ISSN eletrônico 1980-7694

DIVERSITY AND DISTRIBUTION OF TREES ON THE FEDERAL UNIVERSITY OF SÃO CARLOS CAMPUS, BRAZIL: IMPLICATIONS FOR CONSERVATION AND MANAGEMENT

DIVERSIDADE E DISTRIBUIÇÃO DAS ÁRVORES NO CAMPUS DA UNIVERSIDADE FEDERAL DE SÃO CARLOS, BRASIL: IMPLICAÇÕES PARA CONSERVAÇÃO E GESTÃO

Bruno Flório Lessi[1], Fernando Antonio Bataghin[2], José Salatiel Rodrigues Pires[3]

ABSTRACT

The diversity and spatial distribution of trees on the Federal University of São Carlos campus were analyzed. Eighty percent of total individuals of studied area were visited and 130 species belonging to 106 genres and 46 families were founded, of which 51 species are native to the region and 79 exotic species. A satisfactory species diversity was found (H'= 3.89) for an urbanized area. Although the study reveals low dominance of species, the results indicate a same species individuals' aggregation, which all species with the highest abundance have an aggregated spatial distribution. The exotic species number present is bigger than the native species number and should be avoided, especially when it comes to potentially invasive exotic species. The analysis of species distribution in the landscape was a great help to identify the same species individuals' aggregation and to direct management activity on these regions, given the pests and diseases emergence.
Keywords: Urban environment; Georeferencing; Planning; Spatial distribution.

RESUMO

Foi analisada a diversidade e a distribuição espacial das espécies do campus da Universidade Federal de São Carlos através da identificação das espécies de árvore e a georreferenciação dos dados. Foram visitadas 80% do total de indivíduos arbóreos da área de estudos e encontrado 130 espécies ao longo de 106 gêneros e 46 famílias, das quais 51 espécies são nativas da região de estudo, 79 são espécies exóticas. Foi encontrado high diversidade para um ecossistema urbano (H'= 3.89). Apesar do estudo revelar uma pequena dominancia de espécies, os resultados apontam para um agregado de indivíduos da mesma espécies, onde todas as espécies com maior abundância possuem uma distribuição espacial agregada. O número de espécies exóticas presentes é maior do que as espécies nativas e isso deve ser evitado, especialmente quando essas podem ter um potencial de exótica invasora. A análise da distribuição das espécies no espaço foi de grande ajuda para identificar agregados de individuos de mesma espécie e para facilitar futuras ações de manejo nessa área, dado o surgimento de pragas e doenças.

Palavras-chave: Ambiente urbano; Georreferenciamento; Planejamento; Árvore.

Recebido em 14.10.2016 e aceito em 24.03.2017

1 Biólogo. Mestre em Ecologia. Doutorando do PPG-Ecologia e Recursos Naturais (PPGERN) da Universidade Federal de São Carlos (UFSCar). São Carlos-SP, Brasil. bflessi@gmail.com.

2 Biólogo. Doutor em Ciências. Pesquisador da Universidade Federal de Mato Grosso do Sul. Campo Grande-MS, Brasil. bataghin@gmail.com.

3 Ecólogo. Doutor em Ciências. Professor da Universidade Federal de Santa Catarina. Florianópolis-SC, Brasil e Professor do PPG-Ecologia e Recursos Naturais da UFSCar. São Carlos-SP. Brasil. jsalarpi@gmail.com.

INTRODUÇÃO

In urban ecosystems, what includes urban forests, the green spaces can bring some ecosystems services that contribute to a significant quality of life (GÓMEZ-BAGGETHUN; BARTON, 2013; MORGENROTH et al., 2016). In this time of environmental crisis, with particular reference to global warming, a high quality urban forest becomes even more important, considering that the vegetation mitigates the effects of climate change in urban areas and improves the quality of life (MORGENROTH et al., 2016).

The urban ecosystems have been target of a lot of ecological studies in order to understand process and improve them, making this environment more balanced, resilient (BREUSTE; QURESHI, 2011; GÓMEZ-BAGGETHUN; BARTON, 2013). The urban ecology considers cities as urban ecosystems with a vegetation that can be planted artificially or a combination of planted and native remnants of urbanization processes, but it is extremely important for the ecological balance of this ecosystem (ALVEY, 2006; GÓMEZ-BAGGETHUN; BARTON, 2013).

The urbanization processes tend to remove all the natural vegetation, so specified areas for new urban vegetation are limited, this way the urbanization processes often cause large biodiversity loss and extinctions (ALVEY, 2006) furthermore, different land uses, especially the uses more vegetated, are more sustainable and can soften and break with the biodiversity loss (COLDING, 2007).

The urban forest offers ecological benefits to its residents, that are called ecosystems services (GÓMEZ-BAGGETHUN; BARTON, 2013). Ecosystems process such as climate regulation, air purification, pollination, erosion control bring some ecosystems services (MORGENROTH et al., 2016).

Exotic species introduction in urban areas is a common practice (ALVEY, 2006; ANDREATTA, et al., 2011) and some of this species are invasive, what can cause losses in native areas (ALVEY, 2006; NAEEM; DUFFY; ZAVALETA, 2012; NOWAK et al., 2013). We should give preference to local native species because it can be more resistance to local pests, as already developed defenses, offer resources (e.g. fruit, flowers, nesting) for native fauna and maintain a co-evolutionary process between different plant species, pollinators, seed dispersers and their physical environment, as the well-established relationship between available nutrients. In short, native species give more ecosystems functions, providing more resilience and ecosystems services (ALVEY, 2006).

The diversity index is a key parameter to planning the urban ecosystem and your urban forest for bringing information about their biodiversity, what can be well used to measure biodiversity in urban environments. Biodiversity is generally considered a good indicator of ecosystem functions, being key information to assess the environment quality (HARRISON et al., 2014; MORGENROTH et al., 2016).

Peri-urban areas, as university campi, golf field and less density urban areas have a great ecological important for the environment and can bring several ecosystems services (COLDING, 2007). Even so, few studies have been developed in universities campuses to analyze environment quality of this areas (LEAL; PEDROSA-MACEDO; BIONDI, 2009; MELO; SEVERO, 2007).

Inventory of trees is frequently the first step of urban biodiversity management (ALVEY, 2006), and to conduct a good management of urban forests is essential to have information about trees species, number of trees, their location, etc. (NOWAK et al., 2008).

The study aims were to characterize the composition of trees in the Federal University of Sao Carlos campus, located at Sao Carlos city (UFSCar – São Carlos), analyzing the species composition, their diversity, distribution, dominance relationship and species origin.

MATERIAL AND METHODS

Study area

The UFSCar is located in São Carlos city, state of São Paulo, about 21º58' S and 47º 51' W (Figure 1). The region is subtropical with humid summers and dry winters (Koppen: Cwa), with an annual temperature average of 21.2°C and at an altitude of 830m (CEPAGRI, 2016). Around to urbanization the typical vegetation was Cerrado, particularly forest savanna and riparian forests (TOPPA, 2004).

The campus has 632,42 hectares and within the campus, about 22% of the territory is urbanized and includes several greenspaces, most of which were planted and are managed. Monjolinho river running through the urban area of the University divides the campus area into South and North (the study site is North area with 81,7 hectares).

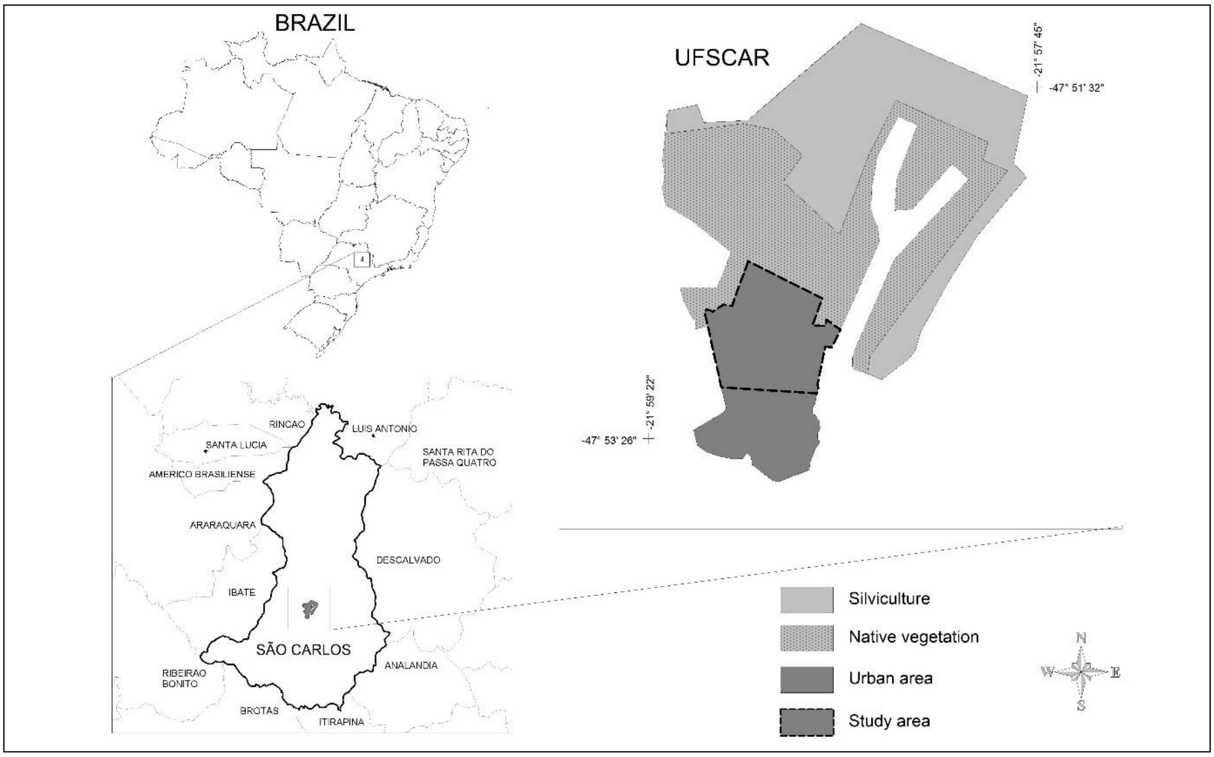

Figure 1. Study area located in the Federal University of São Carlos (UFSCar – São Carlos)
Figura 1. Área de estudo localizada na Universidade Federal de São Carlos (UFSCar – São Carlos)

Data collection

To characterize our survey area, it was use the General Map of UFSCar Campus São Carlos, ceded by UFSCar Physical Development Office (EDF). This General Map contains all university campus infrastructure mapped. It was taken only geographic location tree data, to survey the trees and to do the geographical distribution species analysis. The tree data show 4193 trees in the study area. Trees in remaining vegetation, without building and out of urban core, were not considered, then remaining 3769 trees.

The tree survey was carried by visiting each one randomly and identifying the species name. The natural occurrence of each species was verified according to the literature (BRAZILIAN FLORA, 2015): I- Local native: occurs naturally in vegetation types found within the study area region; II- exotic: it occurs naturally in others vegetation types that we cannot find in the study area.

For diversity analysis, it was used the diversity index of Shannon-Weiner (*H’*). To evaluate the partition of individuals among species was used Pilou Equity (*J*) and to check the species dominance was used Dominance index (*D*) (MAGURRAN, 1988). To spatial distribution analysis of the main species in the area was applied the nearest neighbor (R) (DAVIS, 1986). The calculations were made in the statistical program Past V. 2. 17b.

RESULTS AND DISCUSSION

We measured 3020 trees (80% of total), 2,548 were identified, 302 were unidentified, 22 were dead and 148 were removed. A total of 130 species belonging to 106 genres and 46 families were found (Table 1). By comparing with others campi, our survey considered less trees but with a similar species richness (LEAL; PEDROSA-MACEDO; BIONDI, 2009; MELO; SEVERO, 2007). However, it was found a similar or greater richness than observed in others campi surveys around the world (MARTIN et al., 2011). An urban forest with high species richness is very important to the urban ecosystem acquire more resilience and maximize a multiple ecosystem services provides (MORGENROTH et al., 2016).

Table 1. Species recorded in the UFSCar campus. Family; Species (* Local native; † Exotic; ∞ Invasive exotic; □ Arboreal; ◊ Shrub; ● Palm); Common name; NI - Number of individuals; Freq.- Record frequency

Tabela 1. Espécies encontradas no campus da UFSCar. Família; Espécies (* Nativa Local; † Exótica; ∞ Exótica invasora; □ Arbórea; ◊ Arbusto; ● Palmeira); Nome comum; NI - Numero de indivíduos; Freq.- Frequência

Family / Species	**Common name**	**NI**	**Freq.**
ACANTHACEAE			
Sanchezia oblanga Ruiz and Pav † ◊	Sanquesia	1	0,03
AGAVACEAE			
Furcraea foetida (L.) Haw. * ◊	Piteira	48	1,59
ANACARDIACEAE			
Anacardium occidentale L. * □	Cajueiro	4	0,13
Mangifera indica L. † □	Mangueira	42	1,39
Schinus molle L. □	Aroeira-salsa	194	6,42
Schinus terebinthifolius Raddi. * □	Aroeira-vermelha	7	0,23
Spondias purpurea L. † □	Seriguela	1	0,03
ANNONACEAE			
Annona squamosa L. * □	Anona	4	0,13
APOCYNACEAE			
Plumeria rubra L. † □	Jasmim-manga	17	0,56
Thevetia thevetionoides (Kunth) K. Schum † ◊	Chapéu-de-napoleão	16	0,53
ARAUCARIACEAE			
Araucaria angustifolia Raddi □	Araucária	13	0,43
Araucaria columnaris (J. R. Forst.) Hook † □	Pinheiro-de-natal	1	0,03
ARECACEAE			
Archontophoenix cunninghamiana H. Wendl. and. Drude † ●	Seafortia	17	0,56
Caryota urens L. † ●	Palmeira-rabo-de-peixe	2	0,07
Chamaerops humilis L. † ●	Palmeira-do-mediterrâneo	2	0,07
Dypsis lutescens (H. Wendl.) Beentje and J. Dransf. † ●	Areca-bambu	28	0,93
Phoenix roebelenii O'Brien † ●	Fênix	27	0,89
Roystonea oleracea L. H. Bailey † ●	Palmeira-imperial	14	0,46
Syagrus romanzoffiana (Cham.) Glassman * ●	Jerivá	132	4,37
ASPARAGACEAE			
Agave americana L. † ◊	Piteir- azul	1	0,03
Dracaena fragrans (L.) Ker Gawl. † ◊	Pau-d'agua	4	0,13
Dracaena marginata Lam. † ◊	Dracena-arco-Iris	6	0,20
Yucca elephantipes Regel. † ◊	Iuca-elefante	6	0,20
ASTERACEAE			
Baccharis dracunculifolia DC. * ◊	Vassourinha	3	0,10
BIGNONIACEAE			
Espathodea nilotica Seem. ∞ □	Espatódea	3	0,10
Handroanthus ochraceus (Cham.) Mattos * □	Ipê-amarelo	52	1,72
Jacaranda brasiliana (Lam.) Pers. * □	Jacarandá-boca-de-sapo	31	1,03

Family / Species	Common name	NI	Freq.
Jacaranda macrantha Cham. * □	Caroba	2	0,07
Jacaranda micrantha Cham. □	Caroba	1	0,03
Jacaranda mimosifolia D. Don † □	Jacarandá-mimoso	1	0,03
Tabebuia heptaphylla (Vell.) Toledo * □	Ipê-rosa	175	5,79
Tabebuia heterophylla (DC.) Britton † □	Ipê-de-El Salvador	11	0,36
Tabebuia roseoalba (Ridl.) Sandwith * □	Ipê-branco	134	4,44
Tecoma stans (L.) Juss. Ex Kunth † □	Ipê-de-jardim	10	0,33
BOMBACACEAE			
Bombax malabaricum DC. † □	Paineira-da-índia	2	0,07
CARICACEAE			
Carica papaya L. † □	Mamoeiro	1	0,03
CLUSIACEAE			
Garcinia brasiliensis Mart. □	Mangostão	1	0,03
COMBRETACEAE			
Terminalia catappa L. ∞ □	Sete-copas	1	0,03
CRYSOBALANACEAE			
Licania tomentosa (Benth) □	Oiti	46	1,52
CUPRESSACEAE			
Callitropsis macrocarpa (Hartw. Ex Gordon) D.P. Little † ◊	Cipreste-de-Monterrey	14	0,46
Cupressus lisitanica Mill † □	Cedro	28	0,93
CYCADACEAE			
Cycas revoluta Thunb. † ◊	Cica	9	0,30
DILLENIACEAE			
Dillenia indica Blanco † □	Árvore-do-dinheiro	2	0,07
ERICACEAE			
Rhododendron simsii Planch † ◊	Azaleia	14	0,46
EUPHORBIACEAE			
Codiaeum variegatum (L.) Rumph. Ex A. Juss † ◊	Cróton	2	0,07
Croton floribundus Spreng. * □	Capixingui	9	0,30
Euphorbia leucocephala Lotsy † ◊	Neve-da-montanha	2	0,07
FABACEAE			
Acacia podalyraefolia A. Cunn. Ex G. Don † □	Acácia-mimosa	3	0,10
Albizia polycephala (Benth.) Killip * □	Angico-branco	14	0,46
Albizia niopoides (Spruce ex Benth.) Burkart * □	Farinha-seca	7	0,23
Anadenanthera falcata (Benth.) Speg * □	Angico-do-cerrado	16	0,53
Anadenanthera macrocarpa (Benth.) Brenan * □	Angico-vermelho	11	0,36
Anadenanthera pavonina L. † □	Olho-de-pavão	22	0,73
Bauhinia forficata Link * □	Pata-de-vaca	2	0,07
Bauhinia variegata L. † □	Pata-de-vaca	15	0,50
Caesalpinia echinata Lam. □	Pau-Brasil	3	0,10
Caesalpinia férrea Mart.* □	Pau- ferro	98	3,25
Caesalpinia pluviosa DC. * □	Sibipiruna	221	7,32
Caesalpinia pulcherrima (L.) Sw † ◊	Mini-flamboyant	12	0,40
Calliandra brevipes Benth. ◊	Caliandra	1	0,03
Calliandra tweedii Benth. ◊	Caliandra-vermelha	1	0,03
Cassia fistula L. † □	Cassia-imperial	1	0,03
Cassia grandis L. □	Cassia-rosa	5	0,17
Cojoba sophorocarpa (Benth.) Britton and Rose □	Siraricito	15	0,50
Dalbergia miscolobium Benth. * □	Jacarandá-do-cerrado	14	0,46
Delonix regia (Bojer ex Hook.) Ralf † □	Flamboyant	8	0,26
Enterolobium confortisiliquum (Vell.) Morong * □	Timburi	28	0,93
Erythrina verna Vell. * □	Mulungu	2	0,07
Hymenaea courbaril L. * □	Jatobá	3	0,10
Hymenaea stigonocarpa Mart. Ex Hayne * □	Jatobá-do-cerrado	1	0,03
Inga vera subsp. *affinis* (DC.) nT.D. Penn. * □	Ingá-do-brejo	10	0,33
Machaerium acutifolium Vogel * □	Jacarandá-do-campo	12	0,40
Peltophorum dubium (Spreng.) Taub. * □	Canafístula	32	1,06
Pterocarpus violaceus Vogel * □	Aldrago	3	0,10
Pterogyne nitens Tul. * □	Amendoim-bravo	1	0,03
Senna pendula (Humb.and Bonpl. Ex Willd.) * ◊	Canudo-de-pito	5	0,17
Senna siamea (Lam.) H.S. Irwin and R. C. Barneby † □	Cassia-siamesa	43	1,42
Stryphnodendron adstringens (Mart.) Coville * □	Barbatimão-verdadeiro	12	0,40
Tamarindus indica L. † □	Tamarindo	1	0,03

Family / Species	Common name	NI	Freq.
LAURACEAE			
Nectandra megapotamica (Spreng.) Mez * □	Canelinha	55	1,82
Persea americana Mill † □	Abacateiro	13	0,43
LYTHRACEAE			
Lafoensia glyptocarpa Koehne □	Mirindiba-rosa	12	0,40
Lagerstroemia indica L. † □	Reseda	35	1,16
Punica granatum L. † □	Roma	2	0,07
MAGNOLIACEAE			
Michelia champaca L. † □	Magnólia	32	1,06
MALPIGHIACEAE			
Malpighia glabra L. † □	Acerola	8	0,26
MALVACEAE			
Ceiba speciosa (A. St.-Hill.) Ravenna * □	Paineira-rosa	3	0,10
Eriotheca gracilipes (K. Schum.) A. Robyns * □	Paineira-do-cerrado	8	0,26
Guazuma crinita Mart.* □	Mutamba	13	0,43
Guazuma ulmifolia Lam. * □	Mutambo	11	0,36
Sterculia chicha A. St.-Hill. Ex Turpin * □	Chicha	4	0,13
MELASTOMATACEAE			
Tibouchina granulosa (Desr.) Cogn * □	Quaresmeira	84	2,78
Tibouchina mutabilis (Vell.) Cogn □	Manacá-da-serra	1	0,03
MELIACEAE			
Cedrela fissilis Vell * □	Cedro-rosa	4	0,13
Guarea guidonia (L.) Sleumer * □	Marinheiro	2	0,07
Melia azedarach L. † □	Sinamomo	1	0,03
Swietenia macrophylla King † □	Mogno	1	0,03
MORACEAE			
Artocarpus heterophyllus Lam. † □	Jaqueira	3	0,10
Ficus benjamina L. † □	Fícus	11	0,36
Morus nigra L. † □	Amoreira	23	0,76
MUNTINGIACEAE			
Muntingia calabura L. † □	Calabura	2	0,07
MYRTACEAE			
Callistemon citrinus (Curtis) Skeels † □	Calistemon-imperial	1	0,03
Calistemon viminalis (Sol. Ex Gaertn.) G. Don † □	Escova-de-garrafa	3	0,10
Eucaliptus pilularis Sm. † □	Eucalipto	57	1,89
Eugenia pyriformis Camb. * □	Uvaia	5	0,17
Eugenia uniflora L. * □	Pitangueira	36	1,19
Myrcia bella Cambess * □	Mircia	1	0,03
MYRTACEAE			
Myrciaria jaboticaba (Vell.) O. Berg * □	Jabuticabeira	3	0,10
Psidium guajava L. * □	Goiabeira	45	1,49
Syzygium cumini (L.) Skeels ∞ □	Jambolão	26	0,86
NYCTAGINACEAE			
Bougainvillea glabra Choisy * ◊	Primavera	3	0,10
NYSSACEAE			
Camptotheca acuminata Decne. † □	Árvore-feliz	4	0,13
OLEACEAE			
Ligustrum lucidum W. T. Aiton ∞ □	Alfeneiro	156	5,17
PINACEAE			
Pinus elliotti Engelm. ∞ □	Pinos	5	0,17
PLATANACEAE			
Platanus orientalis L. † □	Plátano	1	0,03
POLYGONACEAE			
Triplaris caracasana Cham. † □	Pau formiga-de-Caracas	7	0,23
PROTEACEAE			
Grevillea banksii R. Br. † ◊	Grevilha-de-jardim	5	0,17
RHAMNACEAE			
Colubrina glandulosa Perkins * □	Sobrasil	1	0,03
ROSACEAE			
Eriobotrya japonica (Thunb.) Lindl † □ ◊	Nêspera	38	1,26
Prunus persica (L.) Batsch † □	Pessegueiro	2	0,07
RUBIACEAE			
Calycophyllum spruceanum (Benth.) Hook. f. ex K. Schum. □	Pau Mulato	1	0,03
Coffea arabica L. † ◊	Cafeeiro	3	0,10

Family / Species	Common name	NI	Freq.
Genipa americana L. □	Jenipapo	4	0,13
RUTACEAE			
Citrus limon L. † □	Limoeiro	13	0,43
Murraya paniculata (L.) Jack † □	Falsa murta	12	0,40
Zanthoxylum roipholium Lam. * □	Tamanqueira	7	0,23
STYRACACEAE			
Styrax ferrugineus L. * □	Laranjinha-do-cerrado	1	0,03
URTICACEAE			
Cecropia pachystachya Trecul * □	Embaúba	6	0,20
VERBENACEAE			
Duranta repens L. ◊	Pingo-de-ouro	10	0,33
VOCHYSIACEAE			
Qualea grandiflora Mart. * □	Pau terra	1	0,03
UNIDENTIFIED			
Unidentified	-	302	10,00
Dry/Dead	-	22	0,73
Removed	-	148	4,90

Among the 130 species, 51 were native to local area and 79 were exotic, of which 102 were characterized as arboreal, 21 shrubs and seven palms. The tree species predominance in relation to shrub and palms species is very important to campus environmental quality, especially for the anthropic comfort. Tree species of medium and large size, that is, with an improved structure can bring more ecosystems services to the urban ecosystem. However, large number of exotic species (79 spp.) bigger than natives (51 spp.) found (Table 1) was a concern. Although this practice is common in urban area (ALVEY, 2006; ANDREATTA, et al., 2011) should be avoided because of the exotic species can cause some ecosystem disservice and invade remnants of native vegetation around the city (ALVEY, 2006; NAEEM; DUFFY; ZAVALETA, 2012; NOWAK et al., 2013). It is certain that all tree species con bring some benefits in urban area, but local native species can bring ecosystems services besides contribute to native species conservation, interact better with the native fauna and being more adapted to the local soil and climate (ALVEY, 2006; FRANK et al., 2006).

The exotic species introduction in urban areas can cause serious ecosystem disservices, as a damage to areas of their surroundings natural ecosystems, as displacing native species, local extinctions and altering this ecosystem (ALVEY, 2006; NOWAK et al., 2013). In this case, our survey revealed six invasive exotic species (Table 1), as *Ligustrum lucidum, Espathodea nilotica, Terminalia catappa, Archontophoenix cunninghamiana, Pinus* spp., *Syzygium cumini* (I3N BRAZIL INVASIVE ALIEN SPECIES DATABASE, 2016), the orientation is that these species should be avoided or even replaced by native species.

Species Native from others region of Brazil should be avoided because they are exotic to local area too. This way we should give preference to local native species, as they can be more resistant to local pests, with already developed defenses, offer resources (e.g. fruit, flowers, nesting) for native fauna, support for epiphytes, maintain co-evolutionary process between the different plant species, their pollinators, seed dispersers and their physical environment, the well-stablished relationship between the available nutrients, in resume, give more ecosystems functions, providing more resilience and ecosystems services.

Biodiversity is generally considered a good indicator of ecosystem functions, being key information to assess the environment quality (HARRISON et al., 2014; MORGENROTH et al., 2016). It was found an index species diversity (H'= 3.89) higher than others studies in urban environments in the State of São Paulo (ROSSATTO; TSUBOY; FREI, 2008; SUCOMINE; SALES, 2010) and average compared with international surveys (JIM; CHEN, 2009; SREETHERAN; ADNAN; AZUAR, 2011). The environment studied by all this authors has particularities and are different from the study area and the type of environment, so it is not possible to know what is the better place or which one has the greatest diversity, but the comparison is a good way to ever improve the environment. In addition, surveys carried in natural vegetation near UFSCar – São Carlos campus indicate a similar diversity index (TOPPA, 2004), revealing that in this study area the species richness is satisfactory.

Data indicate that the richness found has a low species dominance (*D* = 0,035) and high equity among them (*J* = 0.799), which directly contribute to the stability, quality and resilience of the environment, especially in respect of protection against pest and diseases. The high density of a single species is not advisable (SANTAMOUR, 1990), as there are a high susceptibility by large homogeneous populations to the occurrence of pests and diseases. In this sense, it was founded that highest frequency of species does not exceed 8.6%. Regarding the frequency of genres and families, the highest frequencies reach 13.8% in the genre *Tabebuia* and 24.4% in the Family Bignoniaceae (Table 1) which is in accordance to the proposed by Santamour (1990) as a safe diversity against attack from pests and diseases (10% of the same species, 20% of the same genre and 30% from the same family).

Although the study reveals low dominance of species, the result that raises concern is the aggregation of individuals of the species within the area (Figure 2).

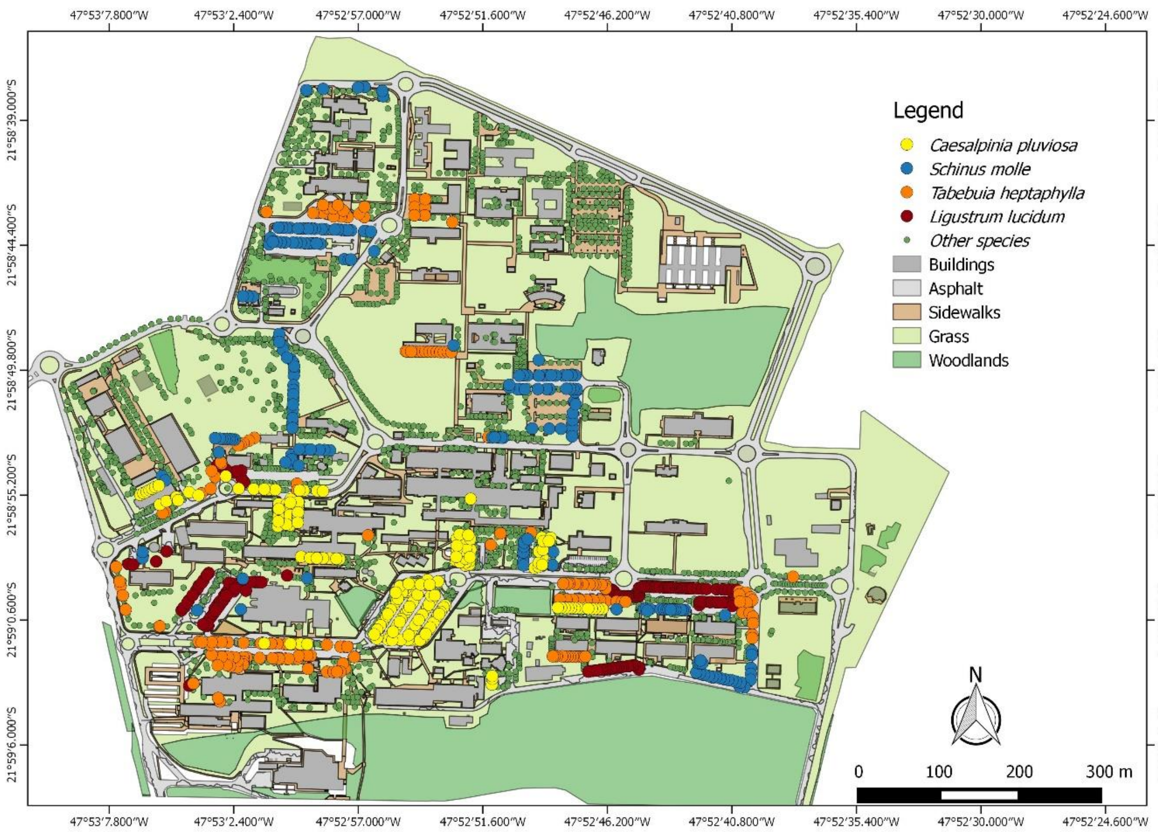

Figure 2. Location of the most abundant species found in the urban trees inventory of the campus UFSCar – São Carlos Area

Figura 2. Localização das espécies mais abundantes encontradas no inventário das árvores urbanas da Área do campus da UFSCar – São Carlos

The nearest neighbor analysis revealed that all of the most abundant species were present in the area with one aggregate spatial distribution (p < 0,0001). The values for the species were: *Caesalpina pluviosa* (R = 0,45); *Schinus molle* (R = 0,32); *Tabebuia heptaphylla* (R = 0,40) e; *Ligustrun lucidum* (R = 0,25). Therefore, although their frequency in the study area as a whole is below 10%, as propose by Santamour (1990), its susceptibility to disease can be high, since proximity between individuals of the same species can facilitate the transmission of pests and diseases. In these terms, and for presenting aggregated spatial distribution, these species should receive special attention during the trees management, as these four species represent 29.2% of the trees, the emergence of a pest can generate big losses, and this species should avoided in futures managements.

CONCLUSIONS

The UFSCar campus has a satisfactory urban trees richness and diversity, but the exotic species number present in the area is bigger than the native species number and this practice should be avoided for futures implementations, especially about invasive species. Although several native species have been found, a management to increase native trees should be considered.

For a better management, the university authorities should pay attention to the aggregations of the species and avoid planting the most abundant species. Exotic species of local vegetation should be avoided as well as invasive species. In the same way, new species of Cerrado must be added to the urban forest, always thinking of maintaining a high diversity without aggregations.

The analysis using a geographic data is a great help to identify the same species individuals' aggregation, and this spatial distribution information shows the species importance to the planning and choice for future planting location and the urban forest management, once the area has aggregated the most abundant species populations.

ACKNOWLEDGMENTS

The authors thank UFSCar – São Carlos and Physical Development Office (EDF) for allowing the research. The Post Graduate Program in Ecology and Natural Resources (PPGERN) and the National Council for Scientific and Technological Development (CNPq) for the financing granted.

REFERENCES

ALVEY, A. A. Promoting and preserving biodiversity in the urban forest. **Urban Forestry & Urban Greening**, Champaign, v. 5, n. 4, p. 195–201, 2006.

ANDREATTA, T.; BACKES, F. A. A. L.; BELLÉ, R. A.; NEUHAUS, M.; GIRARDI, L. B.; SCHWAB, N. T.; SCHMITZ, B. Análise da arborização no contexto urbano de avenidas de Santa Maria, RS. **Revista da Sociedade Brasileira de Arborização Urbana**, Piracicaba, v. 6, n. 1, p. 36–50, 2011.

BRAZILIAN FLORA. **Botanical Garden of Rio de Janeiro.** Disponível em: <http://floradobrasil.jbrj.gov.br/reflora/listaBrasil/PrincipalUC/PrincipalUC.do?lingua=en#CondicaoTaxonCP> Acesso em: 15 fev. 2015.

BREUSTE, J.; QURESHI, S. Urban sustainability, urban ecology and the Society for Urban Ecology (SURE). **Urban Ecosystems**, Washington, v. 14, n. 3, p. 313–317, 2011.

CEPAGRI. **Centro de Pesquisas Meteorológicas e Climáticas Aplicadas à Agricultura**. Disponível em: <http://www.cpa.unicamp.br/outras-informacoes/clima_muni_549.html> Acesso em: 21 out. 2016.

COLDING, J. “Ecological land-use complementation” for building resilience in urban ecosystems. **Landscape and Urban Planning**, Amsterdam, v. 81, n. 1–2, p. 46–55, 2007.

DAVIS, J. C. **Statistic and Data Analysis in Geology.** New York: John Wiley & Sons, 1986. 257p.

FRANK, S.; WATERS, G.; BEER, R.; MAY, P. An analysis of the street tree population of greater Melbourne at the beginning of the 21st century. **Arboriculture and Urban Forestry**, Champaign, v. 32, n. 4, p. 155–163, 2006.

GÓMEZ-BAGGETHUN, E.; BARTON, D. N. Classifying and valuing ecosystem services for urban planning. **Ecological Economics**, Hanover, v. 86, n. 1, p. 235–245, 2013.

HARRISON, P. A.; BERRY, P. M.; SIMPSON, G.; HASLETT, J. R.; BLICHARSKA, M.; BUCUR, M.; DUNFORD, R.; EGOH, B.; GARCIA-LLORENTE, M.; GEAMĂNĂ, N.; GEERTSEMA, W.; LOMMELEN, E.; MEIRESONNE, L.; TURKELBOOM, F. Linkages between biodiversity attributes and ecosystem services: A systematic review. **Ecosystem Services**, Wageningen, v. 9, n. 1, p. 191–203, 2014.

I3N BRAZIL INVASIVE ALIEN SPECIES DATABASE. **The Horus Institute for Environmental Conservation and Development.** Disponível em: <http://i3n.institutohorus.org.br/www/> Acesso em: 21 out. 2016.

JIM, C. Y.; CHEN, W. Y. Diversity and distribution of landscape trees in the compact Asian city of Taipei. **Applied Geography**, Amsterdam, v. 29, n. 4, p. 577–587, 2009.

LEAL, L.; PEDROSA-MACEDO, J.; BIONDI, D. Censo da arborização do Campus III-Centro Politécnico da Universidade Federal do Paraná. **Scientia Agraria**, Curitiba, v. 10, n. 6, p. 443–453, 2009.

MAGURRAN, A. E. **Ecological Diversity and Its Measurement.** New Jersey: Princeton University Press, 1988. 179p.

MARTIN, N. A.; CHAPPELKA, A. H.; KEEVER, G. J.; LOEWENSTEIN, E. F. A 100% tree inventory using i-tree eco protocol: A case study at Auburn University, Alabama, U.S. **Arboriculture and Urban Forestry**, Champaign, v. 37, n. 5, p. 207–212, 2011.

MELO, E. F. R. Q.; SEVERO, B. M. A. vegetação arbórea do campus da Universidade de Passo Fundo. **Revista da Sociedade Brasileira de Arborização Urbana**, Piracicaba, v. 2, n. 2, p. 76–87, 2007.

MORGENROTH, J.; ÖSTBERG, J.; KONIJNENDIJK VAN DEN BOSCH, C.; NIELSEN, A. B.; HAUER, R.; SJÖMAN, H.; CHEN, W.; JANSSON, M. Urban tree diversity-Taking stock and looking ahead. **Urban Forestry and Urban Greening**, Champaign, v. 15, n. 1, p. 1–5, 2016.

NAEEM, S.; DUFFY, J. E.; ZAVALETA, E. The functions of biological diversity in an age of extinction. **Science**, Washington, v. 336, n. 6087, p. 1401–1406, 2012.

NOWAK, D. J.; CRANE, D. E.; STEVENS, J. C.; HOEHN, R. E.; WALTON, J. T.; BOND, J. A ground-based method of assessing urban forest structure and ecosystem services. **Arboriculture & Urban Forestry**, Champaign, v. 34, n. 6, p. 347–358, 2008.

NOWAK, D. J.; HOEHN, R. E.; BODINE, A. R.; GREENFIELD, E. J.; O'NEIL-DUNNE, J. Urban forest structure, ecosystem services and change in Syracuse, NY. **Urban Ecosystems**, Washington, p. 1–23, May, 2013. Disponível em <http://dx.doi.org/10.1007/s11252-013-0326-z>. Acesso em: 21 out. 2014.

ROSSATTO, D.; TSUBOY, M. S. F.; FREI, F. Arborização urbana na cidade de Assis-SP: uma abordagem quantitativa. **Revista da Sociedade Brasileira de Arborização Urbana**, Piracicaba, v. 1, n. 3, p. 1–16, 2008.

SANTAMOUR, F. Trees for urban planting: diversity uniformity, and common sense. In: METRIA CONFERENCE, 7., 1990, Lisle. **Proceedings...** Lisle:1990. p.57-66.

SREETHERAN, M.; ADNAN, M.; AZUAR, A. K. K. Street tree inventory and tree risk assessment of selected major roads in Kuala Lumpur, Malaysia**. Arboriculture and Urban Forestry,** Champaign, v. 37, n. 5, p. 226–235, 2011.

SUCOMINE, N. M.; SALES, A. Caracterização e análise do patrimônio arbóreo da malha viária urbana central do município de São Carlos-SP. **Revista da Sociedade Brasileira de Arborização Urbana**, Piracicaba, v. 5, n. 4, p. 128–140, 2010.

TOPPA, R. H. **Estrutura e diversidade florística das diferentes fisionomias de Cerrado e suas correlações com o solo na Estação Ecológica de Jataí, Luiz Antônio, SP.** São Carlos, 2004. 149f. Tese (Doutorado em Ciências) - Universidade Federal de São Carlos, São Carlos, 2004.