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ARTICLE

Twenty-three years of bird monitoring reveal low extinction and colonization of species in a reserve surrounded by an extremely fragmented landscape in southern Brazil

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ABSTRACT: Human activities have modified landscapes worldwide, promoting fragmentation and isolation of forest habitats. Such landscape modifications are responsible for changes in species composition due to extinction and colonization events. Forest species dynamism is usually affected by forest fragmentation when remaining fragments are small and isolated, but forest dynamism is usually more stable when forest fragments are large and connected. In this study we verified changes in bird composition during 23 years of bird monitoring at the Mata dos Godoy State Park (PEMG). We aimed to evaluate the avian community dynamism of this reserve, as well as its effectiveness in protecting biodiversity in an extremely fragmented landscape. We reviewed historical records of bird species composition and checked for any possible misidentifications, updated the list and created an annual data set of bird species occurrence. We used this list to evaluate species persistence, species loss, and colonization over the study period. Additionally, species were classified according to their guilds in order to determine which species traits were associated with local extinction. A total of 331 bird species were recorded in PEMG over 23 years of monitoring, 17 of which were considered locally extinct or possibly extinct, and 11 were recent local colonizations. This indicates that bird composition in PEMG has been relatively stable over the years. However, local extinction was more likely for large frugivores and insectivores, which are guilds already known to be more susceptible to local extinction. Colonizations, in turn, were associated with guilds of more open habitats, like edge insectivores. We suggest that extinctions and colonizations are also potentially related to species distribution ranges and climate change. Although local extinctions occurred, PEMG still maintains a significant fraction of its historical avifauna and may potentially maintain source populations for many bird species, thus making it an important reserve for the north of Paraná.

KEY-WORDS: avifauna, Atlantic Forest, forest fragment dynamism, Protected Area, species persistence.

INTRODUCTION

Human activities, such as food and energy production, are responsible for the modification of landscapes worldwide (Foley *et al.* 2005, Sodhi & Ehrlich 2010, Haddad *et al.* 2015). These activities contribute to changes in climate regimes, loss of ecosystem services such as air and water quality and decrease in forest cover, all of which result in biodiversity loss (DeFries *et al.* 2004, Foley *et al.* 2005, Zhao *et al.* 2006, Haddad *et al.* 2015). In the Atlantic Forest Biome, a biodiversity hotspot (Myers *et al.* 2000), this scenario is alarming because only 11.4% to 16% of the original forest cover still remains (Ribeiro *et al.* 2009). Exacerbating this situation is the fact that the majority of the remaining forest fragments are smaller than 50 ha (Ribeiro *et al.* 2009) and surrounded by a matrix of anthropogenic habitats (*e.g.* plantations and urban areas) (Tabarelli *et al.* 2010).

The Atlantic Forest Biome consists of several different forest formations that have suffered different deforestation pressures (Galindo-Leal & Câmara 2003). In the north of Paraná state (southern Brazil), which is comprised by semi-deciduous forest formations, deforestation has led to the loss of approximately 98% of the original forest cover (Torezan *et al.* 2005). In this landscape scenario, however, Mata dos Godoy State Park (*Parque Estadual Mata dos Godoy* - PEMG) stands out as potentially the most important reserve since it is the largest and most well preserved forest fragment in the north of Paraná state (Anjos *et al.* 2007, 2009). Even though this reserve is

immersed in an agro-mosaic matrix, much of the regional fauna of anurans (Bernarde & Anjos 1999, Machado & Bernarde 2006), reptiles (Bernarde & Machado 2006) and birds (Anjos *et al.* 1997, Anjos 2001) are well represented in PEMG. Also, PEMG contains 21 threatened species and 15 rare species of Angiosperms (Rossetto & Vieira 2013), which makes PEMG an important reserve for semi-deciduous forest formations. In fact, this protected area has become a regional conservation reference not only because of its intrinsic biological value, but also because of the development of several environmental educational programmes with local communities.

Despite its importance for regional conservation, PEMG still suffers several threats. The biggest threat to PEMG is the expansion of agriculture, which has taken place in the last seven decades, but others threats such as illegal hunting, invasive species and water pollution are also present (IAP 2002). At the landscape level, the continuation of habitat loss has led to an increase in forest fragmentation and its associated negative outcomes, such as edge effects and forest fragment isolation. These landscape modifications could have important consequences for forest fragment dynamism (Laurance 2002). According to the concept of forest fragment hyperdynamism, small and isolated areas tend to be strongly affected by the impacts of fragmentation in a short time frame and should present, for example, high species turnover (Laurance *et al.* 1998, Laurance *et al.* 2002). Conversely, large connected forest fragments tend to suffer fewer changes in the same short time frame with a weak dynamism, because it will usually harbor a higher number of persisting species (Bierregaard *et al.* 1992, 1998, 2002, Laurance 2010). Laurance (2002) suggested that forest fragmentation tends to affect the dispersion of species and individuals, leading to an increase in colonization of generalist, invasive and pathogenic species, which will usually modify biological interactions (*i.e.* through competition). These in turn will affect both species abundance and composition (Bierregaard *et al.* 1992, Laurance *et al.* 2002, Laurance 2002, 2010). However, the effects on forest dynamism will depend on the duration and strength of these and other impacts, and on the characteristics of the forest fragment (Laurance 2002, Laurance *et al.* 2002). At the moment, it is uncertain if PEMG has maintained its biodiversity over the years. Therefore, it is crucial to document how species composition has changed since PEMG became a legal reserve to assess its current and future role in the protection of biodiversity. Moreover, this will provide a better understanding of which species are more susceptible to local extinction in semi-deciduous forest formations of the Atlantic Forest.

In this study we verified if the bird community of PEMG has been maintained over the years after it was recognised as a legal reserve in 1989. Historical data sets are an important component to determine the persistence, colonization and/or local extinction of species. However, before using this type of data it is important to review the historical records of the literature to guarantee that the data does not contain dubious records (*i.e.* misidentification). Lees *et al.* (2014) suggest several ways of dealing with misidentification. For instance, one could use the distributional range of the species in question to determine if it overlaps with the dubious record, or one could possibly determine if suitable habitat for the species occurs in the area in question, or even the possibility of a mix up between very similar species (*e.g. Drymophila ferruginea* and *D. rubricollis*). We have two goals for this study, the first one to present a revised historical checklist for the birds of PEMG, where we present species occurrence data from 1993 to 2015 and check for possible misidentifications. Our second goal is to use this revised checklist to assess the potential species dynamism in this reserve during the last 23 years. Because birds are recognized as good biological indicators and capable of responding to primary and secondary causes of environmental changes (Morrison 1986, Temple & Wiens 1989, Koskimies 1989, Kushlan 1993, Piratelli *et al.* 2008), our approach will allow us to determine how effective PEMG is for the conservation of the regional biota in the north of Paraná state.

METHODS

Study area

Mata dos Godoy State Park (23°27'S; 51°15'W, PEMG, Figure 1) is the largest and best preserved forest fragment in northern Paraná state, south of Brazil (Anjos *et al.* 2007). PEMG is located in Espírito Santo District, 15 km from the center of the municipality of Londrina and over the Tropic of Capricorn. This reserve covers 656 ha and is mainly composed by pristine seasonal semi-deciduous forest (Figure 1, Torezan 2002). PEMG presents a natural variation in topography, which allows one to divide PEMG in two different regions comprised of pristine forest. One of the regions is located in the north and consists of a plateau at an altitude of approximately 600 m, while the second region is located in the south of PEMG and consists of a hillside that ranges from 600 to 470 m a.s.l. (Anjos *et al.* 2007). This difference in elevation is responsible for the widespread occurrence of bamboo vegetation in the southern part of PEMG, which results in differences in the occurrence of bird species between these two areas (see Anjos *et al.* 2007, Santana & Anjos 2010). For more details on the vegetation of PEMG see Silveira (2006) and Rossetto & Vieira (2013). This reserve also harbor an area of secondary forest in the southeast, an

area of open habitats (*e.g.* pasture or initial regeneration) in the northern portion, and a reforestation area that was implemented twenty years ago (IAP 2002; Figure 1).

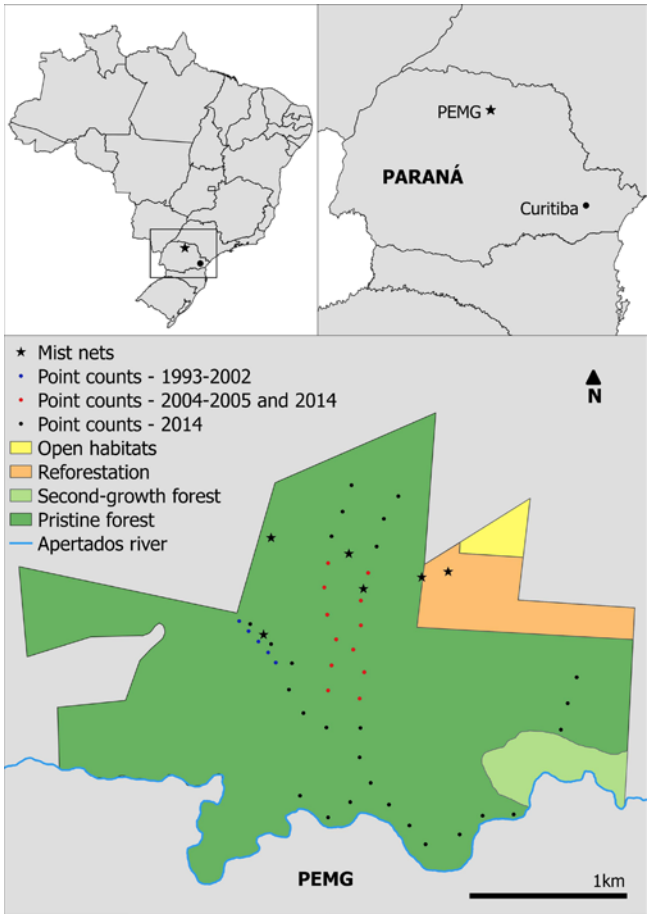

FIGURE 1. Location of Mata dos Godoy State Park (PEMG, 23°27'S; 51°15'W) in the north of Paraná state, south of Brazil.

A matrix of privately owned agricultural land surrounds the northern and western borders of PEMG, while the Apertados River borders the south and a continuous forest fragment borders the east. Considering all forest fragments surrounding PEMG up to a distance of 1 km, connected or not to PEMG, there is a mosaic of forest cover of approximately 2800 ha (Lopes *et al.* 2006). PEMG is situated in the Tibagi River basin (IAP 2002) and according to Köppen classification, the climate of the region is Cfa, subtropical humid with rainy summers, average yearly temperatures of 21°C and average maximum and minimum temperatures of 28°C and 16°C, respectively.

Data set

The historical data set was obtained using both the scientific literature and unpublished data. From the scientific literature, we compiled data on bird species using ten scientific papers published between 1997 and 2015 (Table 1). Several studies (*e.g.* Anjos & Schuchmann 1997, Anjos *et al.* 2010) were excluded from the literature review because bird data from these specific studies had already been published in one of the ten references listed in Table 1.

TABLE 1. Published bird occurrence data in PEMG, Paraná state, Brazil, and the respective period in which fieldwork was conducted.

Published papers	Period of field work
Anjos *et al.* 1997	1992–1996
Anjos & Ferreira 1998	September 1997
Anjos 2001	January–December 1996
Anjos *et al.* 2004	September–December 1997
Anjos *et al.* 2007	September–December 2001
Lopes *et al.* 2006	2003–2004
Anjos *et al.* 2011	2004–2005
Santana & Anjos 2010	2007
Bochio & Anjos 2012	2009–2010
Zaiden *et al.* 2015	2010–2011

Unpublished data, in turn, consisted of different methodologies and sampling efforts that were conducted between 1993 and 2015, these methods were: *ad libitum* searches, point counts, and bird capture with mist nets. *Ad libitum* searches by different observers were conducted in the entire area of PEMG without controlling for sampling effort. Point counts (Vielliard & Silva 1990, Bibby *et al.* 1993) were performed in PEMG during three different periods: (1) 1993–2002, (2) 2004–2005, and (3) 2014. For the first period, point counts were conducted in 1993, 1995–1999, 2001 and 2002. In each of these years, with the exception of 1996, five point counts in pristine forest were sampled twice during spring (October). In 1996, the same point counts were performed once a month from January to December (Anjos 2001). Point counts in all these years (including 1996) were placed 100 m apart and at least 50 m away from the forest edge (Figure 1). Sampling time for each point was 20 minutes, and the radius of detection was unlimited. For the second time period, point counts were conducted every season in 2004 and 2005. In this case, six point counts along two trails were placed 200 m apart, giving a total of 12 points (Figure 1). Point counts were sampled for 15 minutes with a detection radius ≤100 m (Anjos *et al.* 2011). Data from spring and summer from this second time period were published in Anjos *et al.* (2011, 2015), but for the present study we have also incorporated unpublished records from autumn and winter. The third point count sampling period occurred from September to December 2014. In this case, 39 point counts (with 15 min sampling time and a detection radius ≤50 m) were placed along 13 trails, each trail consisted of three point counts at 200 m intervals (Figure 1). Each point count was sampled

four times during the sampling period. In all of the three-time periods, bird sampling was conducted early in the morning and started with species vocal activity. Sampling ended approximately 3 h later.

Mist nets were placed in six different locations in PEMG between February and October 2015 (Figure 1), with a total sampling effort of 10,332 h.m^2. Mist nets procedures followed Roos (2010).

Bird nomenclature and systematic classification are in accordance with the list of Brazilian birds reviewed and updated by the *Comitê Brasileiro de Registros Ornitológicos* (Piacentini *et al.* 2015). The conservation status of each species was based on IUCN (2015), ICMBio (2014) and Mikich & Bérnils (2004) at the global, national and regional levels, respectively. We used Bencke *et al.* (2006) to classify species as endemic to the Atlantic Forest.

Data analysis

The data set was organized on an annual basis and bird records were divided into two larger time periods, before and after 2005 (Appendix I). We only considered presence and absence data because sampling effort among studies, from the scientific literature or unpublished data, were not standardized, making quantitative comparisons unfeasible. Based on this list, we carefully reviewed questionable records (*e.g.* misidentifications) in order to eliminate "false presences". This procedure allowed for the correct evaluation of local species persistence in PEMG (Lees *et al.* 2014) according to the categories presented below.

We categorized bird species as: 1) "forest persistent", forest bird species that were recorded regularly in the entire study period; 2) "non-forest persistent", species that inhabit non-forest habitats and were recorded regularly in the entire study period; 3) "forest persistent and declining", forest species that were recorded regularly up to 2005, but were only recorded in one or two years after 2005; 4) "possibly extinct", forest species that were regularly recorded until 2005, but were not recorded thereafter; 5) "extinct", forest species that were regularly recorded until 2000, but not afterwards, or species that are easily detectable (*e.g. Odontophorus capueira*) but were recorded only in the first years of monitoring (1993–1996); 6) "frequent migrants", migrant species in the south of Brazil that were present during most of the studied years; 7) "occasional migrants", migrant species that were occasionally found during the study period; 8) "colonizer", species that were found in consecutive years in the study area after 2005 and not before; 9) "sporadic species", species for which PEMG harbor unsuitable habitat (*e.g.* Ardeidae) and that had few and infrequent records during the entire study period; 10) "indeterminate", species with few and infrequent records during the entire study period and for which PEMG harbor suitable habitat for the specie. For the last case we were unable to classify the species as persistent, extinct or colonizer. Classification into forest, non-forest and migrant species follows Sick (1997), del Hoyo *et al.* (2015) and our personal observations in the study area. For species that were mentioned in the literature as both forest and non-forest, we used the habitat that was described as preferred for the species.

The Sørensen Index of Similarity (Magurran 1988) was used to analyse variation in species composition over time. We used this index to calculate how similar the two time periods were (before 2005 and after 2005). The following formula was used to calculate the Sørensen Index of Similarity: $Ss = 2j / (a + b)$; where j corresponds to the number of species common to both periods (before 2005 and after 2005), a represents the number of species present before 2005 and b the number of species present after 2005 (Magurran 1988). For this analysis we first pooled the species in the categories "extinct", "possibly extinct", "forest persistent", "non-forest persistent", "forest persistent and declining" and "colonizer". We then excluded "colonizer" species in order to verify only the effects of extinctions over the periods.

In order to evaluate if certain traits made the species more prone to extinction, species were grouped according to their guilds. Species were classified using a combination of food resources explored by the species and habitat choices, which were mainly based on Willis (1979), Ribon *et al.* (2003), Giraudo *et al.* (2008) and our own field observations. Species were classified as: carnivores (CA); carrion eaters (CE); large frugivores (LF); small frugivores (SF); seedeaters (SE); nectarivores (NE); ground insectivores (GI); understory insectivores (UI); trunk and twig insectivores (TI); sub-canopy and canopy insectivores (SCI); aerial insectivores (AI); edge insectivores (EI); nocturnal insectivores (NI); ground omnivores (GO); understory omnivores (UO); sub-canopy and canopy omnivores (SCO); edge omnivores (EO); aquatic omnivores (AO); and piscivorous (PI).

To visualize which guilds increased or decreased in number of species during the last 23 years in PEMG, we plotted a graph with the number of species in each guild that were present before and after 2005. For this analysis, we excluded the following categories: "frequent migrant", "occasional migrant", "sporadic species" and "indeterminate". We considered a species to be declining and in risk of future extinction when it presented a decline in occurrence records after 2005. We used this data to determine the future tendency in the number of species for each guild. Future tendency of a guild was defined as the number of species present after 2005, subtracting the number of species in the category "forest persistent and declining" (Figure 2).

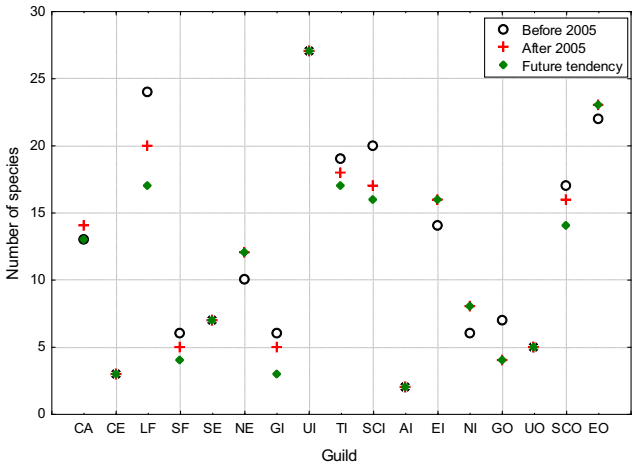

FIGURE 2. Number of species before and after 2005 for each bird guild in Mata dos Godoy State Park (PEMG), Paraná state, Brazil. Only the following categories were considered: "extinct", "possibly extinct", "colonizer", "persistent and declining" and "persistent". For the latter category, both forest and non-forest bird species were considered. Species that presented a decline in occurrence records after 2005 were considered to be declining and in risk of future extinction and this data were used to determine the future tendency in the number of species for each guild. Guild: CA – carnivores; LF – large frugivores; SF – small frugivores; SE – seedeaters; NE – nectarivores; GI – ground insectivores; TI – trunk and twig insectivores; SCI – sub-canopy and canopy insectivores; EI – edge insectivores; NI – nocturnal insectivores; GO – ground omnivores; SCO – sub-canopy and canopy omnivores; EO – edge omnivores.

RESULTS

A total of 331 bird species were recorded during 23 years of bird monitoring in PEMG (Appendix I). Thirteen species found in the literature review were not included in this list of 331 bird species, either because their ranges did not include northern Paraná, or because they were recorded only once and could represent dubious records (Appendix II). Of the 331 species with confirmed presence in PEMG, 74 species are endemic to the Atlantic Forest, while 13 species are considered threatened either at the global, national or regional levels (Appendix I). Furthermore, 19 species are considered "Near threatened" at global and regional levels, and five species are considered as "Data deficient" in the Paraná state.

Bird community composition before and after 2005 was very similar (93%; Ss = 0.932). When colonizer species were excluded, bird species similarity between the two time periods increased (95%, Ss = 0.957), as expected. Therefore, PEMG presented a stable avifauna during the 23 years of bird monitoring. However, the number of species that went extinct promoted a higher dissimilarity (5%) between the two time periods than the number of species that later colonized PEMG (2%). This stability was expected because 191 out of the 331 species, that were originally found in PEMG, were considered as persistent (150 forest persistent, 30 non-forest persistent and 11 forest persistent and declining), while only 12 species were considered locally extinct, five species as possibly extinct and 11 species were considered to be recent colonizations, according to our criteria (Table 2). For the remaining species, 42 species were considered migrants (30 frequent and 12 occasional) and 70 were recorded only once or twice during the monitoring period (37 classified as sporadic and 33 as indeterminate; Appendix I).

A total of 28 bird species (~10%) were considered either as locally extinct, possibly extinct or persistent and declining. Moreover, of the 13 species considered threatened at global, national or regional levels recorded in PEMG during the entire monitoring period, seven are already locally extinct or possibly extinct and three others are considered to be declining (Table 2). Three species considered near threatened at regional and global levels were also considered locally extinct in PEMG. However, two species, *Myiothlypis flaveola* and *Nyctiphrynus ocellatus*, which are threatened bird species at the regional level, were considered to have recently colonized PEMG. If we exclude the species that went locally extinct, PEMG currently harbor 319 bird species (68 endemic to Atlantic Forest), out of which eight are threatened species, 16 near threatened and five data deficient for the Paraná state (Appendix I).

The most representative guilds, considering the total number of bird species originally recorded at PEMG (331), were edge omnivores (n = 36, 10.9%), understory insectivores (n = 31, 9.4%), sub-canopy and canopy insectivores (n = 30, 9.0%), edge insectivores (n = 28, 8.4%), large frugivores (n = 26, 7.8%), sub-canopy and canopy omnivores (n = 23, 6.9%), trunk and twig insectivores (n = 22, 6.6%) and carnivores (n = 22, 6.6%) (Appendix I). In general, insectivores were highly representative with 149 species (45.0%), followed by omnivores (84, 25.4%) and frugivores (35, 10.6%).

The two guilds with the highest number of species going locally extinct were large frugivores (33.3%, n = 4) and ground omnivores (16.6%, n = 2) (Table 3). Possibly extinct species were mainly represented by sub-canopy and canopy insectivores (40%, n = 2). Large frugivores had the highest number of forest bird species that are declining (27.2%, n = 3), followed by ground insectivores (18.2%, n = 2). Colonizers, on the other hand, were well represented by the insectivores and omnivores guilds (Table 3).

Large frugivores are expected to have a higher number of future local extinctions because of the decline in the number of species occurrence for this category (Figure 2). Small frugivores, ground insectivores, ground omnivores, trunk and twig insectivores, as well as sub-canopy and canopy insectivores were guilds that had a high number of species at risk of local extinction. Conversely, edge insectivores, edge omnivores, nocturnal insectivores and nectarivores tended to maintain local populations and may even see increases in the number of species in the future.

TABLE 2. Species considered extinct, possibly extinct, declining and recent colonisers in PEMG, Paraná state, Brazil. Local Status: EX – extinct; PE – possibly extinct; D – forest persistent and declining; C – colonizer. Conservation Status: VU – vulnerable; EN – endangered; CR – critically endangered; NT – near threatened; DD – data deficient; PR – regional level (Mikich & Bérnils 2004); BR – national level (ICMBio 2014); GL – global level (IUCN 2015). Guild: CA – carnivores; LF – large frugivores; SF – small frugivores; SE – seedeaters; NE – nectarivores; GI – ground insectivores; TI – trunk and twig insectivores; SCI – sub-canopy and canopy insectivores; EI – edge insectivores; NI – nocturnal insectivores; GO – ground omnivores; SCO – sub-canopy and canopy omnivores; EO – edge omnivores. Endemic species (E) follows Bencke *et al.* (2006).

Species	Local status	Conservation status	Guild
Crypturellus undulatus (Temminck, 1815)	EX	CR-PR	GO
Aburria jacutinga (Spix, 1825) E	EX	EN-GL; EN-BR; EN-PR	LF
Crax fasciolata Spix, 1825	EX	VU-GL; CR-PR	LF
Odontophorus capueira (Spix, 1825) E	EX		GO
Pulsatrix perspicillata (Latham, 1790)	EX	VU-BR; DD-PR	CA
Chamaeza ruficauda (Cabanis & Heine, 1859) E	EX		GI
Manacus manacus (Linnaeus, 1766)	EX		SF
Lipaugus lanioides (Lesson, 1844) E	EX	NT-GL; NT-PR	LF
Procnias nudicollis (Vieillot, 1817) E	EX	VU-GL	LF
Phylloscartes eximius (Temminck, 1822) E	EX	NT-GL	SCI
Tiaris fuliginosus (Wied, 1830)	EX		SE
Piranga flava (Vieillot, 1822)	EX	NT-PR	SCO
Tinamus solitarius (Vieillot, 1819) E	PE	NT-GL; VU-PR	GO
Campephilus melanoleucos (Gmelin, 1788)	PE		TI
Piprites chloris (Temminck, 1822)	PE		SCI
Hylophilus poicilotis Temminck, 1822 E	PE		EI
Polioptila lactea Sharpe, 1885 E	PE	NT-GL; EN-PR	SCI
Patagioenas plumbea (Vieillot, 1818)	D		LF
Strix hylophila Temminck, 1825 E	D	NT-GL	CA
Pteroglossus aracari (Linnaeus, 1758)	D	VU-PR	SCO
Piculus aurulentus (Temminck, 1821) E	D	NT-GL	TI
Primolius maracana (Vieillot, 1816)	D	NT-GL; EN-PR	LF
Triclaria malachitacea (Spix, 1824) E	D	NT-GL; VU-PR	LF
Grallaria varia (Boddaert, 1783)	D		GI
Hylopezus nattereri (Pinto, 1937) E	D		GI
Heliobletus contaminatus Berlepsch, 1885 E	D		SCI
Oxyruncus cristatus Swainson, 1821	D		SCO
Euphonia pectoralis (Latham, 1801) E	D		SF
Leptodon cayanensis (Latham, 1790)	C		CA
Buteo brachyurus Vieillot, 1816	C		CA
Nyctiphrynus ocellatus (Tschudi, 1844)	C	EN-PR	NI
Hydropsalis parvula (Gould, 1837)	C		NI
Amazilia versicolor (Vieillot, 1818)	C		NE
Amazilia lactea (Lesson, 1832)	C		NE
Myiarchus ferox (Gmelin, 1789)	C		EI
Myiarchus tyrannulus (Statius Muller, 1776)	C		EI
Myiothlypis flaveola Baird, 1865	C	VU-PR	EI
Thlypopsis sordida (d'Orbigny & Lafresnaye, 1837)	C		EO
Haplospiza unicolor Cabanis, 1851 E	C		SE

TABLE 3. Representation of guilds (%) in each category in PEMG, Paraná state, Brazil. Each column corresponds to 100% of the respective category. Guilds are as follows: CA – carnivores; CE – carrion eaters; LF – large frugivores; SF – small frugivores; SE – seedeaters; NE – nectarivores; GI – ground insectivores; UI – understory insectivores; TI – trunk and twig insectivores; SCI – sub-canopy and canopy insectivores; AI – aerial insectivores; EI – edge insectivores; NI – nocturnal insectivores; GO – ground omnivores; UO – understory omnivores; SCO – sub-canopy and canopy omnivores; EO – edge omnivores; AO – aquatic omnivores; and PI – piscivorous.

Guild	Extinct (100% = 12)	Possibly extinct (100% = 5)	Forest persistent declining (100% = 11)	Forest persistent (100% = 150)	Non-forest persistent (100% = 30)	Colonizer (100% = 11)
CA	8.3	-	9.1	4.7	13.3	18.2
CE	-	-	-	2.0	-	-
LF	33.3	-	27.2	11.3	-	-
SF	8.3	-	9.1	2.7	-	-
SE	8.3	-	-	1.3	13.3	9.1
NE	-	-	-	6.7	-	18.2
GI	8.3	-	18.2	1.3	3.3	-
UI	-	-	-	18.0	-	9.1
TI	-	20.0	9.1	10.7	3.3	-
SCI	8.3	40.0	9.1	10.7	-	-
AI	-	-	-	-	6.7	-
EI	-	20.0	-	2.7	30.0	18.2
NI	-	-	-	3.3	3.3	18.2
GO	16.7	20.0	-	2.0	3.3	-
UO	-	-	-	3.3	-	-
SCO	8.3	-	18.2	9.3	-	-
EO	-	-	-	10.0	23.3	9.1
AO	-	-	-	-	-	-
PI	-	-	-	-	-	-

DISCUSSION

Over the 23 years of bird monitoring, PEMG presented low species turnover and a high number of bird species persisting over this time period. Local extinction of bird species, as well as colonization of novel bird species, did occur in PEMG during this time period, but at low numbers. We argue that some features of PEMG contributed to its relative stability, these being high number of bird species, large core area, and functional connectivity with other forest fragments (Laurance 2002, Haddad *et al.* 2015), especially in the eastern area of PEMG, which borders a large forest fragment (Lopes *et al.* 2006). The high number of species in PEMG, in turn, could be explained by the natural heterogeneity of the pristine vegetation encountered in PEMG. This natural heterogeneity is probably the result of topographic variation (plateau vs. hillside), which allows for the coexistence of species with different ecological requirements in this reserve (Anjos *et al.* 2007, Santana & Anjos 2010).

However, PEMG is surrounded by a human dominated landscape that has changed dramatically during the last 23 years. Agriculture (mainly soya beans) has expanded over the years at the northern and western borders of PEMG, compromising the buffer zone of the reserve, especially during the turn of the century. The buffer zone that existed 23 years ago in the west portion of the reserve is completely absent nowadays (L. Anjos, pers. obs.). Other local threats have been detected over the 23 years of monitoring, like illegal hunting activities and the presence of domestic species (*e.g.* cats and dogs) in the study area (IAP 2002), threats that are known to have important impacts on biodiversity and community dynamics (Wright 2005, Galetti & Sazima 2006, Campos *et al.* 2007). The synergic effects of these threats could affect bird composition in the PEMG in terms of both local extinctions and colonizations (Laurance 2010).

Extinctions

Extinctions in the PEMG were biased towards specific bird groups. This was expected because some biological features are known to be better predictors of bird sensitivity to fragmented landscapes (*e.g.* Henle *et al.* 2004, Anjos 2006). For example, body size and feeding habits (Pizo 2001, Ribon *et al.* 2003), dispersal capacity (Sekercioglu *et al.* 2002, Lees & Peres 2009) and geographical distribution (Kattan *et al.* 1994, Anjos *et al.* 2010). In our study, large frugivores had the highest rate of extinction (33.3% of total extinctions) and higher number of species expected to decline in the future. Ground omnivores and

ground insectivores followed in terms of the number of species that went locally extinct or presented a tendency of future decline. These three guilds frequently show high sensitivity to habitat fragmentation (Thiollay 1992, Ribon *et al.* 2003, Franz *et al.* 2010, Loures-Ribeiro *et al*. 2011, Stratford & Stouffer 2015) due to certain biological features that increase their susceptibility to local extinction. Large frugivores, for example, present low population densities and recruitment, and need large living areas to feed on specific resource (Pizo 2001). Ground insectivores, in turn, appear to be sensitive to microhabitat changes (*e.g.* in leaf litter depth and vegetation structure), which frequently occur in disturbed and fragmented habitats (Stratford & Stouffer 2013, 2015). Further, large frugivores and ground omnivores are frequently hunted due to their large body size (Strahl & Grajal 1991, Pizo 2001), and terrestrial birds are more susceptible to predation by domestic species (*e.g.* dogs and cats).

Other guilds that declined and had a high number of species that went "possibly extinct" were sub-canopy and canopy insectivores and sub-canopy and canopy omnivores, which are guilds that are usually not cited as being prone to local extinction due to fragmentation (Bregman *et al.* 2014). Anjos (2006) studied the sensitivity of bird species in the fragmented landscape of PEMG, and found that some particular species in the aforementioned guilds (*e.g. Piprites chloris* and *Oxyruncus cristatus*) presented high local sensitivity to the effects of fragmentation. However, understory insectivorous - a guild that usually declines after forest fragmentation and forest isolation (Stouffer & Bierregaard 1995, Sekercioglu *et al.* 2002, Powell *et al.* 2015) - persisted in stable numbers in PEMG. A possible explanation could be the fact that we considered terrestrial species as "ground insectivores" instead of grouping them as "understory insectivores". We think it is important to consider where in the understory these insectivore bird species forage, because microhabitats in the understory should differ in their response towards fragmentation.

The extinction pattern found for PEMG follows a widespread global pattern in tropical fragmented landscapes, with higher extinction risk and/or declines in insectivores and large frugivores (reviewed in Bregman *et al.* 2014). However, other guilds like sub-canopy and canopy omnivores were susceptible to local extinction or decline in PEMG, a pattern of species loss that does not conform to the usual widespread pattern of global species loss in tropical fragmented landscapes (Bregman *et al.* 2014). Extinctions or decline in other guilds that are usually not affected by fragmentation could be related to particularities of the area in question, such as history, time of isolation, connectivity with other forest areas and surrounding matrix (Sigel *et al.* 2010).

PEMG, for example, lies over the Tropic of Capricorn, a transitional region between Tropical and Subtropical regions and lies at the northern limit for several bird species with a more southern distribution in Brazil. Likewise, it is at the southern limit for the distribution of several bird species with a more northern distribution in Brazil. This peculiarity could explain some of the patterns of extinctions and declines. Species at the border of their distribution have higher probability of going extinct because of the limited rescue effect (Anjos *et al.* 2010) and/or because species may be at their ecological and physiological limits (Kattan *et al.* 1994). PEMG is at the distributional range limit of nine bird species considered as either locally extinct or possibly extinct, and seven bird species considered to be declining. It is noticeable that species with a more southern distribution were more affected (12 species, *e.g. Heliobletus contaminatus*, *Lipaugus lanioides* and *Polioptila lactea*) than species with a more northern distribution (4 species, *e.g. Campephilus melanoleucus* and *Crypturellus undulatus*).

A possible factor responsible for the extinction bias towards bird species with a more southern distributional range is the drastic deforestation that occurred in Paraná state between 1890 and 1990 (Gubert-Filho 2010). Deforestation in Paraná was severe for both semi-deciduous forests (that prevails in northern Paraná) and araucaria forests (that occurs more to the south), eliminating the connectivity that once existed between this two forest formations. Enclaves of *Araucaria* Forest that were close to PEMG did occur in the past (Torezan 2002), but these have been eliminated or have become isolated from the core *Araucaria* Forest present in the south of Brazil. Thus, bird species highly associated to *Araucaria* Forest that occur in PEMG could be disappearing or declining due to the lack of suitable habitats and absence of landscape connectivity that could allow a rescue effect. This could be the case for species like *H. contaminatus*, *Piculus aurulentus* and *Strix hylophila*.

Climate change could also be a contributing factor to the decline of bird species with a more southern distributional range. Changes in temperature and precipitation levels can have direct and indirect effects on bird populations (Crick 2004). Direct effects consist, for example, in shifts in the reproduction period of several bird species (Crick 2004), while indirect effects are changes in bird resources like plants and insects (Bale *et al.* 2002), particularly those with restricted climatic ranges or adapted to lower temperatures (Butterfield & Coulson 1997). Therefore, birds as well as plants and insects associated to colder habitats (as *Araucaria* Forest) could have declined in PEMG due to the elevation of temperatures in this region (Walther *et al.* 2002). For example, *H. contaminatus* has a specialized bill (Whitney & Pacheco 1994) and a foraging strategy that involves searching

arthropods in substrates (*e.g.* moss and lichen) that are more common in colder regions (Parrini *et al.* 2009).

Colonizations

Birds species with a more northern distributional range made up the majority of the 11 colonizing species. For example, *N. ocellatus*, *Amazilia lactea*, *Myiarchus tyrannulus*, *M. flaveola*, and *Thlypopsis sordida*. Some of these species are clearly associated with open areas, like *Cerrado* (*e.g. M. tyrannulus* and *M. flaveola*) (Sick 1997). The elevation of temperature in the region in the last decades (Walther *et al.* 2002), together with forest fragmentation that generates more open habitats for species typical of *Cerrado*, could explain why bird species with a more northern distributional range and of drier habitats are expanding into this more moist region. An emblematic case is *M. flaveola*, considered a threatened species in Paraná, which used to have only a few records in the north of the state (Mikich & Bérnils 2004) but seems to be currently expanding to novel areas (see WikiAves.com.br for current records in Paraná state).

The guilds with the highest number of species to have colonized PEMG were edge insectivores, edge omnivorous, nectarivores and nocturnal insectivores. Bird species from these guilds are mainly associated with more open areas. PEMG is inserted in a fragmented landscape where edge effect is favored, which could explain why guilds associated with open habitats were the ones with the highest number of colonizing species (Thiollay 1992, Franz *et al.* 2010). To reinforce this point, as mentioned above, in the beginning of 2000 there was a deforestation of the buffer zone, which probably increased edge effect in one of the most preserved areas of the reserve.

Two carnivore species, *Buteo brachyurus* and *Leptodon cayanensis*, were considered as colonizers according to our criteria. These species can be easily detected in the field because they constantly vocalize (mainly in the breeding season) and are commonly found on thermals with vultures (Ferguson-Lees & Christie 2001, G. Willrich, pers. obs.). This fact indicates that their absence before 2005 is not a consequence of under-sampling, but could be a possible turnover of predators in PEMG. Forest fragmentation can lead to changes in the composition of raptors without an actual change in the number of raptor species (Jullien & Thiollay 1996). Thus, habitat loss (promoted by agriculture expansion in the region) together with hunting activities, both of which are considered to be the main threats to populations of large raptors (Thiollay 1985, Bildstein *et al.* 1998, ICMBio 2008), could have gradually eliminated large raptors from the landscape, favouring smaller raptors species that can tolerate more fragmented habitats, such as the species mentioned above.

Data limitations

There is little information on the avifauna of northern Paraná state before the colonization and expansion of human activities. For instance, naturalists did not visit the region close to the municipality of Londrina in the 19th century. However, Peter W. Wetscot in the 1930s made an important account about the capture of a single Harpy Eagle (*Harpia harpyja*) individual near the municipality of Londrina (Scherer-Neto & Straube 1995). This record suggests that the avifauna in northern Paraná was originally much richer in species number. Some groups, like great raptors (Accipitridae, *e.g. Spizaetus ornatus*), were never recorded in PEMG or the region, and their presence can only be inferred by the use of distributional maps. This indicates that the avifauna present in PEMG, as well as the number of species locally extinct, could in fact be underestimated because of the lack of information on species distributions prior to the creation of the reserve (Lees & Pimm 2015).

The "indeterminate" species (species with few and infrequent records), which were recorded only in the first years of monitoring could in fact have been common in the past, but our time frame captured the presence of these species when they were at the end of their decline. For example, records of *Sclerurus scansor* and the "Near threatened" *Phylloscartes sylviolus* and *P. paulista* could have been the last ones in PEMG. The maintenance of bird monitoring in PEMG can provide more information to assess the local status of such species in the future.

Future bird monitoring in PEMG should adopt a standardized method so that different time periods can be appropriately compared. For example, if point counts in PEMG had a standardized protocol (*e.g.* the same location, sampling time and radius of detection), we would have been able to use multivariate methods such as NMDS to compare bird abundance and composition along different time periods. We argue that it is important to sample the same points and use the same sampling procedures used in 2014. The reason is the number of trails used and because points are distributed both in the plateau and in the altitudinal gradient of the reserve. We also advocate for the increase in the use of mist net and ringing, as initiated in 2015, so that population sizes could be estimated for several species over the years. The evaluation of the data obtained by these methodologies will allow a better comprehension of species declining tendencies in the future.

Implications for protected areas

The dynamism encountered for this bird community over the years was weak, which indicates that most bird species were able to persist/occupy PEMG after it was declared a

legal reserve. If we consider the avifauna list of Scherer-Neto *et al.* (2011), PEMG harbors almost 45% of all bird species present in Paraná state, and together with the small species dynamism over the years, the role of PEMG for the conservation of biodiversity in northern Paraná is undeniable. Like many other protected areas, PEMG is under constant pressure. For example, a recent plan to build an airport in the vicinity of PEMG was rejected due to the efforts of the Instituto Ambiental do Paraná (IAP) and a local NGO (MAE). However, other development projects such as the implementation of industries next to PEMG are still under discussion.

Furthermore, in a new concept of conservation called "biodiversity-friendly landscapes", which aims to create a more functional and connected landscape that conciliates human necessities and biodiversity conservation (Melo *et al.* 2013), PEMG could act as a source for many bird populations that could expand to surrounding areas of less preserved forest fragments or new restoration areas (Brancalion *et al.* 2013). Together with the use of ecological corridors and restoration areas that increase connectivity within this highly fragmented landscape, it is possible to increase rescue effects among bird populations of nearby forest fragments, thus increasing the chances of maintaining current biodiversity in the long run.

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APPENDIX I

Species recorded to PEMG in 23 years of monitoring. Nomenclature of species follows Piacentini *et al.* (2015) and endemic species (E) of Atlantic Forest follows Bencke *et al.* (2006).
Literature review and unpublished data before 2005 (in parenthesis the period of sampling): 1) Anjos *et al.* 1997 (1993–1996); 2) Anjos & Ferreira 1998 (1997); 3) Anjos 2001 (1996); 4) Anjos *et al.* 2004 (1997); 5) Anjos field works (1993, 1995–1999); 6) Anjos field works (2001–2002); 7) Anjos *et al.* 2007 (2001); 8) Lopes *et al.* 2006 (2003–2004); 9) Anjos *et al.* 2011 and unpublished data (2004–2005).
Literature review and unpublished data after 2005 (in parenthesis the period of sampling): 10) Santana & Anjos 2010 (2007); 11) Bochio & Anjos 2012 (2009–2010); 12) Bochio field works (2009–2010); 13) Oliveira field works (2009–2015); 14) Muzi field works (2010–2012); 15) Zaiden *et al.* 2015 (2011); 16) Rosa field works (2009–2015); 17) Calsavara field works (2013–2015); Willrich field works (2014–2015); Mist nets (2015).
Local Status: FP – forest persistent; NFP – non-forest persistent; D – forest persistent and declining; PE – possibly extinct; EX – extinct; FM – frequent migrant; OF – occasional migrant; C – colonizer; S – sporadic species; I – indeterminate.
Conservation Status: VU – vulnerable; EN – endangered; CR – critically endangered; NT – near threatened; DD – data deficient; PR – regional level (Mikich & Bérnils 2004); BR – national level (ICMBio 2014); GL – global level (IUCN 2015).
Guilds: CA – carnivores; CE – carrion eaters; LF – large frugivores; SF – small frugivores; SE – seedeaters; NE – nectarivores; GI – ground insectivores; UI – understory insectivores; TI – trunk and twig insectivores; SCI – sub-canopy and canopy insectivores; AI – aerial insectivores; EI – edge insectivores; NI – nocturnal insectivores; GO – ground omnivores; UO – understory omnivores; SCO – sub-canopy and canopy omnivores; EO – edge omnivores; AO – aquatic omnivores and PI – piscivorous.

Family/species	Before 2005									After 2005										Local Status	Conservation Status	Guild
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19			
Tinamidade																						
Tinamus solitarius (Vieillot, 1819) E	X		X	X	X	X	X		X											PE	NT-GL; VU-PR	GO
Crypturellus obsoletus (Temminck, 1815)	X		X	X	X	X	X		X		X	X	X	X		X		X		FP		GO
Crypturellus undulatus (Temminck, 1815)	X		X		X															EX	CR-PR	GO
Crypturellus parvirostris (Wagler, 1827)	X		X		X		X		X		X	X	X			X		X		FP		GO
Crypturellus tataupa (Temminck, 1815)	X		X	X	X		X		X		X	X	X	X		X	X	X		FP		GO
Rhynchotus rufescens (Temminck, 1815)													X			X		X		S		GO
Nothura maculosa (Temminck, 1815)	X												X	X				X		NFP		GO
Anatidae																						
Dendrocygna viduata (Linnaeus, 1766)	X																			S		AO
Cracidae																						
Penelope superciliaris Temminck, 1815	X		X	X	X	X	X		X		X	X	X	X	X	X	X	X		FP		LF
Aburria jacutinga (Spix, 1825) E	X		X																	EX	EN-GL; EN-BR; EN-PR	LF
Crax fasciolata Spix, 1825	X		X																	EX	VU-GL; CR-PR	LF
Odontophoridae																						
Odontophorus capueira (Spix, 1825) E	X																			EX		GO
Ardeidae																						
Nycticorax nycticorax (Linnaeus, 1758)													X					X		S		AO

Family/species	Before 2005									After 2005										Local Status	Conservation Status	Guild
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19			
Butorides striata (Linnaeus, 1758)													X							S		AO
Bubulcus ibis (Linnaeus, 1758	X																	X		S		GO
Ardea cocoi Linnaeus, 1766																X				S		AO
Ardea alba Linnaeus, 1758																X				S		AO
Syrigma sibilatrix (Temminck, 1824)																		X		S		GO
Egretta thula (Molina, 1782)																X				S		AO
Threskiornithidae																						
Mesembrinibis cayennensis (Gmelin, 1789)																		X		S	NT-PR	AO
Theristicus caudatus (Boddaert, 1783)													X							S		GO
Cathartidae																						
Cathartes aura (Linnaeus, 1758)	X												X			X		X		FP		CE
Coragyps atratus (Bechstein, 1793)	X												X			X	X	X		FP		CE
Sarcoramphus papa (Linnaeus, 1758)	X															X	X	X		FP		CE
Accipitridae																						
Leptodon cayanensis (Latham, 1790)													X					X		C		CA
Elanoides forficatus (Linnaeus, 1758)	X												X			X		X		FM		AI
Elanus leucurus (Vieillot, 1818)	X												X			X				NFP		CA
Harpagus diodon (Temminck, 1823)	X																			OM		CA
Accipiter striatus Vieillot, 1808	X						X						X							FP		CA
Ictinia plumbea (Gmelin, 1788)	X				X	X	X		X				X			X		X		FM		AI
Heterospizias meridionalis (Latham, 1790)																		X		S		CA
Rupornis magnirostris (Gmelin, 1788)	X						X		X				X			X	X	X		FP		CA
Geranoaetus albicaudatus (Vieillot, 1816)													X							S		CA
Buteo nitidus (Latham, 1790)	X																			I		CA
Buteo brachyurus Vieillot, 1816													X	X				X		C		CA
Aramidae																						
Aramus guarauna (Linnaeus, 1766)																		X		S		AO
Rallidae																						
Aramides saracura (Spix, 1825) E	X				X		X		X		X	X	X					X		FP		GI
Laterallus melanophaius (Vieillot, 1819)	X																			I		GI
Pardirallus nigricans (Vieillot, 1819)																		X		I		GI
Charadriidae																						
Vanellus chilensis (Molina, 1782)	X												X			X		X		NFP		GI

Family/species	Before 2005									After 2005										Local Status	Conservation Status	Guild
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19			
Columbidae																						
Columbina talpacoti (Temminck, 1810)	X												X			X	X	X		FP		SE
Columbina squammata (Lesson, 1831)	X												X			X				FP		SE
Columbina picui (Temminck, 1813)	X												X			X		X		NFP		SE
Claravis pretiosa (Ferrari-Perez, 1886)	X						X		X		X	X			X			X		FP		LF
Patagioenas picazuro (Temminck, 1813)	X		X	X	X	X	X		X		X	X	X		X	X	X	X		FP		EO
Patagioenas cayennensis (Bonnaterre, 1792)	X		X	X	X	X	X		X		X	X	X		X	X		X		FP		LF
Patagioenas plumbea (Vieillot, 1818)	X		X												X					D		LF
Zenaida auriculata (Des Murs, 1847)	X												X			X	X	X		NFP		EO
Leptotila verreauxi Bonaparte, 1855	X		X	X	X	X	X		X		X	X	X	X	X	X	X	X		FP		LF
Leptotila rufaxilla (Richard & Bernard, 1792)	X		X	X	X		X		X		X	X	X	X	X	X		X		FP		LF
Geotrygon montana (Linnaeus, 1758)	X		X	X	X	X	X		X		X	X	X	X	X	X		X		FP		LF
Cuculidae																						
Piaya cayana (Linnaeus, 1766)	X		X	X	X	X	X		X		X	X	X	X		X	X	X		FP		SCI
Coccyzus melacoryphus Vieillot, 1817	X			X					X		X	X	X					X		FM		EI
Coccyzus americanus (Linnaeus, 1758)	X			X		X	X		X											OM		SCO
Coccyzus euleri Cabanis, 1873	X					X	X													OM	DD-PR	SCI
Crotophaga ani Linnaeus, 1758	X		X										X			X		X		NFP		EI
Guira guira (Gmelin, 1788)	X												X			X	X	X		NFP		EI
Tapera naevia (Linnaeus, 1766)	X				X	X					X	X		X		X	X	X		FP		EI
Dromococcyx pavoninus Pelzeln, 1870	X								X		X	X	X	X		X		X		FP		UI
Tytonidae																						
Tyto furcata (Temminck, 1827)	X												X			X		X		FP		CA
Strigidae																						
Megascops choliba (Vieillot, 1817)	X						X						X	X		X		X		FP		NI
Pulsatrix perspicillata (Latham, 1790)	X		X		X															EX	VU-BR; DD-PR	CA
Pulsatrix koeniswaldiana (Bertoni & Bertoni, 1901) E	X		X	X	X	X							X			X		X		FP		CA
Bubo virginanus (Gmelin, 1788)	X																			S		CA
Strix hylophila Temminck, 1825 E	X		X		X											X				D	NT-GL	CA
Strix virgata (Cassin, 1849)																		X		I	DD-PR	CA
Glacidium brasilianum (Gmelin, 1788)	X		X	X	X		X		X				X			X		X		FP		NI
Athene cunicularia (Molina, 1782)	X												X			X		X		NFP		NI

Family/species	Before 2005									After 2005										Local Status	Conservation Status	Guild
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19			
Nyctibiidae																						
Nyctibius aethereus (Wied, 1820)	X																			I	EN-BR; DD-PR	NI
Nyctibius griseus (Gmelin, 1789)	X												X			X		X		FP		NI
Caprimulgidae																						
Nyctiphrynus ocellatus (Tschudi, 1844)													X			X		X		C	EN-PR	NI
Antrostomus rufus (Boddaert, 1783)	X															X				FP		NI
Lurocalis semitorquatus (Gmelin, 1789)	X		X										X					X		FM		NI
Nyctidromus albicollis (Gmelin, 1789)	X											X	X			X		X		FP		NI
Hydropsalis parvula (Gould, 1837)																X		X		C		NI
Hydropsalis torquata (Gmelin, 1789)													X							S		NI
Podager nacunda (Vieillot, 1817)	X												X					X		FM		NI
Chordeiles minor (Forster, 1771)	X																			OM	DD-PR	NI
Chordeiles acutipennis (Hermann, 1783)	X																			OM		NI
Apodidae																						
Cypseloides fumigatus (Streubel, 1848)													X							S		AI
Streptoprocne zonaris (Shaw, 1796)	X												X							S		AI
Chaetura cinereiventris Sclater, 1862	X																	X		OM		AI
Chaetura meridionalis Hellmayr, 1907	X												X			X		X		FM		AI
Trochilidae																						
Phaethornis squalidus (Temminck, 1822) E													X							I		NE
Phaethornis pretrei (Lesson & Delattre, 1839)	X												X							FP		NE
Phaethornis eurynome (Lesson, 1832) E	X		X		X	X	X		X				X	X		X		X		FP		NE
Eupetomena macroura (Gmelin, 1788)	X												X			X	X			FP		NE
Florisuga fusca (Vieillot, 1817) E	X																	X		FP		NE
Colibri serrirostris(Vieillot, 1816)	X																			I		NE
Anthracothorax nigricollis (Vieillot, 1817)	X		X	X									X			X				FP		NE
Stephanoxis lalandi (Vieillot, 1818) E	X															X				I		NE
Chlorostilbon lucidus (Shaw, 1812)	X			X			X		X				X	X				X		FP		NE
Thalurania glaucopis (Gmelin, 1788) E	X			X	X	X	X		X				X	X				X		FP		NE
Hylocharis sapphirina (Gmelin, 1788)	X																			I		NE
Hylocharis cyanus (Vieillot, 1818)		X																		I		NE
Hylocharis chrysura (Shaw, 1812)	X												X	X		X		X		FP		NE
Leucochloris albicollis (Vieillot, 1818) E	X												X							OM		NE

Family/species	Before 2005									After 2005										Local Status	Conservation Status	Guild
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19			
Amazilia versicolor (Vieillot, 1818)													X	X				X		C		NE
Amazilia fimbriata (Gmelin, 1788)	X															X		X		FP		NE
Amazilia lactea (Lesson, 1832)													X	X		X				C		NE
Trogonidae																						
Trogon surrucura Vieillot, 1817 E	X		X	X	X	X	X		X		X	X	X	X	X	X	X	X		FP		SCO
Trogon rufus Gmelin, 1788	X		X	X	X	X	X		X		X	X	X	X	X	X	X	X		FP		SCO
Alcedinidae																						
Megaceryle torquata (Linnaeus, 1766)																		X		I		PI
Chloroceryle amazona (Latham, 1790)																		X		I		PI
Momotidae																						
Baryphthengus ruficapillus (Vieillot, 1818) E	X		X	X	X	X	X		X		X	X	X	X	X	X	X	X	X	FP		UI
Galbulidae																						
Galbula ruficauda Cuvier, 1816	X																			I	NT-PR	EI
Bucconidae																						
Notharchus swainsoni (Gray, 1846) E	X		X										X					X		FP		SCO
Nystalus chacuru(Vieillot, 1816)	X																			S		EO
Nonnula rubecula (Spix, 1824)	X			X			X				X	X	X	X		X	X	X	X	FP		UI
Ramphastidae																						
Ramphastos dicolorus Linnaeus, 1766 E	X		X	X	X		X		X		X	X	X	X	X	X	X	X		FP		SCO
Selenidera maculirostris (Lichtenstein, 1823) E	X		X	X	X	X	X		X		X	X	X	X	X	X	X	X		FP		SCO
Pteroglossus bailloni (Vieillot, 1819) E	X		X		X		X				X	X	X	X	X			X		FP	NT-GL	SCO
Pteroglossus aracari (Linnaeus, 1758)	X		X	X	X	X	X				X				X					D	VU-PR	SCO
Pteroglossus castanotis Gould, 1834																X		X		I		SCO
Picidae																						
Picumnus cirratus Temminck, 1825											X			X						I		TI
Picumnus temminckii Lafresnaye, 1845 E	X		X	X	X	X	X		X				X	X		X	X	X		FP		TI
Picumnus nebulosus Sundevall, 1866	X																			I	NT-GL	TI
Melanerpes candidus (Otto, 1796)	X												X			X	X	X		FP		TI
Melanerpes flavifrons (Vieillot, 1818) E	X		X	X	X	X	X		X		X	X	X	X		X	X	X		FP		TI
Veniliornis spilogaster (Wagler, 1827) E	X		X	X	X	X	X		X		X	X	X	X				X		FP		TI
Piculus aurulentus (Temminck, 1821) E	X			X	X	X							X							D	NT-GL	TI
Colaptes melanochloros (Gmelin, 1788)	X		X	X	X	X					X	X	X	X		X		X		NFP		TI
Colaptes campestris (Vieillot, 1818)	X												X			X		X		FP		TI

Family/species	Before 2005									After 2005										Local Status	Conservation Status	Guild
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19			
Celeus flavescens (Gmelin, 1788)	X		X	X	X						X	X		X		X	X	X		FP		TI
Dryocopus lineatus (Linnaeus, 1766)	X		X	X	X	X	X		X		X	X	X	X		X		X		FP		TI
Campephiluss robustus (Lichtenstein, 1818) E	X			X	X						X	X	X			X		X		FP		TI
Campephilus melanoleucos (Gmelin, 1788)			X	X	X	X														PE		TI
Falconidae																						
Caracara plancus (Miller, 1777)	X						X				X	X	X			X		X		NFP		CA
Milvago chimachima (Vieillot, 1816)	X												X			X		X		NFP		CA
Herpetotheres cachinnans (Linnaeus, 1758)	X		X	X	X	X	X		X							X		X		FP		CA
Micrastur ruficollis (Vieillot, 1817)	X		X		X	X	X						X			X		X		FP		CA
Micrastur semitorquatus (Vieillot, 1817)	X		X	X	X	X	X		X		X	X	X	X		X	X	X		FP		CA
Falco sparverius Linnaeus, 1758	X												X			X		X		NFP		AI
Falco femoralis Temminck, 1822	X												X							NFP		CA
Falco peregrinus Tunstall, 1771													X					X		OM		CA
Psittacidae																						
Primolius maracana (Vieillot, 1816)	X			X	X	X	X				X				X					D	NT-GL; EN-PR	LF
Psittacara leucophthalmus (Statius Muller, 1776)	X		X	X	X	X	X		X		X	X	X	X	X	X	X	X		FP		LF
Aratinga auricapillus (Kuhl, 1820)	X		X		X	X	X		X		X	X	X	X	X	X	X	X		FP	NT-GL	LF
Eupsittula aurea (Gmelin, 1788)	X																			S		LF
Pyrrhura frontalis (Vieillot, 1817) E	X		X	X	X	X	X		X		X	X	X	X	X	X	X	X		FP		LF
Forpus xanthopterygius (Spix, 1824)	X		X		X								X			X		X		FP		EO
Brotogeris tirica (Gmelin, 1788) E	X		X		X	X	X		X		X	X	X		X	X		X		FP		LF
Pionopsitta pileata (Scopoli, 1769) E	X		X	X	X	X	X		X		X	X	X		X	X		X		FP		LF
Pionus maximiliani (Kuhl, 1820)	X		X	X	X	X	X		X		X	X	X	X	X	X	X	X		FP		LF
Amazona aestiva (Linnaeus, 1758)	X		X	X	X	X	X		X		X	X	X	X	X	X		X		FP		LF
Triclaria malachitacea (Spix, 1824) E	X		X	X	X	X	X				X				X					D	NT-GL; VU-PR	LF
Thamnophilidae																						
Dysithamnus mentalis (Temminck, 1823)	X		X	X	X	X	X	X	X		X	X	X	X		X		X	X	FP		UI
Herpsilochmus rufimarginatus (Temminck, 1822)	X		X	X	X	X	X	X	X		X	X	X			X		X		FP		SCI
Thamnophilus doliatus (Linnaeus, 1764)	X					X							X			X				FP		EI
Thamnophilus ruficapillus Vieillot, 1816	X												X			X		X		NFP		EI
Thamnophilus caerulescens Vieillot, 1816	X		X	X	X	X	X	X	X		X	X	X			X		X		FP		UI
Hypoedaleus guttatus (Vieillot, 1816) E	X		X	X	X	X	X	X	X		X	X	X	X		X	X	X		FP		SCI
Mackenziaena leachii (Such, 1825) E						X	X		X											I		UI

Family/species	Before 2005									After 2005										Local Status	Conservation Status	Guild
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19			
Mackenziaena severa (Lichtenstein, 1823) E	X			X	X	X	X	X	X	X	X	X	X	X		X		X		FP		UI
Pyriglena leucoptera (Vieillot, 1818) E	X		X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	FP		UI
Drymophila rubricollis (Bertoni, 1901) E	X			X			X			X			X					X		FP		UI
Drymophila malura (Temminck, 1825) E	X		X	X	X		X			X			X							FP		UI
Conopophagidae																						
Conopophaga lineata (Wied, 1831) E	X		X	X	X	X	X		X	X	X	X	X			X	X	X	X	FP		UI
Grallariidae																						
Grallaria varia (Boddaert, 1783)	X		X	X	X		X		X				X							D		GI
Hylopezus nattereri (Pinto, 1937) E							X			X			X							D		GI
Rhinocryptidae																						
Eleoscytalopus indigoticus (Wied, 1831) E	X		X	X	X		X				X	X	X	X			X	X		FP		UI
Psilorhamphus guttatus (Ménétriès, 1835) E	X		X	X	X		X						X					X		FP	NT-PR	UI
Formicariidae																						
Chamaeza campanisona (Lichtenstein, 1823)	X		X	X	X	X	X		X		X	X	X					X		FP		GI
Chamaeza ruficauda (Cabanis & Heine, 1859) E	X																			EX		GI
Scleruridae																						
Sclerurus scansor (Ménétriès, 1835) E	X		X																	I		GI
Dendrocolaptidae																						
Dendrocincla turdina (Lichtenstein, 1820) E	X		X	X	X	X	X		X		X	X	X	X		X	X	X	X	FP		TI
Sittasomus griseicapillus (Vieillot, 1818)	X		X	X	X	X	X		X		X	X	X	X		X	X	X	X	FP		TI
Xiphorhynchus fuscus (Vieillot, 1818) E	X		X	X	X	X	X		X		X	X	X	X		X		X	X	FP		TI
Campylorhamphus falcularius (Vieillot, 1822) E							X				X	X	X	X		X		X		FP		TI
Lepidocolaptes angustirostris (Vieillot, 1818)				X	X	X	X											X		S	NT-PR	TI
Dendrocolaptes platyrostris Spix, 1825	X		X	X	X	X	X		X		X	X	X	X		X		X		FP		TI
Xiphocolaptes albicollis (Vieillot, 1818)	X		X	X	X	X	X		X		X	X	X	X		X		X		FP		TI
Xenopidae																						
Xenops rutilans Temminck, 1821	X		X	X	X	X	X		X		X	X	X	X		X	X	X		FP		TI
Furnariidae																						
Furnarius rufus (Gmelin, 1788)	X												X			X		X		NFP		EO
Lochmias nematura (Lichtenstein, 1823)							X						X			X		X		FP		UI
Clibanornis dendrocolaptoides (Pelzeln, 1859)E			X																	I	NT-GL	UI
Automolus leucophthalmus (Wied, 1821) E	X		X		X		X		X	X	X	X	X	X		X	X	X	X	FP		UI
Anabacerthia lichtensteini (Cabanis & Heine, 1859) E			X	X	X	X	X		X		X	X	X	X		X		X		FP		SCI

Family/species	Before 2005									After 2005										Local Status	Conservation Status	Guild
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19			
Philydor rufum (Vieillot, 1818)	X		X	X	X	X	X		X				X	X		X	X	X		FP		SCI
Heliobletus contaminatus Pelzeln, 1859 E	X		X		X	X	X			X										D		SCI
Syndactyla rufosuperciliata (Lafresnaye, 1832)	X		X		X				X				X			X		X		FP		UI
Synallaxis ruficapilla Vieillot, 1819 E	X		X	X	X	X	X		X	X	X	X	X	X		X	X	X	X	FP		UI
Synallaxis cinerascens Temminck, 1823	X		X	X	X		X			X	X	X	X	X		X	X	X		FP		UI
Synallaxis frontalis Pelzeln, 1859	X		X		X						X	X	X			X	X	X		NFP		EI
Synallaxis spixi Sclater, 1856	X		X	X	X						X	X	X			X		X		NFP		EI
Cranioleuca obsoleta (Reichenbach, 1853) E			X	X	X	X	X		X	X	X	X	X					X		FP		TI
Pipridae																						
Pipra fasciicauda Hellmayr, 1906	X		X		X		X				X	X	X	X						FP		SF
Manacus manacus (Linnaeus, 1766)	X		X		X															EX		SF
Chiroxiphia caudata (Shaw & Nodder, 1793) E	X		X	X	X	X	X		X		X	X	X	X		X	X	X	X	FP		SF
Oxyruncidae																						
Oxyruncus cristatus Swainson, 1821	X		X	X	X						X	X								D		SCO
Onychorhynchidae																						
Myiobius barbatus (Gmelin, 1789)	X																			I		UI
Tityridae																						
Schiffornis virescens (Lafresnaye, 1838) E	X				X						X	X	X			X				FP		UO
Tityra inquisitor (Lichtenstein, 1823)	X		X		X		X		X		X	X	X	X		X				FP		LF
Tityra cayana (Linnaeus, 1766)	X		X	X	X	X	X		X		X	X	X	X		X		X		FP		LF
Pachyramphus viridis (Vieillot, 1816)	X		X										X			X				FM		SCI
Pachyramphus castaneus (Jardine & Selby, 1827)	X		X	X	X	X	X		X				X			X		X		FP		SCI
Pachyramphus polychopterus (Vieillot, 1818)	X					X	X				X	X	X	X		X		X		FM		SCI
Pachyramphus validus (Lichtenstein, 1823)	X		X		X	X	X						X	X		X		X		FM		SCI
Contigidae																						
Phibalura flavirostris Vieillot, 1816	X																			I	NT-GL; NT-PR	SCO
Pyroderus scutatus (Shaw, 1792) E														X						I	NT-PR	LF
Lipaugus lanioides (Lesson, 1844) E	X																			EX	NT-GL; NT-PR	LF
Procnias nudicollis (Vieillot, 1817) E					X															EX	VU-GL	LF
Pipritidae																						
Piprites chloris (Temminck, 1822)	X		X	X	X		X													PE		SCI
Platyrinchidae																						
Platyrinchus mystaceus Vieillot, 1818	X			X	X		X		X	X	X	X	X	X		X	X	X	X	FP		UI

Family/species	Before 2005									After 2005										Local Status	Conservation Status	Guild
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19			
Rhynchocyclidae																						
Mionectes rufiventris Cabanis, 1846 E	X		X	X	X	X	X						X							FP		UO
Leptopogon amaurocephalus Tschudi, 1846	X		X	X	X	X	X		X		X	X	X	X		X	X	X		FP		UI
Corythopis delalandi (Lesson, 1830)	X						X		X	X	X	X	X	X		X	X	X	X	FP		UI
Phylloscartes eximius (Temminck, 1822) E	X		X		X															EX	NT-GL	SCI
Phylloscartes ventralis (Temminck, 1824)	X		X	X	X	X	X				X	X				X	X			FP		SCI
Phylloscartes paulista Ihering & Ihering, 1907 E					X															I	NT-GL; NT-PR	SCI
Phylloscartes sylviolus (Cabanis & Heine, 1859) E	X																			I	NT-GL; DD-PR	SCI
Tolmomyias sulphurescens (Spix, 1825)	X		X	X	X	X	X		X		X	X	X	X		X	X	X		FP		SCI
Todirostrum cinereum (Linnaeus, 1766)	X						X						X			X		X		FP		EI
Poecilotriccus plumbeiceps (Lafresnaye, 1846)	X		X	X	X	X	X			X			X			X		X		FP		UI
Myiornis auricularis (Vieillot, 1818) E	X		X	X	X	X	X		X	X			X			X	X	X		FP		SCI
Hemitriccus diops (Temminck, 1822) E							X			X			X			X		X		FP		UI
Hemitriccus obsoletus (Miranda-Ribeiro, 1906) E	X						X				X	X	X							FP	DD-PR	UI
Hemitriccus margaritaceiventer (d'Orbigny & Lafresnaye, 1837)	X															X				S		EI
Tyrannidae																						
Hirundinea ferruginea (Gmelin, 1788)													X							S		EI
Euscarthmus meloryphus Wied, 1831	X																	X		S		EI
Tyranniscus burmeisteri (Cabanis & Heine, 1859)	X				X				X		X	X						X		FP	DD-PR	SCI
Camptostoma obsoletum (Temminck, 1824)	X		X	X	X	X	X		X		X	X	X			X		X		FP		SCO
Elaenia flavogaster (Thunberg, 1822)	X												X					X		FP		EO
Elaenia parvirostris Pelzeln, 1868	X												X	X		X		X		FM		EO
Elaenia mesoleuca (Deppe, 1830)	X		X				X									X				FM		EO
Elaenia chiriquensis Lawrence, 1865																		X		OM		EO
Elaenia obscura (d'Orbigny & Lafresnaye, 1837)																		X		I		EO
Myiopagis caniceps (Swainson, 1835)	X		X	X	X	X	X		X		X	X	X	X		X		X		FP		SCI
Myiopagis viridicata (Vieillot, 1817)	X		X										X			X		X		FP		SCI
Capsiempis flaveola (Lichtenstein, 1823)	X		X	X	X		X			X			X			X		X		FP		UI
Phyllomyias virescens (Temminck, 1824) **E**																		X		I		SCI
Serpophaga subcristata (Vieillot, 1817)	X												X			X		X		NFP		EI
Legatus leucophaius (Vieillot, 1818)											X	X	X	X		X		X		FM		SCI
Myiarchus swainsoni Cabanis & Heine, 1859	X				X	X	X		X			X	X			X		X		FM		SCI
Myiarchus ferox (Gmelin, 1789)													X			X		X		C		EI

Family/species	Before 2005									After 2005										Local Status	Conservation Status	Guild
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19			
Myiarchus tyrannulus (Statius Muller, 1776)													X			X		X		C		EI
Sirystes sibilator (Vieillot, 1818)	X		X	X	X	X	X		X		X	X	X	X		X	X	X		FP		SCI
Pitangus sulphuratus (Linnaeus, 1766)	X		X		X		X		X		X	X	X			X		X		FP		EO
Machetornis rixosa (Vieillot, 1819)	X												X			X		X		NFP		EI
Myiodynastes maculatus (Statius Muller, 1776)	X		X	X	X	X	X		X		X	X	X	X		X	X	X		FM		EO
Megarynchus pitangua (Linnaeus, 1766)	X		X	X	X	X	X		X		X	X	X	X		X	X	X		FP		EO
Myiozetetes similis (Spix, 1825)	X		X	X	X		X						X			X		X		FP		EO
Tyrannus melancholicus Vieillot, 1819	X		X		X								X			X		X		FM		EI
Tyrannus savana Daudin, 1802	X												X			X		X		FM		EO
Empidonomus varius (Vieillot, 1818)	X						X						X			X		X		FM		EO
Colonia colonus (Vieillot, 1818)	X		X	X	X	X			X				X			X		X		FP		SCI
Myiophobus fasciatus (Statius Muller, 1776)	X		X	X									X	X		X		X		FM		EI
Pyrocephalus rubinus (Boddaert, 1783)	X												X			X				FM		EI
Arundinicola leucocephala (Linnaeus, 1764)	X																			S		EI
Cnemotriccus fuscatus (Wied, 1831)	X									X	X	X	X			X		X		FM		EI
Lathrotriccus euleri (Cabanis, 1868)	X		X		X	X	X		X	X	X	X	X	X		X		X	X	FM		UI
Contopus cinereus (Spix, 1825)	X												X					X		FP		SCI
Knipolegus cyanirostris (Vieillot, 1818)	X																	X		FP		EI
Satrapa icterophrys (Vieillot, 1818)	X																			S		EI
Muscipipra vetula (Lichtenstein, 1823) E	X																			S		SCI
Vireonidae																						
Cyclarhis gujanensis (Gmelin, 1789)	X		X	X	X	X	X		X		X	X	X			X	X	X		FP		SCO
Hylophilus poicilotis Temminck, 1822 E	X						X													PE		EI
Vireo chivi (Vieillot, 1817)	X						X		X				X			X		X		FM		SCO
Corvidae																						
Cyanocorax chrysops (Vieillot, 1818)	X		X	X	X	X	X		X		X	X	X	X		X	X	X		FP		EO
Hirundinidae																						
Pygochelidon cyanoleuca (Vieillot, 1817)	X												X	X		X		X		NFP		AI
Alopochelidon fucata (Temminck, 1822)	X																			OM		AI
Stelgidopteryx ruficollis (Vieillot, 1817)	X												X	X		X		X		FM		AI
Progne tapera (Vieillot, 1817)	X												X			X		X		FM		AI
Progne chalybea (Gmelin, 1789)	X												X					X		FM		AI
Tachycineta leucorrhoa (Vieillot, 1817)	X																	X		FM		AI

Family/species	Before 2005									After 2005										Local Status	Conservation Status	Guild
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19			
Hirundo rustica Linnaeus, 1758	X																			OM		AI
Petrochelidon pyrrhonota (Vieillot, 1817)	X																			OM		AI
Troglodytidae																						
Troglodytes musculus Naumann, 1823	X		X				X				X	X	X			X	X	X		NFP		EI
Polioptilidae																						
Polioptila lactea Sharpe, 1885 E	X		X	X	X		X													PE	NT-GL; EN-PR	SCI
Turdidae																						
Turdus leucomelas Vieillot, 1818	X		X	X	X	X	X		X		X	X	X	X		X	X	X	X	FP		EO
Turdus rufiventris Vieillot, 1818	X		X		X	X	X		X		X	X	X			X	X	X	X	FP		EO
Turdus amaurochalinus Cabanis, 1850	X		X	X		X	X		X		X	X	X			X		X		FP		EO
Turdus subalaris (Seebohm, 1887) E						X	X					X	X	X		X	X	X		FM		UO
Turdus albicollis Vieillot, 1818	X		X		X		X		X		X	X	X	X			X	X	X	FP		UO
Mimidae																						
Mimus saturninus (Lichtenstein, 1823)	X												X			X		X		NFP		EO
Motacillidae																						
Anthus lutescens Pucheran, 1855	X												X			X		X		NFP		EO
Passerellidae																						
Zonotrichia capensis (Statius Muller, 1776)	X						X						X			X		X		NFP		SE
Ammodramus humeralis (Bosc, 1792)	X												X			X		X		NFP		EO
Arremon semitorquatus Swainson, 1838 E													X							I		SE
Arremon flavirostris Swainson, 1838													X							S		SE
Parulidae																						
Setophaga pitiayumi (Vieillot, 1817)	X		X	X	X	X	X				X	X	X	X		X	X	X		FP		SCI
Geothlypis aequinoctialis (Gmelin, 1789)	X												X			X		X		NFP		EI
Basileuterus culicivorus (Deppe, 1830)	X		X	X	X	X	X		X		X	X	X			X	X	X	X	FP		UI
Myiothlypis flaveola Baird, 1865									X				X	X		X	X	X		C	VU-PR	EI
Myiothlypis leucoblephara (Vieillot, 1817) E	X		X	X	X		X				X	X	X			X	X	X	X	FP		UI
Icteridae																						
Cacicus chrysopterus (Vigors, 1825)													X							I		SCO
Cacicus haemorrhous (Linnaeus, 1766)	X		X	X	X	X	X		X		X	X	X	X		X	X	X		FP		SCO
Icterus pyrrhopterus (Vieillot, 1819)	X												X							FP		EO
Gnorimopsar chopi (Vieillot, 1819)	X																			S		EO
Molothrus oryzivorus (Gmelin, 1788)	X																			S		EO

Family/species	Before 2005									After 2005										Local Status	Conservation Status	Guild
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19			
Molothrus bonariensis (Gmelin, 1789)	X												X			X		X		NFP		EO
Sturnella superciliaris (Bonaparte, 1850)	X												X			X				NFP		EO
Thraupidae																						
Pipraeidea melanonota (Vieillot, 1819)	X			X	X	X	X		X				X	X		X		X		FP		SCO
Cissopis leverianus (Gmelin, 1788)	X		X	X	X	X	X						X			X		X		FP		LF
Tangara seledon (Statius Muller, 1776) E	X																			I		SCO
Tangara sayaca (Linnaeus, 1766)	X		X	X	X	X	X		X		X	X	X			X		X		FP		EO
Tangara preciosa (Cabanis, 1850)	X												X	X						FP		EO
Tangara cayana (Linnaeus, 1766)	X																			I	NT-PR	EO
Nemosia pileata (Boddaert, 1783)	X												X			X		X		FP		SCO
Conirostrum speciosum (Temminck, 1824)	X		X	X	X	X	X		X		X	X	X	X		X		X		FP		SCO
Sicalis flaveola (Linnaeus, 1766)																X		X		S		SE
Haplospiza unicolor Cabanis, 1851 E													X					X		C		SE
Hemithraupis guira (Linnaeus, 1766)	X		X	X	X	X	X		X		X	X	X	X		X		X		FP		SCO
Volatinia jacarina (Linnaeus, 1766)	X												X	X		X		X		FM		SE
Trichothraupis melanops (Vieillot, 1818)	X		X	X	X	X	X		X		X	X	X	X		X	X	X	X	FP		UO
Coryphospingus cucullatus (Statius Muller, 1776)	X												X	X		X		X		NFP		SE
Tachyphonus coronatus (Vieillot, 1822) E	X		X	X	X	X	X				X	X	X			X		X		FP		EO
Ramphocelus carbo (Pallas, 1764)	X																			S		EO
Tersina viridis (Illiger, 1811)	X						X		X				X	X		X		X		FM		SF
Dacnis cayana (Linnaeus, 1766)	X						X		X		X	X	X	X		X		X		FP		SCO
Coereba flaveola (Linnaeus, 1758)	X												X			X		X		FP		NE
Tiaris fuliginosus (Wied, 1830)	X																			EX		SE
Sporophila lineola (Linnaeus, 1758)													X							S		SE
Sporophila collaris (Boddaert, 1783)	X																			S		SE
Sporophila caerulescens (Vieillot, 1823)	X															X		X		NFP		SE
Saltator similis d'Orbigny & Lafresnaye, 1837	X		X		X	X	X		X		X	X	X	X		X		X	X	FP		EO
Saltator fuliginosus (Daudin, 1800) E	X		X	X	X	X	X		X		X	X	X				X	X		FP		LF
Thlypopsis sordida (d'Orbigny & Lafresnaye, 1837)													X			X				C		EO
Pyrrhocoma ruficeps (Strickland, 1844) E	X				X		X						X	X		X		X		FP		UI
Cardinalidae																						
Piranga flava (Vieillot, 1822)	X																			EX	NT-PR	SCO
Habia rubica (Vieillot, 1819)	X		X	X	X	X	X		X			X	X			X	X	X		FP		UO

Family/species	Before 2005									After 2005										Local Status	Conservation Status	Guild
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19			
Amaurospiza moesta (Hartlaub, 1853) E													X							I	NT-GL	SE
Cyanoloxia brissonii (Lichtenstein, 1823)	X																			I		SE
Fringillidae																						
Spinus magellanicus (Vieillot, 1805)	X																			S		SE
Euphonia chlorotica (Linnaeus, 1766)	X		X	X	X	X	X		X		X	X	X			X	X	X		FP		SF
Euphonia violacea (Linnaeus, 1758)	X		X	X	X						X	X	X			X		X		FP		SF
Euphonia cyanocephala (Vieillot, 1818)	X		X						X				X			X		X		FM		SF
Euphonia pectoralis (Latham, 1801)E	X			X	X		X				X	X								D		SF
Chlorophonia cyanea (Thunberg, 1822)	X																	X		I		SF
Estrildidae																						
Estrilda astrild (Linnaeus, 1758)	X																	X		S		SE
Passeridae																						
Passer domesticus (Linnaeus, 1758)	X																			S		EO

APPENDIX II

Species found in literature review and not included in the final list (Appendix I), since they were recorded only once and could represent dubious records or because their distributional ranges do not include northern Paraná state. Nomenclature of species follows Piacentini *et al.* (2015).

Species	Literature
Trogon viridis Linnaeus, 1766	Anjos *et al.* 1997, Anjos 2001
Cyanerpes cyaneus (Linnaeus, 1766)	Anjos *et al.* 1997
Attila rufus (Vieillot, 1819)	Anjos *et al.* 1997
Dysithamnus stictothorax (Temminck, 1823)	Anjos *et al.* 1997, Anjos *et al.* 2004
Drymophila ferruginea (Temminck, 1822)	Anjos *et al.* 1997, Anjos *et al.* 2004
Hemitriccus nidipendulus (Wied, 1831)	Anjos *et al.* 1997
Phylloscartes oustaleti (Sclater, 1887)	Anjos *et al.* 1997
Saltatricola atricollis (Vieillot, 1817)	Anjos *et al.* 1997
Aramides cajaneus (Statius Muller, 1776)	Anjos *et al.* 2007
Anabacerthia amaurotis (Temminck, 1823)	Anjos *et al.* 2007
Patagioenas maculosa (Temminck, 1813)	Bochio & Anjos 2012
Cichlocolaptes leucophrus (Jardine & Selby, 1830)	Bochio & Anjos 2012
Campylorhamphus trochilirostris (Lischtenstein, 1820)	Bochio & Anjos 2012