Article

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Seed bank analysis and species similarity in the Air Force Base of Pirassununga (São Paulo State, Brazil)

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ABSTRACT – (Seed bank analysis and species similarity in the Air Force Base of Pirassununga (São Paulo State, Brazil)). Riparian forests suffered from forest fragmentation, which in turn promote the change in the pattern of seed dispersion and modification of soil seed bank. The aim of this study is to indicate the main species that make up the seed bank of a stretch of riparian forest of the Mogi Guaçu River continued to a fragment of semidecidual forest, located in the Air Force Base of Pirassununga. It was delimited ten plots of 10 x 10 m. Four soil samples was collected by plot with a 25 x 25 cm template. Samples were packed in greenhouse for seed germination and monitored every 15 days for six months. Altogether, 494 individuals from 19 families were sampled, distributed in 30 genera and 40 morphospecies. Diversity and distribution of species in the fragment is homogeneous and can be used as source of propagules for forest restoration.
Keywords: forest fragment, propagules, riparian forest, semidecidual forest

RESUMO – (Análise do banco de sementes e similaridade de espécies na Guarnição da Aeronáutica de Pirassununga (Estado de São Paulo, Brasil)). Florestas ripárias sofrem com a fragmentação florestal, que promove mudanças no padrão de dispersão de sementes e modificação do banco de sementes. O objetivo do presente estudo é indicar as principais espécies que compõem o banco de semntes de um trecho de floresta ripária do Rio Mogi Guaçu River contínuo a um fragmento de floresta estacional, localizada na Guarnição da Aeronáutica de Pirassununga. Foram delimitadas dez parcelas de 10 x 10 m. Quatro amostras de solo foram coletadas através de um molde de 25 x 25 cm. Amostras foram mantidas em estufa para germinação de sementes e monitoradas a cada 15 dias por seis meses. Ao todo, 494 indivíduos pertencentes a 19 famílias foram amostrados, distribuídos em 30 gêneros e 40 morfoespécies. A diversidade e a distribuição das espécies no fragmento é homogênea, podendo ser usado como uma fonte de propágulos para restauração florestal.
Palavras-chave: floresta ripária, floresta semidecidual, fragmentação florestal, propágulos

Introduction

When the vegetation is located close to watercourses, it is renamed as riparian forest, defined as a transition area, extending between the limit of watercourses to the edge of higher lands, being strongly influenced by the water regimen, in addition to presenting high heterogeneity of habitats (Naiman *et al.* 2005).

The fragmentation of forest formations, which are isolated stains of forests enveloped by areas that have suffered anthropic transformation, can generate negative edge effect and also the isolation of species (Cosgrove *et al.* 2018). Fragmentation can also cause change in the pattern of seed dispersal of a certain area (Cordeiro & Howe 2003), altering the maintenance of genetic diversity and gene flow (Wang & Smith 2002). Forest formations such as riparian forests along the course of water are important for maintenance of the gene flow, since they interconnect populations affected by fragmentation (Kageyama & Gandara 2001). In addition, they contribute to the stabilization of margins of watercourse, acting as natural filterers of nutrients and agrochemicals, intercepting and absorbing solar radiation and providing

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shelter and food for aquatic and terrestrial fauna (Sabino & Castro 1990).

The seed bank may present changes in its composition because it is formed by both seeds from the fragment individuals themselves and by dispersers from other areas (Bossuyht & Honnay 2008). The seed bank is a stock of viable, non-germinated seeds, present in the ground, and can germinate within a short time, or remain in a state of latency until optimal conditions arise for germination (Martins 2009).

From the analysis of the stock of the seed bank, it is possible to opt for better strategies regarding the management for native forests or restoration, as well as being used as an ecological indicator for evaluation and monitoring of regeneration in degraded ecosystems (Neto *et al.* 2010, 2014, Bargoena *et al.* 2020, Costa *et al.* 2020).

One of the biggest challenges today is the conservation of the remaining forest fragments (Loyola 2014), since Brazil holds one of the largest biodiversity on the planet (Forzza *et al.* 2012). The lack of information about where efforts should be concentrated and what strategies of restoration should be taken are often an obstacle to biodiversity conservation. In this sense, studies on the seed bank in remaining areas can provide important information about their state of conservation and for restoration actions in their surroundings, with the starting point which are the main vegetable species present there. Thus, the objective of the present study was to indicate the main species that make up the seed bank of a stretch of riparian forest of the Mogi Guaçu River continued to a fragment of semidecidual forest, located in the Air Force Base of Pirassununga (São Paulo State, Brazil).

Material and Methods

Characterization of the study área – This study was conducted in a forest fragment located in the Air Force Base of Pirassununga (FAYS), in latitude 21°59’39,98” S and longitude 47°20’12,73” W, in the municipality of Pirassununga (São Paulo State, Brazil) (figure 1).

FAYS contains about 2608 hectare (ha) corresponding to the forest fragments of lowland, brazilian savanna (cerrado), semidecidual forest, riparian forest and forestry of *Eucalyptus* spp. and *Pinus* spp. The climate is characterized as Cwa (Rolim *et al.* 2007), with hot and rainy summers, while winters are dried. The average temperature of the year 2018 was 21.90 ° C, while the average annual pluviometry registered was 1291 mm (Universidade de São Paulo 2020).

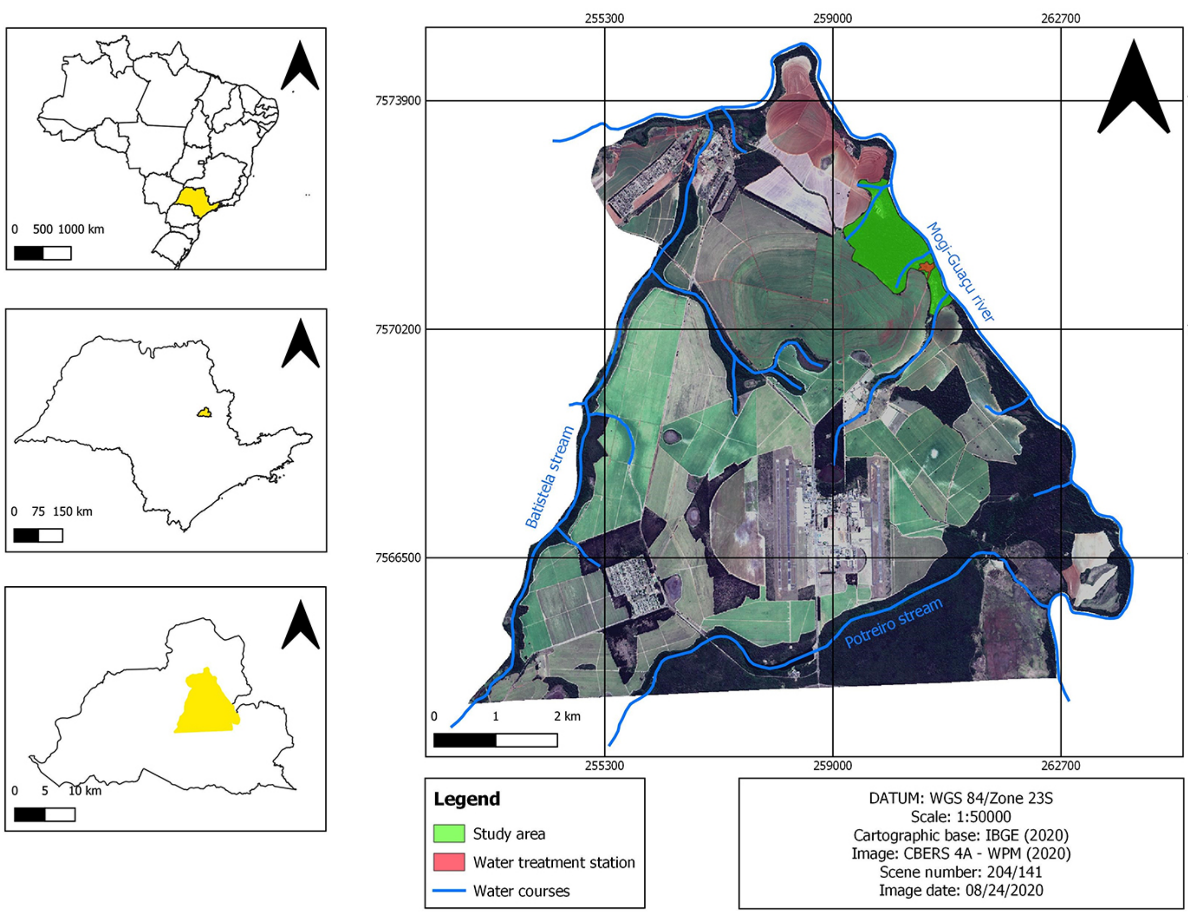

Figure 1. Air Force Base of Pirassununga, Municipality of Pirassununga, São Paulo State, Brazil.

The study fragment corresponds to an area of riparian forest in transition with semidecidual forest of approximately 140 ha (figure 2), located at 620 m altitude, north of FAYS, near the Water Treatment Station, adjacente to the Mogi Guaçu River. It is formed by the Residual Franca / Batatais highlands, composed of the intrusive Serra Geral, containing Typical Red Dystrophial Latosol, moderate to prominent, with clay or very clayey, very deep and softly wavy relief (LV11) (Rossi 2017).

Sampling – To sample the seed bank were marked five plots (10 × 10 meters (m)), located 5 m from the Mogi Guaçu River (R) and a minimum distance of 30 m between them and five plots also 10 × 10 m, located approximately 30 m from the Mogi-Guaçu River (I). Splots I and R were numbered from one to five, wherein the R1 and I1 plots were marked at a distance of 250 m after the Water Treatment Station in order to minimize its influence on the delimited plots. For the measurement of the distance from the entrance to the fragment to the beginning of the plots, as well as the geographical position of each splot (figure 3), a Global Positioning System (GPS) of the GARMIN Mark 20x model was used.

Seed bank – The methodology of this study was defined from the analysis of several articles. We observed that the sampling methodology varied widely between studies, especially in relation to the size of the plots. However, the use of a quadratic template of 25 cm x 25 cm, collecting only at a depth of 5 cm, is unanimous among the different articles analyzed (Braga *et al.* 2008; Martins *et al.* 2008; Martins 2009 ; Franco *et al.* 2012; Cerón 2015; Correia & Martins 2015; Kunz & Martins 2016). Therefore, in an attempt to include a greater number of seeds, we chose to remove the soil at a depth of 0-10 cm, as will be detailed below.

The sampling method in the 10 plots was adapted from Braga *et al.* (2016), consisting of the collection of four samples per splot, with the aid of a 25 cm x 25 cm template. The samples were collected in September 2018 during the transition from the dry season to the rainy, since it is the period in which it is possible to sample greater diversity of species from the seed bank analysis (Braga *et al.* 2016).

From the recommendations of Braga *et al.* (2016), each sample was removed the ground to a depth of 10 cm, in two steps. The first was the removal of the soil of 0-5 cm, being called upper, and in the second, withdrew in the depth of 5-10 cm, called below. Samples of the two depths were packed in different plastic bags. After collecting the samples were arranged in plastic trays, first pouring the lower, covering it with the upper and subsequently, taken to germination in the shading of 60% and two three-minute daily irrigations through microspersors.

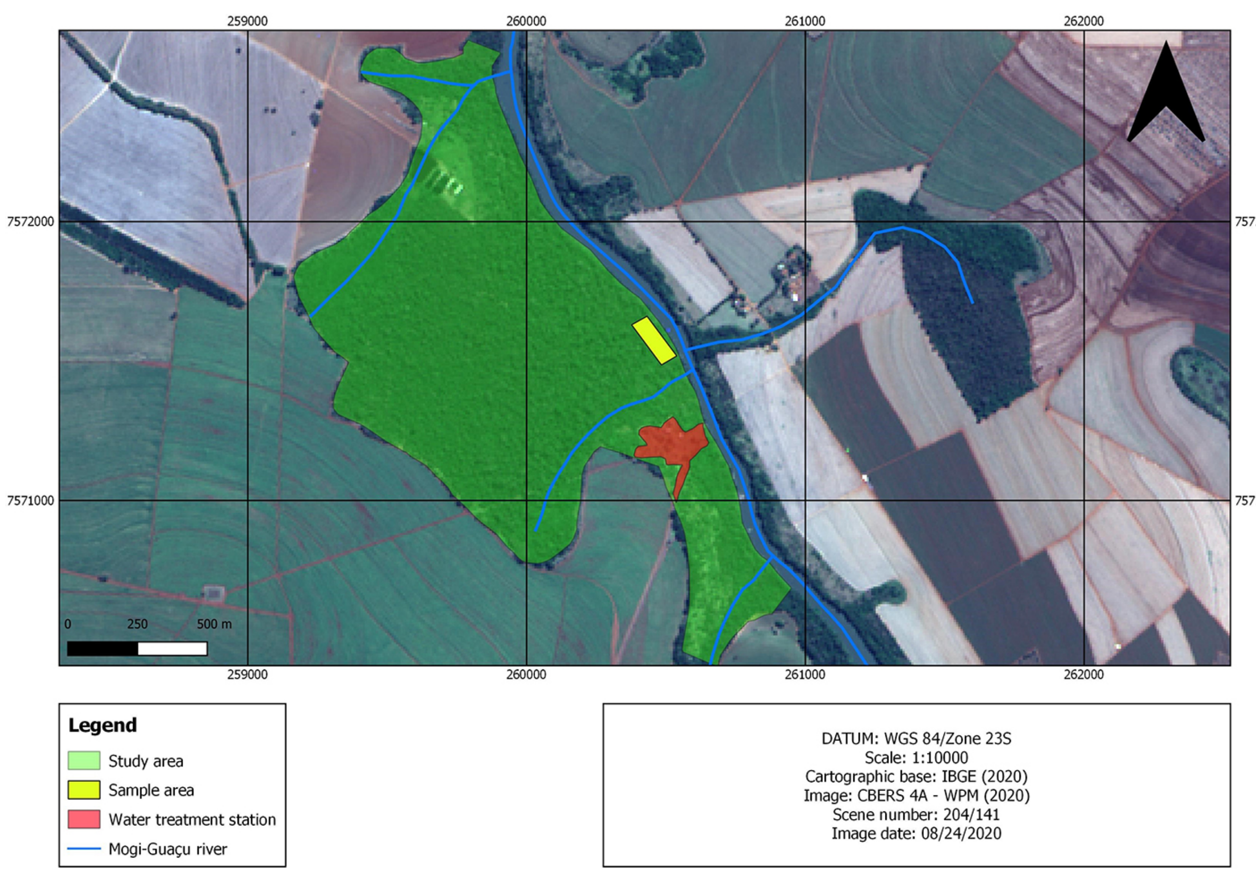

Figure 2. Map of the study area in the Air Force Base of Pirassununga, São Paulo State, Brazil.

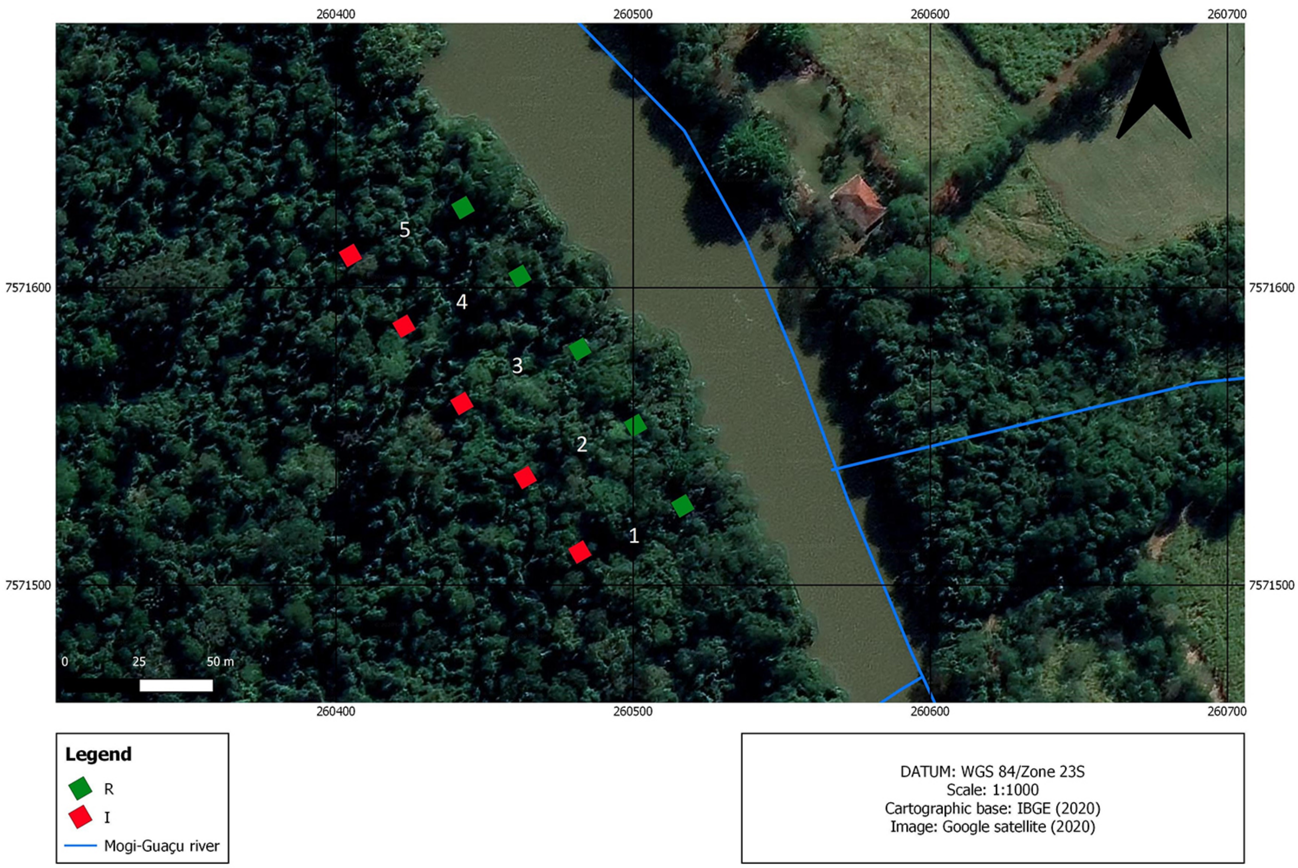

Figure 3. Amostral design in the study area highlighting the position of the plots in relation to the margin of the Mogi Guaçu River, São Paulo State, Brazil. (Image: Google satellite, 2020).

The seedlass emergency method (Simpson *et al.* 1989) was used for seed bank analysis, monitoring them every 15 days for six months. For the best identification of individuals, those who presented an arbustive and arboreal character were peaked to tubes to develop. For the identification of the seedlings some species identification guides, such as Lorenzi (2014) and Brancalion & Nogueira (2016) were used. The exsiccates of the seedlings of the recognized species were made, deposited in the herbarium of Universidade Federal de São Carlos, Campus Araras.

Statistical analysis – Through the Software Past 3.0 (Hammer & Harper 2006), the total number of species, species diversity through the Shannon-Weaver (H') index and the equality rate of Pielou (J) (Krebs 2007) were observed. The T test was used to ascertain if the H 'values differed from each other ($p < 0.05$).

Results and Discussion

Altogether, 494 individuals from 19 botanical families were sampled, distributed in 30 genera and 40 morphospecies (table 1). Among the individuals identified at least at the family level, the greatest diversity of species corresponds to Asteraceae (17.5%), followed by Moraceae (12.5%), Solanaceae (12.5%) and Urticaceae (7.5%). Some individuals had no confirmed identification at the level of genus or species, since they were not in reproductive state and the characteristics in vegetative stage observed were not conclusive for safe identification.

Most species of Asteraceae have anemocory and herbaceous habit (Silva *et al.* 2019), in addition to having many adaptive abilities, allowing them to occur in different ecosystems (Beretta *et al.* 2008). The data obtained here coincide with some studies whose species richness indicates that Asteraceae is expressive in areas of semideciduous forest (Nóbrega *et al.* 2009, Franco *et al.* 2012, Silva *et al.* 2019). It is important to note that Asteraceae is one of the largest families of angiosperms in number of species, with anemochoric dispersion and represented in practically all plant formations in the globe (Lorenzi 2014), which partially justifies its wide occurrence in the study area.

Moraceae was the second in greater diversity of species, represented by five morphospecies and ten individuals, four of *Ficus hirsuta* Schott, three of *Ficus guaranitica* Chodat, and one of *Ficus eximia* Schott. Two individuals were not identified, named *Ficus* sp. 1 and *Ficus* sp. 2.

Table 1. Species sampled in the seed bank of a fragment of the Air Force Base of Pirassununga, São Paulo State, Brazil. Ecological Group (EG), according to Barbosa (2017). NP: not pioneer; P: pioneer; He: herbaceous; Li: liana. Habit (H), according to Flora do Brasil 2020 (2021): Tr: tree; Ss: shrub or sub-shrub; He: herbs; Li: liana. Occurrence in phytophysiognomies (OP) represented in the study area, according to Flora do Brasil 2020 (2021). SF: Semideciduous Forest; RF: Riparian Forest; NR: not reported for SF and or RF. Dispersion syndrome (DS), according to Barbosa (2017). Ane: anemocory; Zoo: zoocory; Aut: autocory. Number of individuals per group of plots. I: distant from the Mogi Guaçu River; R: close to the Mogi Guaçu River. According to Flora do Brasil 2020 (2021), species marked with (*) are considered naturalized and species marked with (#) have no reported occurrence for São Paulo State.

Species	EG	H	OP	SD	I	R
Anacardiaceae						
Astronium graveolens Jacq.	NP	Tr	SF/RF	Ane	0	1
Apocynaceae						
Aspidosperma cylindrocarpon Müll.Arg.	NP	Tr	SF/RF	Ane	2	0
Asteraceae						
Ageratum conyzoides L.	He	H, Ss	NR	Ane	0	1
Conyza bonariensis (L.) Cronquist	He	Ss	NR	Ane	1	1
Conyza canadensis (L.) Cronquist	He	Ss	NR	Ane	1	4
Emilia sonchifolia (L.) DC.*	He	He	NR	Ane	1	0
Erechtites hieracifolius (L.) Raf. *ex* DC.	He	He, Ss	NR	Ane	0	1
Gnaphalium sp.	He	He	-	Ane	1	8
Hypochaeris sp.	He	He	-	Ane	1	0
Cactaceae						
Pereskia grandifolia Haw.	NP	Ss, Tr	SF/RF	Zoo	2	0
Cannabaceae						
Celtis sp.	NP	Ss, Tr	-	Zoo	35	15
Trema micrantha (L.) Blume	P	Ss, Tr	SF/RF	Zoo	19	28
Combretaceae						
Combretum leprosum Mart. #	NP	Ss, Tr, Li	SF	Ane	3	15
Commelinaceae						
Tradescantia sp.	He	He	-	Aut	5	0
Convolvulaceae						
Sp.1	-	Li	-	Aut	1	1
Sp.2	-	Li	-	Aut	3	7
Sp.3	-	Li	-	Aut	3	2
Euphorbiaceae						
Alchornea glandulosa Poepp. & Endl.	P	Ss, Tr	RF	Zoo	1	0
Croton urucurana Baill.	P	Tr	SF/RF	Aut	11	0
Fabaceae						
Peltophorum dubium (Spreng.) Taub.	P	Tr	SF/RF	Ane	1	0
Malpighiaceae						
Banisteriopsis muricata (Cav.) Cuatrec.	NP	Li	SF	Ane	6	7
Moraceae						
Ficus eximia Schott	NP	Tr	NR	Zoo	1	0
Ficus guaranitica Chodat	NP	Tr	SF	Zoo	2	1
Ficus hirsuta Schott	NP	Tr	SF	Zoo	1	3
Ficus sp.1	NP	Tr	-	Zoo	1	0
Ficus sp.2	NP	Tr	-	Zoo	0	1

Table 1 (continued)

Species	EG	H	OP	SD	I	R
Myrtaceae						
Eugenia sp.	NP	Tr	-	Zoo	1	0
Psidium guineense Sw.	NP	Ss, Tr	SF	Zoo	0	1
Phyllanthaceae						
Phyllanthus tenellus (Roxb.)	P	He, Ss	RF	Zoo	0	1
Piperaceae						
Piper aduncum L.	NP	Ss, Tr	SF/RF	Zoo	2	0
Rubiaceae						
Sp.1	-	-	-	-	1	0
Solanaceae						
Capsicum baccatum L.	P	Ss	SF	Zoo	0	2
Nicandra physalodes (L.) Gaertn.*	P	He	NR	Zoo	1	0
Solanum americanum Mill.	P	He	SF/RF	Zoo	17	30
Solanum lycocarpum A.St-Hil.	P	Ss, Tr	NR	Zoo	5	4
Solanum mauritianum Scop.	P	Ss, Tr	NR	Zoo	3	4
Urticaceae						
Cecropia glaziovii Snethl.	P	Tr	SF	Zoo	39	88
Cecropia pachystachya Trécul	P	Tr	SF/RF	Zoo	23	68
Urera baccifera (L.) Gaudich. *ex* Wedd.	NP	He	SF/RF	Zoo	2	0
Verbenaceae						
Lantana camara L.*	He	Ss	SF/RF	Zoo	0	1

Initially, considering the studies conducted by Mendonça-Souza (2006), he assumed that they were probably *Ficus adhatodifolia* Schott in Spreng. and *Ficus obtusiuscula* (Miq.) Miq. However, due to the overlap of vegetative characters between the two species, information about the pseudofruit will be needed to identify them. The seedlings obtained in the present were in a vegetative stage and therefore it was decided not to identify them at the species level. This genus contains the largest number of species in the family, with approximately 800 species, distributed in tropical, subtropical regions and hardly in temperate regions (Pelissari & Romaniuc-Neto 2013). The ecological balance of forests is largely aided by these species, because their pseudofruits, called syconium, serve as food for both mammals, birds and even fish, promoting a high range of dispersion of their seeds (Mendonça-Souza 2006). Pollination of its flowers is carried out by wasps through a highly singular mutualistic relationship (Pelissari & Romaniuc-Neto 2013).

Solanaceae was the third in species diversity. The individuals recognized in the present study are zoochoric, whose dispersion of their seeds is carried out by animals after ingestion (Ruschel *et al.* 2008). We can cite the example of *Solanum lycocarpum* A.St-Hil., in which its main disperser is the guara wolf (*Chrysocyon brachyurus* Illiger, 1815) (Massara *et al.* 2012), an endangered mammal (Brazil 2014). In a work carried out by Müller (2016), the presence of the guara wolf was observed in the areas of the Air Force Base of Pirassununga, which may be the disperser of the species in the study area. About 83% of all species of the Solanaceae family are dispersed by animals, being important in the structuring of forest communities (Albuquerque *et al.* 2006), colonizing open areas such as clearings, pastures and forest edges, as they are categorized as pioneers, needing direct sunlight to develop (Tabarelli *et al.* 1999).

Finally, among the families with the greatest diversity of species is Urticaceae, represented in Brazil by 14 genera and about 116 species (Gaglioti *et al.* 2020). The species are characterized by their accelerated growth, short life cycle, reaching small and medium sizes (Parrota 1995). Most of these species need solar incidence in order to develop (Godoi & Tanaki 2005) and therefore border areas, as well as clearings in the interior of the forests, are regions with a high incidence of these species. Generally, in the soil of primary or secondary tropical forests there is a large number of seeds of this family, mainly those of *Cecropia* spp. (Lobova *et al.* 2003).

Among the species recognized in the present study, a possible new occurrence was found for the São Paulo State, *Combretum leprosum* Mart., initially recognized for the semideciduous forest in Minas Gerais and Espírito Santo States (Flora do Brasil 2020 2021). Queiroz *et al.* (2021) also report the occurrence of *C. leprosum* seedlings for the same study area and bring evidence that suggest the occurrence of this species in the São Paulo State. Ongoing floristic studies may confirm the existence of adult individuals of *C. leprosum* in the study area, thus reinforcing the importance of studies on seed banks as an important tool for studying flora.

As for the families with the largest number of individuals sampled, Urticaceae stands out with 220 individuals (44.53%), distributed in three species, *Cecropia glaziovii* Snethl. (127 individuals), *Cecropia pachystachia* Trécul. (91 individuals) and *Urera baccifera* (L.) Gaudich. *ex* Wedd. (two individuals), followed by Cannabaceae, which presented 97 individuals (19.64%), belonging to *Celtis* sp. (50 individuals) and *Trema micrantha* (L.) Blume. (47 individuals). Solanaceae is the third in number of individuals, with 66 individuals (13.36%), belonging to *Solanum americanum* Mill. (47 individuals), *Solanum lycocarpum* A. St-Hil. (nine individuals), *Solanum mauritianum* Scop. (seven individuals), *Capsicum baccatum* var. *praetermissum* (Heiser & P. G. Smith) Hunz. (two individuals) and *Nicandra physalodes* (L.) Gaertn. (one individual). From these data, it is possible to observe that most of the individuals obtained correspond to pioneer species, suggesting that in a possible transposition of soil for ecological restoration these individuals could contribute to the beginning of the recovery of the area, promoting soil cover and favoring the subsequent development propagules of non-pioneer species.

The species cataloged in the seed bank are similar in 30% (12 species) with the floristic study that is being conducted in the same area as the present study. Thus, this similarity is consistent with the considerations of Marcante *et al.* (2009), who highlight that there is, in general, great differentiation between the composition of the seed bank and the vegetation itself. The diversity of vegetation tends to be greater than the diversity in the seed bank, as some dispersed seeds cannot persist for long periods in the soil in a dormant state, expecting optimal conditions for germination (Martins *et al.* 2015).

Comparing with the study conducted by Neto *et al.* (2020), the dominant species proved to be quite similar, since in the seed bank of a mature semideciduous forest studied by these authors, the species that most emerged were *T. micrantha* (L.) Blume, *Cecropia hololeuca* Miq. and *Solanum* sp. such species are known to remain for a long time in the soil, requiring luminous areas for germination (Martins 2016). These species are essential for the regeneration of forests, as they are of primary nature and germinate in clearings and edges of the fragments (Pereira *et al.* 2010; Correia & Martins 2015), being dispersed by animals, mainly birds (Ruschel *et al.* 2008).

The largest number of pioneer individuals cataloged was in plots R, that is, the largest seed bank in this ecological group was cataloged at the edge of the fragment, which borders the Mogi Guaçu River. Forest areas adjacent to the watercourse have greater stratification of vegetation, allowing direct light to enter the area (Wallace *et al.* 2018), providing subsidy for the germination of species of this ecological group (Pereira *et al.* 2010; Correia & Martins 2015), which justifies the data obtained here. On the contrary, in plots I (farthest from the river), most non-pioneer species were cataloged. This can be explained by the fact that the areas furthest from the edge generally have a more homogeneous canopy, providing shade and humidity (Wallace *et al.* 2018), creating an optimal condition for such species to develop.

Among all the species identified here, 55% have zoochoric dispersion syndrome, 30% anemochoric and 12.5% autochoric. Zoocory is extremely important for maintaining the interaction between fauna and flora, which in turn fosters the conservation and functionality of forest fragments (García *et al.* 2011). Generally, in conserved fragments and large areas of tropical forest, the zoocory dispersion is predominant (Sansevero *et al.* 2011, Jesus *et al.* 2012). As the study area is a fragment with little anthropic disturbance, we can say that it is in a good state of conservation, since more than half of the species have zoochoric dispersion syndrome. Other studies carried out on remnants of semideciduous forest also found values close to the present study, in which more than half of the sampled individuals have dispersion carried out by animals (Silva *et al.* 2019, Neto *et al.* 2020).

Among ecological groups, 37.5% were classified as non-pioneers and 30% as pioneers. The rest of the species were not characterized according to the ecological group because they are herbaceous (22.5%), lianas (7.5%) and undetermined (2.5%). As for ecological groups, non-pioneer species represented the greatest diversity of species, but the largest number of registered individuals (83.6%) belongs to the group of pioneer species. According to some authors, most of the species found in the seed bank of semideciduous forests are pioneering in relation to ecological succession (Thompson 2000, Braga *et al.* 2016, Kunz & Martins 2016), as they are species that persist in the soil for a long time in a state of dormancy, in addition to high seed production (Martins *et al.* 2015). Non-pioneer species do not usually form a population within the seed bank, because due to their large size, they cannot penetrate the litter layer and homogenize with the soil (Martins *et al.* 2015). Failure to incorporate large seeds into the soil promotes exposure to predator attacks (Silva *et al.* 2019), unlike seeds of pioneer species, which are buried more easily due to their small size, and are often protected from potential predators (Thompson 2000). In a study conducted by Nóbrega *et al.* (2009), also in the riparian forest of the Mogi Guaçu river, showed that 47% of the species that emerged from the seed bank are pioneers, in contrast to the present study, in which the emerged pioneers were 30%. In other studies, on the same phytophysiognomy, most of the emerged species were also characterized as pioneers (Franco *et al.* 2012).

Regarding the occurrence in phytophysiognomy of the total number of species identified here (29), eleven have been reported for both semideciduous and riparian forest, seven species have reported for only semideciduous forest, two species have an occurrence reported only for riparian forest and nine species have no reported occurrence for these phytophysiognomies, according to Flora do Brasil 2020 (2021). Considering that the study area is a region of riparian forest continuous to a fragment of semideciduous forest, these data suggest that the influence of the fragment may have a great influence on the diversity of species that make up the riparian forest in question. It is important to highlight that this type of information is not always recorded on labels of exsiccates deposited in herbariums and that a significant part of the information about the occurrence in phytophysiognomies of the species of angiosperms present in Flora do Brasil 2020 (2021) may have been obtained in this way. This may justify the high number of species occurring in the present study not previously reported for semideciduous and riparian forest.

Plots I presented an average in the number of species per plot slightly higher than the plots R, with values of 12.6 and 11.6 respectively. The diversity indices (H ') were higher in plots I, ranging from 1.98 to 2.53, while in plots R, they ranged between 1.74 and 2.02. Equability indices (J) were also higher in plots I, ranging from 0.82 to 0.95, while in plots R they ranged from 0.70 to 0.90 (table 2).

The mean of Shannon's indexes in plots R was lower (1.90) when compared to plots I (2.20), but they were not significantly different by t test ($p > 0.05$). The Shannon-Weaver indexes for the two regions did not exceed the value of 3, and according to Souza *et al.* (2013), areas with values less than 3, are recognized as low diversity. Due to the forest structure being consistent in areas of mature forests, decreasing the seed rain, the diversity and density of the seed bank tend to decrease, causing the species that integrate the community to build a seedling bank (Souza *et al.* 2006).

In a study conducted by Neto *et al.* (2020), the Shannon index was higher during the rainy season, with a value of 2.23, in which these samples were withdrawn between November and April 2017. During the dry season, between the months of May and October of 2017, the index was 1.57, much lower than that found in the present study. On the other hand, in a study carried out by Piña-Rodrigues & Aoki (2014), observing the deposition of seeds in fragments of semideciduous forest, it was found that the greatest deposition of seeds was at the end of the dry season and at the beginning of the wet season, comprising the September onwards. However, as several studies point out that the greatest deposition of seeds occurs at the end of the dry season and the beginning of the humid one (Braga *et al.* 2016), the collection was chosen in September to contemplate greater diversity. Therefore, one of the factors that influence the density and composition of species is the variation of climatic factors (Dalling 2002).

The mean values of the Pielou index were between 0.78 for region R, and 0.87 for region I. Therefore, in region I the species are better distributed, with no ecological dominance, but it can be observed that the values index for both areas are high, resulting in a good distribution of species. When the value for the Pielou index is low, it is possible to assume that the total number of individuals belongs to a few species (Pinã-Rodrigues & Aoki 2014). In a study carried out on the edge of semideciduous forest, the Pielou index found was 0.79, considering the values of the present study (Bargoena *et al.* 2020).

According to the administration of the Air Force Base of Pirassununga, there are areas close to the Mogi Guaçu River in the Pirassununga Municipality that need to be restored (S.M. Barroso, personal communication). Therefore, we compared the species cataloged in the present study with the List of Species Specified for Ecological Restoration for Various Regions of the State of São Paulo (Barbosa 2017) and 18 of the species here reported are indicated for ecological restoration. This indicates that the studied fragment may come to be used as a source of propagules for degraded areas, which may be either by marking seed trees for collecting seeds, and later, by creating seedlings, or by transposing soil and or litter (Brancalion *et al.* 2015).

Therefore, the conservation of forest fragments is extremely important for the maintenance of species, and later, their propagation. Even if there is no anthropic activity aimed at removing these propagules to other areas, the fauna alone already contributes to the dispersion. In a study by Neto *et al.* (2020), after analyzing the seed bank of

Table 2. Values by plots of the total number of species (S), Shannon-Weaver diversity index (H ') and Pielou's equability index (J).

Index	Splots									
	R1	R2	R3	R4	R5	I1	I2	I3	I4	I5
S	13	15	11	10	9	11	11	10	17	14
H'	2,02	1,89	1,79	2,08	1,74	2,00	1,98	1,99	2,53	2,52
J	0,78	0,70	0,74	0,90	0,79	0,83	0,82	0,86	0,89	0,95

abandoned eucalyptus areas, close to preserved fragments, concluded that they can become areas favorable to the natural regeneration of native species, due to this proximity. In view of this, through a low financial cost assessment of the soil seed bank, cataloging the floristic composition and the density of species, it is possible to define strategies for ecological succession in areas that need restoration (Martins 2001, Brancalion *et al.* 2015).

Conclusions

Through this study we can see that at a distance of about 30 meters from the watercourse, there is no significant difference between species diversity. The only factor that separates the border and interior region is the number of individuals and ecological group. There is also an ecological balance between fauna and flora, since most of the cataloged species are dispersed by animals. Therefore, the conservation of natural fragments is important both for the maintenance of plant and animal species, and for obtaining propagules intended for the recovery of degraded areas. From the analysis of the seed bank in the study area, it is possible to recognize the potential of the fragment in question to supply propagules or even litter transposition for ecological restoration, given the recognized floristic diversity.

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Author Contributions

Pedro Henrique de Godoy Fernandes: Substantial contribution in the concept and design of the study; Contribution to data collection; Contribution to data analysis and interpretation; Contribution to manuscript preparation.

Israel Henrique Buttner Queiroz: Contribution to data collection; Contribution to data analysis and interpretation; Contribution to manuscript preparation.

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Conflicts of interest

There is no conflict of interest.

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