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Richness of Native and Exotic Plants in Parks in São Paulo is Determined by Urban Park Size and Age

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HIGHLIGHTS

- Older and larger parks had greater native species richness.
- Regarding exotic plant species, older parks presented greater richness than newer areas.
- Alone socioeconomics did not explain plant species richness, but they did when combined.

Abstract: Green areas have important social, biological and aesthetical values. They might provide house and food for fauna, protect biodiversity and can provide several ecosystem services of provision, regulation, support and culture. This research aimed to analyze composition of native and exotic species in urban parks in São Paulo (Brazil), in response to variables considered drivers of diversity adapted to urban environment and to socioeconomic aspects. We expected that socio-economic factors and age and size of parks would be important determinants of species richness All county parks (municipal management) larger than 1 ha were selected, which summed 68 parks throughout São Paulo. Socioeconomic variables for this study were population, growth rate of population, average per capita income, IDH and population density. We also accessed native and exotic species richness of plants and trees from the flora list of each park. In order to determine the effects of park size and age and neighbourhood socio-economic status on richness of plants and trees we used multiple regression analyses. We found a great species richness in urban parks in São Paulo and that richness associated to park age and size, and to some socio-economic factors, especially when combined to age and size of parks. Bigger sites could offer more resources and area for the growth and establishment of native plants, and older parks in São Paulo likely had more management and interventions improving its biodiversity. Lastly, in vulnerable regions and in smaller and newer parks, we recommend improvement in plant species diversity by managers.

Keywords: Species, Urban Parks, São Paulo, Diversity

INTRODUCTION

Nowadays, more than half of world population lives in cities (54%) and it is estimated that it might reach 66% by 2050 [1]. Growth of cities has led to vegetation and biodiversity loss [2]. Gray infrastructure, substituting vegetation and changing environmental conditions, is responsible for several impacts to urban ecosystems [3]. Besides, climate change and extreme events make cities more vulnerable [4]. Due to these reasons, green areas (as urban parks) can provide several ecosystem services, as cooling of cities, water infiltration, and urban population life quality [5]. Among sustainable targets, promoting sustainable urbanization is recommended [6].

Urban parks, located within cities, protect biodiversity and water bodies and are places for recreation and environmental education (svma.sp.gov.br). These green areas have important social, biological and aesthetical values. They might provide house and food for fauna [7], protect biodiversity and can provide several ecosystem services of provision, regulation, support and culture [8]. Knowing urban parks biodiversity is important for in situ and ex situ conservation and for controlling of exotic and invasive species [9-11]. In Brazil, urban parks can function as useful tools for environmental awareness and education of the native flora [12]. In addition, native species in Brazilian urban parks can help to promote forest conservation and natural regeneration in cities [13,14]. The lack of plant surveys in urban parks bring difficulties in management and city public policies [15].

Urban ecology studies in Brazilian cities are not common [16], but results corroborate with researches that show higher percentage of green cover in rich neighborhoods [18]. Whether these higher income places are richer in urban biodiversity is a question still unanswered. In addition, the role of park size and age in species richness in tropical cities are not studied in Brazil as in Mediterranean-type climate regions (Figueroa, Castro, Reyes and Teillier, 2018 in Santiago, Chile). In natural ecosystems, island biogeography points habitat size as a predictor of higher species richness [19] and older stages of tropical forests succession having greater biodiversity [20].

In São Paulo, older parks might present high biodiversity, since these green areas were seen and managed as plant gardens in the past (for example, Jardim da Luz and Aclimação parks). Also, older parks had more time to suffer interventions as tree plantings and species introduction. Larger parks might also present high biodiversity, since there is more area available and more diversity of ecosystems that could support more species (for example, Anhanguera park). Lastly, parks located in vulnerable neighborhoods might have less biodiversity, since they do not get so much attention, money and actions from public policies, evidencing inequalities and environmental racism (for example, Santa Amélia park). A combination of these reasons could explain even better plant richness.

Urban parks have flora composed by planted and spontaneously regenerating plants, native or exotic, which may be function of park age and size and socio-economic status of the urban population. This research aimed to analyze composition of native and exotic species in urban parks in São Paulo (Brazil), in response to variables considered drivers of diversity adapted to urban environment. Specifically, we analyzed area and age of parks, as well as socio-economic conditions associated with urban population density, income and IDH. By studying 68 parks located in urban São Paulo city, we expected that socio-economic factors and age and size of parks would be important determinants of species richness, including native and exotic species, as well as spontaneous and planted species.

MATERIAL AND METHODS

Study area and data

São Paulo, the largest Brazilian city (1,521.202 km²), has 12.396.372 inhabitants [21], with a population density of 7,398.26 inhabitants per square kilometers [21] and urban land use cover of 1,521 km² (54% of this cover is green area) [22]. Climate is Cwa (lower precipitation and temperature in winter and moderately high temperatures in summer) [23] and vegetation was originally tropical rainforest and savanna. São Paulo has 105 county parks [24].

All county parks (municipal management) larger than 1 ha were selected, which summed 68 parks throughout São Paulo, resulting in 68 sampling units (Table 1). Separated by walls and fences from the neighborhood, all these parks represented management units administered independently from surrounding public infrastructures and activities. Park size varied from 1.26 to 950 ha and park age (in 2023), from 2 to 198 years old (Table 1: data obtained from Secretaria do Verde e Meio Ambiente do Município de São Paulo, SVMA, 2017: 24 and 25). Socioeconomic variables for this study were population (number of inhabitants per neighborhood), growth rate of population (rate of population growth between 2000 and 2010), average per capita income (per neighborhood, all data available at IBGE, 2011: 21), IDH (human population index), which takes into account life expectancy, education and per capita income (data available at IPEA, 2013: 26), and population density (number of inhabitants per hectare in each neighborhood: data available at 27, from 2022). Population density varied from 8.55 to 222.23 inhabitants per ha and IDH from 0.747 to 0.960 (Table 1). We also accessed SVMA website to extract native and exotic species richness of plants and trees data from the flora list of each park [25]. According to Secretaria do Verde e Meio Ambiente do Município de São Paulo, all parks were inventoried by the same staff, which made all lists similar in quality. Plants were collected by SVMA staff, classified in shrubs, trees (more than 4 m height), treelets (less than 4 m height), herbs, bamboos, lianas, epiphytes, palms, Cycas and agaves and were deposited in the municipal herbarium of São Paulo; thus, richness was quantified [25].

Table 1. List of the 68 parks selected in in São Paulo city, Brazil. IDH is a Portuguese acronym for Human Development Index. Age is in 2023.

Park	Neighbourhood	Native species richness	Exotic species richness	Age (years)	Size (ha)	Population density (inhab/ha)	IDH
Aclimação	Aclimação	41	85	84	11.22	186.74	0.858
Águas	Cidade Kemel	69	35	19	7.03	186.73	0.810
Alfredo Volpi	Morumbi	269	55	52	14.24	41.19	0.938
Alto da Boa Vista	Santo Amaro	38	19	2	3.10	45.87	0.943
Anhanguera	Perus	247	104	44	950.00	33.55	0.772
Aterro Sapopemba	São Rafael	28	25	10	30.45	109.08	0.767
Barragem de Guarapiranga	Jardim Guarapiranga	33	24	15	8.86	108.45	0.798
Benemérito José Brás	Brás	13	28	12	2.66	83.61	0.868
Buenos Aires	Higienópolis	26	53	110	1.88	155.04	0.950
Burle Marx	Morumbi	141	32	28	13.83	41.19	0.938
Carmo	Itaquera	89	60	47	150.00	140.32	0.795
Casa Modernista	Vila Mariana	55	27	15	1.26	151.73	0.950
Chácara das Flores	Jardim Nazaré	51	48	21	4.17	153.66	0.765
Chácara do Jockey	Vila Sônia	40	46	7	14.35	109.54	0.895
Chuvisco	Jardim Aeroporto	17	29	6	3.71	74.72	0.932
Cidade de Toronto	Pirituba	51	36	31	10.91	98.21	0.841
Ciência	Cidade Tiradentes	73	16	12	17.75	141.00	0.766
Colina de São Francisco	Vila São Franciso	70	27	19	4.91	122.12	0.895
Cordeiro- Martin Luther King	Chácara Monte Alegre	52	28	16	3.50	76.88	0.921
Ermelino Matarazzo	Jardim Belém	27	67	15	5.00	130.59	0.801
Eucaliptos	Morumbi	60	28	28	154.47	41.19	0.938
Guabirobeira Mombaça	São Mateus	85	21	10	30.39	119.34	0.814
Guanhembu-Benedita Ramos Caruso	Jardim Guanhembu	93	69	12	7.19	67.02	0.815
Guarapiranga	Parque Alves de Lima	189	81	49	15.26	108.45	0.798
Ibirapuera	Vila Mariana	248	341	69	158.40	151.73	0.950
Independência	Ipiranga	107	82	34	16.13	101.78	0.906

Cont. Table 1

Jacintho Alberto	**Jardim Pirituba**	**31**	**65**	**16**	**4.09**	**54.12**	**0.791**
Jardim da Conquista	Jardim da Conquista	80	24	10	59.80	33.55	0.772
Jardim da Luz	Bom Retiro	68	123	198	11.34	84.73	0.847
Jardim das Perdizes	Água Branca	15	31	11	4.60	25.68	0.917
Jardim Felicidade	Jardim Felicidade	43	74	33	2.88	98.21	0.841
Jardim Herculano	Jardim Herculano	70	36	12	7.53	78.99	0.750
Jardim Prainha	Grajaú	124	41	15	9.21	39.22	0.754
Jardim Sapopemba	Jardim Sapopemba	29	51	11	4.43	210.76	0.796
Juliana de Carvalho Torres	Cohab Raposo Tavares	42	31	11	5.44	79.50	0.819
Lajeado	Guaianases	78	52	13	1.41	120.93	0.770
Leopoldina	Vila Leopoldina	15	44	13	5.50	54.84	0.907
Lina e Paulo Raio	Vila Guarani	98	62	42	1.56	128.11	0.844
Lions Clube Tucuruvi	Tucuruvi	22	75	15	2.37	109.38	0.923
Luiz Carlos Prestes	Jardim Rolinópolis	57	44	33	2.71	41.19	0.938
M'Boi Mirim	Jardim Ângela	37	17	11	19.00	78.99	0.750
Nabuco	Jardim Itacolomi	102	71	15	3.12	158.71	0.892
Nascentes do Ribeirão Colônia	Jardim Novo Parelheiros	125	27	3	11.07	8.55	0.747
Nebulosas	São Mateus	34	32	12	4.49	119.34	0.814
Paraisópolis	Campo Limpo	54	21	2	6.80	165.13	0.806
Pinheirinho d'Água	Jaraguá	96	42	14	25.03	66.96	0.791
Piqueri	Tatuapé	64	103	45	9.72	111.80	0.936
Povo	Pinheiros	39	100	15	13.35	81.71	0.960
Praia São Paulo	Capela do Socorro	18	43	14	16.87	29.29	0.841
Previdência	Jardim Ademar	167	80	44	9.15	43.36	0.928
Raposo Tavares	Jardim Olympia	76	107	42	19.50	109.54	0.895
Raul Seixas	José Bonifácio	26	51	34	3.35	88.03	0.804
Rodrigo de Gásperi	Vila Zati	35	79	41	3.90	98.21	0.841
Santa Amélia	Jardim das Oliveiras	40	49	31	3.40	8.55	0.747
Santo Dias	Capão Redondo	324	53	8	13.4	197.59	0.782
São Domingos	Pirituba	71	89	15	8.00	98.21	0.841
Sena	Palmas de Tremembé	43	66	20	2.17	35.04	0.826

Cont. Table 1

Senhor do Vale	**Pirituba**	**27**	**29**	**13**	**2.20**	**98.21**	**0.841**
Sete Campos	Cidade Ademar	15	26	13	8.33	222.23	0.766
Severo Gomes	Granja Julieta	103	91	34	3.49	76.88	0.943
Shangrilá	Grajaú	80	28	15	7.50	39.22	0.754
Tatuapé	Tatuapé	8	17	8	1.91	111.80	0.936
Tenente Brigadeiro Roberto Faria Lima	Parque Novo Mundo	18	61	19	5.03	96.16	0.824
Tenente Siqueira Campos	Cerqueira César	122	56	141	4.86	145.40	0.957
Trote	Vila Maria	36	76	17	12.00	96.16	0.824
Vila do Rodeio	Inácio Monteiro	137	21	19	61.32	141.00	0.766
Vil dos Remédios	Vila Jaguará	113	64	44	10.98	54.12	0.791
Vila Guilherme	Vila Guilherme	36	76	37	6.50	78.74	0.868

Source: Authors (2022)

Statistical analyses

In order to determine the effects of park area, park age and neighborhood socio-economic status on the native and exotic species richness of plants and trees we used multiple regression analyses. Thus, we used one (in this case simple linear regression), two and three variables and native and exotic species richness of plants and trees as dependent variable (Table 3). We performed seven regressions with one explanatory variable, eleven, with two explanatory variables and five, with three explanatory variables in relation to each response variable (the native and exotic species richness of plants and trees), totaling 28, 44 and 20 regressions, respectively (Table 3). To verify autocorrelation between variables, which occurs when the residuals of independent variables are not independent from each other, we used Durbin-Watson test. We performed 64 Durbin-Watson tests (44 with two variables and 20 with three variables), using car package and since all p-values were greater than 0.05, we could reject the null hypothesis and conclude that the residuals in these regression models were not autocorrelated. To comply with the requirements of homoscedasticity, we transformed all variables by log (x). All analysis were performed using R [28].

RESULTS

Our study registered a total of 1,878 plant species in the 68 parks studied. Of these 1084 (57.72%) species were native and 589 (31.36%) were exotic. The number of plant species per park varied between 25 and 589 (Table 1), and the proportion of native species per park fluctuated between 22.68% and 86.70%. Overall, native species had a frequency (100 x number of parks occupied/68) that ranged between 1.47% and 88.24%, while exotic species showed a frequency ranging between 1.47% and 82.35%. Among the species with frequency greater than 50%, we recorded ten native species (*Schinus terebinthifolia, Syagrus romanzoffiana, Eugenia uniflora, Ceiba speciosa, Alchornea sidifolia, Erythrina speciosa, Handroanthus chrysotrichus, Piptadenia gonoacantha, Schizolobium parahyba, Vernonanthura polyanthes*) and 23 exotic species, including *Persea americana, Psidium guajava, Morus nigra, Eucalyptus sp., Libidibia ferrea, Paubrasilia echinata, Eriobotrya japonica, Mangifera indica, Cenostigma pluviosum, Archontophoenix cunninghamiana, Ligustrum lucidum* and *Pleroma granulosum*, mostly trees and Fabaceae (Table 2). Some species considered invasive (as *Leucaena leucocephala*) had high frequency in the studied parks (Table 2).

We found 211 plant families in the 68 parks. Exotic plants represented 110 families and native ones, 173. The six most diverse families of native species (Fabaceae, Asteraceae, Myrtaceae, Solanaceae, Melastomataceae and Rubiaceae) accounted to 33.58% (364 species) of the native flora recorded in the parks, whereas the six most diverse families of exotic (Fabaceae, Arecaceae, Asteraceae, Myrtaceae, Malvaceae and Poaceae) accounted to about 34.30% (202 species) of the exotic flora.

Table 2. Plant species most frequently recorded in parks of São Paulo, Brazil.

Species	Frequency	Origin	Family	Life-form
***Schinus terebinthifolia* Raddi**	88.24%	native	Anacardiaceae	tree
***Syagrus romanzoffiana* (Cham.) Glassman**	88.24%	native	Arecaceae	palm
***Eugenia uniflora* L.**	82.35%	native	Myrtaceae	treelet
***Persea americana* Mill.**	82.35%	exotic	Lauraceae	tree
***Psidium guajava* L.**	80.88%	exotic	Myrtaceae	treelet
***Ceiba speciosa* (A.St.-Hil.) Ravenna**	77.94%	native	Malvaceae	tree
***Morus nigra* L.**	77.94%	exotic	Moraceae	treelet
***Alchornea sidifolia* Müll.Arg.**	76.47%	native	Euphorbiaceae	tree
***Erythrina speciosa* Andrews**	75.00%	native	Fabaceae	tree
***Eucalyptus* sp.**	75.00%	exotic	Myrtaceae	tree
***Libidibia ferrea* (Mart. ex Tul.) L.P.Queiroz**	73.53%	exotic	Fabaceae	tree
***Paubrasilia echinat*a (Lam.) Gagnon. H.C.Lima & G.P.Lewis**	72.06%	exotic	Fabaceae	tree
***Eriobotrya japonica* (Thunb.) Lindl.**	69.12%	exotic	Rosaceae	treelet
***Mangifera indica* L.**	69.12%	exotic	Anacardiaceae	tree
***Cenostigma pluviosum* (DC.) Gagnon & G.P.Lewis**	67.65%	exotic	Fabaceae	tree
***Archontophoenix cunninghamiana* (H.Wendl.) H.Wendl. & Drude**	66.18%	exotic	Arecaceae	palm
***Handroanthus chrysotrichus* (Mart. ex DC.) Mattos**	66.18%	native	Bignoniaceae	treelet
***Ligustrum lucidum* W.T.Aiton**	66.18%	exotic	Oleaceae	tree
***Pleroma granulosum* (Desr.) D. Don**	66.18%	exotic	Melastomataceae	tree
***Tipuana tipu* (Benth.) Kuntze**	64.71%	exotic	Fabaceae	tree
***Dypsis lutescens* (H.Wendl.) Beentje & J.Dransf.**	63.24%	exotic	Arecaceae	palm
***Leucaena leucocephala* (Lam.) de Wit**	63.24%	exotic	Fabaceae	tree
***Ficus benjamina* L.**	61.76%	exotic	Moraceae	tree
***Musa paradisíaca* L.**	61.76%	exotic	Musaceae	herb
***Malvaviscus arboreus* Cav.**	55.88%	exotic	Malvaceae	shrub
***Piptadenia gonoacantha* (Mart.) J.F.Macbr.**	54.41%	native	Fabaceae	tree
Schizolobium parahyba (Vell.) Blake	52.94%	native	Fabaceae	tree
***Tecoma stans* (L.) Juss. ex Kunth**	52.94%	exotic	Bignoniaceae	treelet
***Bauhinia variegata* L.**	51.47%	exotic	Fabaceae	treelet
***Coffea arabica* L.**	51.47%	exotic	Rubiacea	treelet
***Heptapleurum actinophyllum* (Endl.) Lowry & G.M. Plunkett**	50.00%	exotic	Araliaceae	tree
***Hovenia dulcis* Thunb.**	50.00%	exotic	Rhamnaceae	tree
***Vernonanthura polyanthes* (Sprengel) Vega & Dematteis**	50.00%	native	Asteraceae	treelet

Source: Authors (2022)

We found that age, size and age, size and IDH, age and population, age and population density, age and income, age and IDH and all combinations of three socioeconomic variables with age and size explained native and exotic species richness of plants and trees (Table 3). While native species richness and tree native species richness were both better associated to park size, age and neighborhood population, exotic species richness was better linked to age and population growth rate and exotic tree species richness to age and neighbourhood IDH (Table 3). Native and native tree species richness had more significant associations than exotic plants and exotic tree richness (Table 3). Alone socioeconomic variables did not explain richness of exotic and native plants and trees, but with size and age (individually and altogether) they did (Table 3).

Table 3. Results of Multiple regressions that relate native and exotic species richness of plants and trees to independent variables (park size and age, neighborhood population, population density, growth rate, income and IDH). IDH is a Portuguese acronym for Human Development Index. Results are shown as R^2 and p-value (when p<0.05, significant).

	Native species richness	Exotic species richness	Native tree species richness	Exotic tree species richness
Size (S)	0.208, p<0.001	0.005, p=0.256	0.104, p=0.004	-0.013, p=0.683
Age (A)	0.074, p=0.014	0.388, p<0.001	0.155, P<0.001	0.419, p<0.001
Population (P)	0.035, p=0.069	0.010, p=0.202	0.006, p=0.243	0.050, p=0.037
Population density (PD)	-0.011, p=0.626	-0.007, p=0.480	-0.012, p=0.678	-0.002, p=0.359
Growth rate of population (GR)	-0.017, p=0.914	-0.012, p=0.599	-0.009, p=0.500	-0.016, p=0.845
Income (I)	0.002, p=0.295	-0.013, p=0.664	-0.009, p=0.519	-0.001, p=0.331
IDH	-0.001, p=0.346	0.040, p=0.056	-0.006, p=0.446	0.125, p=0.002
S+A	0.249, p<0.001	0.381, p<0.001	0.225, p<0.001	0.412, p<0.001
S+P	0.235, p<0.001	0.017, p=0.211	0.107, p=0.009	0.040, p=0.099
S+PD	0.196, p<0.001	0, p=0.373	0.091, p=0.017	-0.014, p=0.580
S+GR	0.203, p<0.001	-0.002, p=0.392	0.102, p=0.016	-0.028, p=0.834
S+I	0.196, p<0.001	0.009, p=0.284	0.090, p=0.022	-0.005, p=0.437
S+IDH	0.196, p<0.001	0.063, p=0.045	0.091, p=0.017	0.129, p=0.004
A+P	0.152, p=0.002	0.379, p<0.001	0.203, p<0.001	0.421, p<0.001
A+PD	0.069, p=0.036	0.379, p<0.001	0.152, p=0.002	0.411, p<0.001
A+GR	0.035, p=0.135	0.398, p<0.001	0.126, p=0.008	0.445, p<0.001
A+I	0.089, p=0.023	0.376, p<0.001	0.155, p=0.002	0.401, p<0.001
A+IDH	0.099, p=0.013	0.386, p<0.001	0.183, p<0.001	0.458, p<0.001
S+A+P	0.308, p<0.001	0.372, p<0.001	0.263, p<0.001	0.414, p<0.001
S+A+PD	0.240, p<0.001	0.372, p<0.001	0.217, p<0.001	0.404, p<0.001
S+A+GR	0.228, p<0.001	0.394, p<0.001	0.207, p<0.001	0.436, p<0.001
S+A+I	0.247, p<0.001	0.374, p<0.001	0.218, p<0.001	0.391, p<0.001
S+A+IDH	0.246, p<0.001	0.381, p<0.001	0.231, p<0.001	0.450, p<0.001

Source: Authors (2022)

In addition, larger and older parks had more native plant species than smaller and newer parks (Figures 1a and 1b), and also older parks had more exotic species than newer parks (Figure 1c).

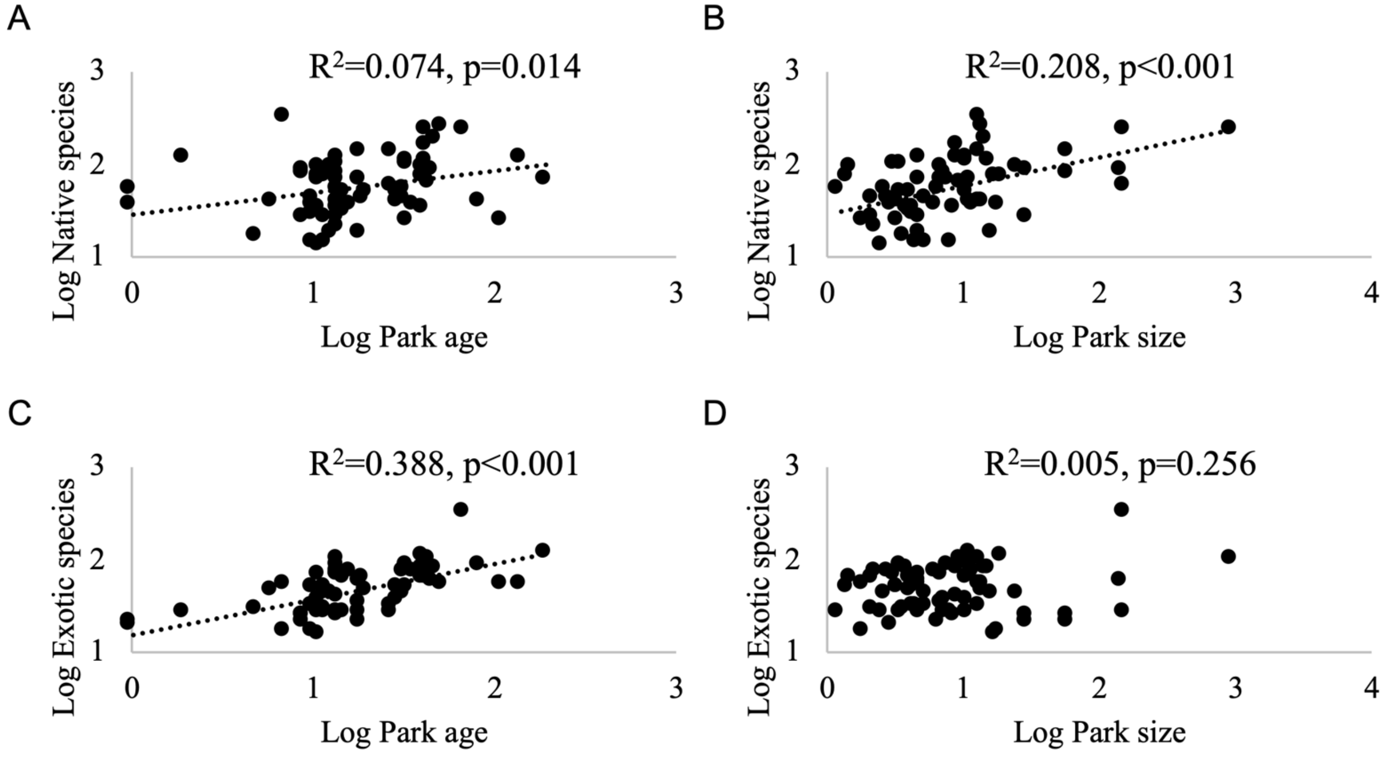

Figure 1. Relation between (A) Log number of native species and Log Park age, (B) Log number of Native Species and Log Park size, (C) Log number of exotic species and Log Park age, and (D) Log number of exotic species and Log Park size in São Paulo. The relationships shown in (A), (B) and (C) are statistically significant (P<0.05). Source: The Authors, 2022.

DISCUSSION

This research aimed to analyze composition of native and exotic species in urban parks in São Paulo (Brazil), in response to variables considered drivers of diversity in natural ecosystems, adapted to urban environment. By studying 68 parks located in urban São Paulo city, we expected that socio-economic factors and age and size of parks would be important determinants of species richness, including native and exotic species, as well as spontaneous and planted species. We found a great species richness in urban parks in São Paulo and that richness associated to park age and size, and to some socio-economic factors, especially when associated to age and size of parks.

We verified a great plant species richness in urban parks in São Paulo city, which corroborates an extensive biodiversity inventory of 2016 [26]. These green areas have important social, biological and aesthetical values. They can function as useful tools for environmental awareness and education of the native flora [12]. In addition, native species in Brazilian urban parks can help to promote conservation and natural regeneration of forest and other native ecosystems in cities and of biodiversity [13,14]. For example, it has been shown that semiurban fragments preserved biodiversity of native butterflies in southeast Brazil and that it is possible to preserve some biological diversity, ensuring the conservation of Neotropical urban areas [29]. Thus, urban parks may have an important role on that. In addition, this great plant richness found may offer several ecosystem services [8], among which we highlight feeding the fauna. The most important (in frequency) families found (Fabaceae, Asteraceae, Myrtaceae, Solanaceae, Melastomataceae and Rubiaceae) and the most important species are known for its fleshy fruits, as another study in São Paulo city already showed [18].

We verified that older and larger parks had greater native species richness, which agrees with the usual drivers of diversity in natural ecosystems (as island biogeography theory and succession of tropical forests studies have been showing). The exact same results was found for urban parks in Santiago of Chile, and they argue that bigger sites could offer more resources and surface area for the growth and establishment of native plants, which we agree [10]. Also, older parks in São Paulo likely had more management and interventions improving its biodiversity. Regarding exotic plant species, older parks presented greater richness than newer areas and that may be explained by the fact that exotic species are nowadays known and seen as potentially invasive and may threat native flora and fauna [30]. There was not an influence of park size on exotic plant species richness.

Lastly, when isolated, socioeconomic variables did not explain plant species richness inside parks, except for IDH and population; thus, denser and less vulnerable regions had more exotic tree species. These characteristics may indicate a neighborhood that is well stablished with older parks having more exotic tree species. We expected that poorer neighborhoods would be negatively related to plant species richness inside urban parks. In São Paulo city, vulnerable portions of the city suffer from a lack of infrastructure and, consequently of green infrastructure and cover [18]. Thus, that relation could be extended into biodiversity of urban parks. Fortunately, that does not seem to be true, as it has been showed for urban parks in Santiago of Chile [10], i.e., urban parks in vulnerable neighborhoods are as diverse as in rich ones. However, when combined to park size and age, socioeconomics were significant, particularly IDH that related to all response variables, indicating that more developed neighborhoods together with older or larger parks had higher biodiversity. Thus, in vulnerable areas (with lower IDH) and in smaller and newer parks, we recommend improvement in plant species diversity by management of Secretaria do Verde e do Meio Ambiente, along with other actions to promote social justice and inclusion into public spaces.

In the last few years, São Paulo city has substantially increased its urban parks, through a policy of increasing green cover and urban afforestation [31]. Based on our results, it is very important to use and manage this public space with its multiple functions [31], incorporating plant diversity conservation and restoration as a target to be pursued.

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