceae	*Tamarindus indica*	Tamarindo			X	2	6.3	0.3	125.0	77,8
Fabaceae	*Stryphnodendron rotundifolium*	Barbatimão	X			2	6.5	1.0	77.0	42,4
Lamiaceae	*Plectranthus barbatus*	Boldo			X	1	1.7	-	6.0	-
Lauraceae	*Persea americana*	Abacateiro			X	1	6.8	-	149.0	-

Family	Species	Common name	Origin			Individuals number	Height (m)		CAP (cm)	
			MS	Brazil	Exotic		Mean	Standard deviation	Mean	Standard deviation
Lythraceae	*Lagerstroemia indica*	Resedá			X	14	2.5	0.7	15.5	10,3
Lythraceae	*Punica granatum*	Romã			X	1	3.3	-	25.0	-
Malpighiaceae	*Malpighia glabra*	Acerola			X	6	2.3	0.4	38.2	41,9
Malvaceae	*Ceiba speciosa*	Paineira	X			1	5.5	-	50.0	-
Malvaceae	*Hibiscus rosa-sinensis*	Hibisco			X	3	1.4	0.4	16.3	5,7
Malvaceae	*Luehea divaricata*	Açoita-cavalo		X		1	9.0	-	91.0	-
Malvaceae	*Pachira aquatica*	Munguba		X		27	7.1	2.0	154.0	59,6
Melastomataceae	*Pleroma granulosum*	Quaresmeira		X		1	1.7	-		
Meliaceae	*Cedrela fissilis*	Cedro	X			1	7.0	-	161.0	-
Meliaceae	*Azadirachta indica*	Nim			X	8	4.4	1.6	36.4	21,0
Moraceae	*Artocarpus heterophyllus*	Jaca			X	1	7.2	-	302.0	-
Moraceae	*Ficus benjamina*	Ficus			X	28	6.0	3.1	141.7	73,4
Moraceae	*Morus nigra*	Amora			X	3	4.5	1.5	43.3	22,0
Moringaceae	*Moringa oleifera*	Moringa			X	4	6.4	1.3	37.5	14,5
Myrtaceae	*Eugenia uniflora*	Pitanga	X			4	1.9	0.2	17.3	3,2
Myrtaceae	*Plinia cauliflora*	Jabuticaba		X		1	1.5	-	38.0	-
Myrtaceae	*Psidium guajava*	Goiabeira		X		13	3.6	1.2	29.6	13,9
Myrtaceae	*Syzygium cumini*	Jamelão			X	3	7.4	3.1	125.3	99,8
Myrtaceae	*Syzygium jambos*	Jambo			X	1	4.8	-	60.0	-
Oxalidaceae	*Averrhoa carambola*	Carambola			X	2	2.7	1.0	43.5	16,3
Rubiaceae	*Genipa americana*	Jenipapo	X			1	2.8	-	10.0	-
Rubiaceae	*Morinda citrifolia*	Noni			X	3	3.6	1.9	23.3	7,2
Rutaceae	*Citrus* spp.	Laranja, Mexerica, Limão				18	3.6	1.4	44.5	28,1
Rutaceae	*Murraya paniculata*	Murta-de-cheiro			X	55	3.1	1.0	49.6	30,3

Family	Species	Common name	Origin			Individuals number	Height (m)		CAP (cm)	
			MS	Brazil	Exotic		Mean	Standard deviation	Mean	Standard deviation
Rutaceae	*Zanthoxylum rhoifolium*	Mamica-de-porca	X			4	8.5	4.6	65.0	39,2
Salicaceae	*Salix babylonica*	Salgueiro-chorão			X	2	4.9	0.7	52.0	4,2
Sapindaceae	*Talisia esculenta*	Pitomba		X		1	3.0	-	45.0	-
Sapotaceae	*Pouteria ramiflora*	Curriola	X			3	8.4	3.9	108.7	85,4
Sapotaceae	*Pouteria torta*	Abiurana	X			1	2.4	-	30.0	-
Solanaceae	*Cestrum nocturnum*	Dama-da-noite			X	1	2.9	-	9.0	-
Urticaceae	*Cecropia pachystachya*	Embaúba	X			1	2.0	-	38.0	-
Verbenaceae	*Duranta repens*	Pingo-de-ouro			X	15	2.3	1.1	17.7	10,0
Verbenaceae	*Aloysia gratissima*	Garupá				1	2.8	-	72.0	-
Vochysiaceae	*Qualea grandiflora*	Pau-terra	X			3	8.2	0.9	79.3	21,1
Vochysiaceae	*Vochysia divergens*	Cambará	X			1	3.3	-	16.0	-
	Standing dead trees					7	2.3	0.9	109.6	87,2
	Undetermined					2	2.2	0.9	14.0	2,0
TOTAL			**47**	**9**	**40**	**1280**	**5.1**	**1.1**	**68.3**	**26.2**

Source: The authors.