nus). During one hunt, eight falcons chased a kingbird for about 1 min until it sought refuge in a mesquite. The falcons followed it, with five waiting in the treetop while three others ran and hopped through the lower branches until the kingbird flushed and was captured, a sequence often exhibited by mated pairs (Keddy-Hector 2000).

3. In 1993, a group of seven falcons chased and caught a Ladder-backed Woodpecker (*Picoides scalaris*). Several falcons fed on it simultaneously, while the others settled on perches nearby. When a Northern Harrier (*Circus cyaneus*) approached the kill site, two of the non-feeding falcons left the group and drove the harrier away while the others continued their meal undisturbed (C. Perez pers. comm.).
4. A wild hatch-year (HY) male falcon was found eating prey while perched on the rafters underneath one of the hack boxes. Attendants reported that this falcon "generously shared" his kill, possibly a swallow, with a female hacked falcon.
5. A wild-hatched adult female arrived at a hack site and led the first successful group hunt of the yr. She captured a meadowlark after chasing it together with two HY hacked falcons, all three stooping in turn. At a different hack site, a previously hacked adult female regularly visited from 1999–2002. This falcon occasionally fed from the tower, joined in hunts and tower defense, and tolerated food-begging from the HY falcons. Attendants described her behavior as "mentoring."

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SUMMER ROADSIDE RAPTOR SURVEYS IN THE WESTERN PAMPAS OF ARGENTINA

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KEY WORDS: *Chimango Caracara;* Milvago chimango; *Crested Caracara;* Caracara plancus; *agriculture; mesquite; Argentina; survey.*

Roadside surveys are useful for assessing habitat preferences of diurnal raptors. Although the limitations and biases inherent in roadside counts are well known (Fuller and Mosher 1987), roadside surveys serve as a practical means for rapidly assessing raptor distribution and abundance over large areas (Ellis et al. 1990). Roadside surveys have been used to compare species richness and abundance between broad regions and to assess impacts of anthropogenic-habitat transformations on raptors. These types of surveys have been carried out in Europe (Meyburg 1973), Africa (Cade 1969), North America (Woffinden and Murphy 1977), Latin America (Ellis et al 1990), Patagonia (Donázar et al. 1993), and a grassland-agricultural ecosystem in Argentina (Leveau and Leveau 2002). The distribution of raptors across central Argentina was surveyed east to west from Buenos Aires to Zapala, Neuquén (Travaini et al. 1995); we add to this body of knowledge and report results obtained from roadside raptor surveys carried out during December 1998 and January 1999 in the provinces of La Pampa, Córdoba, and San Luís.

STUDY AREA AND METHODS

Survey routes extended from Huanchilla, Córdoba in the north and Intendente Alvear, La Pampa in the east to the western border of La Pampa Province, approaching the Río Negro near the city of Neuquén in the province of Neuquén, Argentina (ca. 35°S, 64°W; Fig. 1). The climate becomes more arid from the eastern coast (Buenos Aires) to the mountains of western Argentina, with vegetation changing from agricultural grasslands to mesquite (*Prosopis* spp.) to desert-scrub grasslands. We chose four primary landscape divisions based on characteristics of the predominant vegetation type: agriculture, mixed agriculture/mesquite, mesquite, and desert-scrub grasslands.

The agriculture category consisted of a mix of cattle ranching and row-crop agriculture, with dominant summer crops of alfalfa, sunflower, sorghum, and corn. In the agricultural region, forests and shrubs exist intermittently, generally planted as shade areas for cattle, for wind breaks between fields, and as entrance corridors to estate houses. These forests most frequently consisted of groves of introduced eucalyptus (*Eucalyptus* spp.) trees. The mixed agriculture/mesquite category contained 25–75% mesquite, while the mesquite category contained

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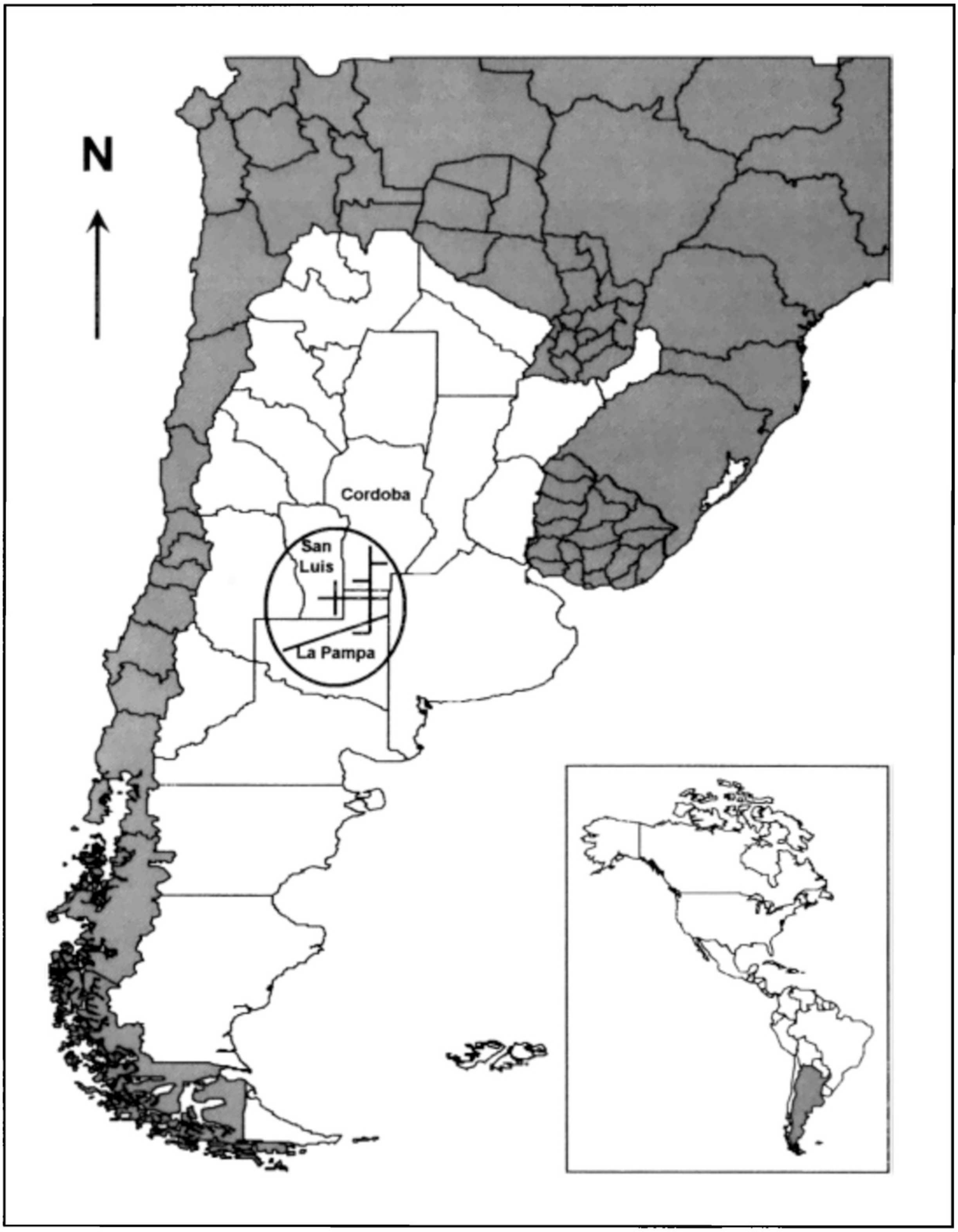

Figure 1. Map of roadside survey locations in the western pampas and central Argentina.

Table 1. Number of raptors observed in landscapes surveyed in the western pampas and central Argentina, December 1998–January 1999.

Species	Scientific Names	Habitat Types: Agriculture	Agriculture/ Mesquite	Mesquite	Desert Scrub	Total
American Kestrel	*Falco sparverius*	2	10	7	1	20
Aplomado Falcon	*Falco femoralis*	2	0	2	1	5
White-tailed Kite	*Elanus leucurus*	0	1	0	0	1
Chimango Caracara	*Milvago chimango*	292	138	38	22	490
Crested Caracara	*Caracara plancus*	42	48	63	19	172
Swainson's Hawk	*Buteo swainsoni*	36	1	0	0	37
Red-backed Hawk	*Buteo polyosoma*	1	1	1	3	6
White-tailed Hawk	*Buteo albicaudatus*	0	3	0	3	6
Burrowing Owl	*Athene cunicularia*	12	1	7	0	20
Short-eared Owl	*Asio flammeus*	1	1	0	0	2
Turkey Vulture	*Cathartes aura*	0	0	0	12	12
Black Vulture	*Coragyps atratus*	0	4	0	1	5
Richness		8	10	6	8	
Abundance		388	208	118	62	776
Richness/100 km		1.5	2.6	2.8	6.0	
Abundance/100 km		74.9	54.6	54.6	46.6	

>75% mesquite with small grassy patches scattered throughout. The desert-scrub grassland category contained <10% tree cover and generally consisted of natural grasslands.

We traveled survey routes between 0600–1100 H and 1630–2030 H (local time; on 1 January 1999 sunrise was at 0545 H and sunset at 2010 H). Surveys were completed on 32 routes over 16 d, with a minimum of 50 km and a maximum of 248 km per route. Each route was surveyed once to ensure bird sightings would be independent. The weather on survey days was partly cloudy to sunny with either no wind or a slight breeze. We recorded each occurrence of birds of prey and New World vultures in each habitat. We traveled on paved highways at approximately 80–90 km/hr, slightly faster than recommended (Fuller and Mosher 1987), but still at speeds at which we were able to detect species in different habitats, particularly the five common species analyzed for habitat selection.

To minimize differences in detectability among surveys, we standardized time of d, weather, driving speed, and number of observers (Fuller and Mosher 1987). In a few cases, we needed to stop the vehicle for positive identification; during these times we did not include new observations. Because of time and distance constraints, time in each habitat was not uniform.

We determined species richness and abundance by habitat type. We used curve-fitting software (CurveExpert©, 1995–2001; Daniel Hyams, Version 1.37) to demonstrate how richness increased with increasing number of km surveyed. CurveExpert© uses double-precision floating-point numbers to calculate and rank best-fit curves. In this manner, we describe the rate of species accumulations in each habitat type and include the correlation coefficient, *r*.

We analyzed habitat preference for the five species with the greatest abundance (≥20 individuals) using a replicated goodness-of-fit test (Sokal and Rohlf 1995). We used replicated goodness-of-fit tests to determine whether raptors were distributed in proportion to available habitat, or whether individual raptor species deviated from the expected proportions in the same fashion (i.e., whether G for the pooled data, G_P, and G for the heterogeneity, G_H, were significant. We did not analyze species with low abundance (<20 observations).

RESULTS

We traveled 518 km through agricultural habitat, 381 km through the mixed agriculture/mesquite habitat, 216 km through pure mesquite habitat, and 133 km through desert-scrub grasslands. We counted 12 species of raptors and vultures totaling 776 individuals (Table 1). Agricultural lands had the lowest relative richness and highest relative abundance (1.5 species/100 km, 74.9 individuals/100 km), while desert scrub had the highest relative richness and lowest relative abundance (6.0 species/100 km, 46.6 individuals/100 km; Table 1). The raptor observations for the four habitat types were determined to have the following species accumulation curves (Fig. 2): the MMF model (Morgan et al. 1975) for agriculture ($y = [ab + cx^d/][b + x^d]$; a = −8.78; b = 0.90; c = 11.03; d = 0.29; SE = 0.45; r = 0.99); the logistic model for mixed argriculture/mesquite($y = a/(1 + b \times e^{-cx})$; a = 9.51; b = 4.07; c = 0.038; SE = 0.79; r = 0.97); the Power Fit for mesquite ($y = ax^b$; a = 0.14; b = 0.68; SE = 0.92; r = 0.94); and the rational function model for desert-scrub grasslands ($y = (a + bx)/(1 + cx + dx^2)$; a = 0.23; b = 0.83; c = 0.11; d = −0.0001; SE = 0.26; r = 0.99).

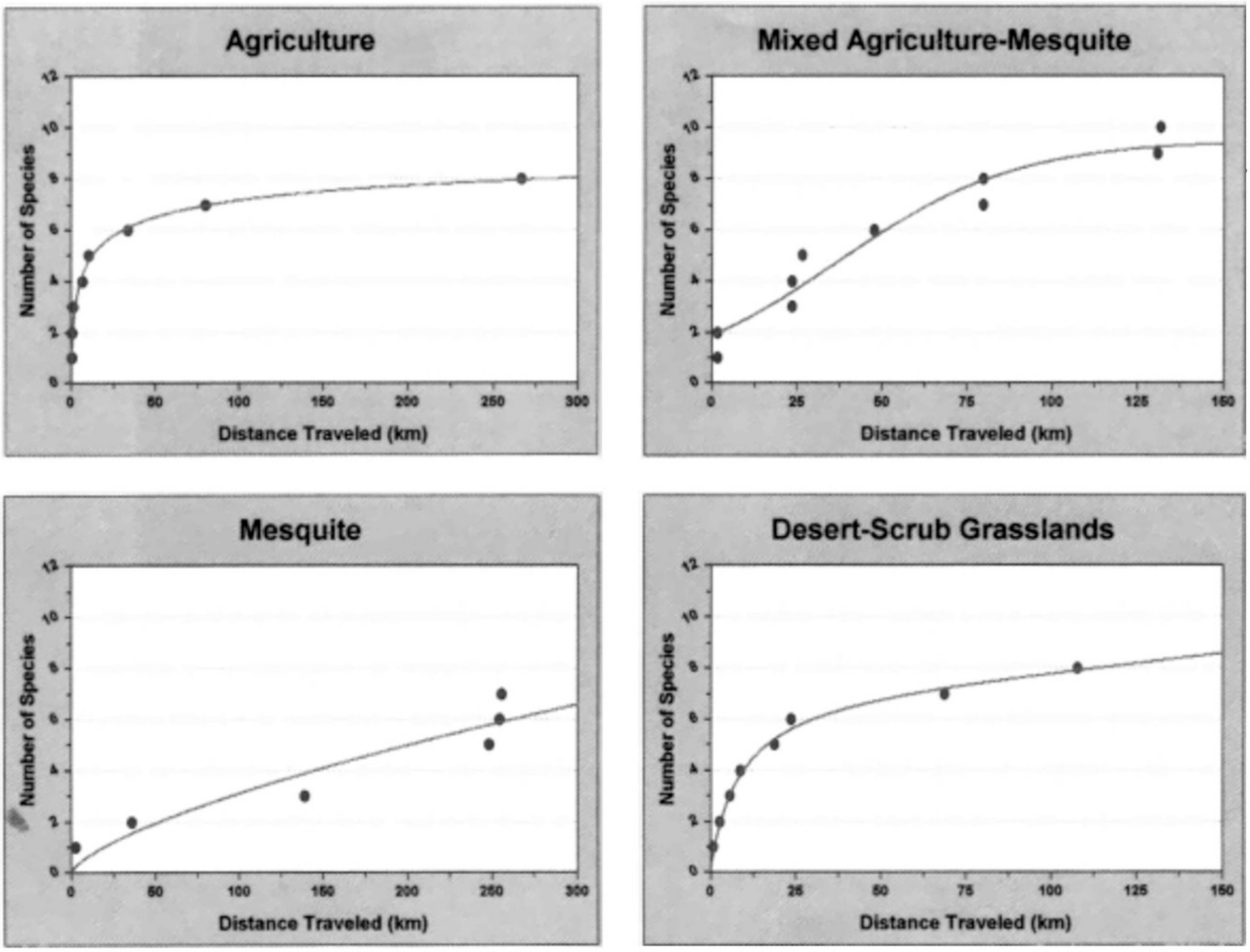

Figure 2. Species accumulation curves for raptors encountered during roadside surveys of four habitat types in Argentina.

Of the 12 species observed, we recorded 7 infrequently: Aplomado Falcon (*Falco femoralis*), White-tailed Kite (*Elanus leucurus*), Red-backed Hawk (*Buteo polyosoma*), White-tailed Hawk (*B. albicaudatus*), Short-eared Owl (*Asio flammeus*), Turkey Vulture (*Cathartes aura*), and Black Vulture (*Coragyps atratus*). Chimango Caracaras (*Milvago chimango*), Crested Caracaras (*Caracara plancus*), American Kestrels (*F. sparverius*), migratory Swainson's Hawks (*B. swainsoni*), and Burrowing Owls (*Athene cunicularia*) were most common. Chimango Caracaras (N = 490) were most frequently found in agriculture or mixed agriculture/mesquite and Crested Caracaras (N = 172) were most frequently found in mesquite. These two species occurred in all habitats and accounted for 85% of the total number of individuals sighted. American Kestrels (N = 20) were recorded infrequently, but also occurred in all surveyed habitats (Table 1). Swainson's Hawks and Burrowing Owls were found most commonly in agriculture. We often found Chimango Caracaras, Crested Caracaras, and Swainson's Hawks in groups (Table 2).

A replicated goodness-of-fit test on the five most common species indicated that raptors were not distributed in proportion to available habitat. The pooled goodness-of-fit test (G_P = 43.8; df = 2; $P < 0.001$) indicated that the raptor community as a whole was observed in habitats in proportions different from those available. In particular, raptor abundance in agricultural lands exceeded the proportion of available habitat. The heterogeneity goodness-of-fit test (G_H = 173.1; df = 12; $P < 0.001$) indicated that individual raptor species did not all deviate from the expected proportions in the same fashion. All individual goodness-of-fit tests also were significant (Table 3). American Kestrels used mesquite and agriculture/mesquite habitats, Crested Caracaras used mesquite, and Burrowing Owls used agriculture or mesquite. Both Chimango Caracaras and Swainson's Hawks were observed largely on agricultural lands.

DISCUSSION

Our results show that the five most commonly encountered species chose habitats differently and not in pro-

Table 2. Group sizes of species observed on roadside surveys.

NO. INDIVIDUALS	1	2	3	4	5	6–10	>10
Species							
American Kestrel	16	2					
Aplomado Falcon	1	2					
Chimango Caracara	200	61	17	7	7	4	2
Crested Caracara	81	22	7	4		1	
Swainson's Hawk	1	1				1	2
Red-backed Hawk	6						
White-tailed Hawk	2	2					
Burrowing Owl	6	2		1			
Turkey Vulture	8	2					
Black Vulture	2		3				

portion to their availability. Chimango Caracaras were more abundant than other species we encountered, similar to findings from other roadside surveys in Argentina. Chimango Caracaras accounted for 54% of all observations in Patagonia (Donázar et al. 1993) and 74% of all raptors surveyed in central Argentina (Travaini et al. 1995). Chimango Caracaras, a poorly studied yet common species, use agricultural areas extensively. This species is often found near trees, foraging on snakes, rodents, birds, and insects, depredating nestlings and eggs, eating roadkills, other carrion, and refuse near houses (M. Goldstein unpubl. data). Previous studies, like current findings, associate Swainson's Hawks with agricultural lands in Argentina, where they forage opportunistically on swarms of grasshoppers (Jaramillo 1993, Goldstein et al. 1999). Opportunistic feeders that forage in groups often are found in association with agricultural fields and rangelands (Ellis et al. 1990, Eakle 1994).

Smaller falcons may be more difficult to detect than larger birds, particularly while completing roadside surveys at fast speeds. Similarly, our ability to detect falcons may change with habitat type. Detectability of small perching falcons may be reduced with dense habitat structure (Fuller and Mosher 1987). Aplomado Falcons

Table 3. Replicated goodness-of-fit test of habitat selection for the five most common raptor species encountered on road surveys in the western pampas and central Argentina. Species numbers are followed by percent observed in parentheses.

SPECIES km	AGRICULTURE 518 (41.5%)	AGRICULTURE/ MESQUITE 381 (30.5%)	MESQUITE 216 (17.3%)	DESERT SCRUB 133 (10.7%)	TOTAL 1248	G
American Kestrel	2 (10%)	10 (50%)	7 (35%)	1 (5%)	20	12.5*
Burrowing Owl	12 (60%)	1 (5%)	7 (35%)	0	20	15.1*
Chimango Caracara	292 (60%)	138 (28%)	38 (8%)	22 (4%)	490	90.1*
Crested Caracara	42 (24%)	48 (28%)	63 (37%)	19 (11%)	172	42.7*
Swainson's Hawk	36 (97%)	1 (3%)	0	0	37	56.5*
Total	384 (52.0%)	198 (26.8%)	115 (15.6%)	42 (5.7%)	739	
						G_H = 173.1*
						G_P = 43.8*
						G_T[a] = 216.9*

[a] $G_T = G_H + G_P$.

* Significant at $\alpha < 0.001$.

and American Kestrels perched on fence posts and barbed wires may stand out more than when perched on trees in forested habitats, which may have led to undercounting in the latter. However, electrical and phone wires did not exist across the entire sample area. There were no wires in the desert scrub habitat and wires were intermittent across other regions. In the two habitats with greater tree structure, mixed argriculture/mesquite and mesquite, we detected more kestrels. In a 35-km section of road with electrical wires, through mixed agricultural and mesquite habitat, we detected six American Kestrels on wires. Although we noted no other landscape differences (e.g., ridges or valleys), we do not know whether American Kestrels were more visible on this section of road, wires influenced their visibility, or they simply had greater abundance in this area.

Relative richness was inversely correlated with the number of km traveled. Although we observed the greatest relative richness in desert-scrub habitat and the lowest relative richness in agriculture, this dichotomy may have been due to unit effort (Heyer et al. 1994). In other words, if the rapid species accumulations we found in these two habitats were equivocal, then relative richness was a function of sampling effort and we over-estimated its value. Nonetheless, our results indicate that common raptors exhibited distinct landscape preferences, and for the two most common species, Chimango and Crested caracaras, it was likely a result of greater foraging opportunities in disturbed landscapes.

RESUMEN.—Contamos 776 rapaces y buitres a lo largo de estudios al borde de carretera que totalizaron 1248 km durante diciembre de 1998 y Enero de 1999. Viajamos 518 km a través de hábitats agrícolas, 381 km a través de un hábitat arbustivo mixto de cultivos agrícolas y mesquite (*Prosopis* spp.), 216 km a través de hábitat de puro mesquite, y 133 km a través de desierto arbustivo en las pampas occidentales y el centro de Argentina. De las 10 especies observadas, los caracaras chimango (*Milvago chimango*) y los Caracaras crestados (*Caracara plancus*) ocurrieron a lo largo de todas las rutas estudiadas en todos los hábitats y fueron los más comunes. Las tierras agrícolas tuvieron la más baja riqueza relativa y la más alta abundancia relativa, mientras que el desierto arbustivo tuvo la más alta riqueza relativa y la más baja abundancia relativa. Un test replicado de bondad de ajuste para las cinco especies mas comunes indicó que las especies no estuvieron distribuidas en proporción al hábitat disponible (G_P = 43.8; $P < 0.001$) y diferentes especies mostraron preferencia por diferentes hábitats.

[Traducción de César Márquez]

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