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EVALUATION OF THE INFLUENCE OF THE MATRIX IN BIODIVERSITY CONSERVATION: EFFECTS ON SEMIDECIDUOUS TROPICAL FORESTS IN SOUTHEASTERN BRAZIL[1]

AVALIAÇÃO DA INFLUÊNCIA DA MATRIZ NA CONSERVAÇÃO DA BIODIVERSIDADE: EFEITOS EM UMA FLORESTA TROPICAL SEMIDECIDUAL NA REGIÃO SUDESTE DO BRASIL[1]

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ABSTRACT - Deforestation process results in a large archipelago of small forest fragments isolated from each other. This is especially important in the Atlantic Forest, a biome with great human occupation and which has been severely deforested. Thus, there is a necessity for verify the effects that different matrices can exert on these remnants. In this study we verified the effect that sugarcane, pasture and *Eucalyptus* matrices can have on forest remnants. It was hypothesized that monoculture of *Eucalyptus* could protect the fragments given their size and relative longevity. The fragments evaluated presented clear signs of edge effect. The forest fragments surrounded by *Eucalyptus* interface presented greater species richness, lower dominance and a lower incidence of pioneer species indicating a degree of protection and a more advanced stage of succession. The use of trees in the surrounding matrix of fragments can be implemented to provide a stable and continuum forest condition, increasing the protection of these remnants with ecological benefits.

Keywords: Forest remnant; Edge effect; Forest protection; Land use system; Matrix.

RESUMO - O processo de desmatamento resulta em um grande arquipélago de pequenos fragmentos florestais isolados uns dos outros. Isso é especialmente importante na Mata Atlântica, um bioma com grande ocupação antrópica e que foi severamente desmatado. Dada tal situação, é necessário verificar os efeitos que as diferentes matrizes podem exercer sobre estes remanescentes. Neste estudo verificamos o efeito que as matrizes de cana-de-açúcar, pastagem e *Eucalyptus* podem causar sob os remanescentes florestais. Hipotetizou-se que a monocultura do *Eucalyptus* poderia proteger os fragmentos devido ao seu tamanho e longevidade. Os fragmentos avaliados apresentaram claros sinais de efeito de borda. Os fragmentos florestais circundados por interface de *Eucalyptus* apresentaram maior riqueza de espécies, menor dominância e menor incidência de espécies pioneiras, indicando um maior grau de proteção e estágio mais avançado de sucessão. Desta maneira, o uso de árvores na matriz circundante de fragmentos pode ser implementado para fornecer uma condição florestal estável e contínua, aumentando a proteção desses remanescentes com benefícios ecológicos.

Palavras-chave: Remanescente florestal; Efeito de borda; Proteção florestal; Uso do solo; Matriz.

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1 INTRODUÇÃO

The Atlantic Forest used to be one of the largest tropical forests in the world, largely well-known for its importance in the conservation of species diversity. This biome presents a high degree of endemism and great species richness (Myers et al., 2000; Giulietti et al., 2005; Ribeiro et al., 2009; Werneck, 2011; Forzza et al., 2012) and it is currently considered one of the five main hotspots in the world for biodiversity conservation (World Wide Fund - WWF Brazil, 2015; Laurance, 2009). The scientific knowledge indicates that Atlantic Forest hosts a plant species diversity per unit area higher than Amazon forests (Joly et al., 2014). Despite its relevance, this biome still suffers severely with the pressure of opening new areas for crops as well as for disarranged human occupation (Villani, 2007; Tabarelli et al., 2010). Furthermore, factors like logging, fire and hunting, contribute to habitat loss and fragmentation (Joly et al., 2014). Deforestation and forest degradation cause forest fragmentation, replacing large areas of native forest by other agro-ecosystems, forming a mosaic of isolated patches (Murcia, 1995). Deforestation promotes several local impacts (Valente, 2001; Tonhasca Jr., 2005), such as canopy destruction, species loss, natural vegetation structure alteration, and microclimate modification, as a result of the reduction and isolation of areas that are important to the survival of the biological populations, also leading to species extinctions (Herrmann et al., 2005; Harper et al., 2005).

Historically, the deforestation of the Atlantic Forest in southeast region has increased by the end of the 19th century, as coffee crop progressed, and, as a "*green wave*", spread from Rio de Janeiro to the entire state of São Paulo (Lobato, 2008), which was accentuated even more with the process of industrialization (Carvalho, 2007). The Semideciduous Seasonal Forest (SSF) is the most degraded forest formation in the state of São Paulo due to soil fertility and favorable land relief to agriculture (Lopes et al., 2012). According to Ribeiro et al. (2009), SSF is the second most threatened formation of the Atlantic Forest biome, remaining only 7.1% of its primary cover. These remaining forests were reduced to countless archipelagos of fragments that are very small and widely spaced apart (Gascon et al., 2000). As reported by Ribeiro et al. (2009), about 83% of the Atlantic Forest fragments in the Brazilian coast are smaller than 50 ha.

Forest fragmentation implies a high density of edge environments, profoundly influencing the diversity of species and composition of tree communities (Metzger, 2000). Fragmentation usually results in remnants immersed in an agricultural matrix, secondary vegetation, degraded soil or urban area (Kramer, 1997). Thus, in an abrupt way, different interfaces are originated and the organisms living in the forest fragments are susceptible to new conditions of a different surrounding environment (Murcia, 1995). Therefore, any forested area that has been fragmented, will inevitably suffer from the edge effects, being subject to stress factors in its bordering zone, which alters the patterns and structures of the species populations, as well as the ecological relationships responsible for the maintenance of isolated biological communities (Oliveira and Nagamura, 2007).

Depending on the fragment size, shape and edge length, the new conditions may affect not only the fragment itself but influence the system as a whole which still lacks further studies. The reduction of the fragments size leads to an increase in their isolation since they are more distant from each other. Consequently, also leads to a reduction of the connectivity and permeability of the fragments, hindering the species transit of fauna and flora (pollen and seeds) (Metzger, 2003). According to Guisard and Kuplich (2008), matrix type can accelerate or retard biodiversity loss, because the surrounding matrix has a great influence on the connectivity of the fragments and on the ability to facilitate biological flows between them (Taylor et al., 1993). The type of neighborhood can also function as a continuity of the habitat, an interconnection between the habitats or as a source of disturbances, which can profoundly affect the sustainability of the native biota (Pivello, 2003).

Thus, if we consider the fact that the Atlantic Forest is mostly intensely fragmented, and that, for the biodiversity, conservation of the surrounding (matrix) matters, and, moreover, if we recognize that the matrix consists of managed ecosystems (mostly by agriculture), then the agricultural ecosystems management become crucial for the biodiversity conservation (Perfecto et al., 2009). So, as stated by Vandermeer (2011) the biodiversity of the fragment can be managed by the surrounding agroecosystem. A change in the landscape mosaic by adopting different production systems, like agroforestry systems, can result in a higher permeability of the matrix, favoring the connection between isolated fragments by using the agricultural matrix (which in many places is bigger than the natural areas) in order to protect and connect forest fragments in a continuum forestry (Righi and Foltran, 2016). Therefore, it would make sense to insert the biodiversity conservation within the management in agricultural landscapes.

A necessary change in conservation planning must be emphasized, defending the idea of matrix types that softens the edge effect and is permeable to the necessary plant and animal flows. The influence of the neighborhood can be decisive for the self-sustainability of the remnant (Sampaio, 2011). Therefore, it is essential that matrices favorable to protection and connectivity are prioritized in areas close to forest fragments. Studies that assess the performance of different neighborhoods (types of land-use systems) in the conservation of biodiversity in forest remnants can help guide management actions and conservation policies in fragmented landscapes.

Considering this, the present work aimed to investigate the influence of surrounding matrix on edge effect in Semideciduous Seasonal Forest fragments located in Southeastern Brazil, where agricultural frontiers have been dramatically increased. Therefore, this study verified the level of interference in the neighborhood of fragments at species level, indicating which surrounding matrix can minimize the edge effect in forest fragments - it was hypothesized that monoculture of *Eucalyptus* performs better than pasture or sugarcane. We predict that the predominance of trees in the surrounding matrix could contribute to the conservation of forest remnants (forest structure and species composition) by reducing the degradation effects of the surroundings.

2 MATERIAL AND METHODS

This study was conducted in the municipality of Piracicaba, São Paulo, Brazil (22°43′30″S, 47°38′51″W). The natural vegetation is classified in the Brazilian Phytogeographic System as a Semideciduous Seasonal Forest (Instituto Brasileiro de Geografia e Estatística - IBGE, 2012). The local climate is subtropical humid, with warm and rainy summers and dry winters, equivalent to Cwa in Köppen's classification (1948), lately updated by Kottek et al. (2006). The annual average temperature is 21.4ºC with a monthly average temperature of 24.8ºC in the summer and 17.1ºC in the winter. According to Instituto Nacional de Meteorologia (1981 - 2010), the annual average rainfall in the region is 1,500 mm and about 70% of the precipitation occurs in the summer (December to March). The soils are predominantly classified as argosoil aluminic abruptic (IBGE, 2015).

Piracicaba and its adjacent regions are one of the pioneers in sugarcane production in the state of São Paulo, due to its secular cultivation with vast extensions of flat land, propitious for planting and mechanized harvesting (Instituto de Pesquisas e Planejamento de Piracicaba - IPPLAP, 2014). According to agricultural and livestock census data for the region held in 2013 sugarcane occupied an area of 60,000 ha (44% of the municipality area) (IBGE, 2015). Agriculture also shares its landscape with vast pasture areas in the rural zone (IPPLAP, 2014), occupying an area of 46,987 ha (34% of the municipality area) (Laboratório de Processamento de Imagens e Geoprocessamento - Lapig, 2017).

Survey of remnant forest cover was carried out in Piracicaba to visualize the existing forest fragments and the surrounding matrix in which they are inserted. According to Forest Inventory, the municipality of Piracicaba has only 23,681 ha of its native forest, which represents barely 17.2% of its total area (Nalon et al., 2020).

The distribution and location of forest fragments and their areas were verified using satellite images (Google Earth, version 9.135.0.2) and available aerial photographs. According to the most recurrent sizes of the observed remnants, two sizes classes were selected consisting of the following dimensions: Size class 1: 3 to 15 ha and Size class 2: 20 to 50 ha. For each size class, three fragments were selected from each of the largest existing interfaces, totalizing 18 forest fragments. The three chosen interfaces are frequently found in the state of São Paulo: ***i.*** sugarcane; ***ii.*** pasture; and ***iii.*** *Eucalyptus* (Figure 1). To reach these 18 selected fragments, 40 fragments were visited. Our selection included the following criteria: shape of the fragment closest to the circular; absence of riversides or larger water courses cutting the fragment (which would make it impossible to install the transect in the center); flat relief and easy access.

To verify the stability of the vegetation cover of the forest remnants, a historical analysis of aerial photographs and satellite images was carried out. The selected fragments were identified in the images of the different years, thus tracing their temporal evolution. Images from 1985 and 2017 were compared to check if the fragments already existed in 1985, therefore, having more than 30 years of existence.

To document floristic composition of the vegetation, three transects of 10 m wide by 50 m long were installed in each fragment, with two of them arranged perpendicularly to the edge (beginning from the edge to the center of the fragment). These transects were installed with a minimum distance of 100 m between each other. The third transect was laid down in the central region of the fragment as reference – assuming that it is less impacted. Each transect was divided into five subplots of 10 m long for a better control and analysis of the variables according to the distance from the edge.

The trunk circumference at breast height (CBH) of the trees with more than 15 cm of circumference was measured with a graduated tape. The floristic identification was achieved directly in the field. Depending on the difficulty in the identification, the plant material containing leaves, flowers and/or fruits were collected and brought to Herbarium ESA "Luiz de Queiroz" (belonging to the University of São Paulo) for further identification and cataloging. Each species was identified by its scientific name, popular name, successional group (Budowsky, 1965) and number of individuals according to the edge distance and in the center of the fragment. The classification of botanical families followed APG IV system (Angiosperm Phylogeny Group - APG, 2016) and the reference used to verify the names of the species was Brazilian Flora (Flora do Brasil, 2020).

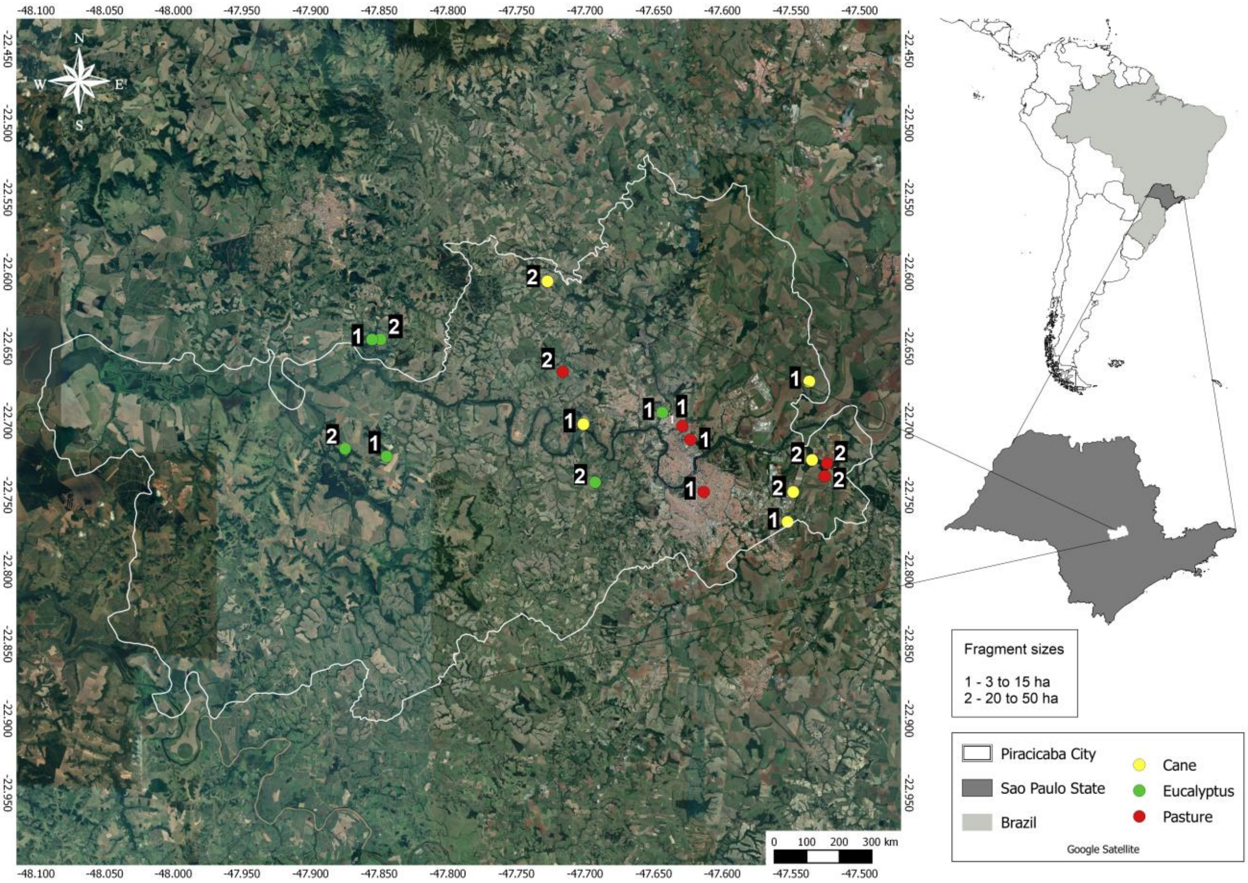

Figure 1. Study location pointing out the 18 selected fragments in Piracicaba-SP, Southeastern Brazil. Subtitle: yellow points = sugarcane interface; green points = eucalyptus interface; red points = pasture interface. Size classes: 1 = 3 to 15 ha; 2 = 20 to 50 ha. Source: Google Maps.

Figura 1. Local do estudo apontando os 18 fragmentos selecionados em Piracicaba-SP, Região Sudeste do Brasil. Legenda: pontos amarelos = interface cana; pontos verdes = interface de eucalipto; pontos vermelhos = interface de pastagem. Classes de tamanho: 1 = 3 a 15 ha; 2 = 20 a 50 ha. Fonte: Google Maps.

The software PAST (Hammer et al., 2001) was used for calculation of species diversity, such as richness (number of species), abundance (total number of individuals), dominance (Simpson index), frequency (%) and Shannon-Weaver index (Shannon and Weaver, 1949).

The design adopted in this experiment was a complete randomized design with a two factors distribution of the treatments (3 interfaces of the selected fragment with others land uses and two size classes) (Table 1). The null hypothesis tested for each factor and for the studied variables (Simpson and Shannon-Weaver indices) were that there are no differences among the treatments. Once the null hypothesis was rejected it was performed the multiple comparison Tukey test to compare the treatments for each factor tested through the analysis of variance (Zar, 1999). Before the analysis of variance be performed each of the variables was tested for heteroscedasticity and normality, using Box-Cox and Shapiro-Wilk tests respectively. If

Box-Cox test indicated any transformation, it was used and tested again for heteroscedasticity. In case of no transformation was necessary ANOVA was performed in the non-transformed data. Otherwise, the data were transformed before performing the ANOVA. In case of indication of new transformation, we used Kruskal-Wallis test in the non-transformed data. For normality, if the data was considered non normal by Shapiro-Wilk test and skewness value was between 2 and -2, ANOVA was performed because it is considered robust toward non normality (George and Mallery, 2010).

Table 1. Analysis of variance table and degree of freedom for the variables tested.

Tabela 1. Tabela da análise de variância e os respectivos graus de liberdade para as variáveis testadas.

Sources of variation	Degrees of freedom
Fragment interface (A)	2
Fragment size (B)	1
Interaction AxB	3
Error	11
Total (corrected)	17

3 RESULTS

The satellite image's analysis revealed that all the selected fragments were more than 30 years old - counted from the oldest local images available. Although it was not possible to provide further details on the local history of each of the analyzed fragments, this finding ensures the type of occupation. Given the trunk diameter of the trees found in the remnants, it was possible to infer that the forests found are even older. In the 54 evaluated transects (18 fragments x 3 transects each), 2,524 individuals were found. Of the total individuals, 93 (3.5%) were found dead in the field and 17 (0,67%) the identification was not possible. The 2414 identified individuals are distributed into 190 different identified species, belonging to 51 families. Only 11 species were identified at genus level and solely one was identified at family level. The complete species list is presented in Table 2. A high percentage of individuals of pioneer species were found (Figure 2), evidenced by the presence of numerous individuals of *Casearia sylvestris*, *Cecropia pachystachya*, *Croton floribundus*, *Moquiniastrum polymorphum* and *Piptadenia gonoacantha* – species typically found in areas at initial succession stages. This pattern of abundance of pioneer species was observed independently of the surrounding matrix and fragment size.

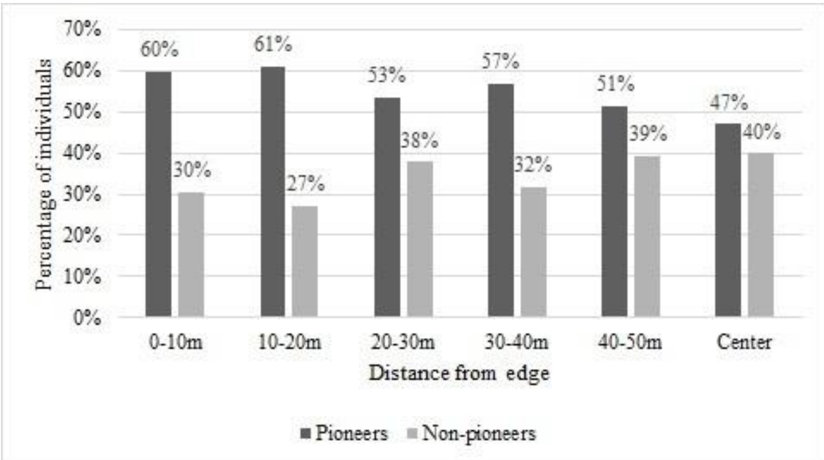

Figure 2. Percentage of individuals of pioneer and non-pioneer species according to the edge distance and in the core of the fragments for both evaluated size classes (3-15 ha and 20-50 ha). No distinction has been made here between the different surrounding agricultural matrixes.

Figura 2. Porcentagem de indivíduos das espécies pioneiras e não pioneiras de acordo com a distância da borda e no centro dos fragmentos para ambas as classes de tamanho avaliadas (3-15 ha e 20-50 ha). Nenhuma distinção foi feita aqui entre as diferentes matrizes agrícolas circundantes.

Table 2. Table of species found in 18 studied fragments divided into: family, scientific name, popular name, origin, SG (successional group – P: pioneers; NP: non-pioneers), occurrence (C: sugarcane; P: pasture; E: eucalyptus), frequency, number of individuals according to edge distance and in the center of fragments. The species are ordered by families and genera.

Tabela 2. Tabela das espécies encontradas nos 18 fragmentos estudados separadas em: família, nome científico, nome popular, origem, SG (grupo sucessional - P: pioneiros; NP: não pioneiros), ocorrência (C: cana-de-açúcar; P: pasto; E: eucalipto), frequência, número de indivíduos de acordo com a distância da borda e no centro dos fragmentos. As espécies estão ordenadas pelas famílias e gêneros.

						Number of individuals						
Family / Scientific name	Popular name	Origin	SG	Occurrence	Freq.	0-10m	10-20m	20-30m	30-40m	40-50m	Center	Total
ANACARDIACEAE												
Astronium graveolens Jacq.	Guaritá	Native	NP	C, P, E	9.3%	3	3	6	5	3	5	25
Lithraea molleoides (Vell.) Engl.	Bugreiro	Native	NP	C	5.6%	4		4			1	9
Mangifera indica L.	Mangueira	Exotic		C, P, E	7.4%		2		1		1	4
Schinus terebinthifolia Raddi	Aroeira pimenteira	Native	P	C, E	9.3%		5	1		2	2	10
Tapirira guianensis Aubl.	Peito-de-pomba	Native	P	C, P, E	14.8%	5	4	3	3	1	1	17
ANNONACEAE												
Annona cacans Warm.	Araticum-da-mata	Native	NP	E	1.9%					1	2	3
Annona sylvatica A.St.-Hill.	Araticum	Native	P	P, E	5.6%						20	20
Guatteria australis A.St.-Hil.	Cortiça	Native	NP	C	1.9%						2	2
APOCYNACEAE												
Aspidosperma polyneuron Müll.Arg.	Peroba-rosa	Native	NP	C, E	7.4%	1	3			1	1	6
Aspidosperma tomentosum Mart. & Zucc.	Peroba-do-campo	Native	NP	C, P	1.9%		1					1
Tabernaemontana hystrix Steud.	Leiteiro	Native	P	C, P, E	16.7%	8	9	2		3	8	30
ARALIACEAE												
Dendropanax cuneatus DC. Decne. & Planch.	Maria-mole	Native	P	E	7.4%		1	1	1	5	5	13
Schefflera calva (Cham.) Frodin & Fiaschi	Mandioqueiro	Native	P	C	1.9%						1	1

to be continued

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continuation – Table 2
continuação – Tabela 2

Family / Scientific name	Popular name	Origin	SG	Occurrence	Freq.	Number of individuals					Center	Total
						0-10m	10-20m	20-30m	30-40m	40-50m		
ARECACEAE												
Euterpe edulis Mart.	Juçara	Native	P	E	3.7%		3	5	1	2	4	15
Syagrus oleracea (Mart.) Becc.	Gueirova	Native	NP	E	1.9%						1	1
ASTERACEAE												
Baccharis dracunculifolia DC.	Alecrim do campo	Native	P	C	1.9%	1						1
Moquiniastrum polymorphum (Less.) G. Sancho	Cambará	Native	P	C, P, E	27.8%	36	28	31	38	31	24	188
Piptocarpha sp.		Native	P	E	1.9%			1				1
Vernonanthura polyanthes Sprengel		Native	P	C	1.9%		1					1
Jacaranda micrantha Cham.	Carobão	Native	P	E	1.9%				3			3
Tabebuia roseoalba (Ridl.) Sandwith	Ipê-branco	Native	NP	P, E	3.7%	1					1	2
Tecoma stans L.	Ipê de jardim	Native	P	P, E	18.5%	11	10	4	3		7	35
Zeyheria tuberculosa Vell.	Ipê-felpudo	Native	NP	P	1.9%						2	2
BORAGINACEAE												
Cordia americana L.	Guajuvira	Native	P	P	1.9%				1			1
Cordia sellowiana Cham.	Chá de bugre	Native	P	C	1.9%			1				1
Cordia superba Cham.	Babosa branca	Native	P	P	1.9%						1	1
BURSERACEAE												
Protium heptaphyllum (Aubl.) Marchand	Almecega	Native	NP	C, E	13.0%	3	14	5	12	6	31	71
CACTACEAE												
Cereus jamacaru DC.	Mandacaru	Native	P	E	1.9%		1					1
CALOPHYLLACEAE												
Calophyllum brasiliense Cambess.	Guanandi	Native	NP	E	3.7%	1	2	5		1	4	13

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continuação – Tabela 2

Family / Scientific name	Popular name	Origin	SG	Occurrence	Freq.	Number of individuals					Center	Total
						0-10m	10-20m	20-30m	30-40m	40-50m		
CANNABACEAE												
Celtis fluminensis Carauta	Esporão de galo	Native	P	C, E	3.7%	1	1		1		1	4
Trema micrantha L.	Crindiúva	Native	P	C, P, E	16.7%	2	1	3	1	2	4	13
CARDIOPTERIDACEAE												
Citronella paniculata (Mart.) R.A.Howard	Pau de corvo	Native	NP	E	1.9%			1				1
CARICACEAE												
Carica papaya L.	Mamão	Exotic	P	C, P	5.6%		1	3	1			5
Jacaratia spinosa (Aubl.) A.DC.	Jaracatiá	Native	P	P	1.9%		2					2
CELASTRACEAE												
Maytenus sp.		Native	NP	E	1.9%						1	1
CLETHEACEAE												
Clethra scabra Pers.	Carne de vaca	Native	P	P	1.9%				2			2
COMBRETACEAE												
Terminalia glabrescens Mart.	Cerneamarelo	Native	P	E	3.7%	1		1				2
Terminalia sp.		Native		E	1.9%	1						1
DILLENIACEAE												
Dillenia indica (L.)	Maçã de elefante	Exotic		P	1.9%						1	1
EUPHORBIACEAE												
Actinostemon concepcionis (Chodat & Hassl.) Hochr.	Folha-fedorenta	Native	NP	E	3.7%	1		1			7	9
Alchornea glandulosa Poepp. & Endl.	Tapiá	Native	P	C, P, E	14.8%	5	5	2	2	1	13	28
Alchornea triplinervia (Spreng.) Müll.Arg.	Tapiá vermelho	Native	NP	C, P	3.7%	1			1		1	3
Aleurites moluccanus (L.) Willd.	Nóz-da-índia	Exotic		E	1.9%				2			2

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Family / Scientific name	Popular name	Origin	SG	Occurrence	Freq.	Number of individuals					Center	Total
						0-10m	10-20m	20-30m	30-40m	40-50m		
Croton floribundus Spreng.	Capixingui	Native	P	C, P, E	18.5%	16	23	21	2	7	19	88
Croton piptocalyx Müll.Arg.	Caixeta	Native	P	E	1.9%				3	4	5	12
Croton urucurana Baill.	Sangra d'água	Native	P	E	3.7%	2		1				3
Gymnanthes klotzschiana Müll.Arg.	Branquinho	Native	NP	E	1.9%				1			1
Mabea fistulifera Mart.	Mamoneira	Native	P	E	1.9%		1					1
Sebastiania brasiliensis Spreng.	Branquilho	Native	NP	P, E	1.9%				1		3	4
FABACEAE												
Acacia mangium Willd.	Acácia australiana	Exotic		E	1.9%		2	3	1			6
Albizia niopoides (Spruce ex Benth.) Burkart	Farinha-seca	Native	P	P	1.9%			1	1			2
Anadenanthera colubrina (Vell.) Brenan	Angico branco	Native	P	C, P, E	7.4%	1			1		7	9
Andira fraxinifolia Benth.	Angelim-doce	Native	P	E	1.9%						3	3
Bauhinia forficata Link	Pata de vaca	Native	P	C, P, E	13.0%	24	6	10	14	6	8	68
Bauhinia longifolia (Bong.) Steud.	Unha de vaca	Native	P	C, E	3.7%			1			3	4
Calliandra foliolosa (Benth.)	Esponginha	Native	P	C, E	5.6%	3	1		1	1	9	15
Centrolobium tomentosum (Guillem. ex Benth.)	Araribá	Native	NP	C, P, E	13.0%	7	6	5		8	10	36
Copaifera langsdorffii Desf.	Copaíba	Native	NP	P, E	7.4%	1		1	1		1	4
Dalbergia frutescens (Vell.) Britton	Rabo de bugio	Native	NP	P, E	9.3%	1		1	1		25	28
Dalbergia nigra (Vell.) Allemão ex Benth.	Jacarandá da Bahia	Exotic	NP	C	1.9%					2		2
Dalbergia sp.		Native		E	1.9%	1				1	1	3
Enterolobium contortisiliquum (Vell.) Morong	Tamboril	Native	P	C, P, E	5.6%	2					2	4
Holocalyx balansae Micheli	Alecrim	Native	NP	C, P	3.7%	1				1	2	4

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Family / Scientific name	Popular name	Origin	SG	Occurrence	Freq.	Number of individuals						
						0-10m	10-20m	20-30m	30-40m	40-50m	Center	Total
Inga laurina (Sw.) Willd.	Ingá-branco	Native	NP	P	1.9%						1	1
Inga marginata Willd.	Ingá-feijão	Native	P	P	3.7%	2	1	1			1	5
Inga striata Benth.	Ingá	Native	NP	C	1.9%	1					1	2
Inga vera Willd.	Ingá do brejo	Native	P	E	13.0%	2	4	4	5		1	16
Lonchocarpus cultratus (Vell.) A.M.G.Azevedo & H.C.Lima	Embira de sapo	Native	NP	C, E	14.8%	2	1	7	3	5	5	23
Machaerium amplum Benth.		Native	P	C, P	5.6%	9	6	15	10	4		44
Machaerium hirtum (Vell.) Stellfeld	Jacarandá de espinho	Native	NP	C, P, E	29.6%	9	1	5	2	4	5	26
Machaerium nyctitans (Vell.) Benth.	Jacarandá bico de pato	Native	P	P, E	7.4%						6	6
Machaerium stipitatum Vogel	Sapuva	Native	NP	C, P, E	11.1%	2		3	2	1	6	14
Machaerium villosum Vogel	Jacarandá paulista	Native	NP	C	1.9%						1	1
Parapiptadenia rigida (Benth.) Brenan	Angico gurucaia	Native	P	P, E	9.3%		2		3	4	10	19
Peltophorum dubium (Spreng.) Taub.	Canafístula	Native	NP	E	1.9%	1						1
Piptadenia gonoacantha (Mart.) J.F.Macbr.	Pau jacaré	Native	NP	C, P, E	37.0%	4	8	12	9	7	19	59
Platypodium elegans Vogel	Jacarandá	Native	P	C, P, E	9.3%	4	5	5	4	5		23
Pterocarpus rohrii Vahl.	Sangueiro	Native	NP	P, E	3.7%			2				2
Schizolobium parahyba (Vell.) Blake	Guapuruvu	Native	P	C, P, E	14.8%	4	1				4	9
Senegalia polyphylla (DC.) Britton & Rose	Angico branco	Native	P	C, P, E	13.0%	2		2	1	2	3	10
Sweetia fruticosa Spreng.	Sucupirana	Native	NP	C	1.9%						1	1
LACISTEMATACEAE												
Lacistema hasslerianum Chodat	Baga de jaboti	Native	NP	E	1.9%	2		2				4

to be continued
continua

continuation – Table 2
continuação – Tabela 2

Family / Scientific name	Popular name	Origin	SG	Occurrence	Freq.	Number of individuals					Center	Total
						0-10m	10-20m	20-30m	30-40m	40-50m		
LAMIACEAE												
Aegiphila integrifolia (Jacq.) Moldenke	Tamanqueira	Native	P	P	1.9%		2					2
Callicarpa reevesii L.	Calicarpa	Exotic	P	E	1.9%	1	1					2
LAURACEAE												
Nectandra grandiflora Nees & Mart	Canela sebo	Native	NP	C	3.7%		2				1	3
Nectandra megapotamica (Spreng.) Mez	Canelinha	Native	NP	C, P, E	18.5%	2			1	1	14	18
Nectandra oppositifolia Nees & Mart.	Canela amarela	Native	NP	E	1.9%			1				1
Nectandra sp.		Native		E	1.9%	2						2
Ocotea diospyrifolia (Meisn.) Mez	Caneleira	Native	NP	C, P	5.6%					2	2	4
Ocotea lanata (Nees & Mart.)	Canela lanosa	Native	NP	C	1.9%				1			1
Ocotea puberula Rich.	Canela guaicá	Native	NP	P	1.9%		1		1			2
Ocotea sp.		Native	P	E	1.9%				1			1
LECYTHIDACEAE												
Cariniana estrellensis (Raddi) Kuntze	Jequitibá branco	Native	NP	P, E	3.7%				1		1	2
Cariniana legalis (Mart.) Kuntze	Jequitibá vermelho	Native	NP	C	1.9%			4				4
LYTHRACEAE												
Lafoensia pacari A.St.-Hil.	Mangava-brava	Native	NP	E	1.9%	1						1
MAGNOLIACEAE												
Magnolia ovata (A.St.-Hil.) Spreng.	Pinha do brejo	Native	NP	E	1.9%				2			2
MALVACEAE												
Bastardiopsis densiflora (Hook. & Arn.) Hassl.	Louro-branco	Native	P	C, P, E	5.6%				5		1	6
Ceiba speciosa (A.St.-Hil.) Ravenna	Paineira	Native	NP	C, P	5.6%	1					2	3
Guazuma ulmifolia Lam.	Araticum bravo	Native	P	P	14.8%	2	4	3	5	2	23	39

to be continued
continua

continuation – Table 2
continuação – Tabela 2

Family / Scientific name	Popular name	Origin	SG	Occurrence	Freq.	Number of individuals						
						0-10m	10-20m	20-30m	30-40m	40-50m	Center	Total
Helicteres brevispira A.St.-Hil.	Rosquinha	Native	NP	P	1.9%				1			1
Heliocarpus popayanensis Kunth	Pau jangada	Native	P	E	1.9%		1					1
Luehea candicans Mart.	Açoita cavalo	Native	NP	C, P	16.7%	3	2	1	2	2	8	18
Luehea divaricata Mart.	Açoita cavalo	Native	NP	C, P, E	14.8%	1		2	5	4	1	13
Luehea paniculata Mart.	Açoita cavalo	Native	P	E	1.9%		1					1
Pterygota brasiliensis Allemão	Pau rei	Native	P	P, E	3.7%		1				1	2
MELASTOMATACEAE												
Miconia cinnamomifolia (DC.) Naudin	Jacatirão açu	Native	P	P	1.9%					1	6	7
Miconia nervosa (Sm.) Triana	Quaresma da mata	Native	NP	P	1.9%						1	1
MELIACEAE												
Cabralea canjerana (Vell.) Mart.	Canjarana	Native	NP	E	1.9%						1	1
Cedrela fissilis Vell.	Cedro	Native	NP	C, E	11.1%	2		3		3	6	14
Guarea guidonia (L.) Sleumer	Cedro branco	Native	NP	C, P, E	5.6%	1		1			1	3
Guarea kunthiana A.Juss.	Canjambo	Native	NP	C, E	7.4%		1	1		4	2	8
Guarea macrophylla Vahl	Catiguá morcego	Native	NP	C, P, E	16.7%		5	2	2	3	6	18
Trichilia casaretti C. DC.	Catiguá	Native	NP	E	1.9%						5	5
Trichilia catigua A.Juss.	Catiguá	Native	NP	C, P, E	9.3%		1	1			9	11
Trichilia clausseni C.DC.	Catiguá vermelho	Native	NP	C, P, E	13.0%		2	2	1		4	9
Trichilia elegans A.Juss.	Catiguazinho	Native	NP	P, E	9.3%		3	6	3	2	1	15
Trichilia pallida Sw.	Baga de morcego	Native	NP	C, P, E	16.7%		1	2	3	3	10	19
MONIMIACEAE												
Mollinedia schottiana (Spreng.) Perkins	Capixim	Native	NP	E	1.9%				1			1

to be continued
continua

continuation – Table 2
continuação – Tabela 2

Family / Scientific name	Popular name	Origin	SG	Occurrence	Freq.	Number of individuals					Center	Total
						0-10m	10-20m	20-30m	30-40m	40-50m		
Mollinedia widgrenii A.DC.		Native	NP	P	1.9%			1				1
MORACEAE												
Ficus eximia Schott	Figueira	Native	NP	C	1.9%						1	1
Ficus guaranitica Chodat	Figueira branca	Native	NP	C, E	3.7%	3					1	4
Ficus sp.	Figueira	Native		E	1.9%				1			1
Maclura tinctoria (L.) D.Don ex Steud.	Amora brava	Native	P	E	1.9%		1					1
MYRTACEAE												
Campomanesia xanthocarpa (Mart.) O.Berg	Guabiroba	Native	NP	P, E	3.7%					1	1	2
Eucalyptus sp.		Exotic	P	C, P, E	14.8%	11	8	5	6	4	26	60
Eugenia brasiliensis Lam.	Grumixama	Native	NP	C, E	1.9%	4						4
Eugenia florida DC.	Guamirim	Native	NP	C, P, E	16.7%	4		1		1	7	13
Eugenia francavilleana O.Berg.		Native	NP	C, P	3.7%	4	7	14	2			27
Eugenia paracatuana O.Berg.		Native	NP	C, E	3.7%				1		5	6
Eugenia uniflora L.	Pitanga	Native	NP	P, E	7.4%					1	4	5
Eugenia sp.		Native		C, P, E	5.6%	1			11	1	15	28
Myrcia hebepetala DC.		Native	NP	E	1.9%						4	4
Myrcia multiflora (Lam.) DC.	Cambuí	Native	NP	C	1.9%						1	1
Myrcia neolucida A.R.Lourenço & E.Lucas	Guamirim	Native	NP	P	1.9%						1	1
Myrcia splendes (Sw.) DC.	Guamirim miúdo	Native	NP	E	1.9%	1						1
Myrcianthes pungens (O.Berg) D.Legrand	Guabiju	Native	NP	E	1.9%						1	1

to be continued
continua

continuation – Table 2
continuação – Tabela 2

Family / Scientific name	Popular name	Origin	SG	Occurrence	Freq.	Number of individuals						
						0-10m	10-20m	20-30m	30-40m	40-50m	Center	Total
Myrciaria floribunda (H.West ex Willd.) O.Berg	Jabuticabinha	Native	NP	E	1.9%						1	1
Plinia peruviana (Poir.) Govaerts	Jabuticabeira	Native	NP	P	1.9%				1	1		2
Psidium guajava L.	Goiaba	Native	P	C, P, E	25.9%	21	20	18	23	10	23	115
Syzygium cumini L.	Jambolão	Exotic	P	P, E	9.3%	4	9	2		1	1	17
NYCTAGINACEAE												
Guapira opposita (Vell.) Reitz	Flor de pérola	Native	NP	P	1.9%					1		1
PERACEAE												
Pera glabrata (Schott) Baill.	Sete cascos	Native	NP	E	11.1%	3		2	2		3	10
PHYTOLACCACEAE												
Gallesia integrifolia (Spreng.) Harms	Pau d'alho	Native	P	P	1.9%				1			1
Seguieria americana L.	Limoeiro do mato	Native	NP	E	1.9%						1	1
PINACEAE												
Pinus sp.		Exotic		C, P	14.8%	20	16	14	8	12	41	111
PIPERACEAE												
Piper arboreum Aubl.	Pimenta de macaco	Native	NP	C, P, E	14.8%			3	1		19	23
POLYGONACEAE												
Coccoloba glaziovii Lindau	Acaçuba	Native	NP	E	1.9%						1	1
Triplaris americana L.	Pau formiga	Native	NP	P	1.9%						1	1
PRIMULACEAE												
Geissanthus ambiguus (Mart.) G.Agostini	Capororoquinha	Native	NP	C	1.9%						5	5
Myrsine coriacea (Sw.) R.Br. ex Roem. & Schult.	Capororoca	Native	P	C, P	9.3%				1	1	15	17

to be continued
continua

continuation – Table 2
continuação – Tabela 2

Family / Scientific name	Popular name	Origin	SG	Occurrence	Freq.	Number of individuals					Center	Total
						0-10m	10-20m	20-30m	30-40m	40-50m		
Myrsine gardneriana A.DC.	Capororoca	Native	NP	E	1.9%	1						1
Myrsine umbellata Mart.	Capororoca-branca	Native	NP	E	1.9%				1	1		2
RHAMNACEAE												
Colubrina glandulosa Perkins	Sobrasil	Native	NP	E	1.9%	1		1			1	3
Hovenia dulcis Thunb.	Uva do japão	Exotic		C, P	1.9%						3	3
Rhamnidium elaeocarpum Reissek	Saguaraji	Native	NP	C, P, E	7.4%		1			2	1	4
ROSACEAE												
Prunus myrtifolia (L.) Urb.	Pessegueiro bravo	Native	NP	P	1.9%						1	1
RUBIACEAE												
Genipa americana L.	Jenipapo	Native	P	E	1.9%	1						1
Randia armata (Sw.) DC.	Limão bravo	Native	NP	P	1.9%		1					1
RUTACEAE												
Balfourodendron riedelianum (Engl.) Engl.	Pau-marfim	Native	NP	P, E	3.7%	1				2	3	6
Citrus sp.	limão	Exotic		E	1.9%	1						1
Dictyoloma vandellianum A.Juss.	Tingui	Native	P	P	1.9%	1						1
Esenbeckia febrifuga (A.St.-Hil.) A. Juss. ex Mart.	Mamoninha do mato	Native	NP	C, E	3.7%		1			1		2
Esenbeckia leiocarpa Engl.	Guarantã	Native	NP	C, P	3.7%	6	6	1		3	1	17
Galipea jasminiflora (A.St.-Hil.) Engl.	Grumixara	Native	NP	E	19%			2	1	1		4
Metrodorea nigra A.St.-Hil.	Chupa ferro	Native	NP	E	5.6%				2	2	13	17
Zanthoxylum caribeum Lam.	Mamiqueira fedorenta	Native	NP	E	3.7%	1		1			1	3
Zanthoxylum rhoifolium Lam.	Mamica de cadela	Native	P	C, P, E	20.4%	1		1	5	3	9	19

to be continued
continua

continuation – Table 2
continuação – Tabela 2

Family / Scientific name	Popular name	Origin	SG	Occurrence	Freq.	Number of individuals 0-10m	10-20m	20-30m	30-40m	40-50m	Center	Total
Zanthoxylum riedelianum Engl.	Mamica de porca	Native	NP	P	3.7%	1	2					3
SALICACEAE												
Casearia gossypiosperma Briq.	Pau de espeto	Native	P	C, P, E	18.5%	13	10	12	15	7	35	92
Casearia sylvestris Sw.	Guaçatonga	Native	P	C, P, E	20.4%	20	36	30	27	18	55	186
Xylosma pseudosalzmanii Sleumer	Sucará	Native	NP	C	1.9%						1	1
SAPINDACEAE												
Allophylus edulis (A.St.-Hil. et al.) Hieron. ex Niederl.	Chalchal	Native	P	C, P, E	11.1%	1	1	1	1		12	16
Cupania vernalis Cambess.	Arco de peneira	Native	NP	P, E	3.7%	1					3	4
Dilodendron bipinnatum Radlk.	Maria-pobre	Native	P	C, P	3.7%	1	4		1	3	11	20
Matayba guianensis Aubl.	Camboatá	Native	P	E	1.9%					1		1
SAPOTACEAE												
Chrysophyllum gonocarpum (Mart. & Eichler ex Miq.) Engl.	Caxeta amarela	Native	NP	C, P, E	9.3%	3	2	1	3	2	5	16
SIPARUNACEAE												
Siparuna guianensis Aubl.	Catingad'anta	Native	NP	E	5.6%			2		1	15	18
SOLANACEAE												
Cestrum schlechtendalii G.Don.		Native		E	1.9%	1	3					4
Solanum argenteum Dunal	Cambará de cheiro	Native	P	C, P	7.4%					1	5	6
Solanum granulosoleprosum Dunal	Gravitinga	Native	P	C, E	3.7%		3			1		4
Solanum mauritianum (Scop.)	Fona de porco	Native	NP	P, E	3.7%		1	1	1			3
URTICACEAE												
Boehmeria caudata Sw.	Urtiga-mansa	Native	P	P	1.9%						3	3

to be continued
continua

continuation – Table 2

continuação – Tabela 2

Family / Scientific name	Popular name	Origin	SG	Occurrence	Freq.	Number of individuals					Center	Total
						0-10m	10-20m	20-30m	30-40m	40-50m		
Cecropia hololeuca Miq.	Embaúba vermelha	Native	P	C	1.9%						2	2
Cecropia pachystachya Trécul	Embaúba branca	Native	P	C, P, E	18.5%	15	5	7	6	2	16	51
Urera baccifera (L.) Gaudich. ex Wedd.	Urtigão	Native	NP	C, P	7.4%	1			1	3		5
VERBENACEAE												
Aloysia virgata (Ruiz & Pav.) Juss.	Lixeira	Native	P	C, P, E	9.3%	7	3	2	1	1	3	17
Citharexylum myrianthum Cham.	Pau viola	Native	P	P, E	5.6%	7	3	6	4	3	8	31
VOCHYSIACEAE												
Vochysia tucanorum Mart.	Pau-de-tucano	Native	P	E	1.9%						1	1
Dead				C, P, E		9	17	11	11	7	38	93
Unidentified				C	3.7%	2	2				13	17
				Total n. Individuals		378	357	351	322	252	864	2524
				Total n. Species		85	73	76	82	73	126	190

Even in the center of the fragments, almost half of the individuals belonged to pioneer species. The only exception occurred in the class 2 fragments (20-50 ha) with *Eucalyptus* interface. In this case, the center of the fragment was formed in its majority (73%) by individuals of non-pioneer species.

Also, the bordering zone of the fragments with *Eucalyptus* interface presented a greater richness (110 species), followed by the pasture interface (80 species) and, lastly, sugarcane interface (63 species). The average number of species per transect is shown in Figure 3.

By analyzing abundance values in Table 3, it is possible to perceive that the number of individuals has increased considerably from the smaller fragments to the larger ones with sugarcane interface. In this case, the increase was of 169 individuals. In the pasture interface, the difference was of 66 individuals and in the *Eucalyptus* edge the difference was of only 10 individuals. Of the results presented in the table, the higher Richness and Shannon index, as well as the smaller dominance, were found in the larger fragments next to *Eucalyptus* plantations. These data suggest that such fragments have a greater floristic diversity compared to those surrounded by sugarcane and pasture.

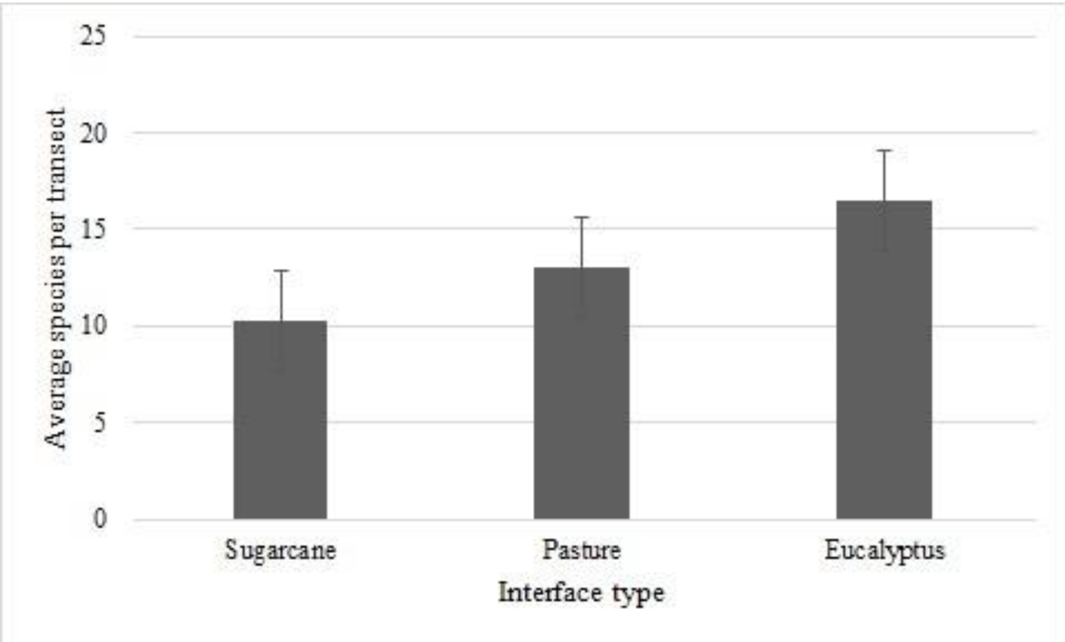

Figure 3. Average species in the edge transects related to each evaluated surrounding matrix – *Eucalyptus* spp., Pasture and Sugarcane.

Figura 3. Média de espécies encontradas nas transecções da borda relacionadas a cada matriz de entorno avaliada - *Eucalyptus* spp., Pasto e Cana-de-açúcar.

The statistical analysis revealed that the type of matrix surrounding the fragments affected very significantly species diversity (given by the indexes of Shannon-Weaver – F value=5.94 and Pr>F = 0.0032 and Simpson – F value = 6.62 and Pr>F=0.0111). It has also demonstrated a significant effect in the interaction for the variables matrix x fragment size for the Simpson Index (F value = 4.84 and Pr>F = 0.0090). According to the Tukey test performed *Eucalyptus* and pasture interface were related besides sugarcane interface were completely different. The statistical analysis did not indicate significant differences for biodiversity indexes between fragment sizes (class 1 or 2) – F value = 2.31 and Pr > F = 0.1300 for Shannon Index and F value = 0.47 and Pr > F = 0.4957 for Simpson Index.

The set of fragments with sugarcane interface presented a predominance of two pioneer species in the bordering zone: *Moquiniastrum polymorphum* - and *Psidium guajava*, represented by 170 ind.ha^{-1} and 110 ind.ha^{-1}, respectively.

The most representative species in the fragments with pasture interface were: *Casearia sylvestris*, *Pinus* spp. and *Bauhinia forficata*, with densities of 128 ind.ha^{-1}, 111 ind.ha^{-1} e 81 ind.ha^{-1}, respectively. These three species together account for 35% of the total individuals sampled.

Table 3. Richness, number of individuals, dominance and Shannon index by fragment size class (3-15 ha and 20-50 ha) and interface of the edge sampled with the surrounded matrix (sugarcane, pasture and *Eucalyptus*).

Tabela 3. Riqueza, número de indivíduos, dominância e índice de Shannon por classe de tamanho do fragmento (3-15 ha e 20-50 ha) e interface da borda amostrada com a matriz circundada (cana-de-açúcar, pasto e eucalipto).

	CLASS 1 (3 to 15 ha)			**CLASS 2 (20 to 50 ha)**		
Interface	**Sugarcane**	**Pasture**	**Eucalyptus**	**Sugarcane**	**Pasture**	**Eucalyptus**
Richness	45	52	61	38	46	78
Nº individuals	192	241	276	361	307	286
Dominance	0.1562	0.0705	0.04729	0.0805	0.1224	0.04387
Shannon	2.145	2.103	2.404	1.904	1.986	2.435

The interface with *Eucalyptus* presents *Moquiniastrum polymorphum* (100 ind.ha^{-1}) and *Protium heptaphyllum* (65 ind.ha^{-1}) as more representative species, totalizing 17% of the sampled individuals.

4 DISCUSSION

By analyzing species composition, we can verify a high abundance of exotic species such as *Pinus* spp. and *Eucalyptus* spp., which were mainly distributed in the first range of the edge (0-10 m), although some individuals were also found in the center of the fragments. High incidence of *Eucalyptus* may be due to invasion coming from different plantations surrounding the fragments. Even though the genus is exotic in Brazil, this forest culture has not been pointed as invasive and aggressive to native vegetation and, in fact, it has been used to recover degraded areas (Feyera et al., 2002; Sartori et al., 2002; Gabriel et al., 2013; Calegario et al., 1993), allowing natural regeneration to develop in different successional stages (Onofre et al., 2010; Sartori et al., 2002). Species of *Eucalyptus* planted with native species, indeed, has been an alternative even in forest restoration projects and can become important allies (Brancalion et al., 2019). Silva Jr. et al. (1995) indicated in his study that a *Eucalyptus grandis* plantation can provide the necessary shade for the regeneration of natural species and can be an effective way for promoting natural regeneration and recovery of tropical forests.

In contrast, species of *Pinus* are highly aggressive and are currently considered a serious issue in the southern hemisphere, since native ecosystems are undergoing biological invasion promoted by species of this genus (Bourscheid and Reis, 2010). These taxa have characteristics that potentiate them as invasive in diverse environments (Zanchetta and Pinheiro, 2007), mainly due to their capacity of adaptation even in adverse environments for the development of conifers (Richardson and Bond, 1991). According to Ricklefs (1996), populations of *Pinus* can cause an inhibiting effect on initial species of succession after disturbance. This effect decreases the resilience of the environment and hampers the restoration process (Gaem-Barbosa et al., 2017).

In the fragments with pasture interface, the high incidence of *Pinus* can be explained by the fact that two of the six fragments with pasture interface are part of the Experimental Station of Tupi, in which reforestations using *Pinus* and *Eucalyptus* were conducted in close areas of the fragments in the 1980s. Although many of these trees were later cut down, some of them dispersed quickly and remain spread in natural areas. According to Padmanaba and Corlett (2014), plantations of *Pinus*, when cultivated around forest fragments, can invade a large portion of the edge and compete aggressively with the native species.

From the period starting when the sampled trees were mapped and plated until their identification (10 months), a great quantity of dead standing trees were found (the fallen ones were not counted). These should be accounted because they were identified alive in the beginning of our study and showed to be dead in subsequent floristic identification. In addition, some trees were found with part of their trunk carbonized, probably as a result of frequent fires in surrounding areas of sugarcane. Considering this was a common practice in sugarcane harvesting in the studied region, mainly used to eliminate leaves and other undesirable materials, it could be hypothesized – and most likely to have occurred – that fire got out of control and entered forest fragments – no records on this was available.

The highest density of initial species of succession in most transects, mainly up to the first 20 meters from the edge, is an indicative of disturbance to which the forest is subjected and clearly results in a high degree of degradation of the remnants. Such situation was also evidenced by Silva et al. (2016) in a study at the same region. In this scenario, Nascimento et al. (1998) argued that the massive presence of early-successional species is usually associated to recent anthropic disturbances, which makes sense given the history of agricultural occupation of the areas around Piracicaba.

An example of the highest density of pioneers was the two pioneer species found in the bordering zone of fragments with sugarcane interface: *Moquiniastrum polymorphum* and *Psidium guajava*. These two species with high representativeness account for almost one-third (30.3%) of the total individuals sampled. In one of the transects, that had a completely opened edge with *Brachiaria* invasion up to 30 meters within the fragment, *Moquiniastrum polymorphum* represented 78.6% of the total individuals. Gaem-Barbosa (2017) also found a predominance of this species in a fragment of SSF in the municipality of Salto de Pirapora, SP, Brazil. The exotic species *Psidium guajava*, although native of Mexico (Soubihe Sobrinho and Gurgel, 1962; Cappelatti and Schmitt, 2009), is considered naturalized in Brazil according to Sobral et al. (2015), due to its sub-spontaneous distribution, being dispersed easily in seasonal forests. Zviejkovski et al. (2009) also found high density of *Psidium guajava* in a SSF after anthropic disturbance. According to Zanchetta and Diniz (2006), exotic species can cause changes in the physiognomy of native vegetation, leading to an acceleration in biodiversity loss.

In contrast, in *Eucalyptus* sp. interface, there was not a high predominance of some species, if compared to the interfaces of sugarcane and pasture. This shows that there is no predominance of few species, but a greater richness. Also, some non-pioneer species were found with high frequency, evidenced by the presence of *Calophyllum brasiliense*, indicated for recovery of waterlogged environments (Lorenzi, 1992); *Euterpe edulis*, a climax species used as a strategy of a seedling-bank regeneration (Fantini et al., 2000); *Metrodorea nigra* and *Pera glabrata*, recommended for restoration (Reis-Duarte, 2004); and *Siparuna guianensis*.

In most of the analyzed fragments, almost half of the species in the center were pioneers. The only exception occurred in the class 2 fragments (20-50 ha) with *Eucalyptus* interface. In such cases, the center of the fragment was formed in majority (73%) by non-pioneer species. *Eucalyptus* species are frequently used to cover the edge of natural fragments, creating a forest environment by increasing exponentially the vegetation area, and reducing the negative effects from the edge (Bernardes et al., 2009).

The low diversity and high dominance in the fragments with sugarcane may be a result of the traditional use of fire in this culture, which has an impact on local flora. In the study of Melo et al. (2007), the occurrence of fire was a determining factor for the loss of floristic richness in the edge community of a SSF. Even small fire outbreaks that occur at the edges can significantly alter the fragment dynamic (Vettorazzi and Ferraz, 1998).

Our species diversity results (Table 2) shows that the center of the fragments, even smaller ones, is the most preserved part of the forest, presenting greater species diversity. As a comparison, other studies conducted in SSF fragments found Shannon index values of 3.41 (Sobrinho et al., 2009), 3.31 (Pinto el al., 2007), and 3.48 (Arruda and Daniel, 2007). According to Meira-Neto and Martins (2000), the Shannon index for this forestry formation vary from 3.2 up to 4.2.

5 CONCLUSIONS

Clear indications of edge effect were found in the three studied interfaces, evidenced by the high incidence of pioneer species along most of the transects, sometimes even in the fragments center. However, a better situation in the fragments surrounded by *Eucalyptus* was found, where species diversity and richness showed to be higher and dominance smaller, in addition to a comparatively low predominance of pioneer species, indicating a more advanced stage of succession in such fragments. This study evidence that it is possible to manage the forest - agriculture interface expanding the preservation concept. As observed here, tree-barriers can increase bordering zone protection in forests remnants, helping to preserve its integrity. In this way, it is possible to think that the formation of a *continuum* of forest structure, even if formed by exotic species such as *Eucalyptus* monocrop plantations and/or agroforestry systems, can significantly reduce the impacts of forest fragmentation. In this way we may extend ecosystem conservation.

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