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Instituto Anchietano de Pesquisas
São Leopoldo – Av. Unisinos, 950 – Bloco B05 108 – Rio Grande do Sul – Brasil

INSTITUTO ANCHIETANO DE PESQUISAS - UNISINOS
Av. Unisinos, 950 - Bloco B05 108 - Bairro Cristo Rei
93022-000 - São Leopoldo, RS – Brasil - Caixa Postal 275
www.anchietano.unisinos.br anchietano@unisinos.br

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CHARACTERIZING URBAN FOREST REMNANTS IN GUARULHOS COUNTY/SP

Rosana Cornelsen Duarte[1]
Fernanda Dall'ara Azevedo[2]
Patricia Bulbovas[3]
Edna Ferreira Rosini[4]

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ABSTRACT

Guarulhos County is located in São Paulo Metropolitan Region. The City grew in an area covered by the Atlantic Forest biome, which has history of degradation due to the colonization process in the region. Nowadays, the remaining vegetation in the area is very fragmented; thus, it is essential managing these remnants to preserve their biodiversity. The aim of the current study is to characterize different groups of urban Atlantic Forest remnants: three parks (PKs), three natural lands (NLs) and three technogenic grounds (TGs) in Guarulhos County, São Paulo State. Vegetation in the forest remnants was characterized as of Dense Ombrophylous Formation of Secondary Atlantic Forest presenting different successional regeneration stages. The assessed Parks and Natural lands presented initial successional stage, except for PK2 and NL2, whose vegetation showed medium successional stage. The assessed TGs showed initial successional stage and significant degradation stage. Fragments at higher successional stages are located at Northern Guarulhos County, where one finds mountains and low anthropic occupation. The collected data can subsidize measures to protect preserved forest areas and to restore degraded public areas, as well as allow the enrichment of urban green areas in Guarulhos County and, consequently, of ecosystem services provided by the local vegetation.

Keywords: Dense Ombrophylous vegetation. Phytophysiognomy. São Paulo Metropolitan Region.

RESUMO

O município de Guarulhos está localizado na Região Metropolitana de São Paulo. A cidade cresceu em uma área coberta pelo bioma Mata Atlântica, que tem histórico de degradação desde que a região foi colonizada. Atualmente, a vegetação remanescente é muito fragmentada. Assim, é essencial gerenciar esses remanescentes para preservar sua biodiversidade. O objetivo do presente estudo foi caracterizar diferentes grupos de remanescentes urbanos de Mata Atlântica: três parques (PKs), três terras naturais (NLs) e três terrenos tecnogênicos (TGs), no município de Guarulhos, Estado de São Paulo. A vegetação dos remanescentes florestais foi caracterizada como Formação Ombrófila Densa de Mata Atlântica Secundária apresentando diferentes estágios

1 Master's Degree in Geo-environmental Analysis, Univeritas UNG University, 07023-070, Guarulhos, SP, Brazil, e-mail: rosanacornelsen@hotmail.com
2 PhD in Ecology, Univeritas UNG University, 07023-070, Guarulhos, SP, Brazil, e-mail: fernanda.azevedo@prof.ung.br
3 PhD in Ecology, Univeritas UNG University, 07023-070, Guarulhos, SP, Brazil, e-mail: pbulbovas@hotmail.com
4 PhD in Vegetal Biodiversity and Environment, Univeritas UNG University, 07023-070, Guarulhos, SP, Brazil, e-mail: edna.ferreira@prof.ung.br

sucessionais de regeneração. Os parques e as terras naturais estudados apresentaram estágio sucessional inicial, exceto PK2 e NL2, cuja vegetação apresentou estágio médio sucessional. Os TGs avaliados apresentaram estágio inicial de sucessão e estão muito degradados. Fragmentos em estágios sucessionais superiores estão localizados ao norte do município, onde há montanhas e baixa ocupação antrópica. Os dados coletados podem subsidiar medidas para proteger áreas de florestas preservadas e restaurar áreas públicas degradadas, permitindo o enriquecimento de áreas verdes urbanas no município de Guarulhos e, consequentemente, os serviços ecossistêmicos que a vegetação oferece.

Palavras-chaves: Formação Ombrófila Densa. Fitofisionomia. Região Metropolitana de São Paulo

INTRODUCTION

Atlantic Forest in Brazil has been facing degradation since the colonization period due to different economic cycles and land use profiles, such as Brazilian redwood and ore extraction, economic cycles based on sugarcane and coffee crops and high population density, mainly in Southeastern Brazil (Forzza *et al.*, 2012). This remarkable urban, industrial and agricultural development has been causing several disturbances in the region (Rocha, 2009), which led to Atlantic Forest degradation and strong fragmentation. This forest is among the most endangered tropical ecosystems; besides, it is one of the 34 biodiversity-conservation hotspots (Mittermeier *et al.*, 2004; Forzza *et al.*, 2012).

The Atlantic Forest domain in São Paulo State consists of a mosaic of ecosystems such as mangroves, sandbanks, dense ombrophylous forests and semideciduous forests. These ecosystems present different structural and floristic features that result from high abiotic condition diversity, which generates different habitats. This mosaic of vegetation is exposed to many climatic factors and grows in different soil types (Pivello and Peccinni, 2002).

Atlantic Forest fragmentation, as well as the constant anthropogenic pressure over forest remnants, affect the quality of life and sustainable use of natural resources. It happens because ecosystem services such as carbon sequestration, hydrological cycle stability, pollutant removal, aesthetic beauty, extreme-weather moderation and the mitigation of natural disasters present deteriorated profile in impacted forests (IPCC, 2007).

Forest remnants in urban areas are known as urban forests, i.e., the total of woody vegetation surrounding and enveloping urban agglomerations. The interaction between natural and anthropogenic systems accounts for the formation of these areas. In addition to providing environmental services, urban forests have great social, political, economic and architectural importance, since they provide the population with historical, artistic and landscape attributes. However, the greater the urbanization, the harder it is for these green areas to survive (Miller, 1997).

Knowledge about the structure of urban vegetation remnants, as well as about the species that make it up, can support management and conservation plans focused on these remnants, since they contribute to the preservation of native forests and ecosystem services available for the urban population (Galindo-Leal and Câmara, 2005; Marcon *et al.,* 2017). Accordingly, the aim of the current study was to characterize three different groups of urban Atlantic Forest remnants: visitation parks, natural areas of anthropized forests in soil without movement and vegetal groupings in soil with constructed and/or induced deposits in Guarulhos County, São Paulo State.

MATERIALS AND METHODS

Study site

Guarulhos territory covers 318,675 km² and is located in Northern São Paulo State Metropolitan Region (IBGE, 2015). Similar to other counties in the Atlantic Forest area, Guarulhos has biome degradation history since its colonization. Such degradation process was intensified by urban expansion, which was mainly boosted by industrial development caused by the implementation of a relevant road network in the region (Andrade and Oliveira, 2008). Nowadays, it is the second most populous city in São Paulo State - approximately 1,213,781 inhabitants (IBGE, 2015). Vegetation in the county is very fragmented, although such fragments hold the larger forest remnants. The assessed remnants are featured by mountains and hills, and are located far North Guarulhos City. Cantareira State Park, its buffer zone (Cabuçu-Tanque Grande Environmental Protection Area) and Baquirivu-Guaçu basin in Jaguari River (Graça *et al.*, 2007) are among these remnants. Climate in the region is classified as mild mesothermic wet, with dry winter and rainy summer - rainfall index ranges from 1,250 to 1,500 mm/year (Andrade *et al.*, 2008).

Data collection

Nine sampling plots presenting different features were selected in a wide territorial space (Fig. 1). Forest remnants in these areas were subdivided into three categories (Table 1): Parks (PK) – forest remnants in visitation sites, Natural Land (NL) – anthropogenic forest remnants without soil movement, Technogenic Grounds (TG) – vegetal groupings in soil-movement areas covered by built-up technogenic and/or induced deposits.

Differences presented by the study site, such as great territorial extension and unfavorable planialtimetry could impair field studies. Thus, the methodologies described below were adopted to allow the full analysis of the assessed area. Sites bigger than 40,000 m² were divided in three parts; each part comprised a transect (4 m width) crossed by a 30-m forest extension measured from the inner border of the forest remnant. This sampling model was applied to Parks PK1 and PK2 and to Natural Land NL2 and NL3. Areas up to 40,000 m² were fully covered (PK3, NL1, TG1, TG2 and TG3).

Table 1. Geographic and structural attributes of the sampling plots

Acronym	Name	Coordinates (UTM)	Area (ha)	Landscape
PK1	Bosque Maia	E343730 – S7405095	17	Fragment Forest
PK2	Núcleo Cabuçu	E343280 – S7411415	7,482	Fragment Forest
PK3	Chico Mendes	E354500 – S7405845	3.4	Fragment Forest
NL1	Várzea Tietê	E354280 – S7403585	3.4	Fragment Forest
NL2	Bairro dos Morros	E344560 – S7409450	7.5	Fragment Forest
NL3	Bonsucesso	E356890 – S7413785	8	Fragment Forest
TG1	Landri Salles	E359715 – S7408655	0.5	Vegetal groupings
TG2	Continental II	E359715 – S7408655	0.26	Vegetal groupings
TG3	Botinha	E351160 – S7403255	3	Vegetal groupings

Successional natural regeneration stages were carried out according to guidelines in CONAMA Resolution 01 (1994), which was validated by CONAMA Resolution 388 (2007). Resolution 01 (1994) defines primary and secondary vegetation profiles in pioneer, initial and advanced Atlantic Forest regeneration stages in order to guide native vegetation exploration in São Paulo State (Table 2).

Table 2. CONAMA 01 (1994) parameters to classify Atlantic Forest successional natural regeneration stages

Parameters CONAMA 01/94	**Initial Stage**	**Medium Stage**	**Advanced Stage**	**Pioneer Stage**
Physiognomy	Savannah low forest	Forestry with trees at different heights	Forestry closed	Campestral
Strata	Stratum ranged from open to closed	Strata of different heights	Large number of well-defined strata	Prevalence of herbaceous stratum
Average height (trees)	1.5 to 8.0 meters	4.0 to 12 meters	> 10 meters	2.0 meters
Average DAP (trees)	10 centimeters	20 centimeters	> 20 centimeters	3.0 centimeters
Epiphytes	Little abundant	Abundant	Very abundant	Do not occur
Climbers	Herbaceous or woody	Generally woody	Usually woody of different species	Generally herbaceous
Litter fall	Slightly thin layer, little decomposed	Thickness and decomposition variations	Thickness variation with intense decomposition	Discontinuous or incipient
Understory	More mature tree-seedlings	Ombrophilous bushes	Ombrophilous and herbaceous shrubs belonging to different species	Do not occur
Diversity	Low, dominance of 10 species, on average	Significant, few dominant species	Very large, representatives belonging to many species	Low, few dominant species
Plant species	Most pioneer	Pioneer, secondary and palm trees	Pioneer, secondary and climactic trees	Herbaceous, heliophyte and exotic / invasive shrubs

Taxonomic identification of the main plant species was carried out *in situ.* The idea was to identify species requiring more photographic records; botanical materials were collected for further identification. The International Plant Names Index (IPNI, 2005) was the instrument to confirm the usual nomenclature. APG IV (2016) was the classification system adopted for angiosperms, since it is the most recent botanical classification system.

Taxon occurrence frequency was calculated based on taxon records, according to the formula: F = n.100/N; wherein, n = number of samples recorded by a certain species; N = total number of analyzed samples. Categories were set based on Matteucci and Colma (1982): > 70% - Very Frequent (VF), ≤ 70% and > 40% - Frequent (F), ≤ 40% and > 10% - Uncommon (U), ≤10% - Rare (R).

The Sörensen Similarity Index was adopted to compare the floristic composition of sampling plots in the same remnant category and in the assessed remnant categories. This index is based on the presence-absence of species in each sampling plot; it is calculated through the formula: Is = 2c/(a+b); wherein, “c” is the number of common species between two points, "a" is the number of species at a certain point and "b" is the number of species in another point (Sörensen, 1948).

RESULTS AND DISCUSSION

According to CONAMA Resolution 01 (1994), PK1, PK3, NL1 and NL3 are at initial regeneration stage; technogenic Grounds TG1, TG2 and TG3 are at pioneer stage and constitutive vegetation NL2 is at medium stage. PK2 presents the three successional regeneration stages: initial, medium and advanced (Table 2 and Table 3).

Parks (PKs) recorded densification in their visitation places due to the presence of vegetal exotic species of great potential for landscaping. Exploring these species may cause negative impacts on natural environments, since it leads to landscape standardization and reduces local biodiversity (Heiden *et al.,* 2006). PK2 belongs to Cantareira State Park, this area stands out for its great territorial extension covered by vegetation and for its location in mountainous sites, as well as for the richness of native vegetal species. Moreover, PK2 is essential for the maintenance of ecosystem services in the county and in the region if one takes into consideration that it acts in climate regulation, soil and water source protection, and in water and food supply for wildlife survival. Similar results were recorded by Baitello (1993) in a study conducted in Núcleo Pinheirinho, by Leonel (2009) during the elaboration of the Management Plan and by Arzolla *et al.* (2011) in the project to expand Guarulhos-Anhanguera transmission line, in Cantareira State Park.

Table 3. Successional stages of the assessed sampling plots

Area	Characteristics	Successional stage
PK1	Low forest, open (walking trails) and closed strata, mean tree height 8 m, mean tree DAP 10 cm, discontinuous and poorly decomposed litterfall, few epiphytes, herbaceous and woody climbers, understory with tree seedlings presenting more mature stages, native and exotic herbaceous species, low diversity of native tree species (mostly pioneer), native tree species not natural to the region and exotic tree species.	Initial
PK2	Characteristics of the three successional stages in different areas: low forest physiognomy, varying height, high and closed forest, tree height ranging from 2.0 to > 20m, tree DAP from 10 to > 20 cm, abundance of epiphytes, herbaceous and woody climber species, litterfall of varying thickness and little decomposed litterfall, understory with seedlings of species in more mature stages, different native ombrophilous bushes and herbaceous species; great diversity of pioneer, secondary and climactic species. Exotic and native species not natural to the region were seen in the recreation area and in areas of greater circulation in the park.	Initial, medium and advanced
PK3	Low forest, open (walking trails) and closed strata, tree height up to 8 m, mean tree DAP 10 cm, absence of epiphytes, herbaceous climber species, thick and poorly decomposed litterfall, understory with emergent tree seedlings, and native and exotic native herbaceous species. The fragment is formed by low diversity of species, arboreal specimens of native species (mostly pioneer), native species not natural to the region and exotic species.	Initial
NL1	Old production forest with specimens of rare pioneer native species in the canopy. Understory composed of young specimens of native tree species (mostly pioneer) interspersed with eucalyptus seedlings from stems in the arboreal stratum - its herbaceous species are exotic. The plot has no epiphytes, few herbaceous and woody climber species, thin and poorly decomposed litterfall, and very low diversity of native and exotic species.	Initial (understory characterization)
NL2	Forest physiognomy, arboreal strata of varying heights (up to 12 m – maximum), mean distribution diameter up to 20 cm, no epiphytes. It has	Medium

	herbaceous and woody climber species, continuous and poorly decomposed litterfall, understory with young plants belonging to arboreal species (in more mature stages), ombrophilous shrubs, herbaceous native and exotic species, significant diversity of pioneer and non-pioneer native tree species. There are few examples of exotic tree species.	
NL3	Low forest physiognomy, arboreal stratum (height up to 8m – maximum), mean arboreal specimen DAP up to 10 cm, absence of epiphytes, herbaceous climber species, thin and poorly decomposed litterfall, understory with seedlings of native and exotic tree, herbaceous native and exotic species, low species diversity; native trees are mostly pioneer and interspersed with specimens belonging to exotic and invasive species.	Initial
TG1	Vegetal grouping physiognomy, herbaceous stratum prevalence, most species are invasive and exotic, incipient litterfall, absent epiphyte, exotic herbaceous climber species, low diversity with few tree species, heliophytes of exotic and invasive origin (majority).	Pioneer
TG2	Vegetal grouping physiognomy, herbaceous stratum prevalence, most species are invasive and exotic, incipient litterfall, absent epiphyte, exotic herbaceous climber species, low diversity with few arboreal species belonging to native pioneer colonizing species and exotic invasive species.	Pioneer
TG3	Vegetal grouping physiognomy, herbaceous stratum prevalence with native colonizing and invasive exotic species, incipient litterfall, absent epiphyte, absent climber species, low diversity, arboreal specimens of exotic invasive origin and specimens belonging to native species planted for urban public tree-planting.	Pioneer

Vegetation in natural land areas (NLs) live in consortium with crop species, mainly with eucalyptus, due to the expanded commercial use of this species in Brazil since the 1960s (Foelkel, 2005). There were young specimens belonging to native tree species in these areas, despite the presence of eucalyptus. Thus, it can be stated that eucalyptus crops in the study sites have not been a barrier for the recruitment of new individuals throughout the forest succession process (Feyera *et al.*, 2002; Nóbrega *et al.*, 2007; Onofre *et al.*, 2010 and Souza *et al*., 2007).

Pioneer native species and eucalyptus seedlings in the sub forest of NL1 represent the forest succession in this site. NL3 recorded the greatest amount of native species in sub forests and in tree stratum; besides, it is at initial regeneration stage. NL2 is at medium ecological succession stage, which is favored by its location in a mountainous area (Table 3).

The assessed technogenic grounds are composed of inert residues on open field. Soil in these grounds is nutrient-poor and mainly colonized by exotic and invasive vegetal species such as *Leucaena leucocephala* (Lam.) de Wit and *Tecoma stans* (L.) Juss. ex Kunth trees (Table 4), as well as by grasses and other herbaceous species. Exotic species have great invasive potential (Ziller, 2002) and have great environmental impact, since they grow fast, hinder natural regeneration and do not get extinguished without human intervention (Nobrega *et al*., 2007; Ziller and Dechoum, 2007). TG3 presented native species diversity given its urban afforestation.

The floristic study showed 220 plant species in the study sites (Table 4): 40 herbaceous species (20 invasive alien species and 20 native species belonging to 14 different families) and 180 tree species (25 alien species, three native species not native to the county and 152 species native to the region). The native tree community in the region was represented by 56 pioneer species and by 96 non-pioneer species belonging to 46 different families. Fabaceae (28 species) and Myrtaceae (15 species) were the families presenting the highest specific richness. They also stood out among the richest families in previous studies about secondary Atlantic Forest remnants in Capão Bonito (Oliveira-Junior *et al.*, 2004), Cotia (Catharino *et al.*, 2006) and São Paulo (Souza *et al.*, 2009; Arzolla *et al.*, 2011); moreover, they were structural components of the Brazilian Atlantic Rainforest (Tabarelli and Mantovani, 1999).

Based on results of the species-distribution frequency analysis, native tree species diversity in most forest remnants is low, since there are few native colonizing species and distribution frequency rates of invasive alien pioneer species are high (Rocha *et al.*, 2008) (Fig. 2). The low distribution frequency recorded for some species in PK2 and, in lower extent, in NL2 - which presented the best preservation conditions - can be justified by successional factors, since most assessed plots presented anthropogenic characteristics, initial successional stages and species belonging to other formations (Hack *et al.*, 2005). Except for native species deriving from old planting activities, 41% of the cataloged native species in the study site are rare in the assessed remnants (Fig. 2). They were only found in PK2, which is protected by the environmental legislation and has rugged relief and altimetric elevation. Forty percent (40%) of species in the study sites were uncommon; they were concentrated in remnants presenting the best environmental preservations (mostly PK2 and NL2 - both located in mountain areas characteristic of Northern Guarulhos); 16% of the species were frequent in remnants presenting anthropogenic characteristic; only 3% of the identified species were very frequent in the study sites and often found in the assessed fragments (Table 4).

The Sörensen Similarity Index indicated low floristic similarity between remnants in each category (Table 5) (Fonseca and Silva-Junior, 2004). The highest floristic similarity rate recorded in the present study was 32%. According to Rodrigues and Nave (2000), floristic similarity is high when it is analyzed in ecosystems located in the same watershed. However, factors such as differences in sampling-plot size and location, in planting of native and exotic species and different soil uses, influence floristic similarity and increase dissimilarities between sampling plots (Kunzet, 2009; Miranda-Neto *et al.*, 2012). The highest herein recorded Sörensen Index indicated great similarity between TG1 and TG2 (32%); both plots were disturbed environments with inert landfill and were not subjected to restoration interventions. The greatest dissimilarity was recorded between NL1 and NL2 (17%), possibly because NL1 was composed of eucalyptus tree specimens and understory with native pioneer species and eucalyptus seedlings. NL2 presents relevant vegetative diversity and medium natural regeneration stage.

Table 4. Species identified in the sampling points and their characteristics: Type: Arboreal (A), Herbaceous (H). Origin: Native (N), Brazilian native without natural occurrence in São Paulo State (BN), alien (Al). Succession class: pioneer (P), not pioneer (NP). Species frequency: > 70% - Very Frequent (VF), ≤ 70% and > 40% - Frequent (F), ≤ 40% and > 10% - Uncommon (U), ≤10% - Rare (R).

Family/Species	**Charact.**	**PK**			**NL**			**TG**			**Frequency F= n.100/N**
		1	2	3	1	2	3	1	2	3	
ANACARDIACEAE											
Lithraea molleoides (Vell.) Engl.	A,N,P		x								11% R
Mangifera indica L.	A,E		x	x							22% U
Schinus molle L.	A,N,P									x	11% R
S. terebinthifolia Raddi	A,N,P	x	x	x		x	x				55% F

Family/Species	**Charact.**	**PK**			**NL**			**TG**			**Frequency F= n.100/N**
		1	2	3	1	2	3	1	2	3	
Tapirira guianensis Aubl.	A,N,NP		x	x		x	x				44%F
ANNONACEAE											
Annona sylvatica (A.St.-Hil.) Mart.	A,N,P		x								11% R
Guatteria australis A. St.-Hil.	A,N,NP		x								11% R
Guatteria sellowiana Schltdl.	A,N,NP		x			x					22% U
Xylopia brasiliensis Spreng.	A,N,NP		x								11% R
APOCYNACEAE											
Aspidosperma polyneuron Müll. Arg.	A,N,NP		x								11% R
Plumeria rubra L.	A,Al			x							11% R
Tabernaemontana hystrix Steud.	A,N,P					x					11% R
AQUIFOLIACEAE											
Ilex theezans Mart. ex Reissek	A,N,NP	x	x			x	x				44% F
ARACEAE											
Anthurium sp.	H,N	x	x								22% U
Monstera deliciosa Liebm	H,N	x	x								22% U
Syngonium angustatum Schott	H,Al	x									11% R
Xanthosoma undipes (K.Koch & CD Bouche) K.Koch	H,N	x	x								22% U
ARALIACEAE											
Dendropanax cuneatus (DC.) Decne. & Planch.	A,N,P		x								11% R
Schefflera actinophylla (Endl.) Harms	A,Al	x		x							22% U
ARAUCARIACEAE											
Araucaria angustifolia (Bertol.) Kuntze	A,N,NP		x								11% R
ARECACEAE											
Archontophoenix cunninghamiana H.Wendl. & Drude	A,Al	x	x								22% U
Astrocaryum aculeatissimum (Schott) Burret	A,N,NP	x									11% R
Euterpe edulis Mart.	A,N,NP		x								11% R
Geonoma schottiana Mart.	A,N,NP	x	x	x		x					44% F
Livistona chinensis (Jacq.) R.Br. ex Mart	A,Al		x	x							22% U
Syagrus romanzoffiana (Cham.) Glassman	A,N,NP	x	x	x	x	x	x				66% VF
ARISTOLOCHIACEAE											
Aristolochia sp.	H,N	x	x	x	x	x	x				66% VF
ASPARAGACEAE											
Dracaena fragrans (L.) Ker Gawl.	A,Al	x	x								22% U
Yucca gigantea Lem.	A,Al	x		x							22% U

Family/Species	**Charact.**	**PK**			**NL**			**TG**			**Frequency F= n.100/N**
		1	2	3	1	2	3	1	2	3	
ASTERACEAE											
Baccharis dracunculifolia DC.	A,N,P		x				x			x	33% U
Moquiniastrum polymorphum (Less.) G.Sancho	A,N,P					x					11% R
Tithonia diversifolia (Hemsl.) A.Gray	H,Al	x						x	x	x	44% F
Vernonanthura polyanthes (Spreng.) A.J.Vega & Dematt	A,N,P		x		x	x	x	x			55% F
BALSAMINACEAE											
Impatiens walleriana Hook.f.	H,Al	x	x								22% U
BIGNONIACEAE											
Handroanthus impetiginosus (Mart. ex DC.) Mattos	A,N,NP	x									11% R
H. chrysotrichus (Mart. ex DC.) Mattos	A,N,NP		x	x						x	33% U
H. heptaphyllus (Vell.) Mattos	A,N,NP		x							x	22% U
H. umbellatus (Sond.) Mattos	A,N,NP			x							11% R
H. vellosoi (Toledo) Mattos	A,N,NP			x							11% R
Jacaranda caroba (Vell.) DC.	A,N,P		x								11% R
J. macrantha Cham.	A,N,P		x								11% R
J. mimosifolia D.Don	A,Al	x									11% R
J. puberula Cham.	A,N,NP		x			x					22% U
Tabebuia roseoalba (Ridl.) Sandwith	A,N,NP			x							11% R
Tecoma stans (L.) Juss. ex Kunth	A,Al					x	x	x	x	x	55% F
BIXACEAE											
Bixa orellana L.	A,NB,NP									x	11% R
BORAGINACEAE											
Cordia americana (L.) Gottschling & J.S.Mill.	A,N,NP		x								11% R
C. ecalyculata Vell.	A,N,NP		x			x					22% U
C. sellowiana Cham.	A,N,P		x			x					22% U
C. superba Cham.	A,N,P	x				x					22% U
C. trichotoma (Vell.) Arráb. ex Steud.	A,N,NP		x			x					22% U
BROMELIACEAE											
Tillandsia sp.	H,N		x								11% R
Vriesea sp.	H,N	x	x								22% U
CANNABACEAE											
Trema micrantha (L.) Blume	A,N,P		x		x	x	x		x		55% F
CANNACEAE											
Canna indica L.	H,Al					x	x				22% U

Family/Species	Charact.	PK			NL			TG			Frequency F= n.100/N
		1	2	3	1	2	3	1	2	3	
CELASTRACEAE											
Monteverdia evonymoides (Reissek) Biral	A,N,NP		x								11% R
M. Gonoclada (Mart) Biral	A,N,NP		x	x		x					33% U
cf. *M. ilicifolia* (Mart. ex Reissek) Biral	A,N,NP		x			x					11% R
CHRYSOBALANACEAE											
Hirtella hebeclada Moric. ex DC.	A,N,NP		x			x	x				33% U
CLETHRACEAE											
Clethra scabra Pers.	A,N,P		x			x				x	33% U
CLUSIACEAE											
Garcinia gardneriana (Planch. & Triana) Zappi	A,N,NP		x								11% R
CYATHEACEAE											
Cyathea sp.	H,N	x	x								22% U
C. atrovirens (Langsd. & Fisch.) Domin	H,N		x			x					22% U
C. delgadii Sternb.	H,N		x								11% R
DICKSONIACEAE											
Dicksonia sellowiana Hook.	H,N		x								11% R
ELAEOCARPACEAE											
Sloanea hirsuta (Schott) Planch. ex Benth	A,N,NP		x			x					22% U
EUPHORBIACEAE											
Alchornea glandulosa Poepp. & Endl.	A,N,P	x	x		x	x	x				55% F
A. triplinervia (Spreng.) Müll. Arg.	A,N,P		x			x					22% U
Aparisthmium cordatum (A.Juss.) Baill.	A,N,P	x		x							22% U
Croton floribundus Spreng.	A,N,P	x	x	x		x	x				55% F
C. piptocalyx Müll. Arg.	A,N,P			x							11% R
C. urucurana Baill.	A,N,P	x	x			x	x			x	55% F
Euphorbia cotinifolia L.	A,Al					x					11% R
Ricinus communis L.	H,Al						x	x	x	x	44% F
Sapium glandulosum (L.) Morong.	A,N,P	x	x	x		x	x				55% F
FABACEAE											
Abarema langsdorffii (Benth.) Barneby & J.W. Grimes	A,N,NP		x								11% R
Albizia cf. niopoides (Spruce ex Benth.) Burkart	A,N,P	x		x							22% U
Andira anthelmia (Vell.) J.F.Macbr.	A,N,NP		x								11% R
Bauhinia forficata Link.	A,N,P	x	x							x	33% U
Clitoria fairchildiana R.A. Howard	A,BN, P			x						x	22% U
Copaifera langsdorfii Desf.	A, N,NP	x									11% R

Family/Species	**Charact.**	**PK**			**NL**			**TG**			**Frequency F= n.100/N**
		1	2	3	1	2	3	1	2	3	
Delonix regia (Bojer ex Hook.) Raf.	A,AI	x									11% R
Erythrina speciosa Andrews	A,N,P	x		x		x				x	44% F
Hymenaea courbaril L.	A,N,NP	x	x	x							33% PF
Inga edulis Mart.	A,N,NP			x							11% R
I. marginata Willd.	A,N,NP	x	x			x					33% U
I. sessilis Mart.	A,N,P		x								11% R
I. vera Willd.	A,N,P				x					x	22% U
Leucaena leucocephala (Lam.) de Wit	A,AI	x			x		x	x	x	x	66% VF
Leucochloron incuriale (Vell.) Barneby & J.W.Grimes	A,N,NP		x								11% R
Machaerium hirtum (Vell.) Stellfeld	A,N,NP					x					11% R
M. cf. nyctitans (Vell.) Benth.	A,N,NP	x									11% R
M. stipitatum Vogel	A,N,NP	x	x								22% U
M. villosum Vogel	A,N,NP	x	x								22% U
Mimosa bimucronata (DC.) Kuntze	A,N, P	x								x	22% U
Paubrasilia echinata (Lam.) Gagnon,H.C.Lima&G.P.Lewis	A,BN,NP			x							11% R
Peltophorum dubium (Spreng.) Taub.	A,N,P	x	x								22% U
Piptadenia gonoacantha (Mart.) J.F.Macbr.	A,N,P	x	x		x	x	x				55% F
Platymiscium floribundum Vogel	A,N,NP		x	x							22% U
Poecilanthe parviflora Benth.	A,N,NP			x							11% R
Pterodon sp.	A,N,NP					x					11% R
Senegalia polyphylla (DC.) Britton & Rose	A,N, P		x	x							22% U
Senna macranthera (DC. ex Collad.) H.S.Irwin & Barneby	A,N,P	x	x	x			x				44% F
S. multijuga (Rich.) H.S.Irwin & Barneby	A,N,P		x				x				22% U
Schizolobium parahyba (Vell.) S.F. Blake	A,N,P					x				x	22% U
HELICONIACEAE											
Heliconia sp.	H,N	x	x			x					33% U
HYPOXIDACEAE											
Molineria capitulata (Lour.) Herb.	H,AI	x									11% R
LAMIACEAE											
Aegiphila verticillata Vell.	A,N,P	x			x	x					33% U
Scutellaria sp.	H,AI							x			11% R
Vitex polygama Cham.	A,N,NP		x								11% R
LAURACEAE											
Nectandra lanceolata Nees & Mart.	A,N,NP					x					11% R
N. oppositifolia Nees & Mart.	A,N,P		x								11% R

Family/Species	Charact.	PK			NL			TG			Frequency F= n.100/N
		1	2	3	1	2	3	1	2	3	
Ocotea catharinensis Mez	A,N,NP		x								11% R
O. pulchella (Nees & Mart.) Mez	A,N,NP		x								11% R
Persea americana Mill.	A,Al			x			x				22% U
LECYTHIDACEAE											
Cariniana estrellensis (Raddi) Kuntze	A,N,NP		x								11% R
C. legalis (Mart.) Kuntze	A,N,NP		x								11% R
LYTHRACEAE											
Lafoensia pacari A.St.-Hil.	A,N,NP		x								11% R
ORCHIDACEAE											
Brassavola sp.	H,N		x								11% R
MAGNOLIACEAE											
Magnolia champaca (L.) Baill. ex Pierre	A,Al		x	x							22% U
MALPIGHIACEAE											
Byrsonima ligustrifolia A.Juss.	A,N,NP		x	x							22% U
MALVACEAE											
Abutilon densiflorum (Hook. & Arn.) Walp.	A,N, P	x		x							22% U
Ceiba speciosa (A.St-Hil.,A.Juss & Cambess.) Ravenna	A,N,NP	x	x	x							33% U
Luehea divaricata Mart.	A,N,NP		x			x					22% U
L. grandiflora Mart.	A,N,NP			x		x					22% U
Malvaviscus arboreus Dill. ex Cav.	H,Al	x	x								22% U
Pseudobombax grandiflorum (Cav.) A. Robyns	A,N,NP	x		x							22% U
MELASTOMATACEAE											
Miconia sp.	H,N		x	x		x	x				44% F
M. cabucu Hoehne	A,N,NP		x								11% R
M. cornifolia (Desr.) Naudin	A,N,NP		x			x	x				33% U
M. cubatanensis Hoehne	A,N,NP		x			x	x				33% U
Pleroma granulosum (Desr.) D.Don	A,N,P			x		x				x	33% U
P. mutabile (Rich. ex DC.) Triana	A,N,P		x	x		x	x				44% F
Tibouchina sellowiana Cogn.	A,N,P		x	x							22% U
MELIACEAE											
Cabralea canjerana (Vell.) Mart.	A,N,NP	x	x	x		x					44% F
Cedrela fissilis Vell.	A,N,NP		x	x							22% U
Guarea guidonia (L.) Sleumer	A,N,NP					x					11% R
G. macrophylla Vahl.	A,N,NP	x	x			x	x				44% F
Melia azedarach L.	A,Al			x							11% R
Trichilia claussenii C.DC.	A,N,NP					x					11% R

Family/Species	**Charact.**	**PK**			**NL**			**TG**			**Frequency F= n.100/N**
		1	2	3	1	2	3	1	2	3	
T. silvatica C.DC.	A,N,NP		x								11% R
MORACEAE											
Artocarpus heterophyllus Lam.	A,Al	x		x							22% U
Ficus sp.	A,N,NP		x				x				22% U
F. benjamina L.	A,Al			x							11% R
F. clusiifolia Schott	H,N	x			x	x					33% U
F. citrifolia Mill.	A,N,NP	x		x		x					33% U
Morus nigra L.	A,Al	x					x				22% U
MYRSINACEAE											
Myrsine coriacea (Sw.) R.Br. ex Roem. & Schult	A,N,P	x	x	x		x	x				55% F
M. gardneriana A. DC.	A,N,P	x	x			x					33% U
M. umbellata Mart.	A,N,P		x								11% R
MYRTACEAE											
Blepharocalyx salicifolius (Kunth) O. Berg	A,N,NP	x					x				22% U
Campomanesia guazumifolia (Cambess.) O. Berg	A,N,NP		x								11% R
Eucalyptus sp.	A,Al	x	x	x	x	x	x				66% VF
Eugenia involucrata DC.	A,N,NP		x	x							22% U
E. pyriformis Cambess.	A,N,NP			x							11% R
E. uniflora L.	A,N,NP	x	x	x		x	x				55% F
Myrceugenia euosma (O. Berg) D.Legrand	A,N,NP		x			x					22% U
Myrcia hebepetala DC.	A,N,NP	x	x	x		x					44% F
M. multiflora (Lam.) DC.	A,N,NP		x	x		x					33% U
M. splendens (Sw.) DC.	A,N,NP		x								11% R
M. tenuivenosa Kiaersk.	A,N,NP	x	x	x		x					44% F
M. tomentosa (Aubl.) DC.	A,N,NP		x								11% R
Pimenta pseudocaryophyllus (Gomes) Landrum	A,N,NP		x								11% R
Plinia cauliflora (Mart.) Kausel	A,N,NP					x					11% R
Psidium cattleyanum Sabine	A,N,NP		x			x					22% U
P. guajava L.	A,N,NP		x	x	x	x	x			x	66% VF
Syzygium cumini (L.) Skeels	A,Al	x									11% R
NYCTAGINACEAE											
Bougainvillea glabra Choisy	A,N,NP			x							11% R
Guapira opposita (Vell.) Reitz	A,N,NP		x								11% R
OLACACEAE											
Heisteria sp.	H,N		x			x					22% U

Family/Species	**Charact.**	**PK**			**NL**			**TG**			**Frequency F= n.100/N**
		1	2	3	1	2	3	1	2	3	
OLEACEAE											
Ligustrum lucidum W.T. Aiton	A,Al									x	11% R
PERACEA											
Pera glabrata (Schott) Poepp. ex Baill.	A,N,P		x								11% R
PHYTOLACCACEAE											
Gallesia integrifolia (Spreng.) Harms	A,N,NP			x							11% R
Petiveria tetrandra Gomez	H,N			x							11% R
PINACEAE											
Pinus elliottii Engelm.	A,Al	x	x	x			x	x			55% F
PIPERACEAE											
Piper aduncum L.	H,Al	x	x	x	x	x	x				66% VF
P. umbellatum L.	H,N		x	x							22% U
PITTOSPORACEAE											
Pittosporum undulatum Vent.	A,Al		x								11% R
POACEAE											
Bambusa balcooa Roxb.	H,Al		x			x	x				33% U
Cenchrus purpureus (Schumach.) Morrone	H,Al								x	x	22% U
Cynodon sp.	H.Al	x						x	x	x	44% F
Dendrocalamus giganteus Munro	H,Al	x						x	x	x	44% F
Melinis sp.	H,Al							x	x	x	33% U
Raddia distichophylla (Schrad. ex Nees) Chase	H,Al			x							11% R
Urochloa sp.	H,Al		x	x	x	x	x	x	x	x	88% VF
U. Eminii (Mez) Davidse	H.Al							x	x	x	33% U
U. maxima (Jacq.) R.D. Webster	H,Al				x			x		x	33% U
PODOCARPACEAE											
Podocarpus sellowii Klotzch ex Endl.	A,N,NP		x	x			x				33% U
POLYGONACEAE											
Coccoloba sp.	A,N,P	x	x			x	x				44% F
Rumex obtusifolius L.	H,Al								x	x	22% U
PROTEACEAE											
Roupala montana Aubl.	A,N,NP		x								11% R
RHAMNACEAE											
Hovenia dulcis Thunb.	A,Al	x	x	x							33% U
ROSACEAE											
Eriobotrya japonica (Thunb.) Lindl.	A,Al		x	x			x				33% U
Prunus myrtifolia (L.) Urb.	A,N,NP	x	x								22% U

Family/Species	**Charact.**	**PK**			**NL**			**TG**			**Frequency F= n.100/N**
		1	2	3	1	2	3	1	2	3	
Rubus rosifolius Sm.	H,N			x							11% R
RUBIACEAE											
Amaioua intermedia Mart. ex Schult. & Schult.f.	A,N,NP		x								11% R
Coffea arabica L.	H,Al	x	x								22% U
Posoqueria acutifolia Mart.	A,N,NP		x								11% R
Psychotria nuda (Cham. & Schltdl.) Wawra	A,N,NP		x	x		x	x				44% F
RUTACEAE											
cf. *Helietta* sp.	A,N,NP	x									11% R
Neesia sp.	A,N,NP	x				x					22% U
Zanthoxylum rhoifolium Lam.	A,N,NP	x		x							22% U
SALICACEAE											
Casearia sylvestris Sw.	A,N,P	x	x	x	x	x	x				66% VF
SAPINDACEAE											
Allophylus edulis (A.St.-Hil.,A.Juss. & Cambess.) Radlk.	A,N,P		x								11% R
Cupania oblongifolia Mart.	A,N,NP		x	x							22% U
Cupania vernalis Cambess.	A,N,NP	x	x	x	x	x	x				66% VF
Matayba guianensis Aubl.	A,N,NP		x								11% R
SAPOTACEAE											
Manilkara subsericea (Mart.) Dubard	A,N,NP		x	x							22% U
SMILACACEAE											
Smilax sp.	H,N		x		x	x	x				44% F
SOLANACEAE											
Lochroma arborescens (L.) J.M.H.Shaw	A,N,P	x			x	x		x			44% F
Solanum mauritianum Scop.	A,N,P	x	x	x	x			x		x	66% VF
S. paniculatum L.	A,N,P		x		x			x			33% U
S. pseudoquina A.St.-Hil.	A,N,P		x			x					22% U
S. viarum Dunal	H,N									x	11% R
URTICACEAE											
Cecropia glaziovii Snethl.	A,N,P	x	x		x	x	x				55% F
C. hololeuca Miq.	A,N,P		x								11% R
C. pachystachya Trécul	A,N,P	x	x	x		x					44% F
VERBENACEAE											
Aloysia virgata (Ruiz & Pav.) Juss.	A,N,P		x	x							22% U
Citharexylum myrianthum Cham.	A,N,P	x	x			x	x			x	55% F
WINTERACEAE											
Drimys brasiliensis Miers	A,N,NP	x				x					22% U

Table 5. Sorënsen Similarity Index between sampling plots in each forest fragment category and between forest fragment categories

		PK			NL			TG		
		1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
	1	-	21%	/	/	/	/	/	/	/
PK	**2**	/	/	21%	/	/	/	/	/	/
	3	20%	/	/	/	/	/	/	/	/
	1	-	/	/	/	17%	/	/	/	/
NL	**2**	-	/	/	/	/	27%	/	/	/
	3	-	/	/	22%	/	/	/	/	/
	1	-	/	/	/	/	/	/	32%	/
TG	**2**	-	/	/	/	/	/	/	/	26%
	3	-	/	/	/	/	/	23%	/	/

The hard access to and, consequent, lower anthropic occupation in Northern Guarulhos justify the best vegetation preservation conditions in sampling plots in the assessed sites, mainly in PK2, which is located in far Northern Guarulhos. As plots move away from far Northern and Northeastern towards Southern Guarulhos, where anthropic occupation is higher due to its planialtimetry, vegetation in the study sites gets more fragmented and their biodiversity gradually decreases due to anthropogenic actions (NL2, NL3, PK1, PK3 and NL1). TGs are quite degraded, but TG3 was recently subjected to public reforestation in order to be restored.

CONCLUSIONS

The assessed Parks (PKs) and Natural Lands (NLs) presented initial successional stage, except for PK2 and NL2, whose vegetation showed medium successional stage. Both areas are located in a mountainous region of Guarulhos County, which has low anthropic occupation. PK2 is an area protected by the environmental legislation. The assessed Technogenic Grounds (TGs) showed initial successional stage and were quite degraded. TG3 presented higher native species diversity given its urban afforestation.

Forty-one percent (41%) of native species were rare in the remnants, 40% of them were uncommon and concentrated in remnants presenting the best environmental preservations, 16% of the species were frequent in remnants presenting anthropogenic characteristic and only 3% of them were very frequent in the study areas.

Based on the Sörensen Similarity Index, floristic similarity between the remnants in each category was low. The highest floristic similarity rate (32%) was observed between TG1 and TG2, which are disturbed environments with inert landfill that were not subjected to restoration interventions.

Results have shown that it is possible recommending the elaboration of management plan focused on preserving the biodiversity and genetic variability of species native to the assessed forest remnants. This process would allow the enrichment of urban green areas in Guarulhos County and, consequently, of ecosystem services provided by the local vegetation.

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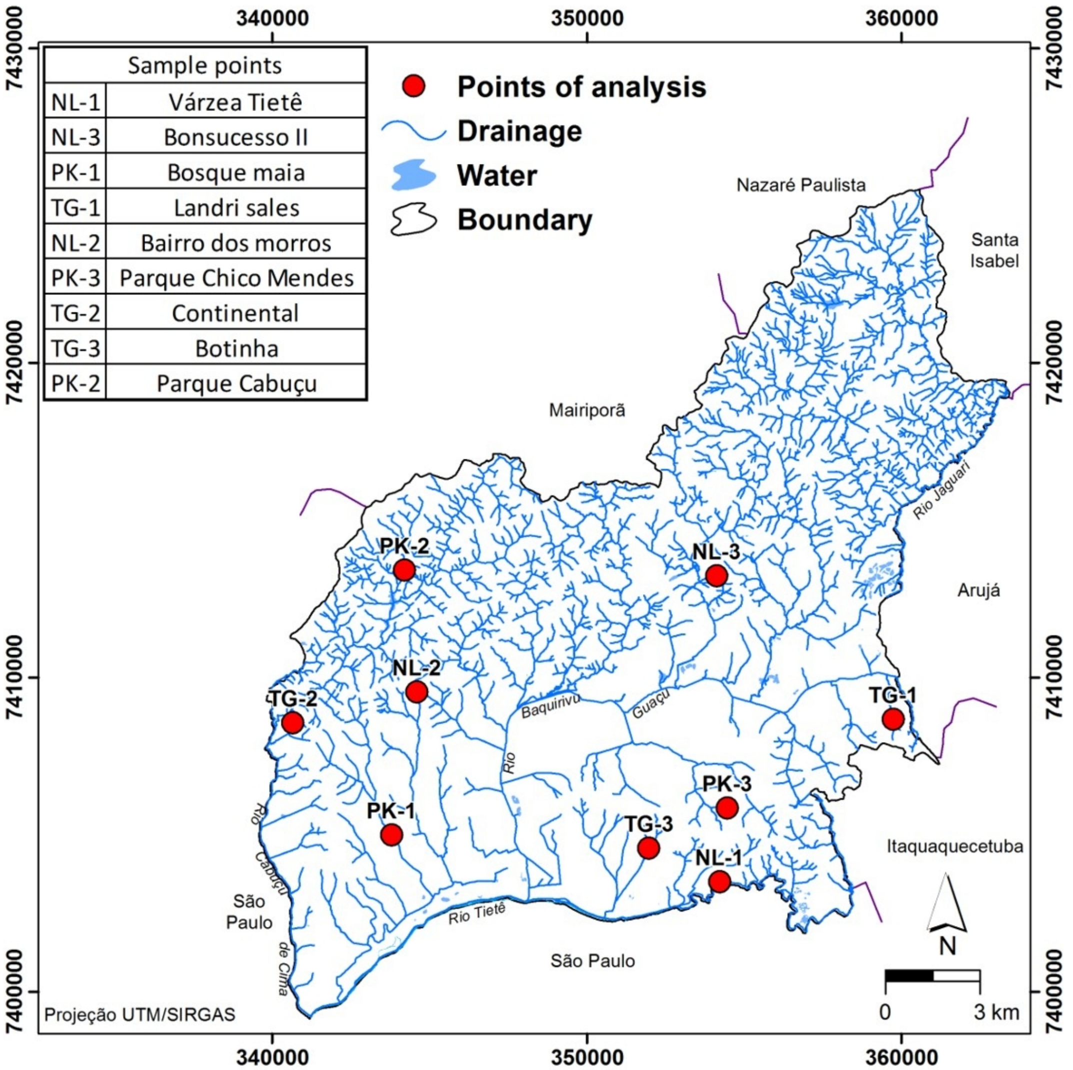

Figure. 1 Sampling plot locations in Guarulhos County – SP

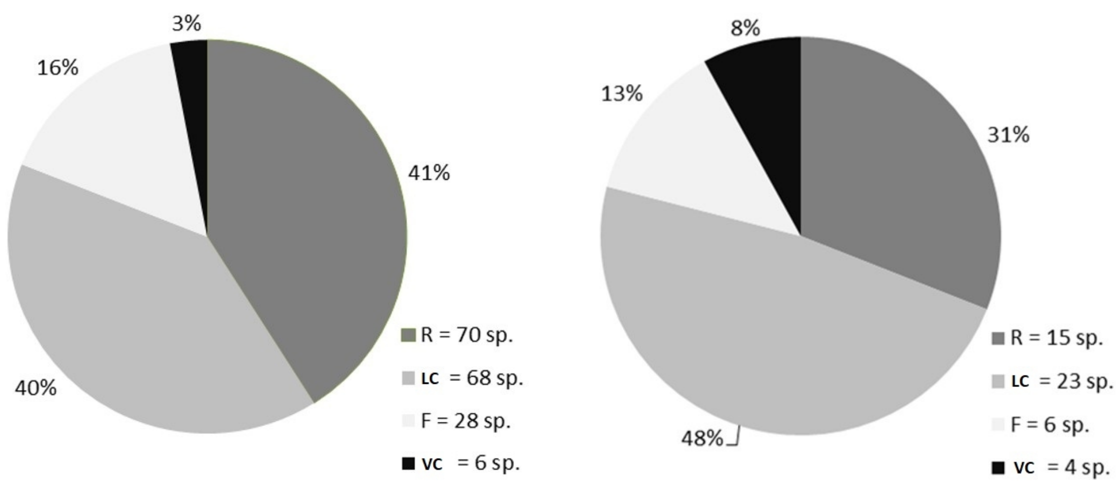

Figure. 2 Distribution Frequency of plant species identified in the assessed fragments: R=rare, LC= less common, F= frequent, VC= very common. 2A - Native species, 2B - Exotic species.