Floristics of road forestry conflicting with the electrical networks: a case study in the southern region of Minas Gerais State[1]

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ABSTRACT

Urban afforestation produces a great enhancement in the flora of cities, but if improperly implanted they generate disturbances, especially if the implanted species are not adapted to electric energy networks The objective of this paper was to carry out a qualitative-quantitative survey on urban afforestation through the interconnection with the electricity network in the five cities with most issues of electricity shutdown caused by trees in the South of Minas Gerais state At the end of the inventory there were 221 individuals belonging to 58 species, 56% of which were exotic and 44% native. Eight species counted for 51.99% of the total inventory, being: *Jacaranda mimosifolia*, *Platanus acerifolia, Murraya paniculata, Lagerstroemia indica, Schinus molle, Ficus benjamina, Bauhinia variegata* and *Poincianella pluviosa.* Only the species *Schinus molle* and *Poincianella pluviosa* are native. More than half of the inventoried trees presented a size incompatible with the electrical network, species of large (55.59%), medium (24.42%) and small (19.99%) sizes, to be implanted for urban afforestation. The selected streets had narrow widths, but the sidewalks had ideal widths for the implantation of afforestation. Treetop pruning was performed in 20% of the individuals evaluated, a practice that is widely used due to the presence of large species. The species evaluated in the inventory showed height ranging from 2 to 6 meters, not reaching their maximum potential when belonging to medium and large species. For the studied cities it is recommended a new evaluation of the urban afforestation, seeking to identify the appropriate patterns to the urban environment.

Keywords: conservation; diversity; electricity; green infrastructure end tree species.

RESUMO

Florística da arborização viária sob rede elétrica: um estudo de caso na Região Sul de Minas Gerais

A arborização urbana viária produz grande ganho na diversidade da flora das cidades, porém as mesmas implantadas de forma inadequada geram transtornos, principalmente se a espécies implantada não for adaptada as redes elétricas de energia. O objetivo deste trabalho foi realizar um levantamento qualitativo-quantitativo sobre a arborização urbana por meio da interligação com a rede elétrica nas cinco cidades com maior número de quedas de eletricidade causadas por árvores no sul de Minas Gerais. Ao final do inventario foi totalizado 221 indivíduos, pertencente a 58 espécies, sendo 56% delas exóticas e 44% nativas. Oito espécies perfizeram 51,99% do total das árvores inventariadas, sendo elas: *Jacarandá mimosifolia, Platanus acerifolia, Murraya paniculata, Lagerstroemia indica, Schinus molle, Ficus benjamina, Bauhinia variegata* e *Poincianella pluviosa*. Somente as espécies *Schinus molle* e *Poincianella pluviosa* são nativas. Mais da metade das árvores inventariadas apresentaram porte incompatível com a rede elétrica, espécies de grande (55,59%), médio (24,42%) e pequeno (19,99%) porte, para serem implantadas na arborização urbana viária. As ruas selecionadas apresentavam larguras estreitas, porém as calçadas possuíam larguras ideais para a implantação de arborização. A destopa foi realizada em 20% dos indivíduos avaliados, uma prática muito utilizada devido a presença de espécies com grande porte. As espécies avaliadas no inventario apresentavam altura variando de 2 a 6 metros, não chegando ao seu potencial máximo, quando pertencente a espécies de médio e grande porte. Para as cidades estudadas recomenda-se uma nova avaliação da arborização urbana, buscando identificar os padrões adequados ao meio urbano.

Palavras-chave: conservação; diversidade; energia elétrica; infraestrutura verde e espécies nativas.

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1. INTRODUCTION

The planning of afforestation in the urban environment requires a careful process that contains the procedures from its conception, implantation until its maintenance (CEMIG, 2011). For the afforestation plan to succeed, planning is of the utmost importance, because if not done properly it can generate damages, issues and future losses (BOBROWSKI, 2012; CABRAL and PERÍCIA, 2013). When properly applied, urban afforestation can generate a number of societal benefits: maintenance of thermal comfort associated with humidity and shade, conservation of microclimate balance, reduction of noise and air pollution, city beautification, water supply, conservation of the genetics of native flora, besides offering conditions to the psychological well-being of the population (CEMIG, 2011; ARMSON et al., 2013, BASSO and CORRÊA, 2014).

The growth of cities in most cases, very fast and disorderly, without proper planning of occupation, results in several problems that interfere in the quality of life of the urban society (CABRAL and PERÍCIA, 2013; LUCON, 2013). According to Vicente and Rondon Neto (2011) one of the main problems encountered in the context of urban afforestation is exactly the compatibility between trees and sidewalks and / or between trees and electricity distribution networks. Only joint qualitative and quantitative evaluations and analysis provide reliable considerations about the studied aspect.

Oliveira et al. (2013) also confirms that the compatibility between trees and electricity distribution networks generates damages and the management and maintenance responsible entities of the trees in the urban environment opt to prune the branches of the larger species or plant small species so that these do not interfere in the electrical system, trying to solve a problem that can be solved when there is an adequate planning of the urban afforestation. Thus, it becomes important to know both quantity and distribution of vegetation in the urban environment, as well as its characteristics (CUPERTINO and EISENLOHR, 2013).

The use of exotic species in urban afforestation has been detected throughout the national territory, allowing the implantation of native species to be secondary and devaluing our flora due to the vast territorial extension of Brazil (CUPERTINO and EISENLOHR, 2013).

Within this context, the success of urban afforestation depends on the choice of species, since conflicts between trees and the electric wire network can cause disruption to both population and energy companies. The objective of this paper was to carry out a qualitative-quantitative survey on urban afforestation through the interconnection with the electricity network in the five cities with most issues of electricity shutdown caused by trees in the South of Minas Gerais State. Presenting the identification and location of species, also characterizing the arboreal invidual.

2. MATERIAL AND METHODS

The inventory was carried out considering five municipalities sampled in the southern region of the state of Minas Gerais that were chosen based on the reports tabulated by Cemig (Companhia Energética de Minas Gerais) of the cities that presented the most electricity shutdowns related to the "conflict with trees". According to this survey, the municipalities of Alfenas, Três Corações, Passa Quatro, Guaxupé and Itajubá were studied (Figure 1).

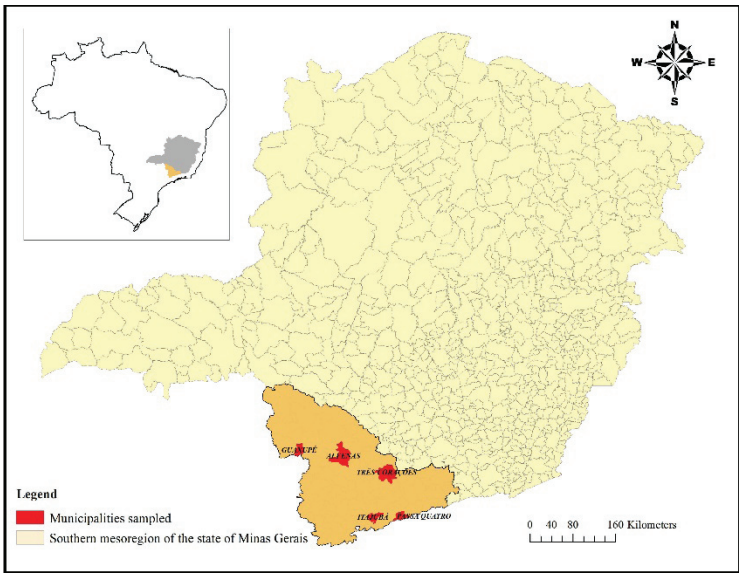

Figure 1. Delimitation of the southern mesoregion of Minas Gerais State.

The urban population, according to IBGE (2010), is greater than 90% in Alfenas, Guaxupé, Itajubá and Três Corações, with demographic densities of 86.75 hab. km^{-2}, 172.59 hab. km^{-2}, 307.42 hab. km^{-2} and 87.88 hab. km^{-2}, respectively. The city of Passa Quatro has 76.91% of its urban population, with a demographic density of 56.21 hab. km^{-2}. The South of Minas Gerais has relevant cities for the state, for instance Alfenas and Itajubá, that influence smaller cities in their surroundings (ANDRADE, 2015).

In the studied cities, circuits with energy interruption were selected due "conflict with trees" and then ranged the electrical devices that serve the largest number of consumers. Ten electrical circuits were chosen for the network composition at the following addresses (Table 1). After the circuits were defined, the survey was applied.

Table 1. Locality of the circuits with the greatest number of interruptions of electric power caused by trees in the five cities selected in the south of Minas Gerais State.

Electric circuit	Location
Alfenas	
A1	Avenue Teixeira da Silva, 180
A2	Street Lúcio Leite Amaral, 1
Guaxupé	
G1	Square Antônio Costa Monteiro
Itajubá	
I1	Street Antônio Rodrigues de Oliveira, 10
I2	Street Capitão Melvin Jones, S/Nº
Passa Quatro	
PQ1	Street Tenente Vioth, 88
PQ2	Street São Geraldo, 25
Três Corações	
TC1	Street Belchior Dias Moreira, 820
TC2	Avenue Cícero, 289
TC3	Avenue Cícero, 82

The identified individuals were georeferenced via GPS and submitted to a qualitative-qualitative evaluation. The place of implantation, as well as the identification of the species, family, size, origin and characterization of the situation of the inventoried individual were analyzed.For the identification of the inventoried species, the consulted literature was Lorenzi et al. (2003), Lorenzi (2009) and Saueressig (2014) to identify scientific name, family, origin if exotic or native to the national territory. Portions of the species were based on Araujo et al. (2012) and Melazo and Nishiyama (2010), which stratify urban tree species.

3. RESULTS AND DISCUSSION

A total of 221 arboreal individuals were distributed in 58 different species, 32 species of exotic origin and 26 species of native origin, being *Jacaranda mimosifolia* (10.40%), *Platanus acerifolia* (8.59%), *Murraya paniculata* (7.69), *Schinus molle* (4.97%), *Ficus benjamina* (4.97%), *Bauhinia variegata* (4.97%) and *Poincianella pluviosa* (4.52%) were the most frequent, accounting for 51.99% of the sample population. The most representative families were Bignoniaceae (20.81%), Fabaceae (14.93%), Platanaceae (8.59%) and Rutaceae (8.14%), which together represented 52.57% of the sampled population (Table 2).

Among the species of the species, 55.59% are large, which are species over 10 meters high; for the medium-sized species there are 24.42%, which are between 6 and 10 meters in height and the small ones with 19.99% which are smaller than 6 meters in height (Table 2).

Table 2. Tree species identified in the partial diagnosis of road arborization, under electric wire network, in the southern region of Minas Gerais State, in the cities of Alfenas, Guaxupé, Itajubá, Passa Quatro and Três Corações.

Scientific Name	Family	Or.	N	S	FR
Jacaranda mimosifolia D. Don.	Bignoniaceae	E	23	G	10.41
Platanus acerifolia (Ailton) Willd.	Platanaceae	E	19	G	8.6
Murraya paniculata (L.) Jacq.	Rutaceae	E	17	P	7.69
Lagerstroemia indica (L.) Pers.	Lythraceae	E	13	P	5.88
Ficus benjamina L.	Moraceae	E	11	G	4.98
Bauhinia variegata L.	Fabaceae	E	11	M	4.98
Schinus molle L.	Anarcadiaceae	N	11	M	4.98
Poincianella pluviosa (DC.) L.P. Queiroz	Fabaceae	N	10	G	4.52
Tibouchina granulosa (Desr.) Cogn.	Melastomataceae	N	9	G	4.07
Handroanthus heptaphyllus (Vell.) Toledo	Bignoniaceae	N	8	G	3.62
Tecoma stans (L.) Juss *ex* Kunth	Bignoniaceae	E	6	M	2.71
Hibiscus rosa-sinensis L.	Malvaceae	E	5	P	2.26
Morus nigra L.	Moraceae	E	4	G	1.81
Terminalia catappa L.	Combretaceae	E	4	G	1.81
Eugenia uniflora L.	Myrtaceae	N	4	M	1.81
Malpighia glabra L.	Malpighiaceae	E	4	P	1.81
Persea americana Mill.	Lauraceae	E	3	G	1.36
Pinus elliottii Engelm.	Pinaceae	E	3	G	1.36
Callistemon viminalis (Sol. *ex* Gaertn.) G. Don *ex* Loud.	Myrtaceae	E	3	M	1.36
Eriobothrya japonica (Thunb.) Lindl.	Rosaceae	E	3	M	1.36
Psidium guajava L.	Myrtaceae	N	3	M	1.36
Delonix regia (Bojer *ex* Hook) Raf.	Fabaceae	E	2	G	0.9
Handroanthus albus (Cham.) Mattos	Bignoniaceae	N	2	G	0.9
Handroanthus ochraceus (Cham.) Mattos	Bignoniaceae	N	2	G	0.9
Licania tomentosa (Benth.) Fritsch	Chrysobalanaceae	N	2	G	0.9
Machaerium nyctitans (Vell.) Benth.	Fabaceae	N	2	G	0.9
Mangifera indica L.	Anacardiaceae	E	2	G	0.9
Tabebuia roseoalba (Ridl.) Sandwith	Bignoniaceae	N	2	G	0.9
Ligustrum lucidum W.T. Aiton	Oleaceae	E	2	M	0.9
Maytenus sp.	Fabaceae	N	2	M	0.9
Tibouchina candolleana (Mart. *ex* DC.) Cogn.	Melastomataceae	N	2	M	0.9
Albizia lebbeck (L.) Benth.	Fabaceae	E	1	G	0.45
Cedrela fissilis Vell.	Meliaceae	N	1	G	0.45
Cordia sellowiana Cham.	Boraginaceae	N	1	G	0.45
Cupressus sp.	Cupressaceae	E	1	G	0.45
Ficus microcarpa L. f.	Moraceae	E	1	G	0.45
Handroanthus impetiginosus (Mart. *ex* Tul.) L.P. Queiroz	Bignoniaceae	N	1	G	0.45
Handroanthus vellosoi (Toledo) Mattos	Bignoniaceae	N	1	G	0.45
Libidibia ferrea (Mart.) L.P. Queiroz	Fabaceae	N	1	G	0.45
Machaerium hirtum (Vell.) Stellfeld	Fabaceae	N	1	G	0.45
Melia azedarach L.	Meliaceae	E	1	G	0.45

Table 2. cont.

Myroxylon peruiferum L.f.	Fabaceae	N	1	G	0.45
Pinus echinata Mill.	Pinaceae	E	1	G	0.45
Platypodium elegans Vogel	Fabaceae	N	1	G	0.45
Spathodea campanulata P. Beauv.	Bignoniaceae	E	1	G	0.45
Triplaris sp.	Polygonaceae	N	1	G	0.45
Citrus sinensis L. Osbeck	Rutaceae	E	1	M	0.45
Dombeya wallichii (Lindl.) K. Schum.	Sterculiaceae	E	1	M	0.45
Dypsis lutescens (H. Wendl.) Beentje & J. Dransf.	Arecaceae	E	1	M	0.45
Leucaena leucocephala (Lam.) R. de Wit	Fabaceae	E	1	M	0.45
Schinus terebinthifolius Raddi	Anarcadiaceae	N	1	M	0.45
Thevetia thevetioides (Kunth) K. Schum	Apocynaceae	E	1	M	0.45
Tibouchina mutabilis (Vell.) Cogn.	Melastomataceae	N	1	M	0.45
Beaucarnea recurvata Lem.	Asparagaceae	E	1	P	0.45
Codiaeum variegatum (L.) Rumph. *ex* A. Juss.	Euphorbiaceae	E	1	P	0.45
Euphorbia leucocephala Lotsy	Euphorbiaceae	E	1	P	0.45
Nerium oleander L.	Apocynaceae	E	1	P	0.45
Schefflera arboricola Hayata	Araliaceae	E	1	P	0.45

Note: Data: Or. (Origin: E-exotic species / N-native species), N (number of individuals evaluated), Pr. (Size: S = up to 6 m, Medium: M = 6 to 10 m, Larger: L = Larger than 10 m), FR (Relative Frequency).

Regarding the width of the streets, almost half (50.68%) of the trees were located in streets that had a width of less than 7 m, being classified as inadequate in terms adequate road structure, according to Cemig (2011). The majority of individuals evaluated (86.42%) were located on walks that had a minimum width of 2 m. The root system of 23.52% of the trees was exposed in the sidewalk showing that the root system can cause problems for walkers, even with an adequate walking space. Also, in these situations, there is no basic structure for maintenance of the species on the sidewalk, such as green trenches, grass surroundings, infiltration spaces at the base or in the lap of the plant (Table 3).

Table 3. Characteristics of the streets and pavements insertion of the trees in the selected circuits for qualitative quantitative inventory of the South of Minas Gerais State, in the cities of Alfenas, Guaxupé, Itajubá, Passa Quatro and Três Corações.

Street width in meters	**Individuals number**	**Frequency**
4 a 7	112	50.68
7 a 10	87	39.37
10 a 13	22	9.95
Sidewalk width in meters	**Individuals number**	**Frequency**
1,5 a 2	30	13.57
2 a 2,5	89	40.27
2,5 a 3	102	46.15
Sidewalk survey	**Individuals number**	**Frequency**
Presence	52	23.52
Absence	169	76.47

Approximately one quarter (24.89%) of the trees presented the height of the first bifurcation greater than 1.80 m, minimum height that allows good accessibility in public roads. In addition, it was observed that 22.63% of the trees had broken, dry or hollow branches, which reflects incipient maintenance by the municipal pruning management entities (Table 4). Pruning training is recommended to solve the problems when there is the presence of branches in the areas of circulation of pests and vehicles (VICENTE and RONDON NETO, 2011). The responsible authorities of the municipality or the electric power supply company should ideally carry out the pruning, once when pruning is not carried out correctly can cause tree death (GROSS et al., 2012).

Table 4. Characteristic of the crown of the trees inventoried in the quantitative inventory of the South of Minas Gerais, in the cities of Alfenas, Guaxupé, Itajubá, Passa Quatro and Três Corações.

1st bifurcation height	**Individuals number**	**Frequency**
Lower than 1.80 meters	166	75.11
Higher than 1.8 meters	55	24.89
Dry / hollow branches	**Individuals number**	**Frequency**
Presence	31	14.03
Absence	190	85.97
Broken splices	**Individuals number**	**Frequency**
Presence	19	8.60
Absence	202	91.40

As for the height of the inventoried trees in the region, only 39.37% of the sample population (88 individuals) had height equal or superior to 6 m, being able to contact the electric network at the moment of the inventory. However, it should be pointed out that the number of trees that can conflict with the electric network increased to 80.01%, which is the value of medium and large height tree species of more than six meters of height.

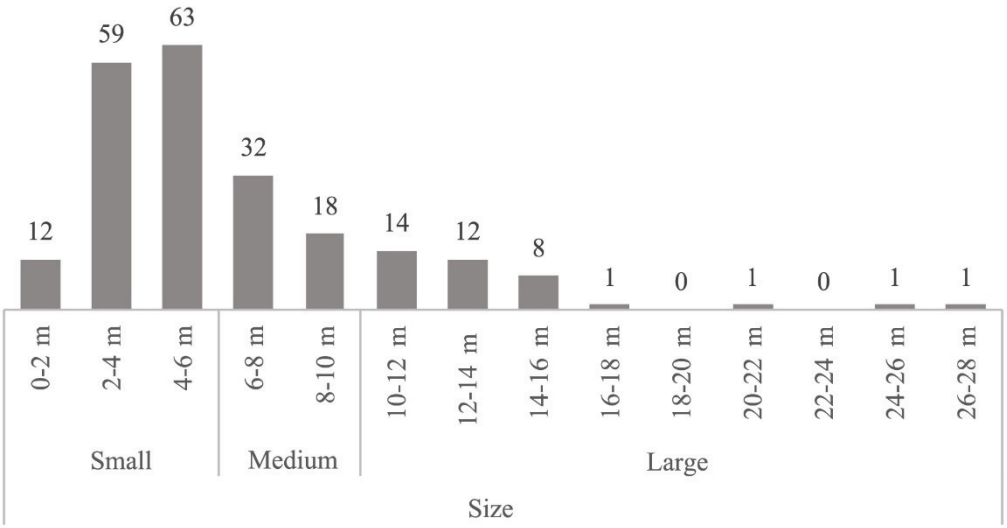

Figure 2. Height of trees in the qualitative-quantitative inventory of southern Minas Gerais State, in the cities of Alfenas, Guaxupé, Itajubá, Passa Quatro and Três Corações.

According to Paiva (2009), in the general context of the circuits sampled in the five cities, the final composition of species and evaluated individuals was satisfactory. However, this analysis must be done with caution, once they are different cities and places with distinct characteristics of urban equipment, and even species adaptation are differentiated.

It should be emphasized that there should be better studies on the application of indexes of diversity, wealth and species equitability to the urban environment,

considering all the dimensions in which the trees are planted: under net, outside the net, in narrow walks, wide walks, close to conservation units, avenues with central plots, parks, among other possibilities. The same is mentioned by Morgenroth, Santos and Cadwallader (2015), who explain that when trees that have no planned planting can generate irreversible damages, recurrent in the roots due to pavements not suitable to receive the planting, and in relation to the maintenance equipment that touches the tree canopy.

In a study about urban expansion in the city of São Lourenço, in the south of Minas Gerais State, the difference was observed between neighborhoods occupied by better-off residents, with tree-lined streets and houses with greater aesthetic zeal while neighborhoods with poor residents are absent from afforestation. In such, it is possible to observe with unfinished constructions and improvised public facilities (MARQUES NETO and ANDRADE, 2010), thus demonstrating the lack of planning on the urban plantation and absence of a director plan; aspects identified in the municipalities evaluated in this work.

Oliveira et al. (2015), in a survey about the pruning modalities used in the urban road afforestation in Minas Gerais State, evaluated 1,643 individuals, of which 69.08% were pruned some way, which were related to pruning modalities or combinations of "conduction or formation", "unilateral", "treetop cut" or "in V".

The actual scenario of urban tree planting is the same for the entire of Minas Gerais State, the presence of large species below the network, has been conflicting with the power grid, generating inconveniences to the population, municipalities and to electricity supply companies.

4. CONCLUSIONS

Much of the afforestation under electricity grid (80.01%) has the potential to reach the network, which justifies the immediate actions of the public administration and the concessionaires. The lack of such actions can lead to serious damage to the population and urban structures, in addition to financial losses.

A new assessment of urban afforestation in the localities studied is recommended, since several crucial factors for an adequate urban/tree/society living standard are out of the minimum standards of suitability. The creation of a specific urban forest management plan may be the most correct path to be followed by cities and responsible bodies.

It is also recommended the replacement or implantation of smaller species, preferably native to compose the urban road afforestation of the region, which will prevent future damage to institutions and population.

The management of urban forest should be done using management techniques that prioritize pruning and planting in the appropriate places, as well as a general awareness of both the population and institutions and organizations working in the area, whether public or private.

AUTHORS CONTRIBUTION

A.F.O. 0000-0001-9475-5268**:** field analysis, data collection and analysis, manuscript preparation and review. **C.L.P.N.** 0000-0003-4471-6580**:** field analysis, data collection and analysis, manuscript preparation and review. **G.A.P.** 0000-0001-5274-0033**:** field analysis, data collection and analysis, manuscript preparation and review. **F.H.S.G.** 0000-0002-2947-9604**:** field analysis, data collection and analysis, manuscript preparation and review. **S.J.C.** 0000-0002-9096-0130**:** field analysis, data collection and analysis, manuscript preparation and review. **J.A.A.P.** 0000-0003-1359-5923**:** field analysis, data collection and analysis, manuscript preparation and review.

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