CIÊNCIA e NATURA

UFSM

Ci. e Nat., Santa Maria v.42, e30, p. 1-26, 2020
DOI:10.5902/2179460X41526
ISSN 2179-460X

Environment Submissão 10/12/19 Aprovação 31/10/19 Publicação 24/06/20

Urban arborization management plan: tool design for efficiency and public safety

Joema Carvalho[I], Leila Teresinha Maranho[II]

ABSTRACT

The inventory of the urban arborization of Positivo University parking lots in Ecoville Campus was conducted through census criteria, concerning the surroundings conflicts related to tree health, origin and phenology, that were scored and weighted. There were 393 individuals, 12 species and five families where 60% were native to Brazil. The main canopy criteria was the reaching branches on the access road in a proportion of 40%; in the trunk analysis, it was observed lesion (45%) and rot (40%); at the base's analysis it was verified injury (43%) and root damage (35%) and exposed root (25%). The presence of fruit (26%) was higher than the flowering. Handroanthus albus presented the best result for the criteria, unlike Anadenanthera macrocarpa and Tipuana tipu. The trees showed a landscaping potential, however, the space available for the large size ones was not adequate and the large size species intensified the conflicts, when there was no planning. The species characteristics should be observed, in relation to the three-dimensional space availability. Thus, future conflicts that can be avoided endanger tree health, urban infrastructure and residents which can lead to economic losses. For this reason, the elaboration of the Municipal Urban Arborization Plan is considered primordial.

Keywords: Urban arborization; Criteria; Conflicts

1 INTRODUCTION

Urban arborization is all existing arboreal coverage present in the cities, located in free public and private areas, following the road system (DANTAS et al., 2011). Its function is to reduce environmental impacts within the cities, by moderating the climate, maintaining energy inside buildings, absorbing carbon dioxide, improving water quality, controlling water runoff and flooding, reducing noise levels, offering shelter for fauna, contributing to the aesthetics, leisure, comfort and well-being, improving the urban quality of life (CHUN; GULDMANN, 2018; HU et al., 2018; ARAUJO; ARAUJO, 2016; KARDEL et al., 2010), of present and future generations, which is the reason why it has a very diffuse character (MPEP, 2018).

[I] Universidade Positivo, Curitiba, PR,Brasil
[II] Universidade Positivo, Curitiba, PR,Brasil

These benefits are enhanced when native species are employed, as they generate identity for urban arborization when providing contact with the local vegetation. They also have higher survival and longevity rates and reduces the maintenance costs (LIMA; JUNIOR, 2010).

The urban environment is adverse for the development of urban trees, commonly taking place compacted and / or altered soils, water and nutrient deficiency, climate change, heat stress, flooding, air pollution, intense solar radiation and reduced space (HUANG et al. , 2019; ARAUJO; ARAUJO, 2016; REVI et al., 2014).

The City Statute, Federal Law 10.257 / 2001, states that it is the municipalities obligation to formulate and execute the master and the urban development plans, regarding the urban arborization, in line with the guidelines, to guarantee the right to sustainable cities and leisure for those present and future generations, to direct and control the land use in order to avoid the deterioration of urbanized areas, the pollution and environmental degradation, protection, preservation and recovery of the natural and built environment and also the landscape heritage (BRAZIL , 2001).

According to the MPEP (2018), is regarded that there is a lack of human resources training for planning, seedling production, implementation, maintenance and urban arborization monitoring and also that any existent incompetence in these matters may lead to difficult or even permanent conflicts. Whereas the urbanization effects which most interfere in the urban arborization planning are related to the size of the streets, sidewalks, tree beds, alteration of the physical and chemical conditions of the soil, the presence of electric power network, underground water pipe, sewage and gas, the car and pedestrian flow (MPEP, 2018).

Araujo and Araujo (2016) believe that the management is hardly adequate. Thus, they found trees with drastic pruning, mechanical damage by vehicle, lawn mower, trunk annealing and vandalism. The size of a city, the type of a road system, the way urban infrastructure is established, and the characteristics of tree species are factors that should be taken into attention in the planning (SILVA, 2008).

Knowledge about the behavior and characteristics of species used in urban arborization should be considered, in order to mitigate the effects of urbanization,

thereby increasing their potential (ABREU; LABAKI, 2010; CARDIM, 2011; SILVA, 2008). Thus, reducing the incompatibility between arborization and infrastructure urban (MONHOTO et. al., 2009).

The inventory of urban tree is essential for its planning and maintenance as a monitoring and evaluation tool, diagnosing the need for management, phytosanitary problems, treatment or removal or even implementation (BRIANEZI et al., 2013; CEMIG, 2011). Subsequently, it is possible to elaborate the Urban Arborizarion Plan, defining public policies, future budget forecasts and management programs, prioritizing interventions and maintenance (SOARES; PELLIZARO, 2019)

The analysis should take into consideration parameters such as location, botanical classification, tree health, dendrological and surrounding characteristics, such as wiring, piping, street width and construction distance (SILVA et al., 2006), and be carried out through efficient and innovative technical criteria, to ensure their conservation and to guide the population on the importance of environmental services (MEUNIER, 2013). Simultaneously, to focus on the effectiveness in urban arborization maintenance, such as proper pruning, in order to avoid destabilization of the trees, which generates morphological problems that favor the occurrence of diseases, pests and putting them at risk of falling (NICODEMO; PRIMAVESI, 2009). The importance of sustainable management of urban green spaces is continuously growing and it is a path that policymakers, practitioners and scientists need to deal with, concerning the conflicts that affect these areas (MCDONNELL; MACGREGOR-FORS, 2016).

Regarding the European Union, strategies based on the 'green infrastructure' (EC, 2013) and 'nature-based solutions' concepts (EC, 2015) are being developed considering the ecosystem and its process, which both terms being tried, tested and effective tools used to successfully deliver ecological, economic and social benefits through natural solutions, related to the human benefits that society derives from nature, built-in spatial planning and territorial development (EC, 2013).

This context aims at planning ecosystem services through the interaction between ecosystems and well-being (HAASE et al., 2014; GÓMEZ-BAGGETHUN et al.,

2013; GÓMEZ-BAGGETHUN; BARTON, 2013).

The research was conducted throught inventory of the urban arborization of Positivo University parking lots in Ecoville Campus. The purpose of this work was provided a tool for the urban arborization management plan elaboration, through appropriate technical criteria and parameters, which aimed at maximizing the benefits and minimizing conflicts with urban buildings and structures, thus reducing maintenance costs and contributing to public safety.

2 MATERIAL AND METHODS

Curitiba is located on the First Paranaense Plateau, latitude 25°25'40" S and longitude 49°16'23" W, average altitude 934.6 m.a.n.m. The average annual temperature is 17.9 ° C, the minimum temperature in the coldest month is 8.7 ° C and the maximum in the warmest month is 27.2 ° C, reaching values below 5 ° C and above 33 ° C (INMET, 2012). Frost formation is common in the region (MAACK, 2012).

Positivo University in Ecoville Campus is located at Prof. Pedro Viriato Parigot de Souza, 5300, Industrial City in Curitiba, Paraná State, Brazil. It has 424.8 thousand m², where capons with remnants of Mixed Ombrophylous Forest and nine parking lots with arborization are verified, following the pattern of urban arborization, as part of the existing landscape. According to Bordignon (2011), it has around 1,700 employees, teachers and trainees, 400 service providers and suppliers, 11,000 undergraduate and graduate students and 3,000 visitors, totaling approximately 13,000 moving people.

The inventory of all trees located in the nine parking lots of the Positivo University Ecoville Campus was performed by census, where the perimeter at breast height (PBH) and total height (TH) and inversion point estimates were measured (IP) of all trees, considering a height equal to or greater than 2.5 and 1.8, respectively. Criteria were selected for the physical and phytosanitary assessments of the canopy, trunk, base of the trunk, root and the conflict between tree individuals and their surroundings, by following the adapted methodology of Santos et al. (2010). Each criteria, considering its verification in the tree individuals, received a score from 1 to 4,

in the on-site observation of the individuals, being 1, "0%" (absent), 2 "from 1% to 20%" (low), 3 "21% to 50%" (intermediate) and 4 "> 51%" (high).

For the canopy evaluation, branches were considered invading the access road and the electric power network; presence of dry and / or hollow branches, bark damage, presence of xylophagous agents and the presence of mistletoes; thin or abnormal foliage, improper pruning and also a need for pruning; for the trunk evaluation, beat damage, rot, bark injury, presence of xylophagous agents, cavity, inclination, tortuosity and cracking; in relation to the base of the trunk, presence of epicormic sprouting, cavities, bark lesions, mowing damage, presence of xylophage agents and curb restriction; damage and exposure of the root and presence of epicormic root were observed. Flowers, fruits and seeds were considered during the sampling period, from March to May 2018.

After performing the inventory, the score obtained for each criteria, tabulated in Microsoft Excel spreadsheets, was multiplied by the number of observations (individuals per species), thus obtaining the weighting. The Coefficient of Variation (CV), which corresponds to the relative standard deviation (SD) over the mean (M), was calculated to verify the degree of certainty of weight acquired through the on-site evaluation of the criteria. The relative weighting values were calculated and thus it was possible to fit the criteria evaluated into four categories: low (0% to 25%), intermediate (26% to 50%), high (51% to 75%) and very high (76% to 100%). Referring to the weighted high and very high values of the criteria. A table was set uo for analysis and discussion of the results, as shown in this article. The main criteria observed in individuals, species and afforestation of the Campus were evaluated in order to obtain the main conflicts present in the environment of Positivo University with regard to afforestation of parking lots.

The origin of the species was defined as native species (typical of the Mixed Ombrophilous Forest); native to Brazil (typical of other biomes in Brazil); exotic (from other countries) and invasive exotic (as per IAP Ordinance 059/2015).

The species were identified *in loco* and subsequently, the scientific names were verified with the help of botanical identification keys, such as Angiosperm Phylogeny

Group IV (APG IV, 2011) and virtual herbariums. Reflora (http://www.reflora.jbrj.gov.br) and Missouri Botanical Garden (http://www.tropicos.org).

3 RESULTS

There were 393 individuals, belonging to 12 species, nine genera and five families. From this total, 235 are native to Brazil (60%), 121 are exotic (31%) and 37 are native to the Mixed Ombrophilous Forest (9.5%) (Table 1).

Lafoensi pacari, *Handroanthus avellanedae* and *Tipuana tipu* had the largest perimeter at breast height (PBH). Considering the total height, *Handroanthus avellanedae*, *Handroanthus heptaphyllus* and *Peltophorum dubium* presented the highest values. Regarding the morphological inversion point, the average per species ranged from 1.8 m to 5.3 m where *Lafoensia pacari*, *Peltophorum dubium* and *Schinus molle* had the highest morphological inversion point height (Table 1). Four individuals of *Schinus molle* and one individual *Peltophorum dubium* were dead.

Table 1 – Tree species at Positivo University parking lots Ecovile Campus, Curitiba, PR (NI = number of individuals; PBH = perimeter at breast height; MTH = mean total height; IP = morphological inversion point.

Family	Species	Origin	NI	PBH (cm)	MTH (m)	IP (m)
Anacardiaceae	*Schinus molle* L.	NB	90	43.4	3.9	2.7
Bignoniaceae	*Handroanthus albus* (Cham.) Mattos	N	21	26.4	3.1	2.0
	Handroanthus avellanedae Lor. Ex Griseb	NB	2	67.0	7.0	2.3
	Handroanthus heptaphyllus (Vell.) Tol.	NB	27	47.5	6.4	2.1
Fabaceae	*Anadenanthera macrocarpa* Benth.	NB	5	57.4	5.2	1.8
	Parapiptadenia rigida Benth.	NB	40	53.8	4.8	2.4
	Peltophorum dubium (Spreng.) Taub. - 1	NB	40	51.9	5.8	5.3
	Peltophorum dubium (Spreng.) Taub. - 2	NB	31	54.8	6.4	1.8
	Tipuana tipu (Benth.) Kuntze	E	38	64.0	4.8	2.1
Lythraceae	*Lafoensia pacari* A. St.-Hil.	N	16	69.6	5.6	4.9
	Lagerstroemia indica (L.) Pers.	E	9	24.4	3.3	1.8

Sapindaceae	*Koelreuteria paniculata* Laxm.	E	74	55.3	6.3	2.3
Total / Average			**393**	**51.3**	**5.2**	**2.6**

Legend: E = exotic; NB = native to Brasil; N = native to Mixed Ombrophilous Forest
Source: authors

Anadenanthera macrocarpa and *Tipuana tipu* showed hight proportions of the criteria considered for the canopy, around 80% of the individuals, as the branches reaching the access route, presence of hollow branches and lesions (Table 2).

In relation to *Tipuana tipu* trunk, it presented 80% rot, 70% inclination and 60% injury; followed by *Anadenanthera macrocarpa* with 70% lesion and *Handroanthus avellanedae* and *Koelreuteria paniculata* with 60% rot and lesion (Table 2).

According to observations from the base, *Peltophorum dubium* (1) presented lesion (70%) and mowing damage (55%), followed by *Lagerstroemia indica* with 70% and 85% and *Anadenanthera macrocarpa* with 70% and 50% for these criteria respectively. *Tipuana tipu* presented a high proportion of injuries (65%) (Table 2).

Anadenanthera macrocarpa and *Schinus molle* presented the highest proportions for exposed roots, obtaining, respectively, the proportion of 67% and 45%.

Phenology showed *Lafoensia pacari* with the highest proportions of fruit (70%) and flowers (60%), followed by *Anadenanthera macrocarpa* with 50% and 40%, respectively. *Handroanthus avellanedae* and *Parapiptadenia rigida* presented 75% and 70% of fruit and *Koelreuteria paniculata* 55% of flowers.

Koelreuteria paniculata was the only species that presented low proportion of conflict with the environment.

Considering the general average of the criteria for all evaluated individuals, related to the canopy evaluation, reaching the branches on the access route it was obtained 40%. Regarding the trunk, injury was the most frequently observed (45%), followed by rotting (40%). The presence of lesions (43%) was verified in the base analysis, followed by mowing damage (35%).

Exposed root obtained 25%. The presence of fruit (26%) was higher than flowering (17%), considering the individuals overall (Table 2).

Table 2 – Relative amount of individyals per species, which scores intermediate (21% to 50%) and high (> 51%) in the evaluation of the recommended criteria for canopy, trunk, base, root, phenology, surroundings in tree species at Positivo University parking lots Ecovile Campus

Estrutura	**Critérios**	**Espécies**												**M**
		KP	**PR**	**AM**		**SM**	**há**	**HAV**	**HH**	**PD1**	**LI**	**TT**	**LP**	**PD2**	
Copa	Via		-	47	87	55	13	3	21	54	49	89	56	-	**40**
	rede/cabos		-	-	-	4	-	-	-	-	-	-	-	-	**0**
	secos		46	24	-	23	30	9	32	23	27	-	11	45	**23**
	ocos		24	-	43	-	-	-	-	-	5	-	-	-	**6**
	lesão		-	25	-	8	-	-	-	10	8	65	-	21	**11**
	agentes xilófagos		-	7	-	4	-	-	-	-	-	10	-	-	-
	erva-de-passarinho		-	-	-	28	-	-	-	8	6	14	-	-	-
	folhagem rala/ de cor anormal		40	29	-	9	-	-	10	16	14	-	-	-	-
	poda inadequada		14	45	-	37	15	-	19	37	36	16	-	9	-
	necessidade de poda		41	42	27	37	13	-	31	37	-	23	-	-	-
Tronco	danos de batida		18	11	-	-	15	-	-	-	-	-	-	-	-
	podridão		63	65	33	41	-	60	40	2	18	83	40	28	**39**
	lesão		64	81	69	31	-	60	48	38	34	58	32	19	**45**
	agente xilófago		18	7	-	-	-	-	-	-	-	-	-	12	-
	cavidade		29	12	-	39	14	-	9	21	22	30	30	30	**20**
	inclinação		21	43	-	52	8	-	12	58	50	72	12	38	**31**
	tortuosidade		36	22	33	16	19	-	18	36	34	28	13	33	-
	rachadura		-	9	50	3	-	-	51	11	9	7	21	-	**13**
Base	brotação epicórnica		-	-	-	-	-	-	-	-	11	-	-	-	-

	cavidade	21	19	44	17	27	-	11	43	42	48	-	13	**24**
	lesão	38	56	71	40	13	-	42	72	75	65	24	23	**43**
	danos de roçada	34	55	50	11	16	-	6	89	84	32	16	23	-
	agentes xilófagos	22	-	-	-	-	-	-	13	-	10	-	-	-
	restrição do meio fio	28	13	50	-	-	-	13	-	-	-	-	-	-
Raiz	exposta	40	30	67	48	-	-	-	29	-	26	40	17	**25**
	danos	31	13	-	-	-	-	-	-	-	-	14	17	**6**
	epicornica	-	-	-	-	-	-	-	-	-	-	-	11	**1**
Fenologia	fruto	-	71	50	3	-	75	30	-	-	12	68	-	**26**
	Flor	55	-	43	7	-	-	9	8	-	6	62	9	**17**
	semente	-	-	-	-	-	-	-	-	-	-	-	-	**0**
Entorno	REE	24	-	-	-	-	-	--	-	-	-	-	-	-
	DVA	0	0	0	0	0	0	0	0	0	0	0	0	0
	TUB	13	-	-	-	-	-	-	-	-	-	-	-	**1**

Legend: *Koelreuteria paniculata* (KP), *Parapiptadenia rigid* (PR), *Anadenanthera macrocarpa* (AM), *Schinus molle* (SM), *Handroanthus albus* (HA), *Handroanthus avellanedae* (HAV), *Handroanthus heptaphyllus* (HH), *Peltophorum dubium* (1) PD!), *Lagerstroemia indica* (LI), *Tipuana tipu* (TT), *Lafoensia pacari* (LP), REE - power grid, DVA - access road distance, TUB - pipelines, media (M).
Source: authors

4 DISCUSSION

The urban arborization of the Positivo University car parking lots was characterized by the presence of native, native Brazilian and exotic species. Most species were native to Brazil, however, the presence of exotic species and the low representativity of native species of the Mixed Ombrophilous Forest (9% of the total), typical of the Curitiba region (IBGE, 2012), were notorious. According to MPPR (2018), Cupertino and Eisenlohr (2013) and Castro et al. (2011), urban arborization should consider the conservation of biological diversity and emphasize local native species.

The Fabaceae family was the most representative with 36% of species and 39% of individuals, higher than the proposed one (SANTAMOUR, 2004), which ponders not to exceed more than 30% of the same family for good urban planning.

It is reasonable to assume an imbalance in the distribution of the number of individuals between species, as *Schinus molle* and *Koelreuteria paniculata* represented about 42% of the total, the latter being exotic. Only *Handroanthus albus* and *Lafoensia pacari* are native to Curitiba's coverage region (IBGE, 2012). *Parapiptadenia rigida*, *Anadenanthera macrocarpa*, *Schinus molle, Handroanthus heptaphyllus*, *Handroanthus avellanedae*, *Peltophorum dubium* are native to Brazil and *Koelreuteria paniculata*, originating in East Asia, *Lagerstroemia indica*, India and *Tipuana tipu*, from Bolivia to Argentina 2003 (CARVALHO; et al., 2003). Locastro et al. (2017), assessed the sustainable use of urban arborization in Cafeara, Paraná and observed the predominance of native (52%), as well as Brianezi et al. (2013) who found 58% for these species in the Campus-Headquarters of the University of Viçosa, Viçosa, MG and they emphasize the importance of this distribution, as it contributes to the pathogens control and conservation.

Amongst the exotic species found in the census, *Koelreuteria paniculata* and *Tipuana tipu* stood out. Similar proportion was verified by Pagliari and Dorigon (2013) in the urban arborization of Lageado, SC, with 36% exotic as well as Guilherme et al. (2018) in the urban arborization of Cassilândia, Chapadão do Sul, Costa Rica and Paranaíba, MS obtained 22% exotic, 69% native from Brazil and 9% native. For Soares and Pellizaro (2019) the exotic made up 86% of the urban arborization of Ampére, PR. Pouey et al. (2003) considered that exotic ones reduce ecological benefits and that investment is high, as they are more demanding on resources for their adaptation far from their origin.

The species with the highest average height were naturally large, over 10 m, such as *Handroanthus avellanedae* (10 m to 50 m), *Handroanthus heptaphyllus* (8 m to 35 m), *Peltophorum dubium* (10 m). 40 m), *Koelreuteria paniculata* (10 m and 15 m, reaching 20 m) (LORENZI et al., 2000; CARVALHO, 2003). In addition to these, *Parapiptadenia rigida* is usually tall, but in adverse situations its size may be small (4 m to 20 m), such as *Schinus molle* (3 m to 12 m), *Handroanthus albus* (3 m to 30 m) and *Lafoensia pacari* (5 m to 15 m). *Anadenanthera macrocarpa* can range from medium to large (8 m to 20 m), *Lagerstroemia indica* is small (3 m to 5 m) and *Tipuana tipu* large

(12 m to 15 m) (LORENZI et al., 2000; CARVALHO, 2003). Faleiro and Amâncio-Pereira (2007) studying road arborization on the campus of the Federal University of Uberlândia, MG, identified a prevalence of tall trees (64%). Soares and Pellizaro (2019) observed that most individuals had a height lower than 6 m (96%) and that *Handroanthus heptaphyllus*, *Parapiptadenia rigida*, also found in this study and, *Persea americana* were the highest.

The average by species of morphological inversion point met the technical criteria established for urban arborization. Individuals used in urban arborization of cities should have an average morphological inversion point greater than 1.8 m, as a way to reduce damage by vandalism, vehicle shocks, less need for pruning throughout the tree's life cycle, generating greater economy. Municipal Public Agencies and reducing the incidence of pests and diseases (MPPR, 2018). Soares and Pellizaro (2019) consider that seedlings when broken or damaged give off new shoots and will generally have the height of the first fork equal to the height of the damaged point.

Schinus molle was the only species that was not characterized by deciduality. *Koelreuteria paniculata*, *Handroanthus* spp., *Peltophorum dubium*, *Lagerstroemia indica*, *Tipuana tipu* are deciduous species and *Lafoensia pacari*, *Anadenanthera macrocarpa* and *Parapiptadenia rigida* semideciduous. Characteristic that justifies the verification of dry branches and sparse foliage with abnormal coloration, considering that the sampling was performed in the fall, when these species lose their leaves. *Lagerstroemia indica* was the only species with single leaves, the others presented composed leaves (CARVALHO, 2003; LORENZI et al, 2003; RODERJAN; BARDDAL, 1998).

The presence of fruit was superior to flowering, considering the overall species. Pagliari and Dorigon (2013) found that 8% of the specimens presented leaves and flowering, 0.4% of the plants presented leaves and fruit, 3.6% of the specimens presented leaves and seeds, 0.4% of the individuals presented leaves, fruit and seeds. Marchiori (2004) points out that phenological information, such as limitation and extension of the leaf deciduous period and

delimitation of the flowering or fruiting period, constitute the basis for the planning of urban arborization, for the plastic modeling of the vegetation, since it requires thorough knowledge of the biological rhythms of plant species, aiming at good aesthetic compositions.

In general, the observed phenology aligned with that described by Carvalho (2003) and Roderjan and Barddal (1998). *Koelreuteria paniculata* and *Peltophorum dubium* presented flowers, *Parapiptadenia rigida* and *Handroanthus avellanedae*, fruit and *Anadenanthera macrocarpa*, *Handroanthus heptaphyllus* and *Lafoensia pacari*, flowers and fruit.

For some species, the phenology was different than expected. According to Carvalho (2003), *Schinus molle* blooms from August to December and have fruit from December to February, but flowers and fruit were observed. *Lagerstroemia indica*, according to Roderjan and Barddal (1998) have fruit in May, but no flowers or fruit were observed and *Tipuana tipu* presented flowers and fruits, but the period of having fruit and flowers is in August and November, respectively. In urban arborization the phenological knowledge of species that live under physiological stress may indicate, according to their rhythm of phenophases in a natural situation, the presence or absence of regularity and, in this case, turns to be the basis for the planning of silvicultural actions that allow better adaptation of species to the urban environment (BRUN et al, 2007).

Xylophagous agents and presence of mistletoes were found in *Schinus molle*, *Tipuana tipu* and *Lagerstroemia indica* as well as in *Parapiptadenia rigida*. According to Carvalho (2003), in pure massifs this species is attacked by fungi and root borers, which may justify the presence of these criteria, even though in low proportion, considering that urban arborization presents low species diversity, constituting a pure massif. *Koelreuteria paniculata* showed some rot, which is possibly related to weak and poorly resistant wood (SANCHÉZ, 2019). Soares and Pellizaro (2019) found that, as regards plant health, most trees were healthy, although with a common presence of termites (11.5%). According to Teixeira (1999), it is recommended that the frequency of a single species should not exceed 0.15, for both, aesthetic and phytosanitary

reasons, and the number of species and proportionality of use should be established. Pouey et al. (2003) also relates the incidence of xylophagous agents to low diversity, considering that in mixed plantings the attacks are widespread, besides the problem concerning the lack of resources as nutrients.

Schinus molle, *Lagerstroemia indica* and *Peltophorum dubium* presented epicornic sprouting. For Carvalho (2003), *Schinus molle* presented branching and formation of mult trunks and *Peltophorum dubium* was able to emit lateral buds and also could be used in micropropagation. In the same way that *Lagerstroemia indica* has had dull shoots that appears at the base from the roots (LORENZI et al., 2003).

Lafoensia pacari was of the climax ecological group and the others species were pioneers, with fast growth, that require high light intensity for their development, have a short life cycle and are not demanding (SWAINE; WHITMORE, 1988; BROKAW, 1985). Carvalho (2003) affirms that *Anadenanthera macrocarpa* is widely used in landscaping, however, due to its short life cycle and size, it is not recommended for urban arborization. The same can be regarded for the other pioneer species found, often planted in urban arborization, as they are undemanding in terms of resources and therefore easily adaptable, although it is necessary to be replaced in a relatively short period or may present phytosanitary problems, indicating end of the cycle and thus increasing the risk of fall and damage.

The species used in the parking lots arborization have high ornamental potential. However, one must consider the characteristics of the species, such as size, architecture, purpose and place of planting. *Koelreuteria paniculata* is very ornamental due to the chromatic impact of its yellow flowering during the summer months, crown aspect, fruit persistence in winter and reddish and yellow bud in autumn (REHMAN; PARK, 2000; SÁNCHEZ, 2019). However, it does not respond well to pruning, so considering its size, it should be planted in large areas, as recommended by Rehman and Park (2000).

Carvalho (2003) considers that *Handroanthus albus*, besides being very ornamental due to yellow inflorescence, is resistant to urban pollution. Guilherme et al. (2018) confirm that species of this genus are indicated for use in arborization,

noted that 81% were in good physical condition and Pagliari and Dorigon (2013) 49%, with vigor and health. According to Carvalho (2003), *Handroanthus avellanedae* is a botanical synonym of *Handroanthus heptaphyllus*, however, Lorenzi et al. (2003), regard as it as being a distinct and very ornamental species due to pink inflorescence, as adopted in this study.

Lorenzi et al (2003) consider that *Tipuana tipu* is widely used in urban arborization throughout the national territory and is recommended for large sites.

Schinus molle presented inclination in the trunk which may be characteristic of the species itself, as Carvalho (2003) described its trunk as branched, inclined and crooked. It was the most frequent species in the sampling carried out in Lages, Santa Catarina (PAGLIARI; DORIGON, 2013). It is very ornamental and often used in squares and parks, but can cause allergic reactions, so it should not be planted in places of intense flow of people (VAN DER JAGT; LAWRENCE, 2019; MPPR, 2018; PAGLIARI; DORIGON, 2013; OAK, 2003).

Criteria such as reaching branches on the access road, hollow branches, the need pruning or presence of the inadequate pruning, verified in the crown, lesion, crack in the trunk, mowing damage, injuries to the base and exposed root, and restriction to the curb, as well as cavities in various structures of the evaluated individuals, are related to the lack of management of arborization, including environmental monitoring and education. Locastro et al (2017) also pointed out that the lack of planning regarding the species to be planted, situations such as pavement uplift, wiring damage or the presence of stumps that hinder the movement of passers-by become common.

These problems are intensified when a tree species is large and thus requires a larger three-dimensional space, such as *Parapiptadenia rigida*, *Koelreuteria paniculata*, *Anadenanthera macrocarpa*, *Handroanthus* spp., *Peltophorum dubium*, *Lagerstroemia indica* and / or tree architecture also requires differentiated space, such as *Schinus molle* and *Tipuana tipu* (CARVALHO, 2003; LORENZI et al, 2003; RODERJAN; BARDDAL, 1998).

Faleiro and Amâncio-Pereira (2007) found that 54% of the trees presented conflicts with the pavement with severe damage. They considered that *Caesalpinia peltophoroides*, species of the same family and profile as *Parapiptadenia rigida*, *Anadenanthera macrocarpa* and *Peltophorum dubium*, when verified at work, was responsible for 63% of the conflicts, due to inadequate planting and insufficient beds, because the species requires large free area, as well as observed in the results of this research for large species. According to these authors, in relation to the quality of the canopy, 55% were vigorous, where 38% showed signs of yellowing, abnormal leaf and branch drop, leaf size reduction, dry hands, whether or not associated with diseases or pests and 7% with a profusion of shoots or branches. Regarding the phytosanitary state, 50% had dead branches, 13% had parasites, 14% had insect parasites and 8% had rust, and emphasized the importance of species diversity as a natural control.

In order to solve problems the branches reaching on the access road, criterium verified in the canopy analysis and which occurred mainly in *Anadenanthera macrocarpa* and *Tipuana tipu*, Soares and Pellizaro (2019) observed that 27% of trees had no pruning during or near the evaluation period, 57% had pruning and 14% drastic pruning and that 63% of the plant specimens had contact with the electric network, which among them, *Schinus molle*, *Handroanthus albus*, *Tipuana tipu*, present in this work. However, in *Schinus molle*, *Tipuana tipu* and *Platanus Acerifolia*, the pruning performed was drastic, being the cause of the individuals' mortality.

According to the Curitiba Forest Code (Law 9806/2000), "Art. 24, is prohibited excessive or drastic pruning of public or private arborization, which significantly affects the natural development of the crown. The Federal Law no. 9605/98, Environmental Crimes Law, reinforces the need to consider the available space and the characteristics of each species to avoid future problems. Guilherme et al. (2018) observed that 10% of individuals had conflicts and related to the planting of large species under spinning, without planning and maintenance pruning. According to

Silva et al. (2008), the contact of trees with electricity wiring raises concerns due to the incompatibility between afforestation and urban road elements.

Regarding the trunk, Soares and Pellizaro (2019) noticed that most of the trees had straight trunk (81%) or a little bent (11%), not disturbing the pedestrian crossing and 6% of the trees caused intense obstruction, although they did not evaluate the tree health, according to this study.

Exposed root was intensely observed in *Anadenanthera macrocarpa* and *Schinus molle*, Paglian and Dorigon (2013) found that 5% of the specimens had apparent roots affecting the sidewalk

As Marchiori (2004) claims, the root outcrop is identified by presenting underground roots that display themselves in an aerial form under environmental or endogenous pressure or under incorrect management, that is, in a natural and balanced way the plant does not exhibit outcrop. For Santos and Teixeira (2001), this is triggered by a free area absence, which generates stem strangulation, hindering the sap circulation. They claim that in sidewalks an absence of free area takes place, thus favoring root outcrops in order to seek these essential elements for root development, so the roots exert pressure, causing an impact in the floor, leading to cracks in fences and walls, usually visible in the sidewalks of urban areas. Soares and Pellizaro (2019) found that 41% of the species did not have free area for an adequate growth and, as a result, 23% outcropped in a free area and 8% affected sidewalk, curb or walls.

Only *Koelreuteria paniculata* showed little conflict with the criteria considered for the surroundings, such as electricity grid, distance from the access road and pipes. Regarding the implantation of urban arborization, this environment was contemplated. However, the specific characteristics and needs of the species were not.

The local where most of trees is located in the streets is inhospitable to their growth, health and longevity, contributing to their mortality, thus limiting the diversity of species adaptable to these conditions. Trees suffer effects of air pollution, heat island, drought, flood, inadequate soil compaction and volume, lack of balance,

nutritional deficiencies, winter and improper pruning (COWETT; BASSUK, 2017). They also consider even if the species are adapting to urban conditions, it may not be suitable for this purpose due to growth and branching habits, such as *Acer saccharinum*, that is fast growing, tolerant to wet and dry soils and easy to transplant. However, it is prone to rot, thus, with the risk of falling branches or the tree itself. These conditions can reach people and urban infrastructure.

Brianezi et al. (2013) observed that 57% of individuals were healthy and suggested that due to low tree heterogeneity, more conscious and permanent planning is needed in order to better exploit the characteristics and benefits linked to each species and to reduce the spread of pathogenicities. They recommend that individuals with poor phytosanitary status should be replaced. According to Van Der Jagt and Lawrence (2019), improper management of urban arborization can lead to problems such as high voltage wire disruption, power supply interruptions, sewage clogging, traffic obstacles and accidents involving pedestrians, vehicles and buildings. Pagliari and Durigon (2013) reinforce the need for planning, as the use of inappropriate species can present hazards and damage to society (PAGLIARI; DURIGON, 2013)

Despite the knowledge regarding the benefits brought by urban arborization and the need for its management, in order to minimize conflicts with the urban area, most countries have unsustainable and ineffective practices. Funding constraints are considered to be a widely reported barrier in Northern Global countries (STOBBART; JOHNSTON 2012; DRISCOLL et al. 2015; KRONENBERG, 2015), except Scotland (RANDRUP et al., 2017). Those responsible for urban arborization generally do not have a comprehensive view of trees and their conditions (STOBBART; JOHNSTON 2012; KRONENBERG 2015). For instance, in Toronto, Canada, the team demonstrated limited knowledge of tree pests, diseases and planting strategies to minimize risks (CONWAY; VANDER VECHT 2015).

As claimed by Pouey et al. (2003), regarding the management of urban arborization, the tree specimens should be mapped and registered, which should be permanently updated, not to mention the development of an annual

planning and forecasting of resources for its execution and that Municipal Seedling Production Centers should be established and preserved along with campaigns concerning permanent tree planting, education and ecological awareness.

According to Cowett and Bassuk (2017), planting conditions for trees can be improved by selecting the appropriate species, considering above and below ground conditions, watering of freshly planted seedlings during establishment and also during the heat periods, converting continuous trenches of the soil and using structural soil to promote root growth under paving in adjacent lawn areas. For MPEP (2018), planting locations should be appropriate to the size of the trees (crown height and canopy diameter) and the typology of the streets (width of the runway and sidewalks), according to the available three-dimensional space, bearing in mind the position of overhead, underground service networks (electrical system, water supply, sewage etc.) and the distance from buildings and signs to define the appropriate size of species and planting position.

Locastro et al (2017) found that the studied of arborization showed some progress. According to representatives of public management, the municipality has been concerned with issues of vegetation management, proven by the intensification of planting native species, constant maintenance of pruning and use of vegetation as a way to attract natural predators of *Aedes aegypt* (Linnaeus). In addition, residents emphasized that through management, arborization has become a reference for the city and region, regarding that care with pruning and central beds goes beyond natural beautification and promote quality of life to residents. In order to train technicians, the municipality has partnerships with municipal schools and state projects.

Van Der Jagt and Lawrence (2019) consider that a systemic shift should take place for a new, broad sense and shared responsibility towards urban tree management, actions that when well executed, increase the number of support and resources available which can be initiated, regardless of institutional constraints.

The MPEP (2018) considers that the proper formulation and execution of the Municipal Urban Arborization Plan is essential not only for the planning of actions and initiatives related to the diagnosis, implementation, maintenance and monitoring of its substantial measures, but also proves crucial for the exercise of police procedures regarding the licensing and authorization of eventual pruning, felling and replacement of trees.

5 CONCLUSION

The study of the urban arborization of Positivo Ecoville University Campus parking lots can be a basis of information for municipalities urban arborization. The species observed are widely used for this purpose not only in this country but in other countries as well, so the potential and conflicts evaluated are common in other studies in different municipalities of Brazil and abroad.

The origin of species should be considered for planting, regarding the use of naturally occurring species in the region of the site, in this case, species of Mixed Ombrophilous forest, as they are better adapted to the environment just as the diversity, following technical and landscaped criteria for urban urbanization.

The deciduality is another factor to be pondered in the landscaping composition of the urban arborization; in this case, the fact that only *Schinus molle* is not deciduous, compromises the aesthetics, since the vast majority will be left without leaves in the unfavorable period. Likewise, the phenology should be included in the planning, seeking to put in the period of fruiting and flowering of species, aiming at landscape effects.

The presence of xylophagous agents, presence of mistletoes and rot is related to resource deficiency and low species diversity. These criteria are verified in larger proportions in species that have, as characteristic, weak and little resistant wood, such as *Koelreuteria paniculata*.

Species that produce epicornic shoots require additional management and investment to control regrowth, such as *Schinus molle*, *Lagerstroemia indica* and *Peltophorum dubium*.

The species used in the parking lots arborization were from the pioneer ecological group, so the life cycle is shorter, except for *Lafoensia pacari*, which is climax. Regarding the difficulty of managing tree individuals in urban arborization, the life-cycle factor should be considered, as it implies the replacement of individuals, demanding human and economic resources, the time for growth in the replaced individual and obtaining the benefits offered through it.

In the management of arborization, which includes the choice and production of seedlings, planting, monitoring (canopy, trunk, base and roots) and environmental education in a broad way, the characteristic size and architecture of the species in relation to the three-dimensional space must be considered. As noted, the lack of management intensifies the problems of large species, reflected in conflicts with the infrastructure and, on the other hand, also compromises the phytosanitary conditions of trees.

The observed conflicts and phytosanitary conditions of trees are due to the flow of vehicles and passersby, generating pressure on the trees in inhospitable urban environments.

The majority of the tree individuals showed mowing damage. The team which performs this work should be oriented, otherwise, the arborization of the parking lots is impaired, causing damage to the trees and financial loss.

Gradual replacement of *Schinus molle* and *Tipuana tipu* is recommended as the size, root type and canopy pattern are suitable for parks and squares, but not for space constrained locations. In addition to that, *Schinus molle* may generate allergic reactions in passersby.

The methodology used, considering the census and the defined criteria evaluation for the trees of the arborization parking lots of the Positivo University, can be used elsewhere as a tool for the elaboration of urban arborization management plans, aiming at its effectiveness and public safety.

REFERENCES

ANGISOSPERM PHYLOGENY GROUP III. **An update of the Angiosperm phylogeny group classification for the ordens and families of flowering plants: APG III.** Annals of the Botanical J. Lin. Soc. 2009. 161:105 - 121.

ABREU LV, LABAKI LC. **Conforto térmico propiciado por algumas espécies arbóreas: avaliação do raio de influência através de diferentes índices de conforto.** Ambient. Constr. 2010;10(4):103-117.

ARAUJO MN, ARAUJO AJ. **Arborização urbana. O Paraná em Debate: Agenda Parlamentar Crea – PR.** Série de Cad. Téc. Ag. Parl.. 2016:43.

BRASIL. LEI N° 10.257/01- **Regulamenta os arts. 182 e 183 da Constituição Federal, estabelece diretrizes gerais da política urbana e dá outras providências.**

BRASIL. LEI N° 9.605/98 - **Dispõe sobre as sanções penais e administrativas derivadas de condutas e atividades lesivas ao meio ambiente, e dá outras providências.**

BRIANEZI D, JACOVINE LAG, GONÇALVES W, ROCHA SJSS. **Avaliação da Arborização no Campus-Sede da Universidade Federal De Viçosa.** 2013. REVSBAU. 8(4): 89-106.

BROKAW NVL. **Treefalls, regrowth, and community strutcture in Tropical Forests.** In: PICKETT STA; WHITE PS (Ed.). The Ecology of natural disturbance and patch dynamics. New York: Academic Press. 1985.

BRUN FGK, SOLON JL, BRUN EJ, FREITAG AS, SCHUMACHER MV. **Comportamento fenológico e efeito da poda em algumas espécies empregadas na arborização do bairro Camobi – Santa Maria, RS.** RVSBAU. 2007.2(1):44-63.

CARVALHO, P. E. R. 2003. **Espécies arbóreas brasileiras.** v.1. Colombo: EMBRAPA. 1.039p

CASTRO ASF, MORO MF, ROCHA FCL. **Plantas dos espaços livres da Reitoria da Universidade de Fortaleza (UNIFOR), Ceará, Brasil.** Rev. Bras. Biocienc. 2011.9(1):126-129.

CONWAY TM, VANDERVECHT J. **Growing adiverse urban forest: species election decisions by practitioners planting and supplying trees.** Landsc Urban Plan. 2015.138:1–10.

COWETT F D, BASSUK N. **Street Tree Diversity in Three Northeastern U.S.** States. Arboric. Urb. For. 2017.43(1):1–14.

CUPERTINO MA, EISENLOHR PV. **Análise florística comparativa da arborização urbana nos campi universitários do Brasil.** Biosci. J. 2013. 29(3):739-750.

DANTAS IC, CHAVES TP, FELISMINO-FERREIRA VMG. **Arborização dos bairros Alto Branco, Lauritzen, Campina Grande / PB: Estudo comparativo.** 2011. REVSBAU. 6(2):76-89.

DRISCOLL AN, RIES, PD, TILT JH, GANIO LM. **Needs and barriers to expanding urban forestry programs: Anassessmento community official sand program managers in the Portland-Vancouver metropolitan region.** Urb. For. Urb. Gr. 2015.14:48-55.

CARDIM, R. **Política do verde urbano: entrevista para site de direito ambiental.** Rev. Obs. Eco. Chicago climate action plan: Our city, our future. 2011.

COMPANHIA ENERGÉTICA DE MINAS GERAIS (CEMIG). **Manual de Arborização.** Belo Horizonte: Cemig e Fundação Biodiversitas. 2011. 112p.

CHUN B, GULDMANN JM. **Impact of greening on the urban heat island: Seasonal variations and mitigation strategies.** Comp. Env. Urb. Sys. 2018. 71:165-176.

CUPERTINO MA, EISENLOHR PV. **Análise florística comparativa da arborização urbana nos campi universitários do Bras.** Biosc. J. 2013. 29(3):739-750.

EC (EUROPEAN COMMISSION). **Green infrastructure (GI) - enhancing Europe's natural capital.** European Commission. 249 final. 2013.

EC (EUROPEAN COMMISSION). **Nature-based solutions & re-naturing cities.** Final report of the horizon 2020 expert group on 'Nature-based solutions and re-naturing cities' (full version). European Commission. Publications Office of the European Union, Luxembourg. 2015.

FALEIRO, W, AMÂNCIO-PEREIRA, F. **Arborização Viária do Campus Umuarama da Universidade Federal de Uberlândia, MG.** Rev. Cient. Eletr. Eng. Flor. 2007. VI (10)

GÓMEZ-BAGGETHUN, E, BARTON DN. **Classifying and valuing ecosystem services for urban planning.** Ecol. Econ. 2013. 86:235-245.

GÓMEZ-BAGGETHUN E, GREN A, BARTON D, LANGEMEYER J, MCPHEARSON T, O'FARRELL P, ANDERSSON E, HAMSTEAD Z; KREMER P. **Urban ecosystem services.** In: Elmqvist T et al (eds) Urbanization, biodiversity and ecosystem services: challenges and opportunities. Springer, Dordrecht. 2013:175-251.

GUILHERME FAG; SILVA MC; CARNEIRO DNM; NASCIMENTO HCA; RESSEL K; FERREIRA WC. **Urban arborization in public pathways of four cities in east Mato Grosso do Sul (MS) Brazil.** Ornam. Hortic. 2018. 24(2):174-181

HAASE D, LARONDELLE N, ANDERSSON E, ARTMANN M, BORGSTRÖM S, BREUSTE J, GOMEZ-BAGGETHUN E, GREN Å, HAMSTEAD Z, HANSEN R, KABISCH N, KREMER P, LANGEMEYER J, RALL E, MCPHEARSON T, PAULEIT S, QURESHI S, SCHWARZ N, VOIGT A, WURSTER D, ELMQVIST T. **A quantitative review of urban ecosystem service assessments: concepts, models, and implementation.** Ambio. 2014. 43:413-433

HU R, BOURNEZ E, CHENG S, JIANG H, NERRY F, LANDES T, SAUDREAU M, KASTENDEUCH P, NAJJAR G, COLIN J, YAN G. **Estimating the leaf area of an individual tree in urban areas using terrestrial laser scanner and path length distribution model.** ISPRS J. Photogramm. Remote Sens. 2018. 144:357-368.

HUANG Q, HUANG J, YANG X, FANG C, LIANG Y. **Quantifying the seasonal contribution of coupling urban land use types on Urban Heat Island using Land Contribution Index: A case study in Wuhan, China.** Sustain. Cities Soc. 2019. 44:666-675.

IBGE. INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. **Manual Técnico da Vegetação Brasileira.** Série Manuais Técnicos em Geociências. nº 1. Rio de Janeiro. 2012.

INMET. INSTITUTO NACIONAL DE METEOROLOGIA. **Banco de dados meteorológicos para ensino e pesquisa.** 2012.

INSTITUTO AMBIENTAL DO PARANÁ. **Portaria Nº 059/15 - Reconhece a Lista Oficial de Espécies Exóticas Invasoras para o Estado do Paraná, estabelece normas de controle e dá outras providências.**

KARDEL F, WUYTS K, BABANEZHAD M, VITHARANA UWA, WUYTACK T, POTTERS G, SAMSON R. **Assessing urban habitat quality based on specific leaf area and stomatal characteristics of Plantago lanceolata L.** Environ. Poll. 2010. 158: 788-794.

KRONENBERG J. **Why not to green a city? institutional barriers to preserving urban ecosystem services.** Ecosyst Serv. 2015. 12:218-227.

LIMA RMC, JÚNIOR MCS. **Inventário da arborização urbana implantada na década de 60 no Plano Piloto, Brasília, DF.** REVSBAU. 2010. 5(4):110-127.

LOCASTRO JK, MIOTTO JL, ANGELIS BLD, CAXAMBU MG. **Avaliação do uso sustentável da arborização urbana no município de Cafeara, Paraná.** Ciência Florestal. 2017. 27(2):549-556.

LORENZI H; SOUZA HM; TORRES MAV; BACHER LB. **Árvores Exóticas no Brasil: madeireiras, ornamentais e aromáticas.** Nova Odessa: Instituto Plantarum, 2003. 385p

LORENZI, H. **Árvores brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil.** 5.ed. Nova Odessa: Instituto Plantarum, 2008. v.1. 368p.

MAACK, R. **Geografia Física do Estado do Paraná.** 4. ED. UFPG. 2012.

MARCHIORI, JNC. **Elementos de Dendrologia.** Santa Maria: Universidade Federal de Santa Maria; 2004. 163p.

MEUNIER, I. **Como começar a arborizar as pessoas.** Rev. Cont. On-line. 2013. 1(152):1-3.

MINISTÉRIO PÚBLICO DO ESTADO DO PARANÁ (MPEP). **Manual para elaboração do Plano Municipal de Arborização Urbana.** 2ª Edição. Curitiba: Ministério Público do Estado do Paraná – PR, 2018

MISSOURI BOTANICAL GARDEN. **Vascular Tropicos (VAST) nomenclatural database and associated authority files.** 1968.. Disponível em: http://www.mobot.org/w3t/search/vast.html. Acesso em: 24/8/2019.

MONHOTO ES, MONTEIRO EA, FISCH STV. **Arborização viária na cidade de Taubaté, SP: no centro comercial histórico e um bairro residencial moderno.** REVSBAU. 2009. 4(2): 82-96.

NICODEMO MLF, PRIMAVESI O. **Por que manter árvores na área urbana?** São Carlos: Embrapa Pecuária Sudeste, 2009.

PAGLIARI, S. C., DORIGON, E. B. **Arborização urbana: importância das espécies adequadas. arborização urbana: importância das espécies adequadas.** Unoesc & Cienc. – ACET. 2013. 4(2):139-148.

POUEY MT, FREITAS R, SATTLER M. **Arborização e sustentabilidade.** Curitiba: Encac-Cotedi, 2003.

PREFEITURA MUNICIPAL DE CURITIBA. **Lei 9806/00 - Institui o Código Florestal de Curitiba.**

REHMAN S; PARK I. **Effect of scarification, GA and chilling on the germination of goldenrain-tree (*Koelreuteria paniculata* Laxm.) seeds.** Sci. Hort. 2000. 85:319-324.

REVI A, SATTERTHWAITE DE, ARAGÓN-DURAND F, CORFEE-MORLOT J, KIUNSI RBR, PELLING M, ROBERTS DC, SOLECKI W. Urban áreas. In: Field CB, Barros VR, Dokken DJ, Mach KJ, Mastrandrea MD, Bilir TE, Chatterjee M, Ebi KL, Estrada YO, Genova RC, Girma B, KISSEL ES, LEVY AN, MACCRACKEN S, MASTRANDREA PR, WHITE LL, editors. **Climate change: impacts, adaptation, and vulnerability.** Part A: Global and sectoral aspects. Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge/New York; 2014. p..535–612.

RODERJAN, C. V.; BARDDAL, M.L. **Arborização de ruas de Curitiba-PR – Guia prático para a identificação das espécies.** Curitiba: FUPEF, 1998.

SANCHÉZ, M. **Koelreuteria paniculata jabonero de la china.** Disponível em: http://www.rjb.csic.es/jardinbotanico/ficheros/documentos/pdf/pubinv/msg/koelreuteria_paniculata.pdf. Acesso: 19/10/2019.

SANTAMOUR JR F S. **Trees for urban planting:diversity uniformity, and common sense.** En C. Ele-vitch, The Overstory Book: Cultivating connections with trees (pp. 396-399). Holualoa, Hawaii: Per-manent Agriculture Resources. 2004.

SANTOS, FC, CASTRO PM, CAMARGO JA. **Avaliação da Sanidade das Árvores do bairro Roosevelt em Uberlândia-MG – Uma Ferramenta para Diagnosticar e Reduzir os Riscos no Fornecimento de Energia Elétrica.** In: XIX Seminário Nacional de Distribuição de Energia Elétrica- SENDI; 2010; São Paulo, Brasil.

SANTOS NRZ, TEIXEIRA IF. **Arborização de vias públicas: ambiente x vegetação.** Porto Alegre: Instituto Souza Cruz; 2001.

SILVA LM. **Reflexões sobre a identidade arbórea das cidades.** REVSBAU. 2008. 3(3): 65-71.

SILVA AG, GONÇALVES W, LEITE HG, SANTOS E. **Comparação de três métodos de obtenção de dados para avaliação quali-quantitativa da arborização viária, em Belo Horizonte - MG.** REVSBAU. 2006. 1(1): 31-44.

SOARES J, PELIZZARO L. **Inventário da Arborização Urbana do município de Ampére (Paraná – Brasil).** Rev. Bras. MA. 2019. 5(1): 111-127.

STOBBART M, JOHNSTON M. **A survey of urban tree management in New Zealand.** 2012. Arboric Urb. For. 38:247–254.

SWAINE MD; WHITMORE TC. **On the definition of ecological species groups in tropical rain forests. Netherlands: Kluwer.** Academic Publishers, Dordrecht. Veg. 1998. (75): 81-86.

TEIXEIRA IF. **Análise qualitativa da arborização de ruas do Conjunto habitacional Tancredo Neves, Santa Maria, RS.** Cienc. Flor., 1999. 9(2): 9-21.

VAN DER JAGT APN, LAWRENCE A. **Local government and urban forest governance: insights from Scotland. Scandinavian J.** For. Res. 2019. 34(1): 53–66.