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RESEARCH ARTICLE

Structure of avian assemblages in grasslands associated with cattle ranching and soybean agriculture in the Uruguayan savanna ecoregion of Brazil and Uruguay

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ABSTRACT
Conversion of grasslands into crops is a major factor leading to the decline of grassland birds. Cattle ranching represents another disturbance to natural grasslands, but may be less detrimental to grassland birds. We studied the diversity, density, and composition of bird species in Brazilian and Uruguayan grasslands under two different land use types: cattle ranching on seminatural grasslands, and soybean fields with interspersed patches of grassland. Cattle sites had higher species richness ($n = 75$ species) than soybean sites ($n = 57$ species). Most birds showed higher densities in cattle sites, but some common and habitat-generalist species were more abundant in soybean sites. Species composition did not differ significantly with land use. The generalist Eared Dove (*Zenaida auriculata*), however, was strongly associated with soybean sites. Among species of conservation interest, either regionally or globally, all had higher densities in cattle sites, highlighting the importance of maintaining these ranching areas. The persistence of grassland birds in soybean fields may be related to the presence of seminatural grassland patches within soybean crops.

Keywords: species richness, bird density, composition, grassland patches, conservation

Estrutura da assembleia de aves em campos associados com pecuária e soja na ecoregião das Savanas Uruguaias do Brasil e Uruguai

RESUMO
A conversão dos campos naturais em cultivos agrícolas é um dos principais fatores que causam declínio de aves campestres. Áreas de pecuária também apresentam distúrbio, no entanto são aparentemente menos impactantes quando comparadas à agricultura. Nesse estudo avaliamos possíveis diferenças na diversidade, densidade e composição de aves entre áreas sob dois diferentes usos do solo (pecuária em campos semi-naturais e plantação de soja com manchas de campo). Utilizamos o método de pontos de contagem para amostrar as aves. As áreas de pecuária apresentaram maior riqueza de espécies ($n = 75$) do que as áreas de soja ($n = 57$). A maior parte das espécies apresentou maior densidade nas áreas de pecuária. Quanto à composição das espécies, não houve uma separação evidente entre os dois tipos de uso, no entanto, *Zenaida auriculata*, uma espécie generalista, apareceu fortemente associada aos cultivos de soja. Registramos cinco espécies regional ou globalmente ameaçadas ou quase ameaçadas, todas com maior densidade em áreas de pecuária, destacando a importância da preservação destes campos. O desenvolvimento de práticas e políticas de manejo que tornem a produção agrícola e pecuária menos prejudiciais à biodiversidade são essenciais, uma vez que a manutenção das aves campestres em campos com soja está relacionada à existência de manchas de campos semi-naturais entre os cultivos.

Palavras-chave: riqueza de espécies, densidade de aves, composição, manchas de campo, conservação

INTRODUCTION

Agricultural intensification is considered one of the major causes of population declines of grassland birds worldwide (Chamberlain et al. 2000, Askins et al. 2007, Azpiroz et al. 2012b). Agricultural areas support less diverse bird communities than native grasslands, and tend to support generalist species (Herzon and O'Hara 2007, Codesido et al. 2013). Species respond differently to habitat changes, according to characteristics such as life history and plasticity (Filloy and Bellocq 2007, Lemoine et al. 2007, Codesido et al. 2012).

Agriculture brings a number of changes that affect virtually all aspects and processes of ecosystems, reducing the area of original habitats and transforming landscapes, which can result in few isolated fragments of natural habitats (Gilpin et al. 1992, Baldi and Paruelo 2008, Bilenca et al. 2008, 2012, Medan et al. 2011). Conversion of grasslands into crops negatively affects biodiversity, through mechanization and use of herbicides and fertilizers, but livestock production on grasslands also has negative effects (Filloy and Bellocq 2007). However, management practices that increase vegetation heterogeneity in structure or composition tend to be positive for grassland birds (Derner et al. 2009). Similarly, the amount of fallow area on a site and the presence of other seminatural habitats can also be positive for grassland birds.

The significant number of threatened grassland birds (50 species in Brazil and 24 in Uruguay) and the low representation of temperate grasslands in protected areas (2.2% in Brazil and 1.7% in Uruguay) underline the necessity of developing strategies to combine agricultural activities with conservation to maintain the biodiversity of the Uruguayan savanna ecoregion (MMA 2007, Develey et al. 2008). Land use in this ecoregion has been changing, with grasslands replaced by crops, particularly soy (*Glycine max*) and corn (*Zea mays*), during the Austral spring and summer, and exotic pastures (oats [*Avena sativa*] and ryegrass [*Lolium multiflorum*]) during the Austral fall and winter (Gressler 2008). Planted pastures increased by 32% between 1980 and 1990 in Uruguay (Martino 2004). Moreover, almost 16% of the original vegetation of Rio Grande do Sul State, Brazil, was replaced from 1976 to 2002, mostly through the introduction of exotic species for forage (i.e. ryegrass, lovegrass [*Eragrostis plana*], and other species), agricultural activity, mainly soybean and rice, and forestry (i.e. *Eucalyptus* spp. and *Pinus* spp.; Martino 2004, MMA 2007, Develey et al. 2008, Cordeiro and Hasenack 2009). In addition, areas of seminatural grassland without any sort of production, or that are managed under low densities of livestock, are almost nonexistent in the region. In this ecoregion, grassland patches remaining within soybean fields are typically unsuitable for agriculture because of topography, soil type, or moisture (Isacch et al. 2004). Most soybean fields in the region include patches of seminatural grassland, varying in size, quantity, and shape.

Azpiroz and Blake (2009) considered the value of barley (*Hordeum vulgare*) and sunflower (*Helianthus annuus*) fields, pasturelands, and native grasslands for grassland birds. Their results highlighted the importance of natural grasslands for specialist species. Here, we extend their study by including grasslands in Brazil and by including soybean fields containing grassland patches. Soybean agriculture is especially important to consider, as soybeans are currently the main crop causing habitat loss in the temperate grasslands of southern Brazil and Uruguay (Oyhantçabal and Narbondo 2011).

Our goal was to determine differences in bird species richness, density, and community composition in areas under two types of land use: (1) cattle ranching on seminatural grasslands (hereafter referred to as cattle sites), and (2) soybean fields with scattered patches of grassland (soybean sites). We hypothesized that both species richness and species density would be greater in cattle sites. To emphasize birds of conservation concern, we also analyzed the responses of birds classified as near-threatened and threatened, regionally and globally (Azpiroz et al. 2012a, IUCN 2013, DOE 2014).

METHODS

Study Area

We worked in eight 300-ha sites in the Uruguayan savanna ecoregion divided into two land use types, cattle sites (C) and soybean sites (S; Figure 1). Cattle sites ($n = 4$) were dominated by seminatural grassland (cattle stocking rate ha^{-1}: C1 = 0.96; C2 = 0.57; C3 = 0.89; C4 = 0.75) and were located in Brazil—in Dom Pedrito county (C1: 30°58′58′′S, 54°20′12′′W) in the state of Rio Grande do Sul—and in Uruguay: Rivera (C2: 30°58′19′′S, 55°26′40′′W), Vichadero (C3: 31°40′04′′S, 54°31′30′′W), and Melo (C4: 32°21′03′′S, 53°58′54′′W). Soybean sites ($n = 4$) had 8–17% coverage of seminatural grasslands, but were dominated by soybean fields during the Austral summer, and either wheat (*Triticum vulgare*; in Uruguay) or ryegrass (in Brazil) during the Austral winter. The locations of soybean sites and percentage of grassland were as follows: Dom Pedrito county (S1: 31°04′25′′S, 54°20′33′′W; 90% soy and 10% grassland) and Santana do Livramento county (S2: 30°56′39′′S, 55°24′45′′W; 92% soy and 8% grassland), both in the state of Rio Grande do Sul, Brazil; and Vichadero (S3: 31°40′23′′S, 54°33′09′′W; 83% soy and 17% grassland) and Melo (S4: 32°13′29′′S, 54°34′01′′W; 89% soy and 11% grassland) in Uruguay.

We chose our study sites based on similar climatic characteristics, type of soil (deep soils), and topography, which ranged from 100 to 400 m asl with undulating features (called *coxilhas*) among flat areas, so that any differences in species composition would not be related to differences in these characteristics (Hasenack et al. 2010). We assumed that dominant plant species in grassland patches within soybean fields were the same as those found on cattle sites. Soybean sites had also been used for cattle ranching until the recent introduction of soybeans; the sites we surveyed were in the second and third year of crop plantations (Oyhantçabal and Narbondo 2011). Cattle sites were mainly composed by the following species: *Andropogon selloanus*, *Axonopus affinis*, *Dichantelium sabulorum*, *Eragrostis neesii*, *Mnesithea selloana*, *Pennisetum clandestinum*, *Sporobolus indicus*, *Stipa setigera*, *Aspilia montevidensis*, *Chaptalia piloselloides*, *Chevreulia sarmen-*

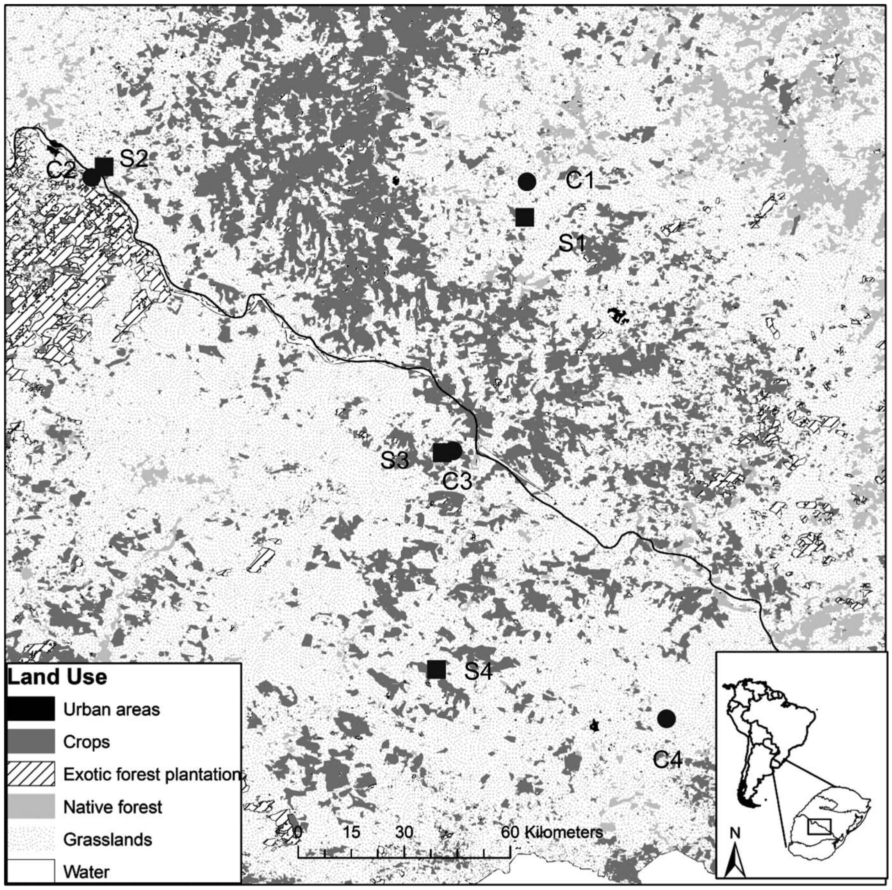

FIGURE 1. Bird species surveys in 2010–2012 in 8 sites in the Uruguayan savanna ecoregion in Brazil and Uruguay: 4 cattle sites (cattle ranching on seminatural grasslands; circles) and 4 soybean sites (soybean fields with scattered patches of grassland; squares).

tosa, *Conyza bonariensis*, *Facelis retusa*, *Gamochaeta americana*, *Baccharis* spp., *Paspalum* spp., *Piptochaetium* spp., *Setaria* spp., *Hypochaeris* spp., *Lucilia* spp., *Senecio* spp., and *Soliva* spp. (Dotta 2013, V. Gomes personal communication). All soybean fields had the same type of management, with no-till of genetically modified seeds and use of glyphosate. The sowing period was in October–November, with a few later-maturing varieties being planted in December, and harvesting began in late March to April (T. W. da Silva and G. Dotta personal observation). Our surveys were carried out across all the main growth stages (i.e. recently sown, emergent, in full flower, in full pod, in full seed, and at full maturity; Pedersen et al. 2007).

Bird Sampling

We surveyed each of the 8 sites during the Austral spring–summer, once in 2010–2011 and once in 2011–2012. We distributed 20 points systematically in each site, at least 100 m from the field edge to avoid edge effects (Ricketts et al. 2001); points were circular plots of unlimited radius, separated from each other by 300 m. Birds counted in soybean sites could be either in soybeans per se or in the patches of seminatural grasslands within the soybean fields. All 20 points were sampled in each of the 2 survey periods. We surveyed birds with 5-min point counts, excluding flyovers (Ralph et al. 1995, Bibby et al. 2000, Matsuoka et al. 2014). Surveys started at 06:00 and lasted ~4 hr. We only carried out surveys on days without wind and/or rain. Distances from the observer to birds were measured with a rangefinder. T. W. da Silva and G. Dotta carried out all surveys. We followed Remsen et al. (2014) for taxonomy.

Statistical Analysis

Species richness. We used ANOVA to test for treatment effects on species richness recorded in all point counts combined in each plot after testing for homoscedasticity with a Levene's test, for all species found and for grassland species only. We estimated species richness for each treatment for all plots combined based on the Chao 1 estimator (Colwell and Coddington 1994), with 100 randomizations, using EstimateS 8.2.0 (Colwell 2009). We also used Chao 1 to estimate numbers of grassland species for each treatment. All statistical analyses were performed using R 2.15.2 (R Development Core Team 2012) package 'car' (Fox and Weisberg 2011).

Population densities. We estimated the density of individual species in each treatment using the MCDS (Multiple Covariates Distance Sampling) engine in Distance 6.0 (Thomas et al. 2009). Aquatic birds, raptors, and swallows were excluded from the density analyses. Species with >30 observations were analyzed individually (following Fritcher et al. 2004). For these species we poststratified analysis by sample, in order to obtain species density in each site. Other species were assigned into 5 groups using characteristics of habitat and conspicuousness, in order to achieve the minimum number of observations required to produce a reliable detection function with Distance (see Buckland et al. 2001:302, Azpiroz and Blake 2009, Phalan et al. 2011). For species analyzed as a group, we used the group detection probability function and poststratified the model by species to obtain each species' density in each site. We truncated the 10% of the data with the longest distances within each species individually and within each group to avoid double-counting of the same individual, as recommended by Buckland et al. (2001). We compared the following models for each species and group: half-normal and hazard-rate key functions with cosine, simple polynomial, and hermite polynomial series expansion adjustments. We chose the final model based on the Kolmogorov-Smirnov probability test for goodness-of-fit and on Cramér–von Mises uniform and cosine probability tests for plausibility, and then compared model AIC (Akaike's Information Criterion) values to select the model with the lowest value. Density estimates are presented with 95% confidence intervals; species with nonoverlapping intervals are considered to have different densities between land use types.

Community composition. Using Nonmetric Multidimensional Scaling (NMDS) with the Bray-Curtis index, we plotted the 8 sites in a multidimensional space defined by the total number of individuals of each bird species to graphically represent associations among sites. For this analysis we used package 'vegan' in R 2.15.2 (Oksanen et al. 2012, R Development Core Team 2012). Aquatic birds, raptors, and swallows were again excluded from these analyses.

RESULTS

Species Richness

We recorded 2,998 individuals from 32 families and 87 species (Appendix): 1,453 individuals from 75 species in the seminatural grassland cattle sites, and 1,564 individuals from 57 species in the soybean sites. Among these species, 38 species that were detected in the cattle sites and 30 species detected in the soybean sites are considered representative of southeastern South American grasslands ('grassland species' hereafter; indicated in the Appendix based on Azpiroz et al. 2012b). Based on raw point count records from each plot, cattle sites had higher species richness than soybean sites for all species (ANOVA, $F_{1,6} = 14.3$, $P = 0.003$) and for just grassland species (ANOVA, $F_{1,6} = 17.9$, $P = 0.07$). Chao 1 curves for all sites combined within each treatment did not reach a plateau for all species or for just grassland species, especially for cattle sites, indicating that more species would be found with more effort (Figure 2). Despite some overlap in 95% CI, the cattle sites showed higher estimated species richness for all species (cattle: Chao 1 estimate = 93 species, 95% CI = 80–140; soybean: Chao 1 estimate = 69 species, 95% CI = 60–105) and for just grassland species (cattle: Chao 1 estimate = 51 species, 95% CI = 40–132; soybean: Chao 1 estimate = 32 species, 95% CI = 30–43).

Population Densities

Among the 56 species for which we analyzed density, most showed higher densities in cattle sites, but only 6 species had nonoverlapping 95% confidence intervals (Table 1): Eared Dove (*Zenaida auriculata*), Rufous Hornero (*Furnarius rufus*), Firewood-gatherer (*Anumbius annumbi*), Great Kiskadee (*Pitangus sulphuratus*), Grassland Yellow-Finch (*Sicalis luteola*), and Rufous-collared Sparrow (*Zonotrichia capensis*). Eared Doves had higher densities in soybean sites, and the other 5 species had higher densities in cattle sites.

Species Composition

The NMDS did not show a clear separation between the two land use types (Figure 3). Although cattle sites were more tightly clustered than soybean sites, two soybean sites fell within that cluster. The Eared Dove was strongly associated with the other two soybean sites, which were highly distinct on NMDS axis 2.

Among the species classified in any of the categories of threat or as near-threatened, either regionally or globally, we recorded 5 species (Table 2): Greater Rhea (*Rhea americana*), Burrowing Owl (*Athene cunicularia*), Black-and-white Monjita (*Xolmis dominicanus*), Sedge Wren (*Cistothorus platensis*; Figure 4), and Saffron-cowled Blackbird (*Xanthopsar flavus*). The first 3 species were recorded in both soybean and cattle sites. The Sedge Wren and Saffron-cowled Blackbird were recorded only in cattle sites.

DISCUSSION

Our results showed that the two land use types did not differ in bird species composition or individual species densities for most species. Nevertheless, cattle sites had higher species richness than soybean sites, and also supported more species considered representative of southeastern South American grasslands. Moreover, some

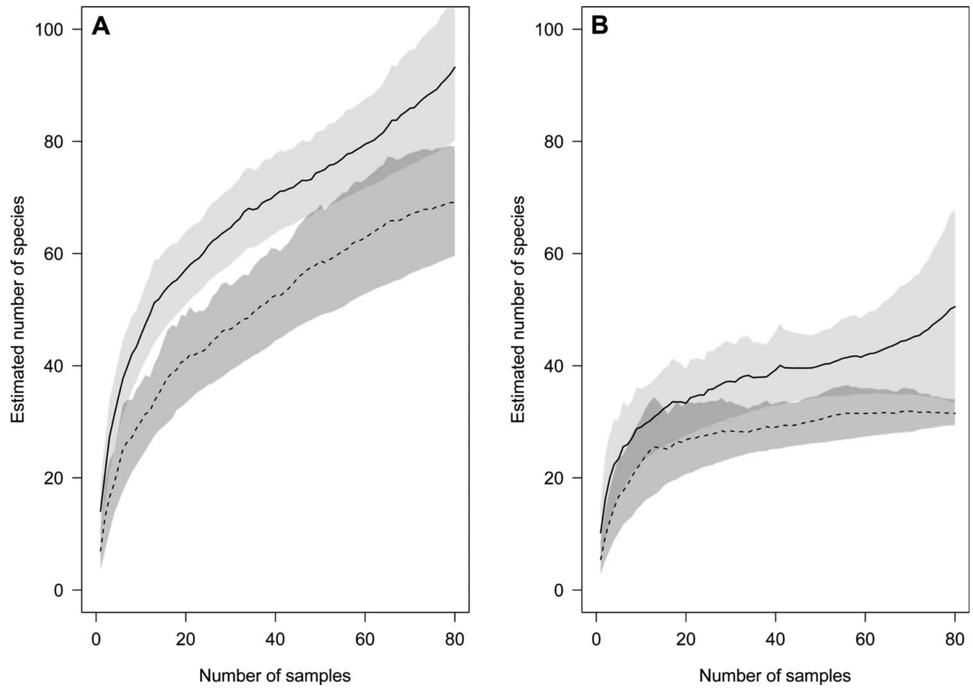

FIGURE 2. Sample-based bird species accumulation curves in 8 sites in the Uruguayan savanna ecoregion in Brazil and Uruguay in 2010–2012 from Chao 1 (Colwell and Coddington 1994) estimates (mean ± 95% CI) for each treatment (cattle sites = solid line, soybean sites = dashed line) for all sites combined within each treatment: (**A**) All species, (**B**) Grassland species only.

threatened species were found only in cattle sites, highlighting the greater value of this land use for bird conservation.

Codesido et al. (2008) found the same pattern for species richness when comparing seminatural grasslands under cattle ranching and crop fields (several crops) in Argentina. The high number of species (57) that we found in soybean fields, including some grassland specialists, is possibly associated with the grassland patches within the soy (Coppedge et al. 2001, Bennett et al. 2006, Cerezo et al. 2011). These patches might increase the heterogeneity of vegetation at the landscape level, supplying areas for foraging that favor the occurrence and abundance of grassland specialists (Herkert 1994, Vickery et al. 1994, Winter and Faaborg 1999, Johnson and Igl 2001, Cerezo et al. 2011). Furthermore, the Black-and-white Monjita and Saffron-cowled Blackbird, which are species of conservation concern, have been reported in crop fields, including soy, albeit not frequently (Azpiroz et al. 2012b, BirdLife International 2014, C. S. Fontana personal observation).

To our knowledge there are no published studies of birds in soybean monoculture in South American grasslands, and it would be useful to examine birds' responses without the presence of interspersed patches of natural habitat. Further, it will be important to understand how grassland patches within row crops change over time in suitability for birds. A relatively high number of bird species can be recorded in crop fields, provided the management processes, from planting to harvest, generate some differences in vegetation structure (Azpiroz and Blake 2009, VanBeek et al. 2014, Weyland et al. 2014). Nevertheless, many bird species are likely to disappear as crops replace natural habitats and as land use switches from a species-rich grassland ecosystem to a simpler system, such as soybean monoculture (Blum et al. 2008).

Agricultural intensification leads to homogeneous landscapes. As such, monocultures affect birds through reducing areas for nesting, food supply, and cover (Filloy and Bellocq 2007, Codesido et al. 2008, Bilenca et al. 2009). Our results on species composition are comparable to those of Filloy and Bellocq (2007) and Codesido et al. (2008), suggesting that replacing seminatural grasslands with crops is more harmful to grassland birds than cattle ranching activities, at least at the vegetation and stocking densities that we sampled. In the grasslands of southern Brazil and Uruguay the matrix is still predominantly composed of seminatural habitat (i.e. grasslands), and although we have not examined the effects of the matrix on bird species composition, the matrix is likely to exert some influence. Moreover, bird communities are likely to be more homogeneous in crop fields than in more complex habitats such as natural grasslands (Hsu et al. 2010).

Among the species of conservation interest, the Greater Rhea was the only one with a larger number of records in soybean fields, highlighting the importance of maintaining

TABLE 1. Density of birds in 2010–2012 in 8 sites in the Uruguayan savanna ecoregion in Brazil and Uruguay based on Distance sampling (individuals ha^{-1}; D), and 95% confidence intervals, at sites with cattle ranching on seminatural grasslands (cattle sites; C) and soybean with grassland patches (soybean sites; S). Nonoverlapping confidence intervals between treatments are in bold.

		Land-use type: D (95% CI)	
Species	Code	C	S
Rhea americana	Rame	0.006 (0.009–0.043)	0.047 (0.011–0.185)
Rhynchotus rufescens	Rruf	0.335 (0.176–0.638)	0.418 (0.227–0.770)
Nothura maculosa	Nmac	0.057 (0.016–0.219)	0.081 (0.029–0.233)
Syrigma sibilatrix	Ssib	0.103 (0.004–0.027)	0.000
Theristicus caerulescens	Tcae	0.010 (0.002–0.045)	0.000
Vanellus chilensis	Vchi	0.159 (0.076–0.335)	0.072 (0.032–0.164)
Calidris bairdii	Cbai	0.006 (0.001–0.031)	0.000
Patagioenas picazuro	Ppic	0.034 (0.003–0.422)	0.013 (0.001–0.162)
Zenaida auriculata	Zaur	0.055 (0.025–0.121)	**1.571 (0.673–3.665)**
Leptotila verreauxi	Lver	0.012 (0.003–0.042)	0.000
Columbina picui	Cpic	0.006 (0.001–0.031)	0.006 (0.001–0.031)
Guira guira	Ggui	0.065 (0.005–0.830)	0.009 (0.001–0.130)
Tapera naevia	Tnae	0.008 (0.002–0.042)	0.000
Athene cunicularia	Acun	0.089 (0.026–0.307)	0.048 (0.015–0.150)
Colaptes melanochloros	Cmel	0.018 (0.006–0.052)	0.000
Colaptes campestris	Ccam	0.046 (0.023–0.095)	0.006 (0.001–0.025)
Cariama cristata	Ccri	0.007 (0.001–0.042)	0.014 (0.003–0.061)
Myiopsitta monachus	Mmon	0.066 (0.023–0.187)	0.049 (0.010–0.241)
Geositta cunicularia	Gcun	0.033 (0.010–0.117)	0.000
Furnarius rufus	Fruf	**0.313 (0.187–0.523)**	0.049 (0.022–0.112)
Phacellodomus striaticollis	Pstr	0.053 (0.016–0.178)	0.029 (0.012–0.071)
Anumbius annumbi	Aann	**0.079 (0.043–0.146)**	0.013 (0.004–0.041)
Hirundinea ferruginea	Hfer	0.053 (0.010–0.277)	0.000
Pyrocephalus rubinus	Prub	0.032 (0.011–0.097)	0.000
Hymenops perspicillatus	Hper	0.021 (0.010–0.042)	0.000
Satrapa icterophrys	Sict	0.041 (0.015–0.114)	0.000
Xolmis cinereus	Xcin	0.020 (0.007–0.230)	0.007 (0.001–0.042)
Xolmis irupero	Xiru	0.041 (0.017–0.104)	0.010 (0.002–0.045)
Xolmis dominicanus	Xdom	0.039 (0.019–0.079)	0.008 (0.003–0.022)
Machetornis rixosa	Mrix	0.064 (0.024–0.193)	0.000
Pitangus sulphuratus	Psul	**0.078 (0.043–0.140)**	0.017 (0.007–0.038)
Tyrannus melancholicus	Tmel	0.040 (0.014–0.124)	0.004 (0.001–0.021)
Tyrannus savana	Tsav	0.389 (0.103–1.471)	0.195 (0.049–0.767)
Cistothorus platensis	Cpla	0.041 (0.019–0.089)	0.000
Turdus rufiventris	Truf	0.012 (0.003–0.049)	0.004 (0.001–0.021)
Turdus amaurochalinus	Tama	0.004 (0.001–0.021)	0.000
Mimus saturninus	Msat	0.062 (0.027–0.143)	0.038 (0.010–0.140)
Anthus lutescens	Alut	0.006 (0.001–0.031)	0.023 (0.007–0.083)
Anthus furcatus	Afur	0.008 (0.002–0.043)	0.000
Anthus hellmayri	Ahel	0.113 (0.048–0.266)	0.068 (0.025–0.180)
Paroaria coronata	Pcor	0.072 (0.040–0.130)	0.033 (0.015–0.071)
Donacospiza albifrons	Dalb	0.034 (0.008–0.141)	0.000
Sicalis flaveola	Sfla	0.016 (0.005–0.056)	0.004 (0.001–0.021)
Sicalis luteola	Slut	**1.001 (0.736–1.361)**	0.272 (0.162–0.457)
Embernagra platensis	Epla	0.176 (0.088–0.351)	0.085 (0.035–0.202)
Saltator aurantiirostris	Saur	0.000	0.029 (0.012–0.071)
Zonotrichia capensis	Zcap	**0.493 (0.320–0.759)**	0.156 (0.079–0.308)
Ammodramus humeralis	Ahum	0.374 (0.230–0.607)	0.367 (0.226–0.597)
Gnorimopsar chopi	Gcho	0.004 (0.001–0.021)	0.000
Xanthopsar flavus	Xfla	0.032 (0.007–0.153)	0.000
Pseudoleistes guirahuro	Pgui	0.057 (0.013–0.252)	0.073 (0.004–1.215)
Pseudoleistes virescens	Pvir	0.199 (0.092–0.432)	0.063 (0.012–0.315)
Agelaioides badius	Abad	0.016 (0.003–0.083)	0.000
Molothrus bonariensis	Mbon	0.152 (0.071–0.327)	0.026 (0.009–0.077)
Sturnella superciliaris	Ssup	0.073 (0.038–0.140)	0.079 (0.042–0.149)
Sporagra magellanica	Smag	0.049 (0.003–0.049)	0.000

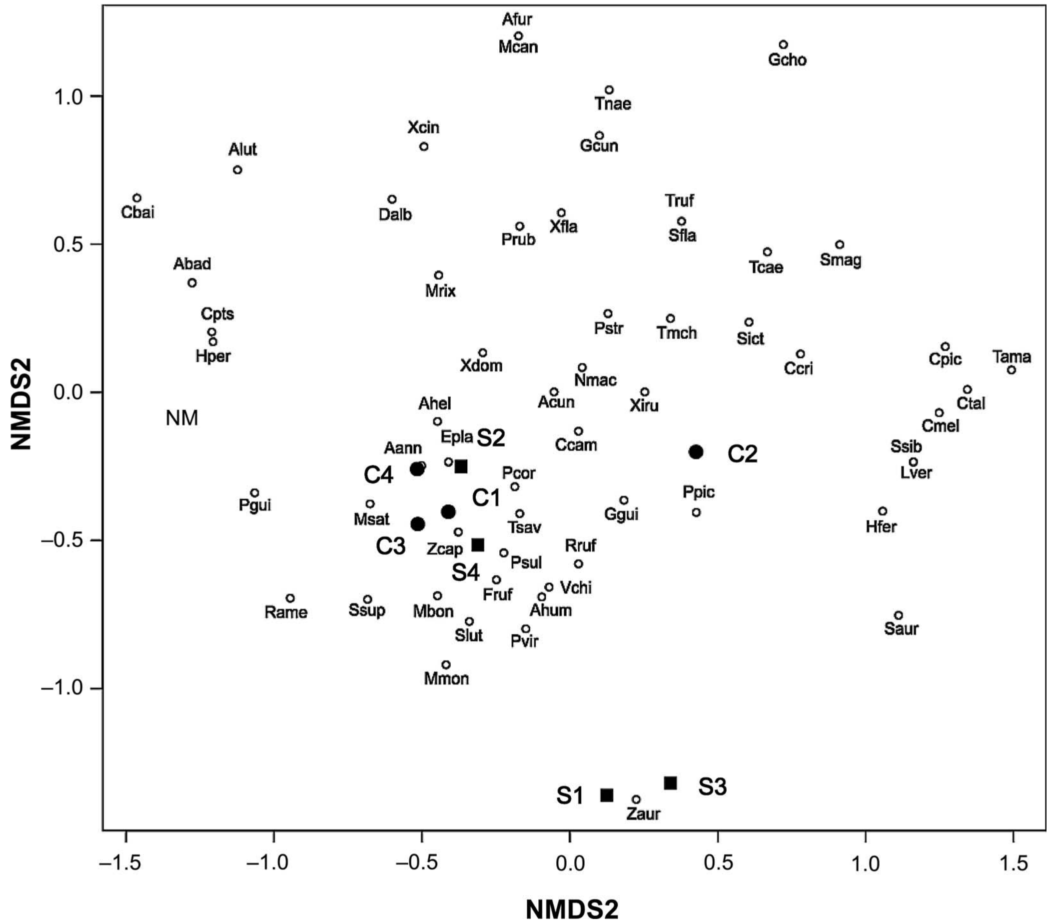

FIGURE 3. Nonmetric Multidimensional Scaling (NMDS) based on the abundance of bird species of 8 sites in the Uruguayan savanna ecoregion in Brazil and Uruguay in 2010–2012 in the two types of land use: 4 cattle sites (circles, C1–C4) and 4 soybean fields with grassland patches (squares, S1–S4), using the Bray-Curtis similarity index. Species abbreviations are in Table 1.

TABLE 2. Number of records and replicates of species of conservation concern in the Uruguayan savanna ecoregion in Brazil and Uruguay in 2010–2012 in cattle sites (C) and soybean sites (S) where threatened species were observed.

	C		S	
Threatened species	No. records	No. replicates	No. records	No. replicates
Rhea americana [a]	6	1	40	2
Athene cunicularia [b]	13	3	7	1
Xolmis dominicanus [c]	17	2*	3	1
Cistothorus platensis [d]	7	1	0	0
Xanthopsar flavus [c]	8	2	0	0

[a] Near-threatened globally.
[b] Near-threatened in Uruguay.
[c] Vulnerable in Brazil, Uruguay, and globally.
[d] Near-threatened in Brazil and Vulnerable in Uruguay.
* We observed this species on a third replicate of cattle sites while moving between sites.

other habitats for species of conservation concern. Both Saffron-cowled Blackbird and Black-and-white Monjita populations have been declining, mainly due to natural habitat destruction and alteration of land use (Bencke et al. 2003, Azpiroz et al. 2012a, IUCN 2013). The fact that the Black-and-white Monjita was recorded in soybean fields might represent a legacy effect of the recent conversion of the site, or might reflect actual persistence in soybean fields with interspersed grassland remnants, with these remnants perhaps providing foraging opportunities amongst the soybeans. It is important to note that a pair and a young individual of the species were observed more than once in a seminatural grassland area adjoining a soybean field. On the other hand, Azpiroz and Blake (2009) recorded the Black-and-white Monjita only in crop areas (barley and sunflower fields) in a study carried out in Paysandú and Salto, Uruguay, and Gressler (2008) observed the species adjacent to corn crops. Perhaps additional study will reveal how this species uses mixed agricultural landscapes.

FIGURE 4. Sedge Wren (*Cistothorus platensis*). Photo credit: G. Dotta.

Implications for Conservation

Agricultural production and conservation of biodiversity compete for land in the Uruguayan savanna ecoregion. Conservation practices and agricultural production in this region should be considered together, and discussed among farmers, conservationists, and government agencies. Future studies should focus on monitoring species densities through time and carrying out research on the breeding biology, distribution, and population viability of grassland birds. Our research did not evaluate possible within-season heterogeneity in bird use of soybean fields as the fields developed from sowing through to harvesting, but this could reveal more detailed patterns of bird use, especially whether birds are able to complete breeding cycles. Soybean fields are a recent addition to the region, and remnant patches of seminatural grassland might provide birds with opportunities for feeding and breeding. Our results can be considered a first step in a range of research that is still needed to understand the factors that allow persistence of grassland birds in crops with grassland patches.

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APPENDIX

Number of individuals of species sampled in 2010–2012 in the two types of land use of the Uruguayan savanna ecoregion, including aquatic birds, raptors, and swallows. C = cattle sites (cattle ranching on seminatural grasslands) and S = soybean sites (soybean fields with scattered patches of grassland).

Family and species	Habitat	
	C	S
Rheidae		
Greater Rhea (*Rhea americana*)*	6	40
Tinamidae		
Red-winged Tinamou (*Rhynchotus rufescens*)*	33	47
Spotted Nothura (*Nothura maculosa*)*	9	10
Anhimidae		
Southern Screamer (*Chauna torquata*)	5	6
Anatidae		
White-faced Whistling-Duck (*Dendrocygna viduata*)	0	4
Brazilian Teal (*Amazonetta brasiliensis*)	0	12
Silver Teal (*Anas versicolor*)	0	7
Masked Duck (*Nomonyx dominicus*)	0	20
Ciconiidae		
Wood Stork (*Mycteria americana*)	1	0
Ardeidae		
Cocoi Heron (*Ardea cocoi*)	0	1
Great Egret (*Ardea alba*)	1	1
Whistling Heron (*Syrigma sibilatrix*)	5	0
Snowy Egret (*Egretta thula*)	0	1
Threskiornithidae		
White-faced Ibis (*Plegadis chihi*)	3	0
Bare-faced Ibis (*Phimosus infuscatus*)	0	3
Plumbeous Ibis (*Theristicus caerulescens*)	4	0

Continued.

Family and species	Habitat	
	C	S
Cathartidae		
Turkey Vulture (*Cathartes aura*)	7	5
Lesser Yellow-headed Vulture (*Cathartes burrovianus*)	2	0
Black Vulture (*Coragyps atratus*)	1	0
Accipitridae		
White-tailed Kite (*Elanus leucurus*)*	0	1
Savanna Hawk (*Buteogallus meridionalis*)*	1	1
Rallidae		
Common Gallinule (*Gallinula galeata*)	0	1
White-winged Coot (*Fulica leucoptera*)	0	22
Charadriidae		
Southern Lapwing (*Vanellus chilensis*)*	53	79
Recurvirostridae		
Black-necked Stilt (*Himantopus mexicanus*)	0	18
Scolopacidae		
Baird's Sandpiper (*Calidris bairdii*)	1	0
Columbidae		
Ruddy Ground Dove (*Columbina talpacoti*)	2	0
Picui Ground Dove (*Columbina picui*)	1	1
Picazuro Pigeon (*Patagioenas picazuro*)	24	13
Eared Dove (*Zenaida auriculata*)	26	868
White-tipped Dove (*Leptotila verreauxi*)	5	0
Cuculidae		
Guira Cuckoo (*Guira guira*)	27	4
Striped Cuckoo (*Tapera naevia*)	2	0
Strigidae		
Burrowing Owl (*Athene cunicularia*)*	13	7

Continued.

Family and species	Habitat	
	C	S
Alcedinidae		
Green Kingfisher (*Chloroceryle americana*)	1	0
Picidae		
White Woodpecker (*Melanerpes candidus*)	1	0
Green-barred Woodpecker (*Colaptes melanochloros*)	3	0
Campo Flicker (*Colaptes campestris*)*	26	5
Cariamidae		
Red-legged Seriema (*Cariama cristata*)*	5	2
Falconidae		
Southern Caracara (*Caracara plancus*)*	1	2
Yellow-headed Caracara (*Milvago chimachima*)	4	2
Chimango Caracara (*Milvago chimango*)*	4	2
American Kestrel (*Falco sparverius*)*	20	6
Psittacidae		
Monk Parakeet (*Myiopsitta monachus*)	113	86
Furnariidae		
Common Miner (*Geositta cunicularia*)*	4	0
Rufous Hornero (*Furnarius rufus*)*	103	18
Freckle-breasted Thornbird (*Phacellodomus striaticollis*)*	9	5
Firewood-gatherer (*Anumbius annumbi*)*	38	9
Tyrannidae		
Cliff Flycatcher (*Hirundinea ferruginea*)	9	0
Vermilion Flycatcher (*Pyrocephalus rubinus*)	8	0
Spectacled Tyrant (*Hymenops perspicillatus*)*	8	0
Yellow-browed Tyrant (*Satrapa icterophrys*)	7	0
Gray Monjita (*Xolmis cinereus*)*	3	1
White Monjita (*Xolmis irupero*)*	19	4
Black-and-white Monjita (*Xolmis dominicanus*)*	17	3
Cattle Tyrant (*Machetornis rixosa*)*	11	0
Great Kiskadee (*Pitangus sulphuratus*)	78	20
Tropical Kingbird (*Tyrannus melancholicus*)	10	1
Fork-tailed Flycatcher (*Tyrannus savana*)*	51	22
Hirundinidae		
Blue-and-white Swallow (*Pygochelidon cyanoleuca*)	7	0
Brown-chested Martin (*Progne tapera*)*	7	13
Gray-breasted Martin (*Progne chalybea*)	5	2
White-rumped Swallow (*Tachycineta leucorrhoa*)*	2	0
Cliff Swallow (*Petrochelidon pyrrhonota*)*	1	0
Troglodytidae		
Sedge Wren (*Cistothorus platensis*)*	7	0
Turdidae		
Rufous-bellied Thrush (*Turdus rufiventris*)	4	1
Creamy-bellied Thrush (*Turdus amaurochalinus*)	1	0
Mimidae		
Chalk-browed Mockingbird (*Mimus saturninus*)*	20	12
Motacillidae		
Yellowish Pipit (*Anthus lutescens*)*	1	4
Short-billed Pipit (*Anthus furcatus*)*	1	0
Hellmayr's Pipit (*Anthus hellmayri*)*	23	13
Thraupidae		
Red-crested Cardinal (*Paroaria coronata*)	39	18
Long-tailed Reed Finch (*Donacospiza albifrons*)*	5	0
Saffron Finch (*Sicalis flaveola*)	4	1
Grassland Yellow-Finch (*Sicalis luteola*)*	126	35
Great Pampa-Finch (*Embernagra platensis*)*	29	15
Incertae sedis		
Golden-billed Saltator (*Saltator aurantiirostris*) [a]	1	4

Continued.

Family and species	Habitat	
	C	S
Emberizidae		
Rufous-collared Sparrow (*Zonotrichia capensis*)	63	20
Grassland Sparrow (*Ammodramus humeralis*)*	58	63
Icteridae		
Chopi Blackbird (*Gnorimopsar chopi*)	1	0
Saffron-cowled Blackbird (*Xanthopsar flavus*)*	8	0
Yellow-rumped Marshbird (*Pseudoleistes guirahuro*)*	14	18
Brown-and-yellow Marshbird (*Pseudoleistes virescens*)*	95	39
Bay-winged Cowbird (*Agelaioides badius*)	4	0
Shiny Cowbird (*Molothrus bonariensis*)*	96	15
White-browed Blackbird (*Sturnella superciliaris*)*	26	30
Fringillidae		
Hooded Siskin (*Sporagra magellanica*)	3	0

* Species representative of southeastern South American grasslands (Azpiroz et al. 2012b).
[a] Formerly placed in the Thraupidae.