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RELATIVE ABUNDANCE, HABITAT USE, AND SEASONAL VARIABILITY OF RAPTOR ASSEMBLAGES IN THE FLOODING PAMPAS OF ARGENTINA

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Abstract.—We evaluated the species composition, relative abundance, habitat use, and seasonal variability of raptor assemblages in the Flooding Pampas of Argentina, which represents the southeastern part of the biome known as the Rio de la Plata Grasslands. We conducted seasonal roadside surveys to detect raptors in modified and natural habitats over a 3-yr period from spring 2006 through autumn 2009. We classified raptor species according to their relative abundances and occurrence frequencies, and compared the assemblage composition among land-cover types (croplands, grazing fields, periurban areas, and grasslands) and seasons. The raptor assemblage in the Flooding Pampas comprised 16 species, representing approximately 43% of all raptor species in the biome. The Chimango Caracara (*Milvago chimango*) was the dominant species in all land-cover types and seasons. The Southern Caracara (*Caracara plancus*), American Kestrel (*Falco sparverius*), and Roadside Hawk (*Rupornis magnirostris*) were all abundant and very frequently observed species, whereas Burrowing Owl (*Athene cunicularia*), White-tailed Kite (*Elanus leucurus*), and Long-winged Harrier (*Circus buffoni*) were less abundant but recorded during most surveys. The remaining raptors (Aplomado Falcon [*Falco femoralis*], Cinereous Harrier [*Circus cinereus*], Short-eared Owl [*Asio flammeus*], Sharp-shinned Hawk [*Accipiter striatus*], and Snail Kite [*Rostrhamus sociabilis*]) were much less abundant in the study area. We also recorded four other raptor species (Variable Hawk [*Geranoaetus polyosoma*], Black-chested Buzzard-Eagle [*G. melanoleucus*], Striped Owl [*Asio clamator*], and Barn Owl [*Tyto alba*]), but only outside of the standard transect surveys. Species composition differed among land-cover types, but we detected no distinct overall seasonal patterns except that species diversity indices were lower in autumn and especially, spring. *Milvago chimango* was important to determine similarity in assemblage composition within land-cover types, but other less abundant species, such as *C. plancus, A. cunicularia*, and *R. magnirostris,* were more important to differentiate land-cover types based on raptor composition. Species diversity was highest in grazing fields and grasslands, and lowest in periurban areas. Our results suggest that although some raptor species appear to benefit from land-cover patterns in the study area, many other species may be threatened by the expansion of urban areas and agriculture in the Pampas region.

Key Words: *agroecosystems*; *Argentina*; *grasslands*; *habitat use*; *Flooding Pampas*; *species diversity*; *urbanization.*

ABUNDANCIA RELATIVA, USO DE HÁBITAT Y VARIABILIDAD ESTACIONAL DE LA COMUNIDAD DE RAPACES EN LA PAMPA ARGENTINA

Resumen.—Evaluamos la composición de especies, la abundancia relativa, el uso de hábitat y la variabilidad estacional de la comunidad de rapaces en la Pampa Deprimida de Argentina, la cual representa la región sudeste del bioma conocido como Pastizales del Río de la Plata. Durante un periodo de tres años, desde la

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primavera de 2006 al otoño de 2009, se realizaron censos estacionales en carretera para detectar rapaces en hábitats naturales y modificados. Clasificamos las especies de acuerdo con su abundancia relativa y frecuencias de aparición, y se comparó la composición de la comunidad entre tipos de uso del suelo (cultivos, campos de pastoreo, áreas periurbanas y pastizales) y entre estaciones. La comunidad de rapaces de la Pampa Deprimida estuvo compuesta por 16 especies, que representaron aproximadamente el 43% del total de especies de rapaces del bioma. *Milvago chimango* fue la especie dominante en todos los hábitats y estaciones. *Caracara plancus, Falco sparverius,* y *Rupornis magnirostris* fueron todas especies muy frecuentes y abundantes, mientras que *Athene cunicularia, Elanus leucurus,* y *Circus buffoni* fueron menos abundantes aunque registradas en la mayoría de los censos. Las restantes especies (*Falco femoralis, Circus cinereus, Asio flammeus, Accipiter striatus,* y *Rostrhamus sociabilis*) fueron mucho menos abundantes en el área de estudio. Además, registramos otras cuatro especies (*Geranoaetus polyosoma, G. melanoleucus, Asio clamator,* y *Tyto alba*) pero solamente fuera del transecto de censo. La composición de especies difirió entre usos del suelo, pero no se encontró ningún patrón a nivel estacional, con excepción de los índices de diversidad de especies que fueron menores en otoño y especialmente en primavera. *M. chimango* fue importante para determinar la similitud en la composición de la comunidad dentro de cada uso del suelo, pero otras especies menos abundantes, como *C. plancus, A. cunicularia,* y *R. magnirostris* fueron más importantes para diferenciar los usos del suelo en base a la composición de rapaces. Los valores más altos de diversidad se encontraron en campos de pastoreo y pastizales y los más bajos en áreas periurbanas. Nuestros resultados sugieren que, aunque algunas especies parecen beneficiarse de ciertos patrones de usos del suelo, muchas otras especies podrían estar amenazadas por el avance de las áreas urbanas y la expansión agrícola en la región de la Pampa.

[Traducción de los autores editada]

South America supports a high proportion of global raptor diversity in a relatively small area (Bierregaard 1998). Although this diversity has been traditionally associated with rainforest and tropical environments (Bildstein et al. 1998), a growing number of studies have reported that the extensive grasslands and savannas that cover the Neotropics are important habitats for many raptor species (Ellis et al. 1990, Travaini et al. 1994, Goldstein and Hibbitts 2004, Jensen et al. 2005, Pedrana et al. 2008, Petersen et al. 2011). Despite the importance of these open environments, little is known about the habitat use and seasonal trends of most raptor species that inhabit Neotropical grasslands (Jensen et al. 2005, Zilio et al. 2014).

The Flooding Pampas subregion is included in the biome known as the Rio de la Plata Grasslands, which comprises prairie grasslands that cover the plains of South America (Soriano et al. 1991). The Pampas grasslands represent one of the world's most important grassland ecosystems (Chaneton et al. 2002), and they provide important wintering and breeding habitats for a variety of raptor species (Filloy and Bellocq 2007, Azpiroz et al. 2012). As in many other regions, habitat loss has occurred as natural and seminatural grasslands have been modified for agricultural and urban uses (Bilenca and Miñarro 2004, Viglizzo et al. 2006), affecting the richness and diversity of native bird species (Schrag et al. 2009, Gavier-Pizarro et al. 2012).

The loss of natural habitats may influence the abundance and diversity of raptors, which may be especially sensitive to habitat modification (McCrary et al. 1984, Sánchez-Zapata et al. 2003). Such sensitivity is related to their position as top predators, their low density, and their need of large areas to fulfill their ecological requirements (Newton 1979). For these reasons, they are considered important indicators of habitat integrity (Bierregaard 1998). However, raptor species do not exhibit a uniform response to habitat conversion (Cardador et al. 2011). These differential responses may be influenced by several factors, such as prey availability (Thirgood et al. 2003), location of nest sites (Newton 1998), and the presence of competitors or predators (Preston 1990). For example, several raptor species of the Pampas region respond negatively to grassland modification, especially those dependent on this habitat for breeding (e.g., Long-winged Harrier [*Circus buffoni*]; Pedrana et al. 2008, Codesido et al. 2012), whereas other species may increase in number as a result of improved foraging opportunities in the disturbed landscapes (e.g., Chimango Caracara [*Milvago chimango*]; Travaini et al. 1994, Goldstein and Hibbits 2004, Filloy and Bellocq 2007). Thus, the abundance and distribution of raptors depend on the local conditions and the particular ecological requirements of each species (Sorley and Andersen 1994, Rodríguez-Estrella et al. 1998, Sánchez-Zapata et al. 2003), and seasonal fluctuations in these factors may influence the composition and structure of raptor assemblages (Zilio et al. 2014).

Extended monitoring of raptor assemblages is important for understanding how species composition changes among habitats and seasons (e.g., Lederle et al. 2000, Palomino and Carrascal 2007, Tuule et al. 2011). We conducted a 3-yr series of roadside surveys of diurnal raptors in modified and natural habitats in the Flooding Pampas grasslands of Argentina to evaluate the species composition, habitat use, and seasonal variability of raptor assemblages. Roadside surveys are valuable for examining regional abundances, seasonal changes in populations, population trends, and habitat use of raptors (Fuller and Mosher 1981, Viñuela 1997, Andersen 2007). The results of our study are useful for understanding how habitat modification may affect the distribution and diversity of raptor species inhabiting grassland environments.

METHODS

Study Area. The natural vegetation of the Pampas region was originally a tall grassland, dominated by *Stipa*, *Piptochaetium*, *Aristida*, *Bromus*, and *Poa*, intermingled with prairies, marshes, and edaphic communities (Soriano et al. 1991). This landscape has since been highly modified for agriculture (Bilenca and Miñarro 2004). The study area in the Flooding Pampas is characterized by lowland plains and periodic flooding, which varies in intensity and duration according to topography (Vervoorst 1967). Because the wet conditions and saline soils of these flood-prone areas do not support crops, the Flooding Pampas has been less affected by human activity than other subregions of the Pampas (e.g., Rolling Pampas; León et al. 1984). Most of the land is devoted to livestock production, generally involving low-intensity grazing regimes (Ghersa and León 2001). Although few areas in the Flooding Pampas remain unmodified, rangelands usually have a high proportion of seminatural vegetation. In addition, this subregion has the largest areas of relict grasslands in the Pampas, which are of primary importance for wildlife (Comparatore et al. 1996).

We conducted our study in Mar Chiquita County in southeastern Buenos Aires Province, Argentina (37°32′–37°45′S, 57°19′–57°26′W), which is one of the most representative areas of the Flooding Pampas (Fig. 1). This area is characterized by its heterogeneity, including a diverse array of natural vegetation, such as native grasslands, marshes, coastal dunes, and native forests, as well as modified environments, such as grazing fields, croplands, and periurban zones (Isacch 2008). Natural vegetation is primarily restricted to the Mar Chiquita Biosphere Reserve. The reserve consists of a coastal lagoon surrounded by marshes and grasslands (8600 ha; Isacch 2001), and a multiple-use zone with privately owned ranches dedicated mainly to livestock production that makes up approximately 60% of the reserve (16,200 ha; Isacch 2008). This habitat heterogeneity supports a high faunal diversity that represents a wide spectrum of potential prey for raptors (Martínez 2001).

Raptor Surveys. We conducted roadside surveys on paved and unpaved roads from spring 2006 through autumn 2009. We surveyed the same transect throughout the study period at least once per season (n = 13 total surveys), always during morning hours (0800–1200 H) on clear days. We performed all surveys in the middle of each season,

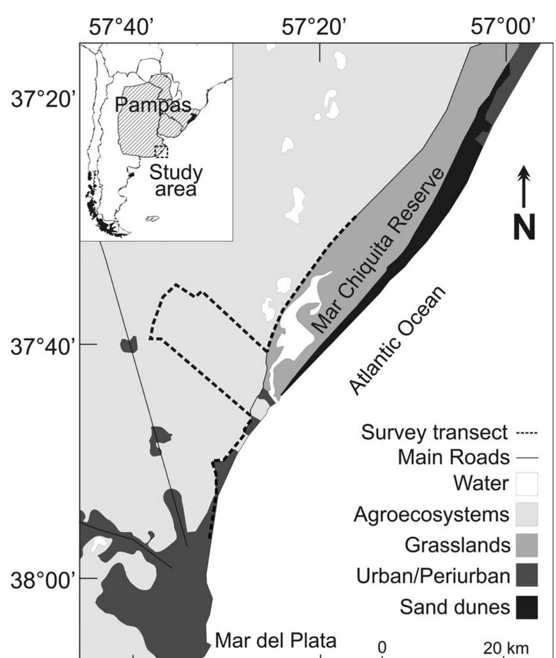

Figure 1. Distribution of land-use/land-cover types in the study area located in the southeastern portion of the Flooding Pampas of Argentina.

except during summer 2007 and autumn 2008, when we performed one survey early and another late in the season. Although we surveyed the same transect repeatedly, the time between surveys was sufficient that we treated each survey as temporally independent. The transect started on the outskirts of Mar del Plata city and traversed diverse land-cover types across 95 km. Driving at speeds of 40–50 km/hr with four observers in the vehicle, we identified and tallied raptors on both sides of the vehicle out to a distance of approximately 150 m on each side. The total area covered by the survey transect was approximately 28,500 ha.

We spotted and usually identified raptors by naked eye, but used binoculars (10 × 50) to verify identifications when needed. We recorded the species of each raptor we observed and classified habitat associations according to the four main land-cover types (Fig. 1). The primary land-cover types were: (1) grazing fields, which comprised mainly seminatural areas used for cattle ranching, and was the dominant land-cover type in the study area (58% of the transect area); (2) croplands, mainly represented by soybeans, sunflowers, and wheat, as well as plowed fields (27% of transect area); (3) grasslands, typically represented by patches of tall grasslands located mainly in Mar Chiquita Biosphere Reserve (8% of transect area); and (4) periurban areas, comprising small tourist villages with few residents (<800 inhabitants) in scattered houses (7% of transect area). Other land-cover types, such as forested areas and waterbodies, covered <1% of the transect area. We used more detailed land-cover subcategories (e.g., location on the edge or in the interior part of a habitat patch, perch type, and crop type) only for descriptive purposes, including information about a raptor's specific location.

For each raptor species, we estimated its: (1) average abundance (N_i), calculated as the total number of individuals of species i observed during the transect surveys divided by the number of surveys ($n = 13$); (2) relative abundance ($\%N_i$), calculated as the ratio (expressed as %) of the total number of individuals of species i and the total number of individuals of all species recorded during each survey; and (3) occurrence frequency ($\%FO_i$), calculated as the ratio (expressed as %) of the number of transect surveys in which species i was recorded and the total number of surveys ($n = 13$). We then classified raptor species according to $\%FO_i$ and $\%N_i$ (Martínez 2001, Azevedo et al. 2003, Petersen et al. 2011). We assigned each species to one of four frequency categories: very frequent ($\%FO_i = 100$), frequent ($50 \leq \%FO_i < 100$), less frequent ($10 \leq \%FO_i < 50$), and infrequent ($\%FO_i < 10$). We also assigned each to one of five abundance categories: very abundant ($\%N_i > 10$), abundant ($2 \leq \%N_i \leq 10$), common ($1 \leq \%N_i < 2$), occasional ($0.1 \leq \%N_i < 1$), and scarce ($\%N_i < 0.1$).

We complemented the road surveys with opportunistic sightings to provide a better qualitative description of the raptor assemblage (Aumann 2001), recognizing that some raptor species are not reliably detected during road surveys because of their habits (e.g., nocturnal species) or the habitats they occupy (e.g., woodlands; Fuller and Mosher 1981). We excluded the opportunistic sightings from calculations of standardized indices and all statistical analyses.

Habitat Use and Seasonal Variability. We evaluated habitat use by raptors based on their relative density; i.e., raptor abundances standardized according to the percentage of each land-cover type in the transect area. We constructed a dissimilarity matrix (Bray–Curtis distance) for the raptor assemblage, using season and land-cover type as explanatory factors. We square-root transformed the abundance data to diminish the influence of extreme values (Quinn and Keough 2002). We used the ANOSIM (analysis of similarity) procedure to test the significance of assemblage differences among land covers and seasons (Clarke 1993, Clarke and Warwick 1994); this procedure assesses differences between groups using permutation methods on the dissimilarity matrix. We then used the SIMPER (similarity of percentages) procedure to identify species that were important for differentiating land-cover types based on raptor species composition. This procedure reduces the average similarity into separate contributions for each species (as a percentage) in order to determine which species contributed most to the dissimilarity among groups (land-cover types or seasons) and to similarity within groups (Clarke 1993, Clarke and Warwick 1994). We performed these analyses using PRIMER v5 software (Clarke and Warwick 1994). In addition, we calculated species diversity indices to describe seasonal and land-cover patterns in raptor assemblages, estimated using the Shannon–Wiener index:

$$H' = -\Sigma p_i \log p_i,$$

where p_i represents the proportion of observations recorded in a given season or land-cover type that were classified as species i (Krebs 1989).

RESULTS

We recorded 3544 individuals of 12 raptor species during the road surveys (Table 1). The Chimango Caracara was the dominant species in all land-cover types and seasons, accounting for 65% of all individuals observed, with counts of 99–447 individuals per survey. This was the only species we classified as both very abundant and very frequent. Three other species were also highly representative of the raptor assemblage: Southern Caracara (*Caracara plancus*), American Kestrel (*Falco sparverius*), and Roadside Hawk (*Rupornis magnirostris*). We recorded these species at high frequencies and as abundant (5–10 individuals per survey) throughout the study period. Four other raptors also were important for characterizing the assemblage, having been observed during most surveys. The abundance levels of these species varied, however, with Burrowing Owl (*Athene cunicularia*) classified as abundant, White-tailed Kite (*Elanus leucurus*) and Long-winged Harrier (*Circus buffoni*) as common, and Aplomado Falcon (*Falco femoralis*) as occasional. We occasionally observed Cinereous Harriers (*Circus cinereus*) and Short-eared Owls (*Asio flammeus*) throughout the study period, and classified those species as uncommon, infrequent members of the raptor assemblage. We also classified Sharp-shinned Hawks (*Accipiter striatus*) and Snail Kites (*Rostrhamus sociabilis*) as rare, infrequent members of the raptor assemblage (Table 1). Complementary information obtained through occasional, opportunistic sightings outside of the standard transect surveys confirmed the presence of four additional species: two Accipitriformes, Variable Hawk (*Geranoaetus polyosoma*) and Black-chested Buzzard-Eagle (*Geranoaetus melanoleucus*), and two Strigiformes, Striped Owl (*Asio clamator*) and Barn Owl (*Tyto alba*).

Variation in relative densities among land-cover types indicated differential use of habitats among species (Fig. 2). Chimango Caracara, Southern Caracara, Roadside Hawk, White-tailed Kite, and American Kestrel occurred in all land-cover types, with the densities of the latter three species similar across all types. The Chimango Caracara was the most abundant species in all land covers, but most prominently so in periurban areas. Burrowing Owls showed the strongest association with periurban areas (70% of 91 total individuals), where we usually observed them on the ground near burrow entrances (92% of individuals). In contrast, the Southern Caracara was well represented in all land-cover types

Table 1. Abundance, frequency, and classification according to abundance and occurrence of raptor species observed during road surveys along a 95-km transect in the Flooding Pampas of Argentina.

SCIENTIFIC NAME	COMMON NAME	ABUNDANCE[a]	%N[b]	ABUNDANCE CATEGORY[c]	%FO[d]	OCCURRENCE CATEGORY[e]
Falconiformes						
Milvago chimango	Caracara Chimango	214.6 ± 96	77.7 ± 7.1	VA	100	VF
Caracara plancus	Southern Caracara	27.8 ± 16.1	10 ± 4.2	A	100	VF
Falco sparverius	American Kestrel	5.0 ± 4.4	2 ± 1.9	A	100	VF
Falco femoralis	Aplomado Falcon	1.0 ± 1.2	0.4 ± 0.6	O	53.9	F
Accipitriformes						
Rupornis magnirostris	Roadside Hawk	9.6 ± 6.7	3.9 ± 2.7	A	100	VF
Elanus leucurus	White-tailed Kite	3.7 ± 2	1.4 ± 0.7	C	92.3	F
Circus buffoni	Long-winged Harrier	2.9 ± 2.6	1.3 ± 1.2	C	92.3	F
Circus cinereus	Cinereous Harrier	0.5 ± 1.1	0.3 ± 0.5	O	30.8	LF
Accipiter striatus	Sharp-shinned Hawk	0.1 ± 0.3	0.04 ± 0.1	S	7.7	I
Rosthramus sociabilis	Snail Kite	0.1 ± 0.3	0.02 ± 0.1	S	7.7	I
Strigiformes						
Athene cunicularia	Burrowing Owl	7 ± 6.5	2.9 ± 2.7	A	92.3	F
Asio flammeus	Short-eared Owl	0.3 ± 0.8	0.1 ± 0.3	O	15.4	LF

[a] Average number of individuals counted per seasonal survey ±SD.
[b] Relative abundance: percentage of all individuals recorded on a survey that were of the given species, averaged (±SD) across all surveys.
[c] VA: very abundant ($\%N_i > 10$), A: abundant ($2 \leq \%N_i \leq 10$), C: common ($1 \leq \%N_i < 2$), O: occasional ($0.1 \leq \%N_i < 1$), S: scarce ($\%N_i < 0.1$).
[d] Occurrence frequency: percentage of surveys in which the species was recorded.
[e] VF: very frequent ($\%FO_i = 100$), F: frequent ($50 \leq \%FO_i < 100$), LF: less frequent ($10 \leq \%FO_i < 50$), I: infrequent ($\%FO_i < 10$).

except periurban areas, with <1% of 361 total individuals observed in urbanized areas. Most of the remaining species occurred only infrequently or not at all in periurban areas (Fig. 2).

Although most species used agroecosystems (grazing fields and croplands) to some extent, they differed in the way they used these land-cover types. For example, most Chimango Caracaras and Southern Caracaras used poles and fence posts along the margins of agroecosystems (54% and 58% of individuals, respectively), and both species showed an important association with stubble and plowed fields within croplands (84% and 63% of individuals, respectively). White-tailed Kites and Roadside Hawks also used agroecosystems extensively, but were mainly associated with groves of trees on the margins of crop fields and near ranch entrances (58% and 47% of individuals, respectively). Aplomado Falcons and American Kestrels frequently perched on tall utility poles or power lines at the margins of grazing fields (63% and 68% of individuals, respectively). Although most species used grasslands, only the Long-winged Harrier and Cinereous Harrier occurred primarily in this habitat type, and typically only in the interior portions of grassland patches (Fig. 2). Scarce records of Short-eared Owls were at the margins of agroecosystems, whereas we observed Sharp-shinned Hawks only in the margins of periurban areas and Snail Kites only in an agricultural wetland.

Species composition varied by land-cover type (ANOSIM, global R = 0.461). The Chimango Caracara contributed the most to similarity within land-cover types and contributed little to the dissimilarity among land covers (Table 2). Differences in species composition among land covers resulted primarily from variable contributions of Southern Caracaras and Burrowing Owls, and, to a lesser extent, Roadside Hawks. The two agroecosystems (croplands and grazing fields) showed the lowest average dissimilarity, with no single species showing a contribution higher than 20%. In contrast, grassland and periurban areas showed the highest dissimilarity (Table 2). Species diversity indices also varied among land-cover types: highest in grasslands ($H' = 0.830$) and grazing fields ($H' = 0.829$), intermediate in croplands ($H' = 0.658$), and lowest in periurban areas ($H' = 0.585$).

No consistent seasonal patterns were evident in the raw counts (Fig. 3), and ANOSIM tests also

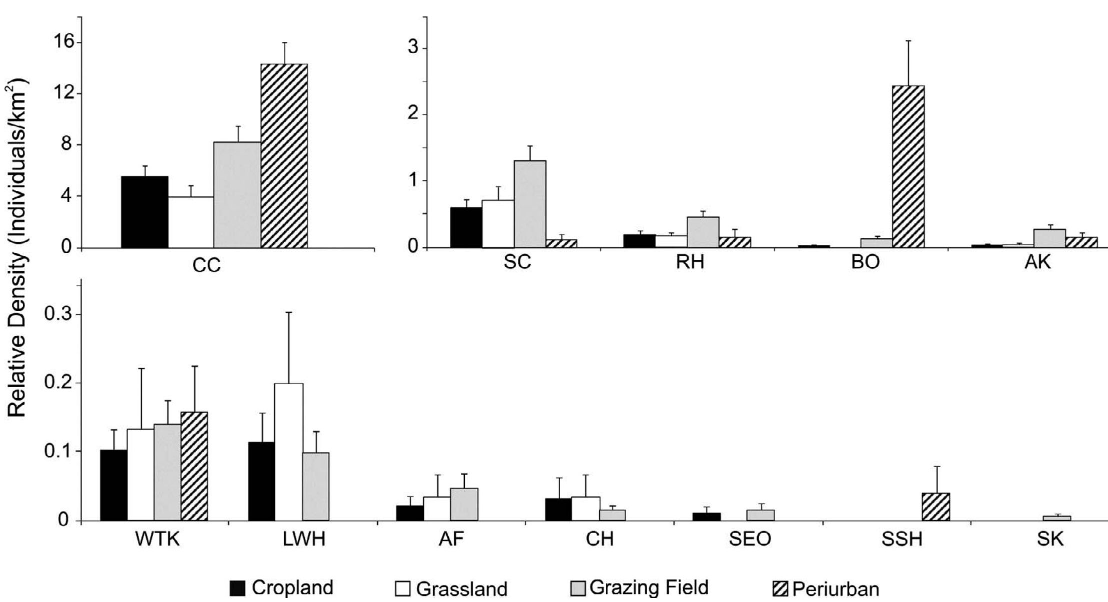

Figure 2. Relative density (number of individuals per km^2; mean ± SE) of raptor species observed in different land-cover types along a 95-km-long, 300-m-wide transect in the Flooding Pampas of Argentina from 2006 to 2009. Species codes are CC: Chimango Caracara, SC: Southern Caracara, RH: Roadside Hawk, BO: Burrowing Owl, AK: American Kestrel, WTK: White-tailed Kite, LWH: Long-winged Harrier, AF: Aplomado Falcon, CH: Cinereous Harrier, SEO: Short-eared Owl, SSH: Sharp-shinned Hawk, and SK: Snail Kite.

indicated no consistent seasonal pattern in the assemblage structure (global R = –0.035). We found some variation in diversity indices, however, with higher values for summer (H′ = 0.986) and winter (H′ = 0.976), a lower value for autumn (H′ = 0.818), and the lowest value for spring (H′ = 0.675).

DISCUSSION

The raptor assemblage in the southeastern portion of the Flooding Pampas comprised a variety of Accipitriformes (eight species), Falconiformes (four species), and Strigiformes (four species), collectively representing 43% of all raptors found in the Rio de la Plata Grasslands biome (Azpiroz 2012). Falconiformes (falcons and caracaras) were the best represented group in the study area, accounting for 57% of the species listed by Azpiroz (2012) for the whole biome. Accipitriformes (hawks, kites, and harriers) and Strigiformes recorded in the study area represented 47% and 44%, respectively, of the total number of species in each order found in the biome (*sensu* Azpiroz 2012). We did not observe the three species of vultures (Cathartiformes) listed by Azpiroz (2012). Although the species composition coincided with general descriptions for the area (Martínez 2001) and the observed associations of some raptor species with different land covers had been described before (Travaini et al. 1994, Goldstein and Hibbitts 2004, Filloy and Bellocq 2007, Pedrana et al. 2008), to our knowledge this is the first study to examine simultaneously the habitat use and seasonal trends of raptor species in the Pampas region.

Chimango Caracaras predominated in all land-cover types; this species has been considered one of the most common raptors in the world (Ferguson-Lees and Christie 2001). The ubiquity of Chimango Caracaras has been attributed to its generalist habits, innovative skills, and colonization capabilities (Biondi et al. 2010), which allow this raptor to quickly occupy new habitats (Leveau and Leveau 2002, Carrete et al. 2009, Cardoni et al. 2011). They were the most abundant and frequently observed species in all land-cover types, which reflects the ability of this raptor to thrive in a variety of environments, especially heterogeneous, disturbed habitats (Pedrana et al. 2008, Gavier-Pizarro et al. 2012). Our findings are in agreement with previous studies that suggested the Chimango Caracara benefits from agriculture (Filloy and Bellocq 2007, Bellocq et al. 2008) and urbanization (Travaini et al. 1994, Carrete et al. 2009, but see Garaffa et al. 2009) in the Pampas region.

We found that the raptor assemblage showed a consistent pattern of variation among land-cover types, but no consistent seasonal variation. Because of its high abundance in all land-cover types, the Chimango Caracara did not contribute strongly to differentiating raptor assemblages among land

Table 2. Contribution of raptor species to similarity/dissimilarity among land-use types in the Flooding Pampas of Argentina based on SIMPER analysis (Clarke and Warwick 1994). Land-use codes are C: cropland, F: grazing field, G: grassland, P: periurban.

	Contribution to Similarity (%)				Contribution to Dissimilarity (%)					
Raptor Species	C	F	G	P	C vs. F	C vs. G	G vs. F	C vs. P	G vs. P	F vs. P
Chimango Caracara	76.2	59.6	88.5	78.9	10.5	16	12.3	8.1	12.9	6.0
Southern Caracara	15.4	18.4	7.3	0	18.7	32.3	27.1	25.1	22.3	27.6
Roadside Hawk	4.3	6.9	2.3	0.2	14.8	16.3	15.2	11.0	11.0	13.1
Burrowing Owl	0	4.5	0	20.3	11.7	0.9	9.6	29.8	31.8	22.3
White-tailed Kite	2.3	2.4	0	0.2	10.5	9.1	6.2	8.6	2.9	6.8
American Kestrel	0.2	4.1	0	0.5	12.7	4.9	10.7	5.6	5.7	10.1
Aplomado Falcon	0	0.5	0	0	4.8	2.4	4.2	0.9	1.4	3.3
Long-winged Harrier	1.2	3.6	1.9	0	10.4	12.1	10.8	6.0	8.1	7.6
Cinereous Harrier	0	0	0	0	3	4.4	2.5	1.9	2.1	0.5
Long-eared Owl	0	0	0	0	2.2	1.5	0.6	1.3	0	0.6
Sharp-shinned Hawk	0	0	0	0	0	0	0	1.6	1.7	1.5
Snail Kite	0	0	0	0	0	0	0.4	0	0	0.4
Average similarity	72.3	78.1	64.4	80.9						
Average dissimilarity					32.2	32.6	35.8	37.9	38.6	36.9

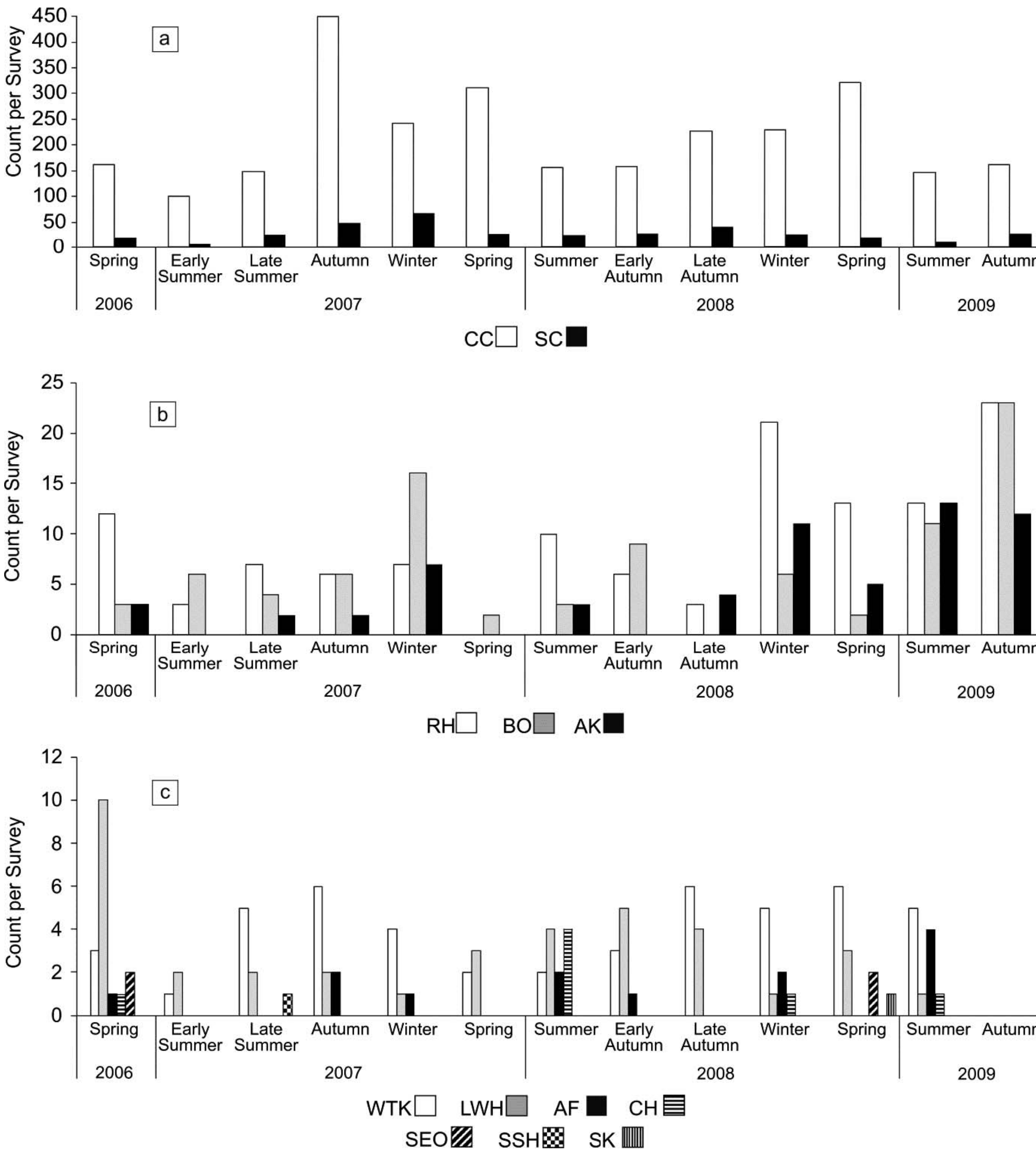

Figure 3. Seasonal variation in the abundance of raptor species recorded along a 95-km-long, 300-m-wide transect in the Flooding Pampas of Argentina from 2006 to 2009. Results are shown separately for (a) most abundant species: Chimango Caracara (CC) and Southern Caracara (SC); (b) intermediate abundant species: Roadside Hawk (RH), Burrowing Owl (BO), and American Kestrel (AK); and (c) least abundant species: White-tailed Kite (WTK), Long-winged Harrier (LWH), Aplomado Falcon (AF), Cinereous Harrier (CH), Short-eared Owl (SEO), Sharp-shinned Hawk (SSH), and Snail Kite (SK).

covers. Instead, this species' contribution was similar to that of other, much less abundant species, such as Roadside Hawk, American Kestrel, and Long-winged Harrier. In contrast, Southern Caracara and Burrowing Owl were the most useful species to differentiate raptor assemblages by habitat type.

The composition of the raptor assemblage in periurban areas differed the most compared to other land covers, having both a different species composition and the lowest species diversity of all sampled habitats. Other than the ubiquitous Chimango Caracara, the Burrowing Owl appeared to be the only species able to thrive in this land cover. This owl is frequently associated with modified areas (Azpiroz and Blake 2016) and especially urbanized habitats (Conway et al. 2006, Carrete and Tella 2011), a habit that may be attributable to the presence of shortgrass patches in vacant lots that are suited to nesting owls (Berardelli et al. 2010). The low species diversity of the raptor assemblage in periurban areas suggests that urbanization may be one of the most critical environmental threats faced by raptors in the Flooding Pampas region, as has been observed in other areas of South America (Eduardo et al. 2007).

The two agroecosystems, croplands and grazing fields, had a similar species composition, as reflected in the low dissimilarity value between them. This resulted from the dominance of the most abundant species (Chimango and Southern Caracaras) in agroecosystems, but also reflected similar contributions of other, less abundant species, such as Roadside Hawk and White-tailed Kite. The presence of these species in agricultural areas is probably related to food availability. For example, Chimango Caracaras may concentrate in plowed or harvested fields to feed on insects disturbed by these practices (Josens et al. 2013). Similarly, agroecosystems likely provide a variety of food resources for Southern Caracaras, such as livestock carcasses to scavenge, high availability of insects and rodents in fields, and an abundance of vegetal matter (Vargas et al. 2007). Roadside Hawks and White-tailed Kites also may benefit from the higher abundance of insects and rodents along the margins of agroecosystems (Bilenca et al. 2007, Solari and Zaccagnini 2009). These habitats also provide convenient hunting perches for hawks and kites on utility poles and fence posts, as well as suitable breeding sites where small groves of trees commonly occur at ranch entrances and around agricultural fields (Isacch et al. 2001).

Conversely, although the absence of vultures in grazing fields of the Flooding Pampas may appear counterintuitive given the apparent abundance of food resources for scavenging birds derived from cattle ranching, three factors may discourage large scavengers in this subregion. First, vulture reproduction may be limited by a lack of suitable nesting sites (e.g., caves, cliff ledges, holes in large trees; Winkler et al. 2015) in the study area (Travaini et al. 1994). Second, food resources may be scarcer and more difficult to find than in arid subregions (e.g., Patagonia), because in the Pampas carcasses are scattered and often removed quickly as a sanitary measure (Vargas et al. 2007). Third, given that dominance hierarchy in avian scavenging guilds is determined by body size and number (Lambertucci et al. 2009), the numerical dominance of smaller facultative scavengers, such as Southern and Chimango caracaras, may competitively exclude larger but less abundant vultures in the Flooding Pampas.

Our results indicate that diversity and richness of raptor species were highest in grazing fields, the dominant land cover in the study area, and in grasslands, one of the least common habitats in the area. The latter result suggests strong selection of grasslands by most raptor species, thus highlighting the importance of relict, native grasslands for maintaining diverse raptor assemblages. The prevalence of grazing fields in the Flooding Pampas contrasts with the characteristics of the northern Rolling Pampas, where intensive croplands predominate (Filloy and Bellocq 2007). In the study area, fields devoted to cattle ranching are mostly under low-intensity grazing regimes and usually present seminatural vegetation. It is also common for the margins of grazing fields to conserve natural habitat (Isacch 2008). Such linear environments are considered important factors in maintaining local biodiversity in agricultural landscapes (Di Giacomo and López de Casenave 2010, Cerezo et al. 2011), and may represent an important resource for raptors, because they serve as corridors and refuges for a variety of potential prey (Bilenca et al. 2007, Solari and Zaccagnini 2009).

Grassland raptor assemblages differed from those in agroecosystems in containing fewer Southern Caracaras and Roadside Hawks, but this habitat was important for harriers (also see Isacch et al. 2001). The loss of native grassland is expected to have a greater effect on grassland specialist species (Codesido et al. 2012). The low abundance of Cinereous Harriers and Long-eared Owls during our study compared to previous studies only 15 yr earlier in the area (Martínez 2001) suggests that these species' populations may be declining, likely as a result of the conversion of Pampas grasslands to agricultural land (Codesido et al. 2012).

Habitat modification is a matter of concern in the Rio de la Plata Grasslands, in general, and in the Pampas region, in particular, because <1% of the grasslands in Argentina are protected (Bilenca and Miñarro 2004). The richness and diversity of bird species in the Pampas have been positively associated with the cover of native vegetation, and conversion to agriculture and urbanization may extirpate grassland specialist species and lead to overrepresentation of generalist species that benefit from human activities (Travaini et al. 1994, Filloy and Bellocq 2007, Carrete et al. 2009, Shrag et al. 2009, Codesido et al. 2012). Likewise, our results demonstrate the importance for maintaining diverse raptor assemblages of conserving remaining areas of native grassland, as well as seminatural grasslands in agricultural landscapes that resemble natural habitat conditions. In addition, we think that land-use planning strategies for the region should incorporate three specific actions: (1) encourage the use of low-intensity agricultural practices rather than intensive cropping, (2) maintain the connectivity of agroecosystem edges to promote conservation of the many raptor species that rely on this environment, and (3) monitor the effects of expanding urbanization in natural and rural areas on raptor abundance and species diversity to help develop understanding necessary to reduce the effects of expanding development.

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