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BIRD FAUNA IN SECONDARY FOREST STAGES: A STUDY IN A SOUTHERN BRAZILIAN PROTECTED AREA

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Abstract: Environmental changes resulting from forest succession process may lead to changes in the abundance and composition of species. In each successional stage, faunal composition will depend on the structure of the habitats and the ecological requirements of each species. The effects seem to be more evident in small isolated forest fragments. In this study we recorded bird species composition and richness at different stages of secondary forest in a protected area located in a highly-fragmented region in southern Brazil. We predicted that bird species composition and richness will change according to the secondary forest stage, and will be affected by the ecological requirements of species. The study was carried out in the Mata do Rio Uruguai Teixeira Soares Municipal Park (TSP), in the northern part of the state of Rio Grande do Sul, Brazil. The park is the largest protected area in the region, with 423 ha. Representative areas of the three successional stages of secondary forest within TSP were selected, and the bird species in each area were recorded using the counting point sampling method. A total of 145 bird species were recorded in the three areas. There were differences in species composition between the areas, indicating that the structure of the bird community is directly linked to successional stages. This relationship is improved by differences in the number of birds with certain ecological traits between the areas. The size, connectivity of the forest fragments and the availability of habitats may be affecting the distribution of the avifauna in the park. Changes in the landscape may promote a restructuring of avifaunal communities, where species with certain ecological traits can be favored or excluded. The TSP, although relatively small, is important for the maintenance of bird species because it is a rare, well-preserved fragmented of the deciduous seasonal forest in the region.

Keywords: avifauna; conservation; diet; habitat use.

INTRODUCTION

Intense deforestation and fragmentation has meant that the Atlantic Forest biome is predominantly composed of small forest fragments (< 50 ha) (Rodrigues *et al.* 2009, Almeida 2016). Most of these forest fragments are isolated or composed of secondary forest at early and intermediate stages of

secondary forest succession (Metzger *et al.* 2009). This type of vegetation cover has increased in extent and importance, as primary forests are exploited, fragmented, and converted to agricultural use (Joly *et al.* 2014).

Vegetation structure and environmental conditions at early stages of succession are different from those of mature or advanced-stage forests (Bazzaz & Pickett 1980, Dent & Wright 2009). Environmental changes resulting from the forest succession process, due to the alteration of the structure of the plant community, may lead to changes in the abundance and composition of animal species that occupy the different stages of succession (Inger & Colwell 1977, Chazdon *et al.* 2003, Veddeler *et al.* 2005). In each successional stage, the fauna composition will depend on the new habitat structure and the ecological requirements of each species (Gimenes & Anjos 2003). Changes in forest structure imply a restructuring of these animal communities, resulting that species with specific ecological requirements to survive might disappear (Donatelli *et al.* 2004), while generalist species may become dominant over specialist species (Van Langevelde 2000, Beier *et al.* 2002).

There are a range of effects of successional stages on birds, from benefits due to habitat alterations and increases in population size to exclusion from the environment (Marini & Garcia 2005). Changes in forest structure directly interfere with the abundance and richness of bird species (Willis 1979, Stoufer & Bierregaard 1995, Marsden *et al.* 2001, Antunes 2005). The main environmental factors involved are forest area, degree of isolation, habitat diversity, vegetation heterogeneity, and edge effects (Gimenes & Anjos 2003, Silva *et al.* 2017). These effects usually are more evident in small and isolated forest fragments (Ribon *et al.* 2003, Anjos 2006, Piratelli *et al.* 2008, Ribeiro *et al.* 2009).

Some specific groups of birds, mainly those that are forest dwelling, suffer more from landscape changes. More sensitive species are generally of medium or large size, have restricted mobility and high specialization, forage and nest in the soil, have low tolerance to a matrix habitat, low density, and a low survival rate (Loiselle & Blake 1992, Sieving & Karr 1997, Şekercioğlu *et al.* 2002). On the other hand, forests submitted to selective forest exploitation may demonstrate increased species richness and abundance because generalist species can occupy forest areas exploited for economic purposes (Aleixo 1999, Protomastro 2001).

One of the highest bird species richness on the planet is found in the Atlantic Forest (MMA 2000), with a high degree of endemism (about 20%). The main threat to Brazilian birds is the loss and fragmentation of habitats (Marini & Garcia 2005). Understanding how birds are distributed through the different stages of succession may provide important data for the definition of conservation strategies for the group, or to indicate how secondary stage forest areas can contribute to the maintenance of bird communities. The Mata do Rio Uruguai Teixeira Soares Municipal Park (TSP) is a protected area located in a highly-fragmented region in southern Brazil, within the Atlantic Forest. Our main goal was to record the bird species composition and richness at different stages of secondary forest succession in the TSP. We predicted that bird species composition and richness would change according to the secondary forest stage, and be affected by the ecological requirements of species.

MATERIAL AND METHODS

Study area

The TSP covers an area of 423 ha, and is located in the municipality of Marcelino Ramos in the north of Rio Grande do Sul state, Brazil (Figure 1). The TSP was created in June 2008 as a compensatory measure for the area flooded by the Itá Hydroelectric Plant reservoir (Park Management Plan 2012). The landscape in the study area is composed mainly by seasonal deciduous forest (Leite & Klein 1990). This forest follows the banks of the Uruguay River, with widths varying from 30 to 50 km. It extends through the valleys of the tributaries of the Uruguay River, where it connects with the mixed ombrophilous forest. The climate is sub-tropical humid, with an average annual temperature of 17.7°C and precipitation of 1700 mm (Park Management Plan 2012). The altitudinal range in the park is from 472 to 572 m a.s.l. The relief varies from hills next to the Uruguay River to cliffs in places with higher altitude (Park Management Plan 2012).

The landscape of TSP presents a mosaic of forest successional stages due patterns of past use. These

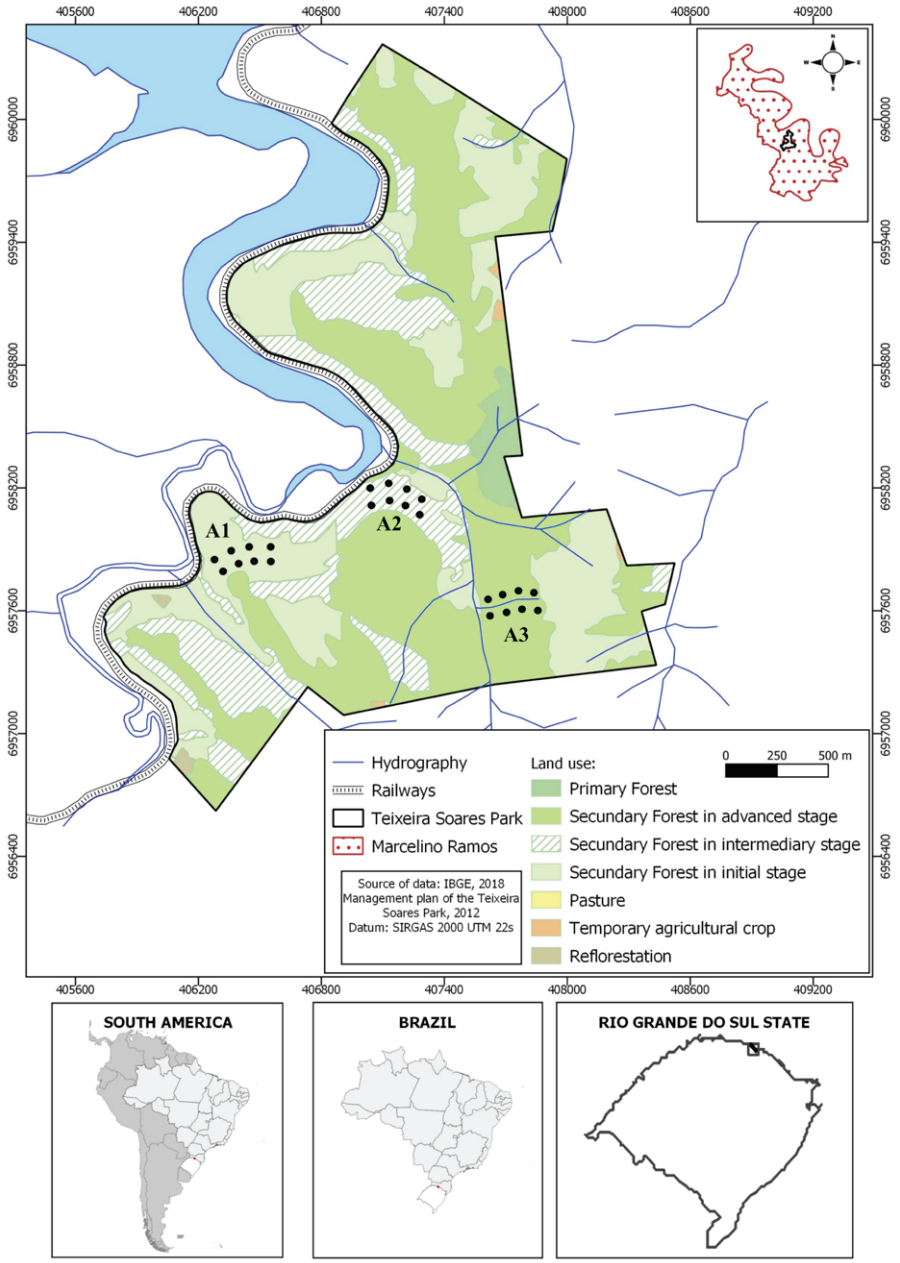

Figure 1. Study area and sampling points in Mata do Rio Uruguai Teixeira Soares Municipal Park, southern Brazil. Area 1 (A1) - secondary forest in initial succession stage; Area 2 (A2) - secondary forest in intermediary stage; Area 3 (A3) - secondary forest in advanced stage.

stages present the following characteristics: (*i*) Secondary forest in initial stage of succession (Figure 2a), characterized by the dominance of herbaceous/shrub heliophyte species, low vegetation cover (up to 4 m), and slightly shaded understory; (*ii*) Secondary forest in intermediate stage of succession (Figure 2b), where pioneer species typical of open environments still dominate the tree stratum, but with the presence of emergent tree species; and (*iii*) Secondary forest in the advanced stage of succession (Figure 2c), characterized by trees that are 12 m high on average forming a closed and relatively uniform canopy, with a higher species richness than that found in the initial stage, and located in areas of difficult access. There was total deforestation in the initial (about 15 years ago) and intermediate (about 25 years ago) stages of succession. In the advanced stage of succession, only trees with commercial value were removed, and this forestry use ended about 30 years ago (Park Management Plan 2012).

Data collection

Three sample areas were selected, representing the three successional stages of secondary forest, according to the Park Management Plan (2012) and a previous analysis of area: Area 1 - secondary forest in initial succession stage (approximately 27 ha); Area 2 - secondary forest in intermediary stage (approximately 26 ha); and Area 3 - secondary forest in advanced stage (approximately 24 ha; Figure 1). A 500 m minimum distance was preserved between the three sampling areas. Eight sampling points were established in each area 100 m apart and arranged in two transects with four points each (Wunderle 1994, Bibby *et al.* 2000; Figure 1). Transects in Area 3 were established 200 m from the edge with Area 2, to avoid edge effects (Figure 1).

We used the counting point sampling method to record species richness and number of individuals in each area (Volpato *et al.* 2009). Two observers remained for 15 minutes at each point (Cavarzere *et al.* 2013) and recorded birds sighted and heard within approximately 30 m. Samples were taken from October to December 2016, during the reproductive period of most bird species in southern Brazil (Belton 1994).

Observations took place in the morning, between 06:00 and 11:00 h. Each area was sampled six times (one area sampled per day), totaling 18 sampling days (about 180 h of sample effort, distributed over the study period). Birds were observed with binoculars; and photographs and vocalization records were taken whenever possible. Photographs and recorded vocalizations served to identify or confirm species identification. The Belton (2004) and Sigrist (2014) bird guides were consulted to help visual identification. The taxonomic order and nomenclature of the species followed Piacentini *et al.* (2015). Bird species sighted or heard outside sampling points, but within the limits of TSP, or only in flight over the areas, were recorded as occasional encounters (OE) and were not considered in comparative analyses among the areas.

Data analysis

Bird species were categorized according to their eating habits and habitat use to compare ecological traits. We followed the descriptions of Motta-Júnior (1990), Parker *et al.* (1996), Anjos (2001), Sick (2001), and Telino-Júnior *et al.* (2005) to determine the ecological traits of the birds. The following categories of feeding habits were recorded for TSP birds: carnivorous (Car; captures and consumes other animals, mainly vertebrates), detritivorous (Det; primarily eats carcasses), frugivorous (Fru; fruit-eating specialists), granivorous (Gra; eat primarily grains or seeds), insectivorous (Ins;

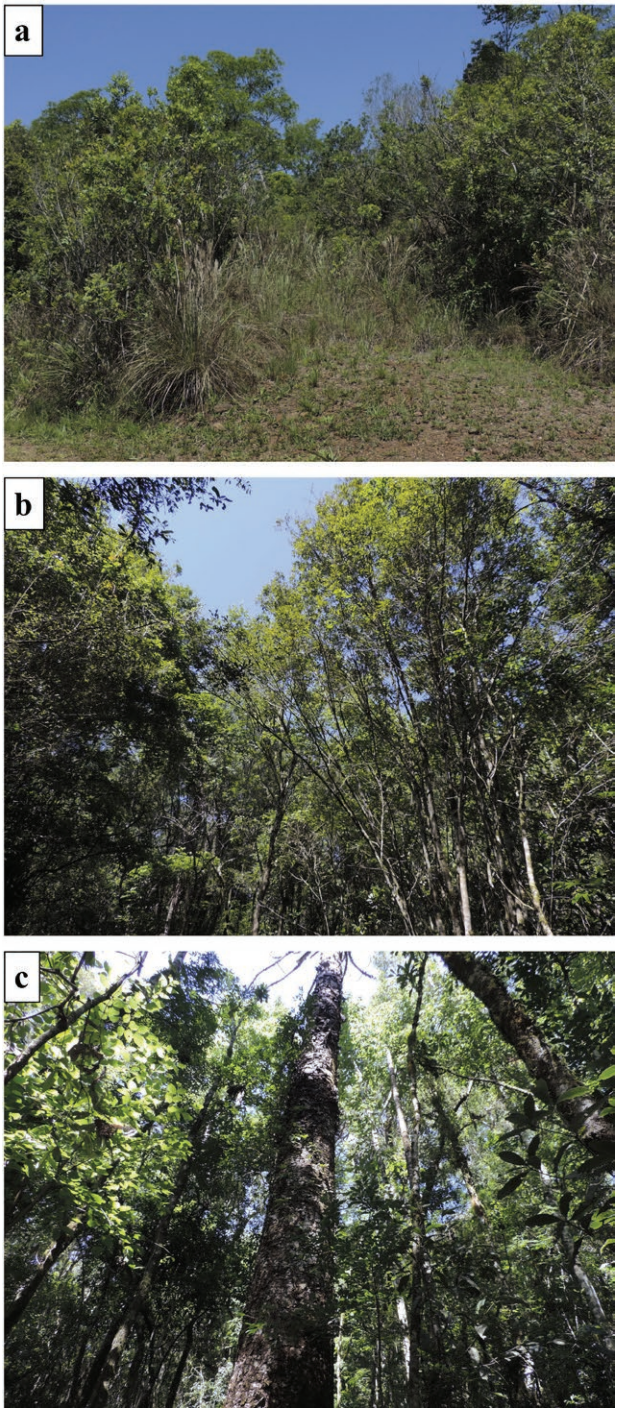

Figure 2. Secondary forest in initial succession stage (a), secondary forest in intermediary stage (b), and secondary forest in advanced stage (c), in the Mata do Rio Uruguai Teixeira Soares Municipal Park, Rio Grande do Sul state, Brazil.

specialized carnivorous that feed on insects and other arthropods), nectarivorous (Nec; feeds on flowers nectar), omnivorous (Oni; have a widely varied diet, are able to consume different food items), and piscivorous (Pis; catches and consumes primarily fish). The recorded bird species made use of the following habitats: broad (Bro, a variety of different habitats, including anthropic areas), forest (For, typical of inside the forest), forest edge (Fe; primarily forest borders), open area (Oa, primarily native open area), and wetland (Wet, primarily swamps).

We used the Jackknife 1 estimator (Chao 1984), calculated in the EstimateS 9.0 software for the total and per sampled area species richness estimation. We used the Jaccard similarity coefficient (SJij) to compare the similarity between areas. Areas were compared for species richness (number of species recorded per area by sampling), number of individuals (number of individuals recorded per area per sample), and ecological traits (number of species recorded in each category per sampling area) using One-way ANOVA and Tukey post-hoc test, with a p-value < 0.05. Data normality was evaluated using a Shapiro-Wilk test and the homogeneity of the variances was tested by Bartlett's test. The diversity of the three areas was compared using the Shannon H' Index. To test whether there was difference between the H' values obtained for each area, we applied the t-Test for specific diversity, with $p < 0.05$, using Past 3.15 software (Hammer *et al.* 2001).

RESULTS

A total of 145 bird species were recorded in TSP, distributed through 18 orders and 42 families (see Appendix 1). Of these, 125 species were recorded in the sample areas and 20 as occasional encounters. The Jackknife 1 estimator indicated that 88.62% of species richness was recorded in the three areas together ($N_{(J1)} = 41.05 \pm 3.49$). The Jackknife 1 estimator indicated that more than 80% of the species richness was recorded for each area (Area 1: 84.89%; $N_{(J1)} = 104.83 \pm 3.51$; Area 2: 87.69%; $N_{(J1)} = 108.33 \pm 3.80$; and Area 3: 83.61%; $N_{(J1)} = 101.66 \pm 2.47$).

The highest species richness was recorded in Area 2 (N = 95), followed by Area 1 (N = 89), and Area 3 (N = 85) (Appendix 1). There was no significant difference in the number of species between the areas ($F_{2,15} = 0.74$; $p = 0.48$). Area 2 also had the highest number of individuals (N = 1100), followed by Area 3 (N = 982), and Area 1 (N = 940). There was no significant difference in the number of individuals recorded between the areas ($F_{2, 15} = 0.99$; $p = 0.39$).

Only 53 species were registered in all three areas (Figure 3). The greatest overlap occurred between Areas 1 and 2 (N = 72), followed by Areas 2 and 3 (N = 70), and Areas 1 and 3 (N = 55). The similarity was greater between the areas in the nearest succession stages (Areas 1 and 2: SJij = 0.64; Areas 2 and 3: SJij = 0.63), and lower between more distant areas (Areas 1 and 3: SJij = 0.46). Area 1 had a higher number of exclusive species (N = 15), followed by Area 3 (N = 13), and Area 2 (N = 6). The highest diversity was in Area 1 (H' = 4.04), followed by Area 2 (H' = 4.03) and Area 3 (H' = 3.74). Area 3 differed from the other two ($p < 0.01$), but there was no difference between Areas 1 and 2 ($p = 0.77$).

There was a predominance of omnivorous (N = 60) and insectivorous (N = 52) species in TSP, followed by frugivorous (N = 12), granivorous (N = 8), carnivorous (N = 5), nectarivorous (N =

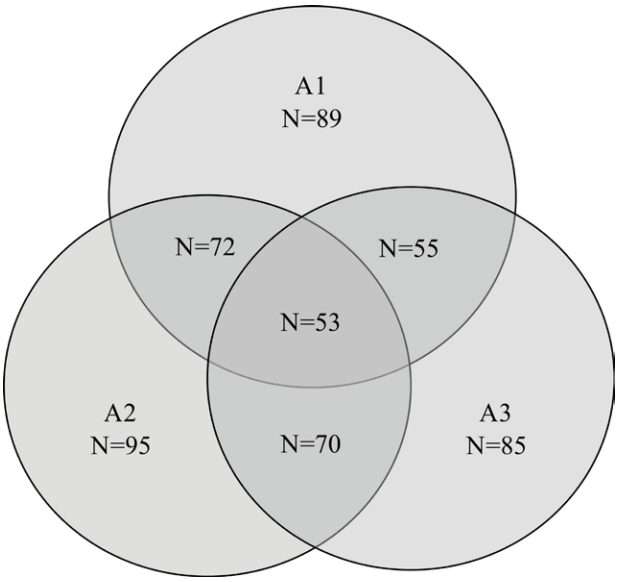

Figure 3. Number and overlap of species recorded between sampling areas), in the Mata do Rio Uruguai Teixeira Soares Municipal Park, Rio Grande do Sul state, Brazil. Area 1 (A1) - secondary forest in initial succession stage; Area 2 (A2) - secondary forest in intermediary stage; Area 3 (A3) - secondary forest in advanced stage.

4), detritivorous (N = 2) and piscivorous (N = 2) (Appendix 1). There was difference in species richness from a determined ecological trait among the areas. The number of frugivorous and insectivorous species was lower in the initial stage of forest succession (Area 1) than in the advanced stage (Area 3). In contrast, the number of granivorous species in the initial stage (Area 1) and omnivorous species in the intermediary stage (Area 2) were higher than in the advanced stage (Area 3). Detritivorous and piscivorous species were exclusively recorded in the initial stage of forest succession (Area 1). There were no differences in nectarivorous species between areas (Table 1, Figure 4).

Species of broad habitat were more commonly found in the initial stage (18.27%) and less often in the advanced stage (9.09%). Forest species were less often recorded in areas of initial succession (37.63%). Forest edge species were less often in the advanced stage (12.5%) than in the initial stage (22.58%). Open area species were most frequently recorded in areas of early succession (15.05%; Table 1, Figure 5).

DISCUSSION

The total species richness of 145 bird species can be considered high in comparison to other areas composed by mosaics of successional stages in south of the Atlantic Forest: 137 species in area of seasonal deciduous forest with riparian and secondary forest fragments (Valls *et al.* 2016), 103 species in area of secondary forest and anthropic fields (Santos & Cademartori 2007), 92 species in area composed by fields used for agricultural activities and secondary forest (Santos & Cademartori 2015) and 77 species in successional stage of Araucaria Forest (Kaminski *et al.* 2016). The richness found in the present study suggests that forests composed of different secondary successional stages are important for the maintenance of diversity in the Atlantic Forest (*e.g.*, Vianna *et al.* 1997, Kaminski *et al.* 2016). The pattern of continuous and heterogeneous forest, formed by mosaics of successional stages, seems to contribute to the maintenance of bird populations in the Atlantic Forest (Casas *et al.* 2016), due to its high floristic recovery capacity (Guariguata & Ostertag 2001, Protomastro 2001, Dewalt *et al.* 2003). Forest restructuring processes make it possible for species with different ecological requirements to occur, affecting the community composition and species richness of a determined region (Aleixo 1999, Lehman & Tilman 2000). The heterogeneity of forest environments found in TSP due to different stages of forest succession may thus explain the large number of bird species in the area (Junior *et al.* 2016), although the effects of

Table 1. Comparisons of species richness per feeding habit and habitat use of bird species among the tree sampling areas (Area 1 - secondary forest in initial succession stage; Area 2 - secondary forest in intermediary stage; Area 3 - secondary forest in advanced stage) through Analysis of Variance with Tukey post-hoc test ($p < 0.05$), in the Mata do Rio Uruguai Teixeira Soares Municipal Park, Rio Grande do Sul state, Brazil.

Feeding habit	Three areas	Area 1 and 2	Area 1 and 3	Area 2 and 3
Carnivorous	$F = 3.35$; $p = 0.06$	-	-	-
Frugivorous	$F = 3.92$; $p = 0.04$	-	$p < 0.05$	-
Granivorous	$F = 5.49$; $p = 0.01$	-	$p < 0.05$	-
Insectivorous	$F = 4.14$; $p = 0.03$	$p < 0.05$	$p < 0.05$	-
Nectarivorous	$F = 1.23$; $p = 0.31$	-	-	-
Omnivorous	$F = 4.90$; $p = 0.02$	-	-	$p < 0.05$
Habitat use				
Broad	$F = 26.38$; $p < 0.01$	$p < 0.05$	$p < 0.05$	$p < 0.05$
Forest	$F = 18.88$; $p < 0.01$	$p < 0.05$	$p < 0.05$	-
Forest edge	$F = 5.21$; $p = 0.01$	-	$p < 0.05$	-
Open area	$F = 12.07$; $p < 0.01$	$p < 0.05$	$p< 0.05$	-
Wetlands	$F = 1.09$; $p = 0.36$	-	-	-

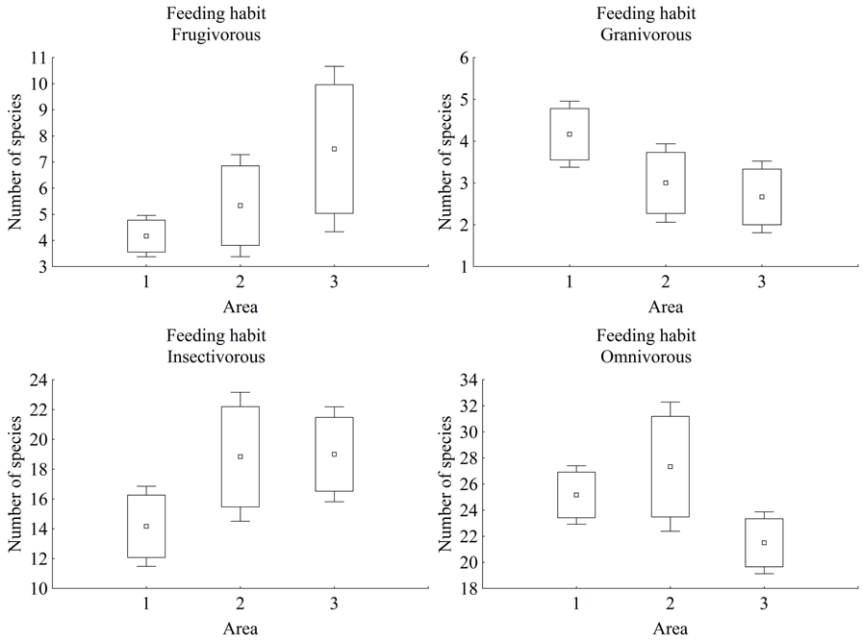

Figure 4. Number of bird species per feeding habit type in the Mata do Rio Uruguai Teixeira Soares Municipal Park, Rio Grande do Sul state, Brazil. Only groups for which the species richness differed between the areas are shown. Middle point (mean), boxes (mean ± standard errors), and vertical bars (mean ± conf. interval). Area 1 - secondary forest in initial succession stage; Area 2 - secondary forest in intermediary stage; Area 3 - secondary forest in advanced stage.

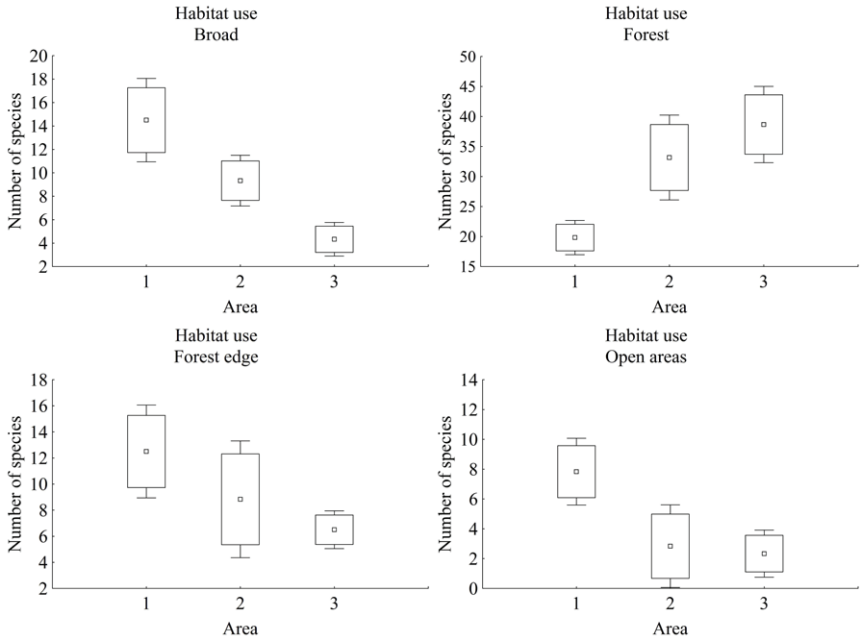

Figure 5. Number of bird species per habitat use type in the Mata do Rio Uruguai Teixeira Soares Municipal Park, Rio Grande do Sul state, Brazil. Only groups for which the species richness differed between the areas are shown. Middle point (mean), boxes (mean ± standard errors), and vertical bars (mean ± conf. interval). Area 1 - secondary forest in initial succession stage; Area 2 - secondary forest in intermediary stage; Area 3 - secondary forest in advanced stage.

other factors, such as distance from source areas and connectivity (Martensen *et al.* 2012), should be evaluated in future studies. Furthermore, even though almost 90% of the species richness has been recorded, it is probable that by increasing sampling time, new species will be added, increasing the total bird species richness for the TSP.

In regions with different stages of forest succession, intermediate stages are expected to harbor the greatest bird abundance, since they have more heterogeneous habitats that can be used by several bird species with flexible behaviors and broad environmental tolerance (Sick 2001, Casas *et al.* 2016). Intermediate stages of forest succession, especially when physically connected to the early and advanced stages, also tend to have transitional landscape features (Garcia *et al.* 2011). This characteristic may allow species typical of other successional stages to occupy the area, albeit sporadically. The greater species overlap and similarity with the other areas and the smaller number of exclusive species in Area 2 corroborate this hypothesis.

When more preserved areas are continually reduced, birds that are more demanding in relation to environmental quality tend to disappear over time (Leck 1979). In addition to the distinct matrix, forest clearings around the forest fragment may represent a barrier to many bird species adapted to live inside the forests, which prevents the flow of individuals between the fragments (Goerck 1997, Gimenes & Anjos 2003). Different successional stages can function as a selective filter for the dispersion of individuals (Loures-Ribeiro *et al.* 2011), determining which species will be able to cross it and how often. Thus, even different successional stages might be considered matrix habitat for certain groups of birds (Berg 1997). Consequently, species richness in advanced stages seems to be associated not only with the total fragment size, but also with the quality of the surrounding habitat (Dunford & Freemark 2005, Smith *et al.* 2011).

TSP is one of the few forest fragments in the region covering more than 400 ha (including all successional stages). The advanced stage comprises approximately 40% of the park area. However, areas in an advanced stage of succession are rare and usually small around the TSP, and areas in the initial and intermediate stages are relatively common (Park Management Plan 2012). Primary and secondary forests in advanced stage of succession are expected to include species that are more sensitive to habitat modification (Boçon 2010). In fact, even small preserved forest fragments are considered important for the persistence of more demanding birds in Neotropical fragmented landscapes (Whitmore 1997, Anjos *et al.* 2011). It seems the case for *Corythopis delalandi*, *Habia rubica*, *Mionectes rufiventris, Sclerurus scansor* and *Tinamus solitarius*, which tend to be sensitive to the edges and restricted to the most preserved area in the present study.

There was a predominance of omnivorous and insectivorous species in TSP. According to Willis (1979), omnivory is a common and opportunistic trophic category in open areas and under the anthropic influence, since it has a buffer effect against fluctuations in food supply. Environmental changes may lead to an increase in omnivorous and possibly less specialized insectivorous birds, and a decrease in more specialized frugivorous and insectivorous birds (Willis 1979). The high percentage of insectivorous bird species is a pattern in the tropical region (Sick 2001).

Even though there was no significant difference in the number of species and individuals recorded between the areas, there was a difference in species composition. Insectivorous species were mostly recorded in the intermediate and advanced stages of succession. This reinforces the proposal that insectivorous are sensitive to human impacts (Lohr *et al.* 2002, Roshan *et al.* 2017), since they were less common in the most impacted area (Area 1). The granivorous birds were more common in the initial stage of succession, possibly due to the presence of large open areas with grass cover, which provide a high amount of seeds (Roshan *et al.* 2017). The detritivorous species were only found in Area 1, represented by *Coragyps atratus* and *Cathartes aura*, because they do not inhabit forest areas exclusively and do not require them for survival (Belton 2004).

The presence of frugivorous birds in secondary successional stages positively affects the forest recovery process, since they contribute to the dispersion of seeds from more advanced stages (Metzger *et al.* 2009). Frugivorous species were less commonly recorded in the initial stage, and apparently are among those susceptible to habitat

reduction and mischaracterization (Aleixo 1999). On the other hand, omnivorous species were more often associated with the intermediary stage, indicating that they can occupy less preserved areas.

Species of forest habitat were the most common in TSP, which may be related to the complexity of the vegetation and the high density of arboreal species in comparison with the other areas. Open-area bird species were recorded in Area 1, because the conditions in this area allowed its occupation by species that inhabit fields, such as *Sporophila caerulescens*, *Volatina jacarina*, *Sicalis flaveola* and *Zonotrichia capensis*, which occupy open and shrub areas (Sick 2001, Belton 2004, Ridgely & Tudor 2009).

Broader and forest edges habitats species were more frequent in the initial stage, because this area is the most altered, which possibly enables occupation by generalist species such as *Coragyps atratus*, *Molothrus bonariensis*, *Troglodytes musculus* (Sick 2001, Cavarzere *et al.* 2009), as it enables the presence of omnivorous species that use a relatively broad range of resources or habitats (Colles *et al.* 2009).

The coexistence of bird species typical of more preserved forests and secondary stage of succession, recorded in this study, may be associated with the TSP forest matrix, which is formed of a mosaic of closely related environments, and favors the circulation of species (Aleixo 1999, Barlow *et al.* 2007). The differences found in ecological traits between the areas reinforce the possibility that the species occupy habitats associated with their ecological limits. This emphasizes the importance of maintaining areas at an advanced stage of succession (Loures-Ribeiro *et al.* 2011), especially because these forested areas are proportionally smaller in size and quantity in the park

Differences in species composition and diversity between areas indicate that bird community structure seems linked to the successional stages (Lehman & Tilman 2000, Antongiovanni & Metzger 2005). This relationship is reinforced by the differences in the presence of birds with specific ecological traits between the areas, and by the number of exclusive species in the initial and final stages of succession. Past changes in the landscape promoted a restructuring of the community, when species with particular ecological traits were favored or excluded from the successional stages (Beier *et al.* 2002, Gimenes & Anjos 2003, Silva *et al.* 2017).

The high diversity found in this study highlights the importance of TSP for bird conservation. Located in a region with a highly fragmented landscape and composed of different stages of forest succession, the TSP is one of the few fragments of deciduous seasonal forest (Uruguay River Forest) in the study region. Even areas that have undergone deforestation in the past, and today include different stages of forest succession, may comprise conservation possibilities for birds typical of subtropical forest.

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Appendix 1. Bird species recorded, in the Mata do Rio Uruguai Teixeira Soares Municipal Park, Rio Grande do Sul state, Brazil. Feeding habits: Carnivorous (Car), detritivorous (Det), frugivorous (Fru), granivorous (Gra), insectivorous (Ins), nectarivorous (Nec), omnivorous (Oni), Piscivorous (Pis); Habitat use: broad (Bro), forest (For), forest edge (Fe), open area (Oa), wetland (Wet). Succession stage: Secondary forest in initial succession stage (A1), secondary forest in intermediary stage (A2), secondary forest in advanced stage (A3). Occasional encounters (OE).

Taxa	Feeding habit	Habitat use	A1	A2	A3	OE
TINAMIFORMES						
Tinamidae						
Crypturellus obsoletus	Gra	For		X	X	
Tinamus solitarius	Oni	For			X	
GALLIFORMES						
Cracidae						
Penelope obscura	Oni	For				X
PELECANIFORMES						
Ardeidae						
Bubulcus ibis	Ins	Oa				X
Egretta thula	Pis	Wet				X
Syrigma sibilatrix	Oni	Oa	X			
Threskiornithidae						
Mesembrinibis cayennensis	Oni	Wet	X	X	X	
Plegadis chihi	Oni	Wet				X
Phimosus infuscatus	Oni	Wet				X
Theristicus caudatus	Ins	Oa	X	X	X	
CATHARTIFORMES						
Cathartidae						
Cathartes aura	Det	Bro	X			
Coragyps atratus	Det	Bro	X			
ACCIPITRIFORMES						
Accipitridae						
Ictinia plumbea	Ins	Fe	X		X	
Elanoides forficatus	Car	Bro				X
Rupornis magnirostris	Car	Bro	X	X	X	
GRUIFORMES						
Rallidae						
Aramides saracura	Oni	For	X	X	X	
CHARADRIIFORMES						
Charadriidae						
Vanellus chilensis	Oni	Oa	X	X		
COLUMBIFORMES						
Columbidae						
Columbina talpacoti	Gra	Oa	X	X	X	
Leptotila rufaxilla	Oni	For	X	X	X	
Leptotila verreauxi	Gra	For	X	X	X	
Patagioenas picazuro	Gra	Bro	X	X	X	

Appendix 1. Continued on next page…

Appendix 1. ...Continued

Taxa	Feeding habit	Habitat use	A1	A2	A3	OE
Zenaida auriculata	Oni	Bro	X	X		
CUCULIFORMES						
Cuculidae						
Crotophaga ani	Ins	Oa				X
Crotophaga major	Ins	For				X
Guira guira	Ins	Oa	X			
Piaya cayana	Ins	Fe	X	X		
Tapera naevia	Ins	Oa	X			
CAPRIMULGIFORMES						
Caprimulgidae						
Hydropsalis forcipata	Ins	Fe	X			
Hydropsalis torquata	Ins	Oa	X			
Nyctidromus albicollis	Ins	Fe				X
APODIFORMES						
Apodidae						
Chaetura meridionalis	Ins	Fe	X	X		
Trochilidae						
Chlorostilbon lucidus	Nec	Bro	X	X		
Leucochloris albicollis	Nec	Fe	X	X		
Phaethornis pretrei	Nec	Fe			X	
Stephanoxis loddigesii	Nec	Fe	X	X	X	
TROGONIFORMES						
Trogonidae						
Trogon surrucura	Oni	For	X	X	X	
CORACIIFORMES						
Alcedinidae						
Chloroceryle americana	Car	Wet				X
Megaceryle torquata	Pis	Wet	X			
PICIFORMES						
Ramphastidae						
Ramphastos dicolorus	Oni	For	X	X	X	
Picidae						
Colaptes campestris	Ins	Oa	X	X		
Colaptes melanochloros	Oni	Oa	X	X	X	
Melanerpes candidus	Oni	Bro	X			
Piculus aurulentus	Ins	For		X	X	
Picumnus temminckii	Ins	For		X		
Veniliornis spilogaster	Ins	For	X	X	X	
CARIAMIFORMES						
Cariamidae						
Cariama cristata	Oni	Oa				X

Appendix 1. Continued on next page…

Appendix 1. ...Continued

Taxa	Feeding habit	Habitat use	A1	A2	A3	OE
FALCONIFORMES						
Falconidae						
Micrastur semitorquatus	Car	For				X
Micrastur ruficollis	Car	For			X	
Milvago chimachima	Oni	Bro		X		
PSITTACIFORMES						
Psittacidae						
Pionopsitta pileata	Fru	For		X	X	
Pionus maximiliani	Fru	For	X	X	X	
Pyrrhura frontalis	Fru	For	X	X	X	
PASSERIFORMES						
Thamnophilidae						
Dysithamnus mentalis	Ins	For		X	X	
Thamnophilus caerulescens	Ins	For	X	X	X	
Thamnophilus ruficapillus	Oni	Oa		X		
Formicariidae						
Chamaeza campanisona	Ins	For		X	X	
Scleruridae						
Sclerurus scansor	Ins	For			X	
Dendrocolaptidae						
Dendrocolaptes platyrostris	Ins	For		X	X	
Lepidocolaptes falcinellus	Ins	For	X	X	X	
Sittasomus griseicapillus	Ins	For	X	X		
Xiphorhynchus fuscus	Ins	For		X	X	
Furnariidae						
Lochmias nematura	Ins	For	X	X	X	
Philydor rufum	Ins	For		X	X	
Synallaxis cinerascens	Ins	For		X	X	
Synallaxis ruficapilla	Ins	For		X	X	
Synallaxis spixi	Ins	Oa	X	X		
Syndactyla rufosuperciliata	Ins	For		X	X	
Pipridae						
Chiroxiphia caudata	Fru	For		X	X	
Tityridae						
Pachyramphus polychopterus	Oni	Fe	X	X	X	
Pachyramphus validus	Ins	For			X	
Schiffornis virescens	Oni	For			X	
Tityra cayana	Oni	Fe	X	X	X	
Tityra inquisitor	Fru	Fe				X
Platyrinchidae						
Platyrinchus mystaceus	Ins	For			X	

Appendix 1. Continued on next page…

Appendix 1. ...Continued

Taxa	Feeding habit	Habitat use	A1	A2	A3	OE
Rhynchocyclidae						
Corythopis delalandi	Ins	For			X	
Leptopogon amaurocephalus	Ins	For	X	X	X	
Mionectes rufiventris	Oni	For			X	
Phylloscartes ventralis	Ins	For	X	X	X	
Poecilotriccus plumbeiceps	Ins	For	X	X	X	
Tolmomyias sulphurescens	Ins	For	X	X	X	
Tyrannidae						
Camptostoma obsoletum	Ins	Bro	X	X		
Elaenia flavogaster	Oni	Fe		X		
Elaenia mesoleuca	Oni	Fe	X	X	X	
Elaenia parvirostris	Oni	Fe	X	X		
Elaenia spectabilis	Oni	Fe				X
Empidonomus varius	Ins	Fe	X	X	X	
Legatus leucophaius	Oni	Fe	X	X	X	
Megarynchus pitangua	Oni	Fe	X	X	X	
Myiarchus swainsoni	Oni	For	X	X	X	
Myiodynastes maculatus	Oni	For	X	X	X	
Myiopagis viridicata	Ins	For	X	X	X	
Phyllomyias virescens	Ins	For	X	X		
Pitangus sulphuratus	Oni	Bro	X	X	X	
Serpophaga subcristata	Ins	Oa		X		
Sirystes sibilator	Oni	For		X		
Tyrannus savana	Ins	Oa				X
Tyrannus melancholicus	Ins	Fe	X	X		
Vireonidae						
Cyclarhis gujanensis	Oni	Fe	X	X	X	
Hylophilus poicilotis	Oni	For		X	X	
Vireo chivi	Oni	For	X	X	X	
Corvidae						
Cyanocorax chrysops	Oni	For	X	X	X	
Hirundinidae						
Progne chalybea	Ins	Bro				X
Troglodytidae						
Troglodytes musculus	Ins	Bro	X			
Turdidae						
Turdus albicollis	Oni	For	X	X	X	
Turdus amaurochalinus	Oni	Bro	X	X	X	
Turdus leucomelas	Oni	Bro	X	X	X	
Turdus rufiventris	Oni	Bro	X	X	X	
Turdus subalaris	Oni	For	X	X	X	

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Appendix 1. ...Continued

Taxa	Feeding habit	Habitat use	A1	A2	A3	OE
Mimidae						
Mimus saturninus	Oni	Oa				X
Passerellidae						
Zonotrichia capensis	Oni	Bro	X	X		
Parulidae						
Basileuterus culicivorus	Ins	For	X	X	X	
Geothlypis aequinoctialis	Ins	Oa	X			
Myiothlypis leucoblephara	Ins	For	X	X	X	
Setophaga pitiayumi	Ins	For	X	X	X	
Icteridae						
Agelaioides badius	Oni	Oa				X
Cacicus chrysopterus	Oni	For	X	X	X	
Cacicus haemorrhous	Oni	For	X	X	X	
Icterus pyrrhopterus	Oni	For			X	
Molothrus bonariensis	Oni	Bro	X			
Thraupidae						
Conirostrum speciosum	Ins	For		X	X	
Coryphospingus cucullatus	Oni	Fe	X	X		
Embernagra platensis	Oni	Oa				X
Haplospiza unicolor	Oni	For	X	X	X	
Hemithraupis guira	Fru	For		X	X	
Microspingus cabanisi	Oni	Fe	X	X		
Pipraeidea bonariensis	Fru	Bro	X			
Poospiza nigrorufa	Oni	Wet	X	X		
Pyrrhocoma ruficeps	Ins	For	X	X	X	
Saltator similis	Oni	For	X	X	X	
Sicalis flaveola	Gra	Bro	X			
Sporophila caerulescens	Gra	Oa	X			
Stephanophorus diadematus	Fru	Fe	X	X		
Tachyphonus coronatus	Oni	For	X	X	X	
Tangara preciosa	Fru	For	X	X	X	
Tangara sayaca	Oni	Bro	X	X	X	
Tersina viridis	Oni	Fe				X
Trichothraupis melanops	Oni	For		X	X	
Volatinia jacarina	Gra	Oa	X			
Cardinalidae						
Cyanoloxia brissonii	Oni	Fe	X	X		
Habia rubica	Oni	For			X	
Piranga flava	Oni	Bro		X		
Fringillidae						
Chlorophonia cyanea	Fru	For			X	

Appendix 1. Continued on next page…

Appendix1. ...Continued

Taxa	Feeding habit	Habitat use	A1	A2	A3	OE
Euphonia chalybea	Fru	For	X	X	X	
Euphonia chlorotica	Fru	Bro			X	
Spinus magellanicus	Gra	Oa	X	X	X	