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DIFFERENT GRAZING STRATEGIES ARE NECESSARY TO CONSERVE ENDANGERED GRASSLAND BIRDS IN SHORT AND TALL SALTY GRASSLANDS OF THE FLOODING PAMPAS

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Abstract. We evaluated how grazing affects bird assemblages in short and tall coastal salty grasslands at Samborombón Bay, Argentina. We studied ranches with three patterns of grazing (spatial rotation, continuous, and winter grazing) and a control site, at each censusing birds and surveying vegetation monthly. Results allowed us to compare the various treatments and their effects on endangered birds of short and tall grassland. Three species of special conservation concern showed significant responses to grazing. In short grasslands, the Buff-breasted Sandpiper (*Tryngites subruficollis*) is supported by continuous grazing. In tall grasslands, the Bay-capped Wren-Spinetail (*Spartonoica maluroides*) uses only grasslands with extensive cover of tall grass, whereas Hudson's Canastero (*Asthenes hudsoni*) uses those with high levels of cattle grazing. The diverse responses of grassland birds to grazing of different types of grassland leads us to propose a system of heterogeneous grazing that optimizes both production and conservation of grassland birds.

Key words: Pampas grasslands, Spartina densiflora *grasslands, shorebirds,* Spartonoica maluroides, Tryngites subruficollis.

Diferentes Estrategias de Pastoreo Son Necesarias para Conservar las Aves Amenazadas en Pastizales Halófitos Cortos y Altos de la Pampa Deprimida en Argentina

Resumen. Se evaluó de qué manera el pastoreo afecta los ensambles de aves que habitan pastizales halófitos cortos y altos de la bahía Samborombón, Argentina. El estudio se realizó en establecimientos rurales donde se desarrollaban tres tipos de sistemas pastoriles (rotación espacial, pastoreo continuo e invernal) y en un sitio de control. En cada sitio y ambiente, mensualmente se realizaron censos de aves y muestreos de la fisonomía de la vegetación. Los resultados permitieron determinar un contraste entre los tipos de manejo ganadero y sus efectos sobre diferentes aves amenazadas de pastizales altos y cortos. Tres especies de particular importancia para la conservación mostraron respuestas significativas a los tratamientos de pastoreo. *Tryngites subruficollis* utiliza principalmente pastizales cortos con pastoreo continuo, *Spartonoica maluroides* utiliza pastizales altos con bajos niveles de pastoreo, y *Asthenes hudsoni* utiliza pastizales altos con pastoreo continuo y rotativo. Las diversas respuestas de las aves de pastizal al pastoreo en los diferentes tipos de pastizales nos llevan a proponer un sistema de pastoreo heterogéneo que optimice al mismo tiempo la producción y la conservación de las aves de pastizal.

INTRODUCTION

Although disturbance is frequently associated with habitat destruction (see Botkin 1990), certain disturbances are today assumed by conservation ecologists and biologists to play a fundamental and creative role in the maintenance of natural heterogeneity of the environmental conditions that an organism experiences through time and space (Brawn et al. 2001). Rangelands have been described as essentially diverse ecosystems with composition and vegetation structure varying with topo-edaphic characteristics and species interacting at several spatial scales (Fuhlendorf and Smeins 1998, Fuhlendorf et al. 2006). In addition, grazing of domestic cattle has been and continues to be one of the main drivers generating and maintaining heterogeneity of grasslands around the world (e.g., Senft et al. 1987, Cid and Brizuela, 1998, Jacobo et al. 2006). Given that organisms respond differently to the intensity of cattle grazing, grazing can be used as a tool to substitute for natural processes in already altered environments (Severson 1990).

Vegetation structure can be modified in response to the frequency, intensity, and seasonality of grazing. Intensive grazing is detrimental to plant growth and survival. It changes primary productivity and species composition, but forage quality is often improved by frequent grazing (Briske et al. 2008). Physiognomy is a main component of birds' habitat selection (MacArthur and MacArthur 1961, Wiens 1973,

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Roth 1976). Birds presumably select habitats that supply food, nesting sites, and shelter from predators with the combination of resources most favorable to multiple activities (Hilden 1965, Fretwell and Lucas 1970, Block and Brennan, 1993, Steele 1993). Thus disturbance, such as grazing by domestic animals, modifies habitat complexity, affecting all aspects of avian habitat quality and selection from the microhabitat to regional scale (Wu et al. 2006, Wiens 2009), resulting in changes in bird composition and abundance associated with these habitats (Roxburgh et al. 2004).

The Pampas of Argentina and the Campos of Uruguay and Brazil, jointly forming the Río de la Plata grasslands (Soriano et al. 1991), cover an area of 700 000 km^2 and are the largest grassland ecosystem in South America (Cabrera 1976). The suitability for agriculture of the Pampas first enabled the development of livestock production and later other agricultural uses. Agroecosystems have replaced grasslands in most of the region, and semi-natural grasslands are only preserved in areas with serious impediments to agriculture (León et al. 1984). The eastern part of the Pampas region has suffered less than the rest of the region, mainly because the frequently flooded and brackish soils are generally unsuitable for intensive agriculture (León et al. 1984). Therefore, traditional grazing on natural grasslands still thrives. The development of new technologies, however, has allowed the conversion of pasture into cropland (Viglizzo et al. 2001). As a consequence of the expansion of the frontier of crops (mainly the soybean; Paruelo et al. 2005), livestock has been concentrated in areas marginal for agriculture, posing an additional threat to the ecological integrity of the highly vulnerable relicts of natural grassland (Ghersa and Martínez-Ghersa 1991, Bilenca and Miñarro 2004).

Habitat requirements of grassland birds of the eastern Pampas are diverse (Martínez 2001), and bird assemblages include shorebirds that use short grasslands (Myers and Myers 1979, Lanctot et al. 2002, Isacch and Martinez 2003a), species adapted to live in tall grasslands (Comparatore et al. 1996, Isacch et al. 2004), and generalist species associated with different habitats (Filloy and Bellocq 2007). Therefore, different species should respond differently to different types and intensities of grazing (Isacch and Martínez 2001, Zalba and Cozzani 2004, Azpiroz and Blake 2009). We studied the response of grassland birds to grazing by assessing the effect of three patterns of grazing on the bird assemblage inhabiting short and tall grasslands in the eastern part of the flooding Pampas of Argentina. We put special emphasis on an endangered migratory shorebird of short grass, the Buff-breasted Sandpiper (*Tryngites subruficollis*; Birdlife International 2010, AA/AOP and SAyDS 2008) and endangered species of tall grass, the Dot-winged Crake (*Porzana spiloptera*), Bay-capped Wren-Spinetail (*Spartonoica maluroides*), and Hudson's Canastero (*Asthenes hudsoni*; Birdlife International 2010, AA/AOP and SAyDS 2008). We analyze the results in a framework that helps to determine which regime of grazing optimizes the conservation of endangered grassland birds.

METHODS

STUDY AREA

Our study took place in a representative area of Samborombón Bay, located in the municipality of General Lavalle (36° 28′ S, 56° 45′ W to 36° 20′ S, 56° 60′ W; Buenos Aires province, Argentina; Fig. 1) and lying in the eastern portion of the Pampas (Cabrera 1976). The relief is flat with small undulations created by bands of fossil shells that run sub-parallel to the coast. The small variations in topography lead to changes in vegetation (Cagnoni and Faggi 1993). Halophytic tall grasslands dominated by *Spartina densiflora* grow on the lowlands (Cagnoni and Faggi 1993, Isacch et al. 2006). The uplands

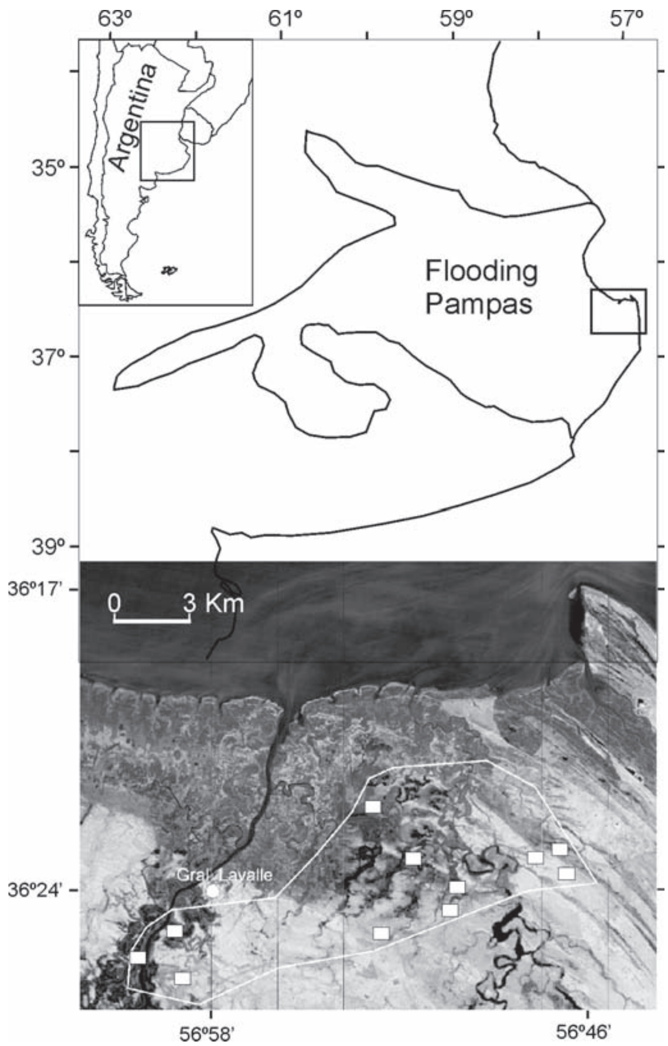

FIGURE 1. Location of the study area within the flooding Pampas, Argentina, in the lower part represented by a polygon on a Landsat 5 satellite image of the south side of Samborombón Bay. White squares represent the fields surveyed.

support isolated natural stands of *tala* (*Celtis tala*) forest intermixed with overgrazed grasslands of *Stipa* spp. (Vervoorst 1967, Cagnoni and Faggi 1993). The area between the lowlands and uplands is dominated by salty and wet prairies (Vervoorst 1967, Cagnoni and Faggi 1993). Therefore, the study area's two main grassland habitats are tall grasslands, typical of the lowlands and dominated by *S. densiflora* with tussocks ~1 m high, and short grasslands, lying between lowlands and uplands, with grasses of height ≤35 cm.

SAMPLING DESIGN

Following Ausen and Treweek (1996) we defined three treatments of grazing. We also considered a control area without cattle grazing for tall grasslands only, since there were no ungrazed natural short grasslands to be used as control plots in the region. The treatments were as follows. (1) Rotational grazing, in which cattle were rotated several times among different plots throughout the year (every 15 to 30 days during spring and summer; every 3 to 4 months during autumn and winter). Average stock 0.71 cows ha^{-1}. (2) Continuous grazing, in which grazing was maintained throughout the year on the same plots. Average stock 0.63 cows ha^{-1}. (3) Winter grazing, in which grazing occurred during the autumn and winter only; the rest of the year the fields were left to rest. Average stock 0.86 cows ha^{-1}. (4) No grazing, at Campos del Tuyú Natural Reserve, a reserve of tall natural grassland closed to any agricultural use. This site was accidentally burned in February, and we include no data from after that fire.

SURVEYS OF SHORT GRASSLAND

We surveyed for birds in short grasslands from September 2008 to February 2009, the period when nearctic grassland shorebirds are present in the region (Myers and Myers 1979, Isacch and Martínez 2003b). In each treatment, we selected five or six points, depending on the spatial availability of short grasslands, and sampled birds monthly with fixed-distance (120 m) counts of 5 min at each point (Hutto et al. 1986, Isacch and Martínez 2003a). In tall grasslands, fixed-distance point counts may underestimate the abundance of the more secretive species. Therefore, we walked randomly inside the count circle after the completion of the 5-min survey to check for undetected birds, which were included in the census. Because our plots in ranches of the region are large (300–1000 ha) and few, we had to include more than one point per plot in most of the treatments. Points by plot in each treatment were distributed as follows: five points in five plots for rotational grazing (one point per plot), six points in two plots for continuous grazing (four and two per plot), and six points in two plots for winter-only grazing (three points per plot). We also recorded the cover of grass <15 cm in two squares of 1 × 1 m at each bird-sampling point once per month from October to February.

Values of abundance and richness indicate numbers of individuals and species per transect, respectively. We evaluated the null hypothesis of no difference in bird richness and abundance and shorebird abundance (Buff-breasted Sandpiper and American Golden Plover; see Table 1 for scientific names) among the three treatments with grazing (rotational, continuous, and winter only) by using a one-way ANOVA for each month and an a posteriori LSD Fischer test (Zar 1999).

SURVEYS OF TALL GRASSLAND

We surveyed for birds in tall grasslands from September 2008 to July 2009 by using eight randomly distributed transects for each treatment of grazing. Because the treatment without grazing was unintentionally burned, we surveyed it only up to January 2009. Because plots in ranches of the region were few and large (300–1000 ha), we had to include more than one transect per plot in every treatment. Transects by plot in each treatment were distributed as follows: eight transects in two plots each for rotational (six and two transects per plot), continuous (four and four per plot), and winter-only (six and two per plot) grazing and eight transects in one plot in no grazing. We sampled birds monthly by a fixed-width strip transect (100 × 60 meters), recording species and number of individuals (Conner and Dickson 1980). Within the fixed width of the transect, we assumed that all species' detectability was the same (after Isacch and Martínez 2001, Isacch et al. 2004, Cardoni et al. 2007). We recorded the height and the percent cover of the dominant vegetation (i.e., *Spartina densiflora*) monthly from November to July in two squares of 1 × 1 m in each transect.

On the basis of previous research on similar habitats (Comparatore et al. 1996, Isacch and Martínez 2001, Isacch et al. 2001, 2004, Cardoni et al. 2007), we classified birds into four groups, detailing their dependence on tall-grass habitats. Tall-grass specialists are those that require high cover of tall grasslands for nesting and feeding, whereas tall-grass generalists are those that need tall grasses for nesting and feeding but eventually use other environments. A single species, Hudson's Canastero, requires patches of short grass within a matrix of tall grass; it nests at the base of tall grasses (Canevari et al. 1991). The tall-grass specialists serve as an indicator of null or low levels of grazing. Species belonging to these groups are detailed in Table 1.

Values of abundance and richness indicate the numbers of individuals and species per transect, respectively. We used a one-way ANOVA and an a posteriori LSD Fischer test (Zar 1999) to evaluate the null hypothesis of no difference among the four grazing treatments in bird variables (richness, abundance and species groups) and vegetation variables (cover and height of tall grass).

ANALYSIS OF SHORT AND TALL GRASSLANDS

In comparing the bird assemblages of tall and short grasslands we put special emphasis on species with particular habitat requirements, such as migratory shorebirds, tall-grass specialists, tall-grass generalists, and Hudson's Canastero. The comparisons covered the period between September and February,

TABLE 1. Frequency of birds recorded in short and tall salty grasslands managed with different regimes of cattle grazing at Samborombón Bay, Argentina. RG, rotational grazing; CG, continuous grazing; WG, winter-only grazing; NG, no grazing. For species recorded in tall grassland, the habitat column shows the species' degree of affinity with that habitat: TGS, tall-grass specialist; TGG, tall-grass generalist, T-SG, species of tall-grass matrix with scattered short grasses.

	Short grassland			Tall grassland				
	RG	CG	WG	RG	CG	WG	NG	Habitat
Greater Rhea *Rhea americana*	—	0.12	0.19					
Spotted Tinamou *Nothura maculosa*	—	—	0.08	0.03	—	—	—	
Red-winged Tinamou *Rynchotus rufescens*	—	—	0.03	0.01	0.01	—	—	
Chimango Caracara *Milvago chimango*	0.11	0.06	—	0.01	—	0.06	0.07	
Southern Caracara *Caracara plancus*	—	0.03	0.03	0.01	—	—	—	
Long-winged Harrier *Circus buffoni*				—	0.01	—	—	
Cinereous Harrier *Circus cinereus*				—	0.01	0.01	—	
Southern Screamer *Chauna torquata*	0.03	—	—					
Maguari Stork *Ciconia maguari*				—	0.01	0.01	—	
Great Egret *Ardea alba*				—	—	0.01	—	
White-faced Ibis *Plegadis chihi*	0.03	0.06	0.03	—	0.01	—	—	
South American Snipe *Gallinago paraguaiae*				0.01	—	—	—	
South American Painted-Snipe *Nycticryphes semicollaris*				—	—	0.04	—	
American Golden Plover *Pluvialis dominica*	0.31	0.74	0.11					
Rufous-chested Dotterel *Charadrius modestus*	—	0.03	—					
Southern Lapwing *Vanellus chilensis*	0.86	0.91	0.36	0.03	0.26	—	—	
Buff-breasted Sandpiper *Tryngites subruficollis*	0.14	0.65	0.03					
Lesser Yellowlegs *Tringa flavipes*	—	0.03	—					
Wilson's Phalarope *Phalaropus tricolor*	—	0.03	—					
Plumbeous Rail *Pardirallus sanguinolentus*				—	0.01	—	—	
Dot-winged Crake *Porzana spiloptera*				—	—	—	0.04	TGS
Short-eared Owl *Asio flammeus*				—	—	0.01	0.07	
Burrowing Owl *Athene cunicularia*	—	—	0.03					
Green-barred Woodpecker *Colaptes melanochloros*	—	—	0.06					
Campo Flicker *Colaptes campestris*	0.03	0.03	0.06					
Rufous Hornero *Furnarius rufus*	0.11	0.03	—					
Bar-winged Cinclodes *Cinclodes fuscus*	0.06	0.06	—	0.03	0.08	0.01	—	
Bay-capped Wren-Spinetail *Spartonoica maluroides*				0.04	0.10	0.49	1.00	TGS
Freckle-breasted Thornbird *Phacellodomus striaticollis*				—	—	0.03	0.25	TGS
Sulphur-throated Spinetail *Cranioleuca sulphurifera*				—	—	—	0.21	TGS
Hudson's Canastero *Asthenes hudsoni*				0.24	0.19	—	—	T-SG
Spectacled Tyrant *Hymenops perspicillatus*	0.03	0.06	—	—	—	0.01	0.04	TGG
Fork-tailed Flycatcher *Tyrannus savana*	—	0.06	—	—	—	0.01	—	
Austral Negrito *Lessonia rufa*	0.17	0.24	—	—	—	0.01	—	
Great Kiskadee *Pitangus sulphuratus*	0.14	0.03	—	—	0.01	—	—	
Cattle Tyrant *Machetornis rixosus*	—	—	0.03					
Sedge Wren *Cistothorus platensis*				0.01	—	0.33	0.50	TGS
Correndera Pipit *Anthus correndera*	0.78	0.85	0.36	0.53	0.61	0.14	—	
Long-tailed Reed-Finch *Donacospiza albifrons*				—	—	0.01	—	TGS
Grassland Yellow-Finch *Sicalis luteola*	0.06	0.12	—	0.29	0.15	0.32	0.14	TGG
Great Pampa-Finch *Embernagra platensis*				0.14	0.28	0.13	0.11	TGG
Rufous-collared Sparrow *Zonotrichia capensis*				0.06	—	—	—	
Yellow-winged Blackbird *Agelasticus thilius*	—	—	0.03	—	0.01	0.07	—	TGG
Brown-and-yellow Marshbird *Pseudoleistes virescens*	0.17	0.18	0.14	0.01	0.04	—	—	TGG
Shiny Cowbird *Molothrus bonariensis*	0.03	0.06	0.03	0.01	—	—	—	
Total species	14	19	14	16	16	18	10	

when data were available for both habitats. We calculated the β diversity of birds (Whittaker 1960) by considering each habitat separately; β is the relationship between the averages of α over γ, α being the number of species in a patch (grazing treatment within a type of habitat), γ the total number of species at the site (all grazing treatments or habitat and treatment considered together). Higher values of β indicate a higher turnover of species among patches. We calcuated a Bray–Curtis similarity index (Bray and Curtis 1957) to assess affinities among bird assemblages under regimes of grazing of the same and different habitats. The similarity index is expressed as a percentage, the value 0 indicating no species in common and 100 the same species with the same frequency in both treatments.

RESULTS

SHORT GRASSLANDS

Percentage of short grass cover was always 100% in areas under continuous grazing, from 100 to 70% in those under rotational grazing, and from 100 to 0% in those under winter-only grazing (Fig. 2). In cases where the cover of short grass was <100%, grass height was never higher than 35 cm. After cattle were removed from areas of winter-only grazing, the percentage of short-grass cover decreased to zero (Fig. 2).

We recorded 28 species of birds in short grasslands (Table 1). Taken together, the American Golden Plover and Buff-breasted Sandpiper, both nearctic migratory shorebirds, represented 70.9% of the total number of individuals. Other species notable by frequency and/or abundance were the Southern Lapwing and Correndera Pipit, followed by the Brown-and-yellow Marshbird, Austral Negrito and Greater Rhea (Table 1). The Austral Negrito is an austral migrant in the study area. Many other species, such as the Rufous Hornero, Fork-tailed Flycatcher, Great Kiskadee and Spectacled Tyrant, used short grasslands occasionally.

By month, the number of species did not vary in a clear pattern by regime of grazing, though richness was lower in most months under winter-only grazing than under the other two grazing treatments (Fig. 3). When the number of individuals differed by treatment it was always higher under continuous grazing (Fig. 3). The number of individuals was greatly influenced by the number of grassland shorebirds. The Buff-breasted Sandpiper was always most numerous in areas of continuous grazing, while it was almost undetected in those of winter-only grazing (Fig. 4). From November to January, American Golden Plover numbers were higher under continuous grazing, but in October there was no significant difference for this species by grazing treatment. This species was not detected in areas of winter-only grazing from November to February (Fig. 4).

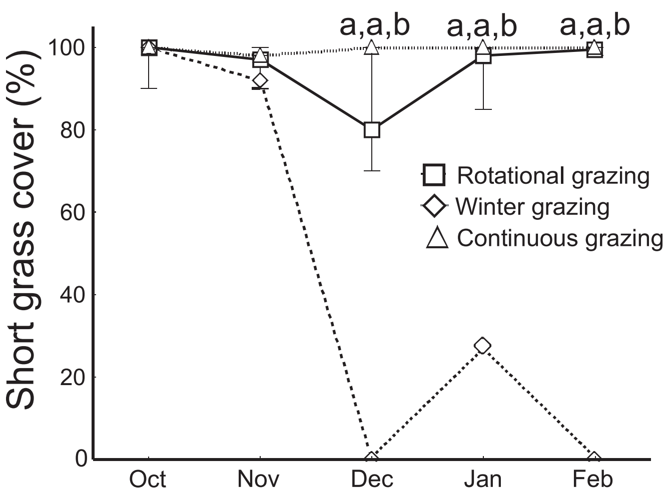

FIGURE 2. Vegetation height in the short salty grassland at Samborombón Bay, Argentina, compared by three regimes of grazing. Symbols represent averages; lines represent standard errors. The letters above the plot represent differences by month from an a posteriori LSD test ($P < 0.05$).

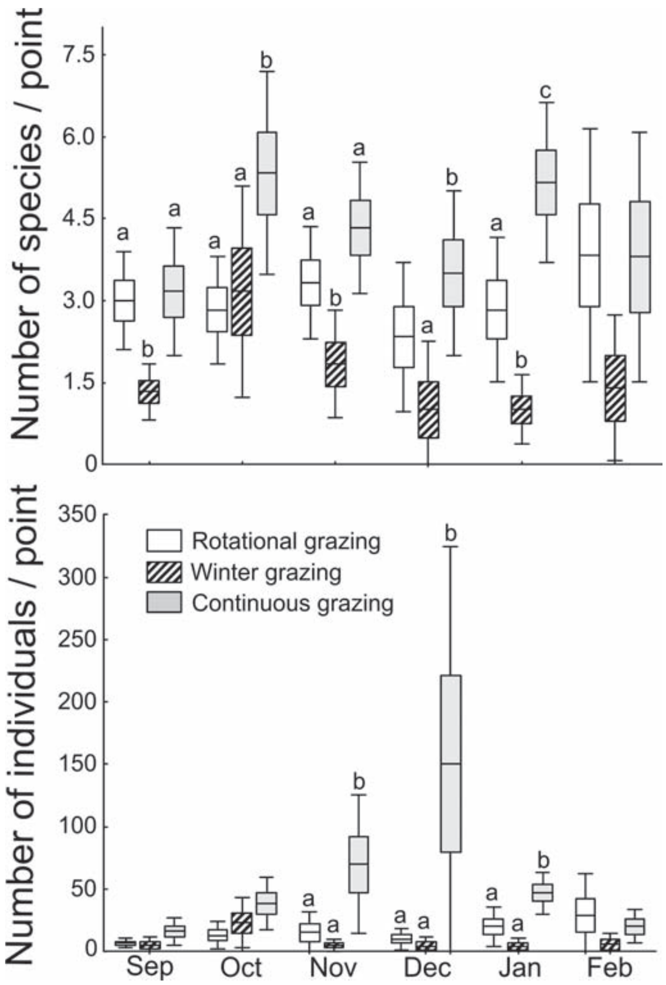

FIGURE 3. Number of species and individuals of birds recorded in short salty grasslands at Samborombón Bay, Argentina, managed with three systems of cattle grazing. Boxes represent the standard error, whiskers the standard deviation, and the line inside the boxes the average. The letters above the plot represent differences from an a posteriori LSD test ($P < 0.05$).

TALL GRASSLANDS

Cattle grazing was related to changes in vegetation variables, with height and percent cover of grass always decreasing when cattle grazing intensified. Vegetation was always taller in plots without cattle than in grazed plots, whatever the treatment. Vegetation cover was always greater in plots not grazed and grazed in winter only than in plots grazed rotationally or continuously (Fig. 5).

All four treatments combined, we recorded 33 species of birds in grasslands of tall *Spartina densiflora* (Table 1). The abundance and richness of birds under each treatment were similar in eight out of ten months (Fig. 6). Only during July both abundance and richness were higher in plots grazed continuously than in those grazed rotationally and in winter only (Fig. 6).

The four regimes of grazing differed in their effects on birds associated with tall grasslands. Tall-grass specialists (Table 1) were most abundant on ungrazed plots, less so in those grazed in winter only, and least abundant in those grazed rotationally and continuously (Table 1; Fig. 7). Tall-grass generalists differed in abundance only in two months, with higher values in plots grazed rotationally and winter only than in those not grazed or grazed continuously (Table 1; Fig. 7). Hudson's Canastero, a species that uses the matrix of short and tall grass, was recorded only in plots grazed continuously and rotationally. Numbers of individuals were highest in continuously grazed plots in some months, in rotationally grazed plots in others, and similar in still others (Fig. 7).

COMPARISON OF SHORT AND TALL GRASSLANDS

From September through February, we recorded 29 species in tall grasslands and 28 in short grasslands; 14 species were common to both habitats. Tall-grass specialists and Hudson's Canastero occurred only in tall grasslands, migratory grassland

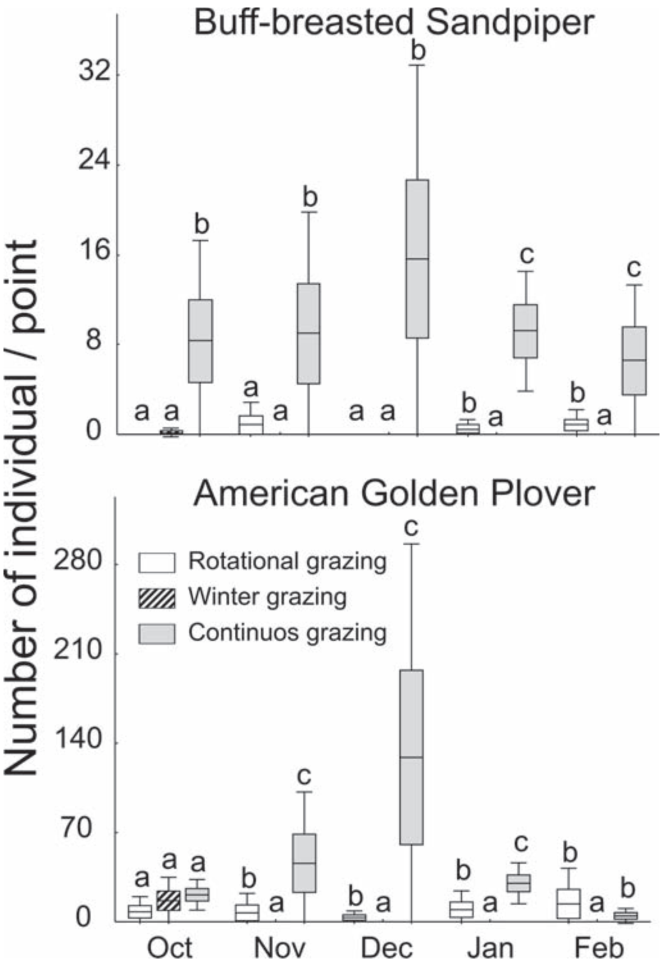

FIGURE 4. Number of individuals of the Buff-breasted Sandpiper and American Golden Plover recorded in short salty grasslands at Samborombón Bay, Argentina, managed with three systems of cattle grazing . Boxes represent the standard error, whiskers the standard deviation, and the line inside the boxes the average. For the control area of no grazing only data from October to January are presented because after that date the control area was unintentionally burned. The letters above the plot represent differences from an a posteriori LSD test ($P < 0.05$).

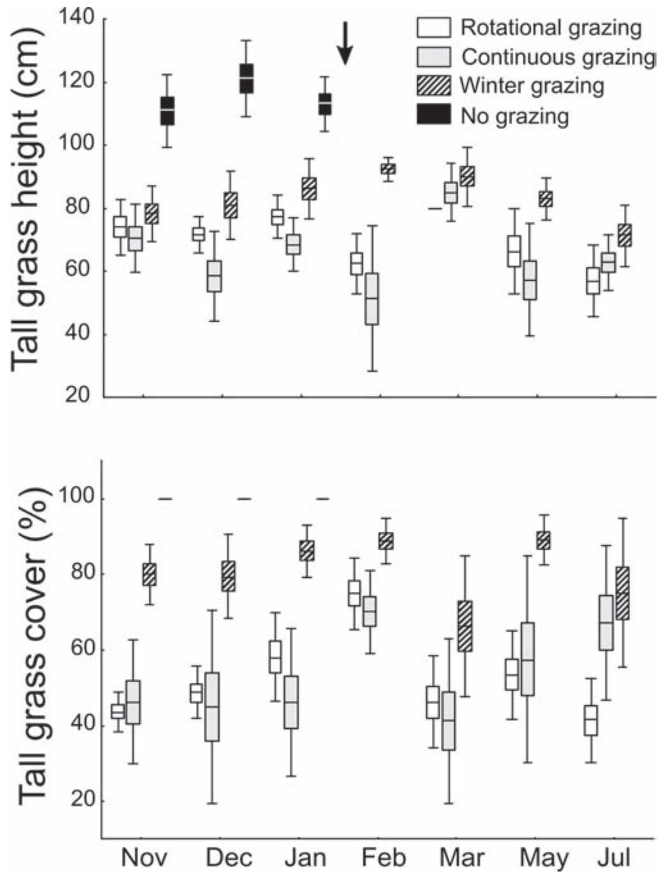

FIGURE 5. Vegetation height and tall-grass cover in tall salty grasslands at Samborombón Bay, Argentina, managed with three systems of cattle grazing and in a control area of no grazing. For the control area only data from October to January are presented because after that date the control area was unintentionally burned. Boxes represent the standard error, whiskers the standard deviation, and the line inside the boxes the average. The letters above the plot represent differences from an a posteriori LSD test ($P < 0.05$).

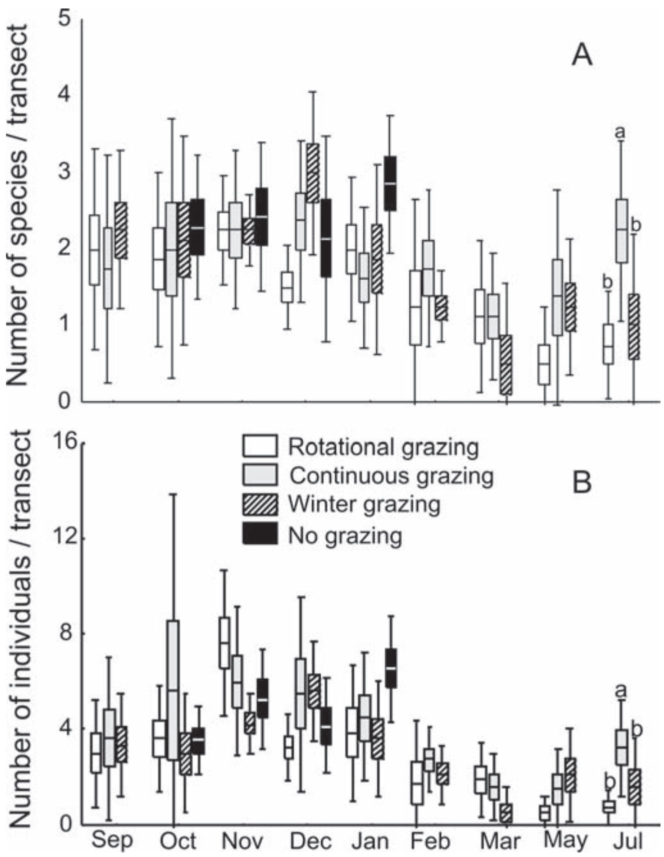

FIGURE 6. Number of species and individuals of birds recorded in tall salty grasslands at Samborombón Bay, Argentina, managed with three systems of cattle grazing and in a control area of no grazing. For the control area only data from October to January are presented because after that date the control area was unintentionally burned. Boxes represent the standard error, whiskers the standard deviation, and the line inside the boxes the average. The letters above the plot represent differences from an a posteriori LSD test ($P < 0.05$).

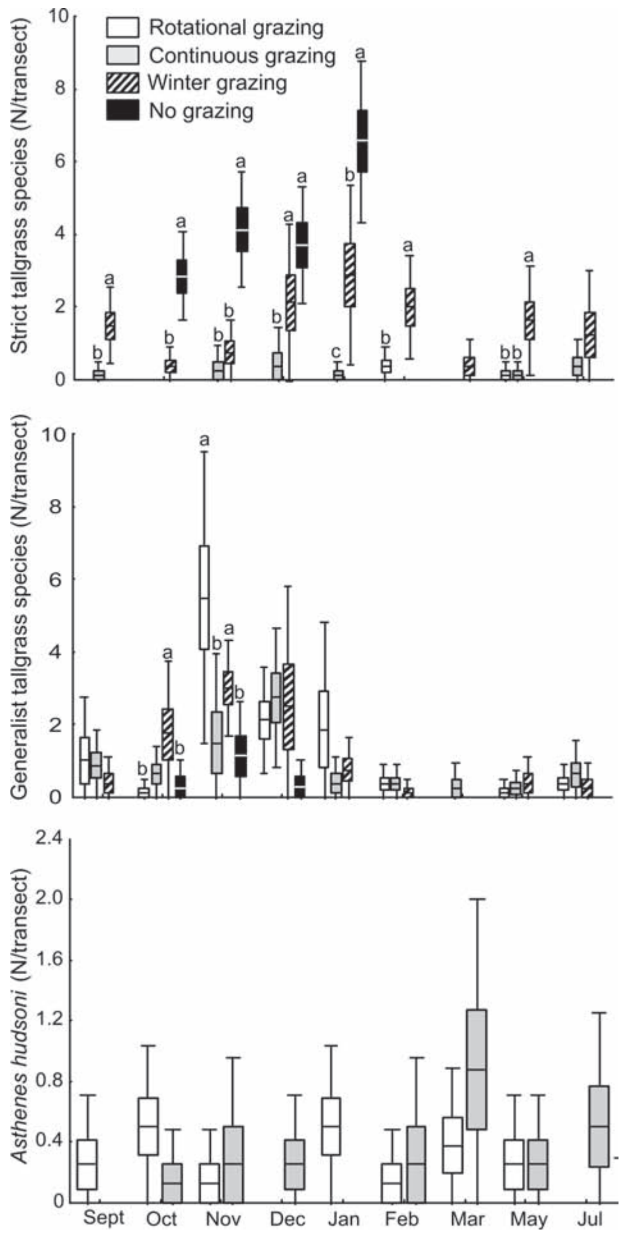

FIGURE 7. Number of individuals of categories of grassland birds, defined by their affinity with the tall grassland, recorded in tall salty grasslands at Samborombón Bay, Argentina, managed with three systems of cattle grazing and in a control area of no grazing. For the control area only data from October to January are presented because after that date the control area was unintentionally burned. See Table 2 for species included in each category. Boxes represent the standard error, whiskers the standard deviation, and the line inside the boxes the average. The letters above the plot represent differences from an a posteriori LSD test ($P < 0.05$).

shorebirds only in short grasslands. Among tall-grass generalists, however, some species occurred only in tall grasslands (Great Pampa-Finch), some mainly in tall grasslands (Grassland Yellow-Finch), and some mainly in short grasslands (Brown-and-yellow Marshbird) (Tables 1 and 2). The species turnover generated by the grazing treatments was higher in tall grasslands than in short grasslands ($\beta_{TG} = 2.23$, $\beta_{SG} = 1.64$), and the value of species turnover was higher when tall and short grasslands were considered together ($\beta_{total} = 2.86$).

Similarity of bird assemblages within the same habitat was greater for treatments in which the intensity of grazing was similar (i.e., between no grazing and winter-only grazing with little or no grazing in tall grasslands; between rotational and continuous grazing more intense in short grasslands; Table 2). The similarity of the bird assemblages in tall grasslands to that of the short grasslands increased as the intensity of cattle grazing increased in tall grasslands (the similarity value of no grazing of tall grassland with all treatments of short grassland was around 4, with winter-only grazing it was around 14, with rotational grazing it was 32, and with continuous grazing it was 49; Table 2). Indeed, continuously grazed tall grasslands are more similar to most short grasslands than for any comparison of treatments within short grassland, except for rotational with continuous.

DISCUSSION

SHORT GRASSLANDS

The pattern of bird abundance in short salty grasslands was greatly influenced by the abundance of two migratory grassland shorebirds, the American Golden Plover and Buff-breasted Sandpiper. In this habitat bird richness had no clear temporal pattern. Short-grass cover was related directly to grazing treatment, given that plots with higher pressure of cattle grazing (i.e., rotational and continuous grazing) had greater cover of short grass. Shorebirds were absent from areas where cattle grazing was interrupted during spring and summer (winter-only grazing), since grass grew rapidly (~30 cm) and grasslands had low percentages of short-grass cover.

The arrival of shorebirds (early spring) on the fields of the Lavalle area coincides with the beginning of the growing season of grasses in short salty grasslands. Therefore grazing during this period is critical to ensure areas of short grass available to shorebirds. Regarding the effect of different types of grazing treatment, we observed that treatments (i.e., continuous grazing) that allow the maintenance of 100% of short grasses support more shorebirds than those (i.e., rotational grazing) with spatially heterogeneous cover of short grass. Similar patterns have been recorded for grassland shorebirds in this and other regions of the world (Colwell and Dodd 1995, 1997, Lanctot et al. 2002, Isacch and Martínez 2003a, Alfaro et al. 2008).

Other species recorded in short salty grasslands were common and widely distributed, such as the Southern Lapwing, Correndera Pipit, Austral Negrito, and Field Flicker (Canevari et al. 1991), or had habitat requirements not directly related with short-grass cover, such as the Greater Rhea, Brown-and-yellow Marshbird, and Chimango Caracara (Comparatore et al. 1996, Herrera et al. 2004, Bellis et al. 2008). From a conservation perspective then, migratory grassland shorebirds should be a group to be targeted in the management of the short salty grasslands of the eastern Pampas. On the other hand, grazing that creates habitat suitable for grassland shorebirds (i.e., continuous grazing on short grasslands) should have no negative effects on bird diversity of short grassland.

TABLE 2. Bray–Curtis similarity of the frequency of bird species by habitat (short and tall salty grasslands) and pattern of grazing (none, NG; winter only, WG; continuous, CG; rotational, RG) at Samborombón Bay, Argentina. Higher values of similarity are highlighted in **bold**.

		Tall grassland			Short grassland		
		NG	WG	CG	RG	WG	CG
Tall grassland	WG	**55.1**					
	CG	11.3	29.7				
	RG	10.4	36.8	**67.9**			
Short grassland	WG	0.0	12.1	49.1	30.1		
	CG	6.4	14.1	44.1	30.3	41.5	
	RG	4.7	14.7	**53.8**	35.4	47.0	**74.7**

TALL GRASSLANDS

Cattle grazing on *Spartina densiflora* grasslands affects the habitat's physiognomy directly and so affects the bird assemblage indirectly. Increased cattle grazing reduces vegetation height and tall-grass cover. Although the richness and abundance of birds in all grazing treatments were similar, composition changed, with more specialized tall-grass species in ungrazed fields, more specialized and generalist tall-grass species in fields grazed in winter only, and these species and Hudson's Canastero in fields grazed rotationally and continuously.

Grazing on *S. densiflora* grasslands negatively affects birds specializing in tall grassland, the target group to conserve in this habitat because their habitat requirements (i.e., high cover of tall grasses) are the most constrained. Null or minimal grazing may be necessary to ensure viable populations of these species. However, certain birds of tall grassland (e.g., Hudson's Canastero) and tall-grassland generalists were recorded in fields managed with more cattle grazing. Cattle grazing often produces patches of bare ground that some birds, such as the Grasshopper Sparrow (*Ammodramus savannarum*; Vickery 1996) and Hudson's Canastero (J. P. Isacch, pers. obs.), need for foraging. Tall grasslands may have been subjected to natural disturbances such as fires and light grazing by native species, like the Pampas Deer (*Ozotoceros bezoarticus*), which should have created patches of low vegetation amid taller grasses. Nowadays, this heterogeneity can be generated with a mosaic of patches of different intensities of cattle grazing, resulting in the conservation of the larger part of the diversity of tall-grassland birds.

GRASSLAND GRAZING MANAGEMENT

Comparison of short and tall salty grasslands reveals that each one has exclusive bird species, such as tall-grassland specialists and Hudson's Canastero in tall grasslands and migratory shorebirds (American Golden Plover and Buff-breasted Sandpiper) in short grasslands. Some tall-grassland generalists (e.g., Grassland Yellow-Finch, Spectacled Tyrant) were also recorded in short grasslands, but it should be noted that all of these species depend on tall grasslands to breed (Canevari et al. 1991, Comparatore et al. 1996). We also recorded short-grassland species (e.g., Correndera Pipit, Southern Lapwing) in heavily grazed tall grasslands, but they are common and have habitat requirements wider than those of tall-grassland generalists (Canevari et al. 1991). The importance of habitat heterogeneity to bird diversity is demonstrated by the relatively high value of β diversity in tall grasslands, which indicates a relatively high turnover of species among habitats and grazing treatments.

Many ranches near the coast of the Pampas include both short and tall salty grasslands (Marino 2008). Usually each ranch has one regime of grazing for all habitats. Our results specify differences among the effects of these regimes on birds of tall and short grasslands. In short salty grasslands, shorebirds are favored by a continuous grazing, while in tall salty grassland tall-grassland specialists are favored by little or no grazing. On the other hand, numbers of Hudson's Canastero are higher in grazed tall grasslands, where tall-grassland generalists are also present. Therefore, grassland birds of the eastern Pampas have different habitat requirements and are found in different situations, including heavy grazed short grasslands, ungrazed tall grasslands, and grazed tall grasslands, presenting an interesting problem for management.

At the regional scale, the spatial heterogeneity of vegetation structure generated by different practices of grazing provides greater breadth of habitat and increases the variety of grassland bird communities that can occupy the landscape over traditional approaches to management and conservation (i.e., natural reserves). Management has not been developed to promote heterogeneity and provide habitat for co-existing species with different habitat requirements, even though the role of heterogeneity has been acknowledged in the maintenance of productivity and biodiversity in numerous ecosystems (Collins 1992, Adler et al. 2001, Fuhlendorf and Engle 2001, Benton et al. 2003). Our study supports the importance of grazing-created heterogeneity for conservation of grassland birds, and we propose that it be used to promote habitat for endangered species with different requirements. The Buff-breasted Sandpiper (near-threatened at a global scale; Birdlife International 2010) uses mainly short salty grasslands managed by continuous grazing. The tall grassland specialists, including among others the Bay-capped Wren-Spinetail (near-threatened at a global scale) and the Dot-winged Crake (vulnerable at a global scale; Birdlife International 2010), use only salty grasslands with extensive cover of tall grass managed without or with low levels of cattle grazing, while Hudson's Canastero (vulnerable for Argentina; AA/AOP and SAyDS 2008) uses tall salty grasslands with high levels of cattle grazing. In this regard, we recommend different strategies for management of the two environments considered (tall and short salty grasslands), to keep or increase grazing on short grasslands and to reduce grazing on tall grasslands. In this way, ranchers should be able to maintain or balance the levels of livestock productivity. Protected areas are necessary, and management with grazing contributes crucially to the preservation of the avifauna of salty grasslands. At a larger scale, the extensive grasslands of Samborombón Bay could be envisioned as a mosaic of habitat types composed of reserves with ungrazed tall grasslands and ranches grazed under various regimes. The key is to prioritize the options that benefit target grassland birds in each habitat.

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