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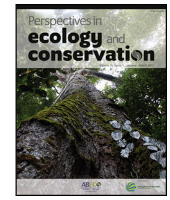

Research Letters

Bird-grassland associations in protected and non-protected areas in southern Brazil

Lucilene Inês Jacoboski[a,*], Raquel Klein Paulsen[b], Sandra Maria Hartz[a]

[a] Laboratório de Ecologia de Populações e Comunidades (LEPeC), Programa de Pós-Graduação em Ecologia, Universidade Federal do Rio Grande do Sul (UFRGS), Porto Alegre, Rio Grande do Sul, Brazil
[b] Laboratório de Ecologia de Populações e Comunidades (LEPeC), Graduação em Ciências Biológicas, Universidade Federal do Rio Grande do Sul (UFRGS), Porto Alegre, Rio Grande do Sul, Brazil

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ABSTRACT

Conversion of grasslands in other land uses is the main threat for grassland birds. We investigated habitat use by grassland birds in Permanent Preservation Areas surrounded by *Eucalyptus* plantation stands and non-protected grasslands (grazed native grasslands). As there is no evidence whether Permanent Preservation Areas are effective habitats for grassland avifauna, we compared such areas with grazed native grasslands, regarding richness, abundance and composition of grassland birds. Short and tall grassland bird specialists were recorded, with some species related to the non-protected areas and others to the protected areas. Thus, both areas are fundamental habitats for conservation of grassland bird species. We highlight the importance of grassland mosaics to maintain grassland bird species. Furthermore, we highlight the necessity of maintaining Permanent Preservation Areas in ranching and cropland areas, in order to connect grassland remnants in an extremely converted landscape and to conserve especially bird species that are more sensitive to disturbances.

Introduction

Grassland ecosystems are among the most threatened at global scale due to the great disparity between habitat loss and the low percentage of protected area (Hoekstra et al., 2005). Such ecosystems are submitted to strong anthropic pressure owing mainly to changes in land-use caused by monocultures (Azpiroz et al., 2012; Develey et al., 2008). In Brazil, grasslands of Pampa biome have a high degree of degradation, in the state of Rio Grande do Sul more than 50% of native grasslands has been converted mainly for agriculture and forest plantations (Bencke, 2009; Fontana et al., 2016).

Afforestation and agriculture with nonnative species have expanded over grazed native grasslands in extensive areas of Pampa biome (Azpiroz et al., 2012). The traditional cattle production is a compatible activity with conservation biodiversity if adequately managed (Develey et al., 2008; Isacch and Cardoni, 2011). The moderate grazing does not cause the suppression of native vegetation, maintaining the main characteristics of grassland ecosystems (Overbeck et al., 2007). On the other hand, tree monocultures totally replace the native local vegetation structure, affecting distribution of bird populations by reducing availability of resources that are important for nesting and feeding (Codesido et al., 2008). Tree plantations are known to alter the structure of bird communities in forest ecosystems, benefiting generalist and edge bird species (Jacoboski et al., 2016). However, in grassland landscapes, tree plantations can have more detrimental effects in birds than in forest ecosystems (Filloy et al., 2010).

The legal protection can effectively avoid conversion of native grasslands into other uses, and thus prevent complete loss of grassland biodiversity (Overbeck et al., 2007). Legal protection measures proposed by the Brazilian Forest Code determine the areas that must be preserved and which regions are allowed for cultivation, law n° 12.651/12 (CFB, 2012). Between the vegetation to be protected, is the marginal vegetation surrounding aquatic ecosystems. This vegetation, denominated Permanent Preservation Area (PPA), must be maintained by the delimitation of a buffer zone for both margins, which varies according to the width of a water course. A PPA consists of a protected area, covered or not by native vegetation, with the environmental function of preserving water resources, landscape, geological stability, and biodiversity, as well

* Corresponding author.
E-mail address: lucilene.jacoboski@yahoo.com.br (L.I. Jacoboski).

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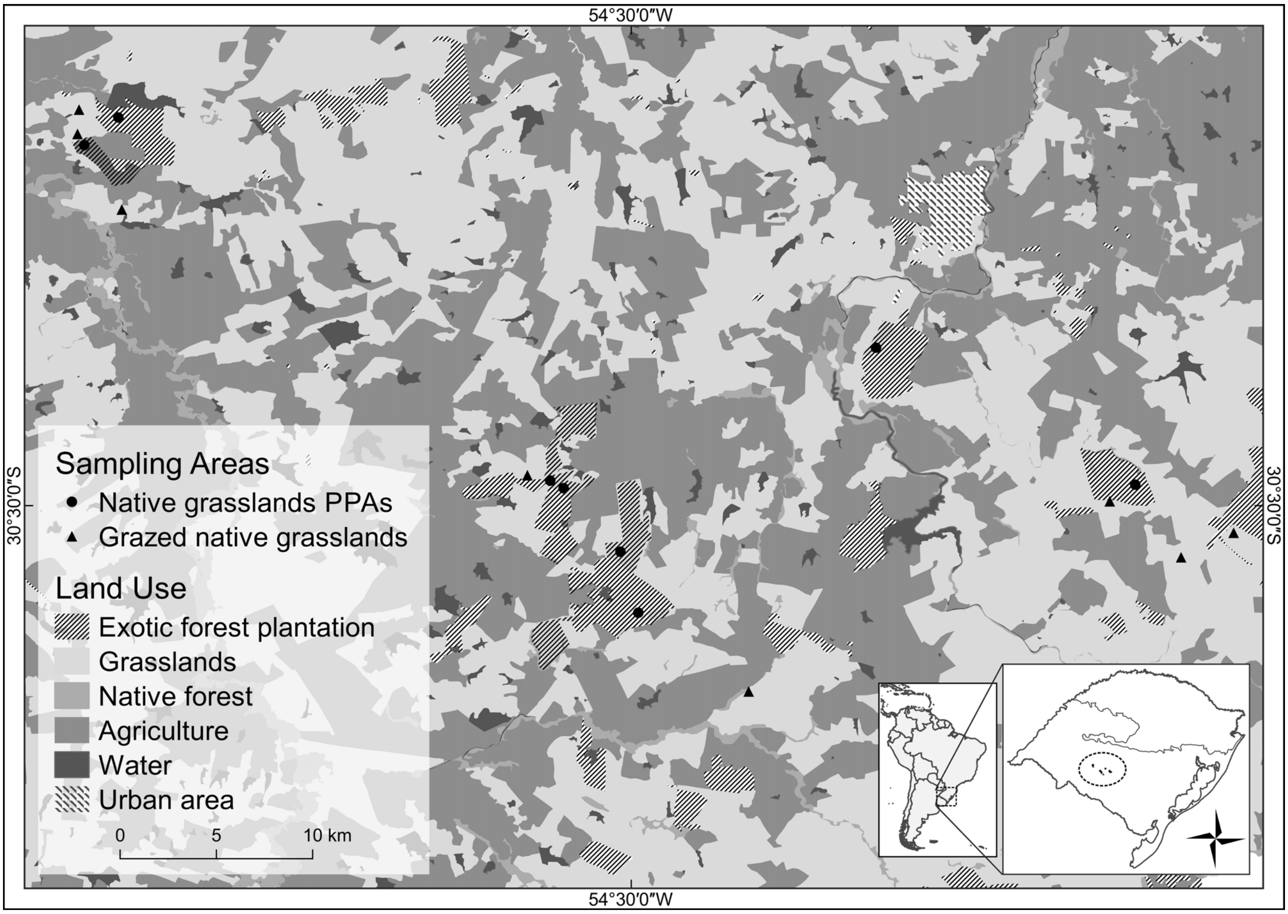

Fig. 1. Location of the study area in the state of Rio Grande do Sul. Circles represents sampled grazed native grasslands and triangle Permanent Preservation Area.

as of facilitating genetic flow of fauna and flora and protecting the soil. In tree plantations, the regulation of law is performed, however, in cattle ranching farms or soybean, such regulation is often not maintained, and when maintained, the tendency is to consider forest vegetation more than non-forest vegetation, even in grassland biomes (Develey et al., 2008; Overbeck et al., 2015).

Our goal was to investigate whether protected native grasslands (PPAs within *Eucalyptus* plantation stands) are viable to grassland birds. Furthermore, we aimed to identify whether these species are different from those recorded in non-protected areas (grazed native grasslands). Toward this aim we compared richness, abundance and composition of bird species between PPAs and grazed native grasslands. We hypothesized that (1) PPAs are viable for grassland species use because *Eucalyptus* stands are located in a matrix of grassland vegetation and possess connections among native grassland areas; (2) species composition should differ between protected and non-protected grasslands areas due to their differences in vegetation structure caused by grazing.

Material and methods

Study area

We conducted the study in two types of grassland vegetation: eight non-grazed PPAs located within *Eucalyptus* plantation stands (surrounded by eucalyptus), and eight areas of grazed native grasslands, for a total of 16 sample sites. These sites are located in the South Region of Brazil, in the municipalities of São Gabriel (30°, 20′11″ S, 54°, 19′12″ W) and Rosário do Sul (30°, 15′30″ S, 54°, 54′51″ W). The study area is located in the Pampa biome. Each *Eucalyptus* stand comprises a distinct silviculture area for cellulose production. The eucalyptus plantations had ages of cultivation between four and six years, which superior height to 15 m. For each of the eight *Eucalyptus* stands, adjacent areas of grazed grassland were sampled (Fig. 1).

The sampled sites were first selected using Google Earth (2014) images and subsequently checked in the field. The main characteristics taken into account for site selection were that sites for both PPAs and grassland areas should possess native vegetation and, specifically for PPAs, they should have predominantly grassland vegetation and be 100 m wide minimum. The PPAs composed of mostly forest vegetation were not included. The selected PPAs are located within *Eucalyptus* stands, protect margins of small water courses and have a minimum width of 100 m and varied length that depends on the forest stand size. No type of management is allowed within PPAs (e.g. ranching, fire). For the grazed native grassland, we included the sites that experienced low to intermediate grazing intensity and all pasture sites also had water courses, though without PPA delimitation.

Bird sampling

We carried out bird sampling once at each one of the 16 sites during the austral spring, between 2014 and 2015, including two reproductive seasons. Bird sampling was undertaken by applying the point count method (Bibby et al., 1992). We distributed the count points according to site size, ranging from three to nine points equally separated from each other by a distance of 200 m. We recorded all bird species seen or heard during a period of 10 min within a 50 m radius around each one of the points. We sampled

50 count points in each type of grassland, PPA or grazed native grassland ($n = 100$). Observations were limited to a 50 m radius in order to maximize detectability and to minimize the potential for observer error in identifying cryptic grassland species over long distances (Hovick et al., 2015). Sampling always started 10 min after sunrise and lasted for a maximum of 3 h. We performed all samplings during days without wind or rainfall. Birds in flight were not considered. Only grassland bird species were considered in the analyses, following the classification of Vickery et al. (1999) and Azpiroz et al. (2012). We also categorized the birds in relation to the height of the used vegetation, short or tall. Species restricted to short grass (<20 cm) or tall grass (>40 cm) and those that use both short and tall grasslands (*sensu* Azpiroz et al., 2012), besides on our own personal observations. We followed the Red Lists of IUCN (IUCN, 2015) and Rio Grande do Sul (DOE, 2014) to verify whether recorded species found were of conservation concern.

Vegetation sampling

To characterize vegetation of each sample site, we measured plant height and density using a stick subdivided into centimeters (Dias and Scarano, 2007). This method consists of positioning the stick vertically over the soil to record: (1) the number of times the stick was touched by vegetation (density); (2) height at which vegetation touches the stick. We performed four measurements of height and density at each bird count point ($n = 400$). Each measure was undertaken toward one of the four cardinal points (east, west, north and south), starting from the center count point in the distances of 5, 15, 30 and 50 m. Distance and direction to place the vegetation sampling points were randomly selected. To carry out the statistical analyses, we used mean values of plant height and density for each count point.

Statistical analyses

Initially, to check whether there was spatial autocorrelation in the sampled sites, we performed a Mantel correlation test between a matrix generated from taxonomic composition data (Bray–Curtis dissimilarity) and a matrix generated from geographical coordinate data of each count point (Euclidean distance).

To evaluate differences in richness and abundance of bird species, as well as in plant height and density between sample sites, we performed Analysis of Variance (ANOVA). To test differences in the species composition, we carried out a Multivariate Analysis of Variance (MANOVA), using Euclidean distance as the dissimilarity measure, both with 999 permutations. To test the influence of vegetation structure on taxonomic composition of grassland bird species, we employed a Canonical Correspondence Analysis (CCA). MANOVA and CCA were performed with logarithmized species abundance data ($\log x + 1$). We tested CCA significance with an ANOVA. Analyses were conducted with *vegan* package (Oksanen et al., 2015) on R 3.2.2 software (R Development Core Team, 2015).

Table 1
Total species number of grassland bird species sampled in Permanent Preservation Areas (PPAs) and grazed native grasslands (GNG), preferred grass height (*sensu* Azpiroz et al., 2012) and conservation status (IUCN, 2015; DOE, 2014). Acronyms of Fig. 2 also shown.

Species	PPAs	GNG	Grass height[a]	Conservation status[b]
Agelaioides badius (Agba)	3	0	Broad	LC
Ammodramus humeralis (Amhu)	23	49	Broad	LC
Anthus hellmayri (Anhe)	0	11	Short	LC
Anumbius annumbi (Anan)	0	4	Broad	LC
Cariama cristata (Cacr)	0	2	Broad	LC
Cistothorus platensis (Cipl)	1	4	Tall	NT (R)
Colaptes campestris (Coca)	3	6	Broad	LC
Columbina talpacoti (Cota)	0	1	Broad	LC
Culicivora caudacuta (Cuca)	2	0	Tall	VU (R, G)
Donacospiza albifrons (Doal)	8	0	Broad	LC
Emberizoides herbicola (Emhe)	27	19	Tall	LC
Emberizoides ypiranganus (Emyp)	10	2	Tall	LC
Embernagra platensis (Empl)	27	1	Tall	LC
Falco sparverius (Fasp)	0	3	Broad	LC
Furnarius rufus (Furu)	1	6	Broad	LC
Gallinago paraguaiae (Gapa)	0	4	Short	LC
Geranoaetus albicaudatus (Geal)	0	1	Broad	LC
Gnorimopsar chopi (Gnch)	1	2	Broad	LC
Mimus saturninus (Misa)	0	1	Broad	LC
Molothrus bonariensis (Mobo)	0	7	Broad	LC
Nothura maculosa (Noma)	3	5	Broad	LC
Progne tapera (Prta)	1	0	Broad	LC
Pseudoleistes guirahuro (Psgu)	0	3	Broad	LC
Rhynchotus rufescens (Rhru)	5	6	Broad	LC
Sicalis luteola (Silu)	7	33	Broad	LC
Sporophila caerulescens (Spca)	5	1	Broad	LC
Sporophila cinnamomea (Spci)	3	0	Tall	VU (G)
Sporophila pileata (Sppi)	1	0	Tall	VU (R)
Tapera naevia (Tapa)	3	0	Tall	LC
Tyrannus savana (Tysa)	5	20	Broad	LC
Vanellus chilensis (Vach)	2	11	Short	LC
Volatinia jacarina (Voja)	8	0	Tall	LC
Xanthopsar flavus (Xafl)	0	13	Broad	VU (R, G)
Xolmis irupero (Xoir)	0	2	Broad	LC
Zenaida auriculata (Zeau)	1	0	Broad	LC
Zonotrichia capensis (Zoca)	44	38	Broad	LC
Total	194	255		

[a] Association with the height vegetation, short or tall; the broad category indicates species that are less dependent of the grasslands height.
[b] VU, vulnerable; NT, near threatened; LC, least concern; R, regional threat; G, global threat.

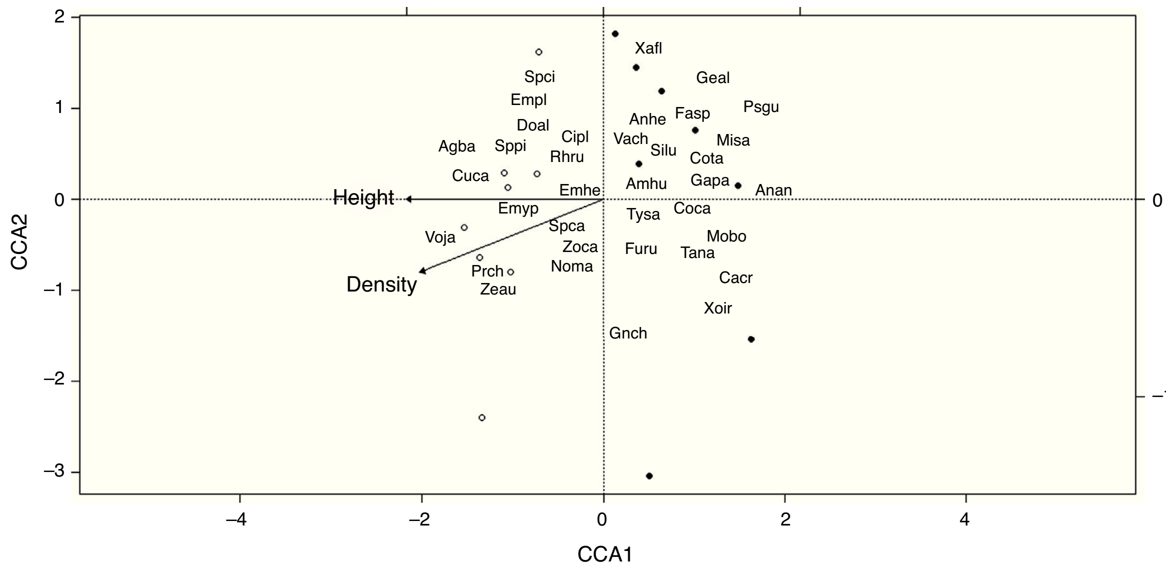

Fig. 2. Ordination diagram generated by the Canonical Correspondence Analysis (CCA) of bird species composition in relation to vegetation structure. Dark circles represent areas of grazed native grasslands; empty circles represent Permanent Preservation Areas (PPAs). Arrows represent mean plant height and mean plant density, respectively. Species names acronyms in Table 1.

Results

We recorded 36 grassland bird species (Table 1), 24 in the PPAs and 27 in the grazed native grasslands. Most of the recorded species uses both tall and short grasslands. However, only 15 species were shared between areas. The most abundant species were *Zonotrichia capensis* ($n = 44$) and *Ammodramus humeralis* ($n = 49$), in the PPAs and in the grazed native grassland, respectively. In relation to sample units, the Mantel test indicated that count points were independent as there was no significant spatial correlation ($r = 0.02$, $p = 0.15$). Both species richness and abundance did not present significant differences between sampled areas ($F_{1,14} = 1.91$, $p = 0.21$ and $F_{1,14} = 6.61$, $p = 0.07$, respectively). On the other hand, species composition differed significantly between areas ($F_{1,14} = 2.85$, $p = 0.001$). A clear segregation of species was observed between PPAs and grazed native grassland in the CCA (Fig. 2).

The CCA showed an association between birds species composition and vegetation structure. For example, typical tall grass species are associated with PPAs, while grazing selects species are less dependent on tall grasslands.

However, the CCA model was not significant when we tested it with an ANOVA including the two vegetation variables. Both variables were significant when we analyzed them separately: height ($F_{1,14} = 1.84$, $p = 0.002$) and density ($F_{1,14} = 1.7$, $p = 0.02$). Thus, mean plant height explained 12% of the variation in species composition and mean plant density explained 11%. Also, we detected significant differences in plant height and density when we tested PPAs versus grazed native grassland sites with an ANOVA ($F_{1,14} = 68$, $p = 0.001$ and $F_{1,14} = 40$, $p = 0.001$), respectively (Fig. 3).

Four of the species recorded are threatened in regional or global categories (*Sporophila pileata*, *Sporophila cinnamomea*, *Culicivora caudacuta*, *Xanthopsar flavus*) and one as regionally near threatened species (*Cistothorus platensis*). The three first species were

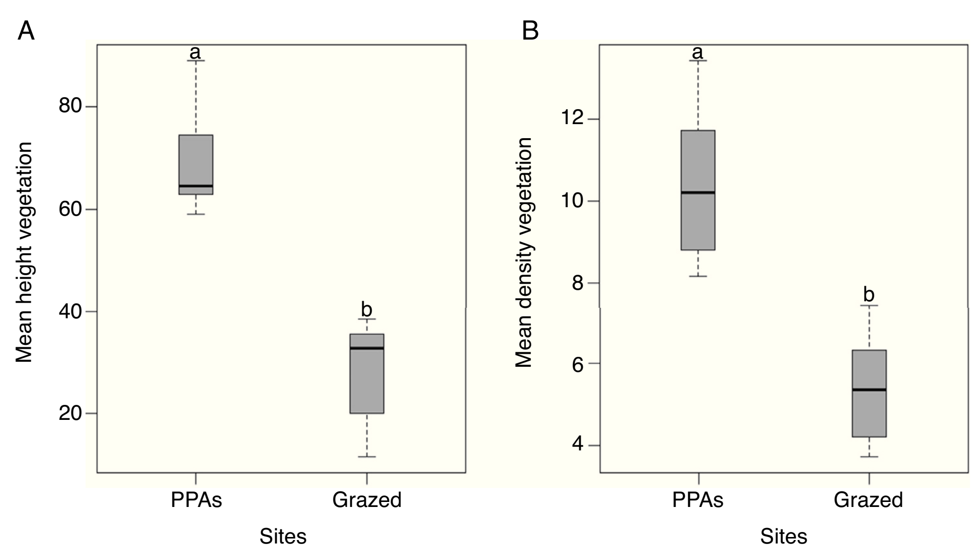

Fig. 3. Boxplots of mean plant height (A) and mean plant density in each one of the sampling sites (B), showing differences among sampled sites, with their maximum and minimum values and standard error. Different letters indicate significant differences between treatments.

exclusively observed in the PPAs, whereas *X. flavus* was only found in the grazed native grasslands. *C. platensis* was recorded in both areas.

Discussion

Our results demonstrate a turnover of species between areas, bird species recorded in the PPAs that depend on tall grass and preserved vegetation (e.g. *Sporophila* sp.) were replaced by species associated with short grass and (besides) by species that are less dependent on the height of the vegetation in the grazed native grasslands (e.g. *Anthus* sp.). These results demonstrate that presence of PPAs and grazed native grasslands with moderate levels of grazing are essential for the conservation of grassland birds, because two groups of species are benefited, short and tall grass dependent. Grassland birds differ in their sensitivity to disturbance of grasslands by grazing (Azpiroz et al., 2012). Areas with lower or no grazing are necessary to ensure viable populations of specialized tall grass species (Isacch and Cardoni, 2011). On the other hand, in grazed grasslands, a short grass assemblage of birds is benefited (Azpiroz et al., 2012).

Specific variations in habitat characteristics, such as the difference in recorded plant height and density, demonstrated to determine differences in bird species composition in the study areas. In the studies developed by Fisher and Davis (2010) and Dias et al. (2014), the authors indicated that plant height was the main factor associated with diversity and composition of bird species in grasslands. This difference in vegetation demonstrates the importance of grassland mosaics with plants of different heights for bird diversity. Many grassland birds require a mosaic with different habitat patches to fulfill their reproductive requirements (Dias et al., 2014). Currently, these mosaics are generated by patches with different grazing intensity, thereby contributing to the conservation of a great part of bird diversity (Isacch and Cardoni, 2011). On the other hand, Vickery et al. (1999) recommend that some areas should not be managed, for obtaining the maximum diversity of grassland birds. They also recognize that specific management practices can satisfy the specific requirements of a subset of species, but cannot benefit the others. Thus, this habitat heterogeneity is necessary to ensure species coexistence and maintaining the diversity of grassland bird communities (Codesido et al., 2013; Dias et al., 2014; Hovick et al., 2015).

The register of threatened *X. flavus* in grazed native grasslands demonstrated the importance of adequate management in private farms for maintain grassland-associated birds (Develey et al., 2008; Fontana et al., 2016). Furthermore, three threatened bird species found in our study were exclusive to the PPAs. These species are typical of tall and well preserved grasslands, in addition to being sensitive to any sort of disturbance (Bencke, 2009). The presence of threatened species in PPAs is satisfactory from the conservation point of view. However, we do not know whether these populations will remain viable in the long run, since indirect effects of afforestation in adjacent areas are still scarcely known. Indirect effects of neighboring tree plantations can affect the physical and biotic characteristics of adjacent areas, such as facilitation of shrub encroachment and increase of nest predation rates (Azpiroz et al., 2012; Reino et al., 2010).

Our results demonstrate the importance of maintaining protected and non-protected grasslands for conservation of grassland bird species. However, it is fundamental to investigate whether populations in the PPAs remain stable or these areas are only a temporary refuge in the face of imminent extinction. Furthermore, the maintenance of grassland PPAs and managed grasslands in a sustainable way might favor a high diversity of bird species in the study region, and help to avoid the processes that lead to extinction of strictly grassland species. Our results also highlighted the necessity of maintaining PPAs, especially in agricultural and grazing areas. Although PPAs in grasslands are protected by law, they are often neglected. For example, in sampled grazed native grasslands, grassy vegetation along the water courses is not protected, and thus cattle have free access to these areas. Therefore, the maintenance of grasslands PPAs by the landowners might be a useful tool to increase protection of the grasslands vegetation in private land, since landowners can act as important agents for the conservation of birds in the grasslands of south Brazil.

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Conflicts of interest

The authors declare no conflicts of interest.

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