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HABITAT USE BY SWAINSON'S HAWKS ON THEIR AUSTRAL WINTERING GROUNDS IN ARGENTINA

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ABSTRACT.—We examined the use of agricultural habitats by Swainson's Hawks' (*Buteo swainsoni*) in La Pampa and Santa Fe provinces, Argentina. We found an association of foraging Swainsons' Hawks with permanent pastures such as fallow, natural, and alfalfa fields. The hawks also used plowed fields for sunning, resting, and preening. Fields planted with annual crops and pastures were used very little, except when they were cut for hay, plowed, and harvested, or when low crop height and cover allowed the hawks to land in fields. The availability of abundant, yet widely-spaced and transient food-sources, such as insect outbreaks, appeared to be the principal factor influencing habitat use by the hawks. Their reliance on agricultural habitats makes Swainson's Hawks highly vulnerable to pesticide contamination and has contributed to the occurrence of significant mortality events on their wintering grounds.

KEY WORDS: *Swainson's Hawk*; Buteo swainsoni; *agroecosystems*; *Argentina*; *habitat use*; *wintering grounds.*

USO DE HÁBITAT DEL AGUILUCHO LANGOSTERO EN SUS ÁREAS DE INVERNADA AUSTRAL EN ARGENTINA

RESUMEN.—Estudiamos el uso de ambientes agrícolas por aguiluchos langosteros (*Buteo swainsoni*) en las provincias de La Pampa y Santa Fe, Argentina. Encontramos una fuerte asociación de los aguiluchos langosteros con pasturas perennes tal como campos enmalezados, naturales y alfalfa, que utilizaron para alimentarse en el suelo. Los aguiluchos también utilizaron campos arados para exponerse al sol, descansar y acicalarse. Los lotes de cultivos y pasturas anuales fueron usados muy poco, excepto cuando fueron cortados y enfardados, arados o cosechados, o cuando la baja altura y cobertura de las plantas les permitieron a los aguiluchos posarse en el suelo. La disponibilidad de fuentes de alimento abundantes, aunque ampliamente espaciadas y pasajeras, como las mangas de insectos, sería el factor principal que explicaría los patrones observados de uso de hábitat en estas escalas. La asociación de los aguiluchos con ambientes agrícolas hace estas aves altamente vulnerables al uso de plaguicidas, y habría contribuído a la ocurrencia de episodios de mortandad masiva en sus áreas de invernada.
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Migratory birds use different habitats according to their life history requirements and seasonal environmental changes (Newton 1979, Alerstam 1990, Moore et al. 1995, Morrison et al. 1998). Their mobility and exposure to a variety of environments on breeding and wintering grounds make it especially challenging to understand their habitat use patterns (Cody 1985, Rappole 1995). In addition, their reliance on multiple habitats at different times of the year makes them particularly vulnerable to impacts from human activities (Rappole 1995), particularly agricultural activities, given the reliance that many of these birds have on crop fields and edge areas (Rodenhouse et al. 1995).

Among migratory birds, the trophic level and slow reproductive rates of raptors make them especially vulnerable to human-induced, environmental changes such as habitat fragmentation and pesticide contamination (Newton 1979, Alerstam 1990, Tella et al. 1998). Although only a small number of raptors are long-distance migrants (Alerstam 1990), most species of raptor performs some kind of migratory movement in at least part of its range. In all cases, these movements are generally associated with variations in prey availability (Newton 1979).

The Swainson's Hawk (*Buteo swainsoni*), a Neotropical migratory raptor that breeds in North America and migrates to South America for the austral summer, is typically associated with open fields such as grasslands. It has adapted to environments with a high proportion of agriculture, both in its breeding and wintering ranges (Mouchard 1996, England et al. 1997). As examples, 17.7% and 75.4% of the area within 1 km of Swainson's Hawks nests in North Dakota were cultivated crops and pasture/hayland, respectively (Gilmer and Steward 1984), and 42% of the area within foraging radius of radio-marked individuals in California was active agriculture (Woodbridge 1991). This makes the species vulnerable to impacts from agricultural practices, such as habitat modification and pesticide applications. Understanding the ecology of the Swainson's Hawk is crucial to reduce these impacts over its entire range.

Although the habitat use of the Swainson's Hawk is well documented on its breeding grounds (Bechard 1982, Schmutz 1984, 1989, Estep 1989, Woodbridge 1991, Babcock 1995, Smallwood 1995), there is little information on its habitat use on the wintering grounds (England et al. 1997, Herkert and Knopf 1998, Kirk and Hyslop 1998).

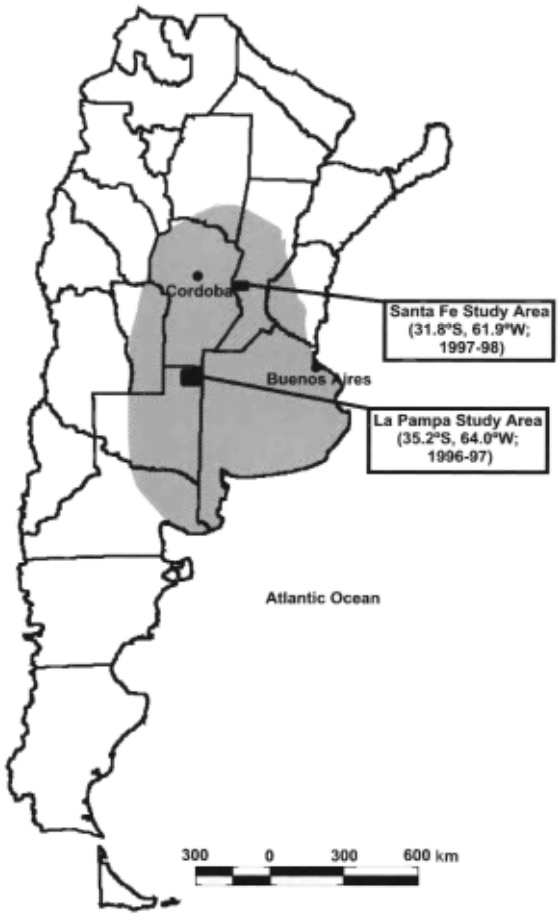

Figure 1. Approximate wintering range of Swainson's Hawks in Argentina (from CIPA 1987 and England et al. 1997) and location of the study areas.

As part of a more comprehensive project started in the austral summer of 1995–96, this study focused on the analysis of habitat use by wintering Swainson's Hawks in two areas in La Pampa and Santa Fe provinces of Argentina. Our goal was to obtain information on the ecology of wintering Swainson's Hawks in Argentina that could help to reduce the potential negative impacts of agriculture.

STUDY AREAS

Fieldwork was conducted in the northeastern portion of La Pampa and central portion of Santa Fe provinces, Argentina (Fig. 1). Between 28 November 1996 and 16 March 1997, a 2250 km^2 (50 × 45 km) area was established around a principal roost at "Chanilao" ranch (35.2°S, 64.0°W) in La Pampa. The area included several

locations where mass mortalities of Swainson's Hawks occurred during the previous austral summer (Woodbridge et al. 1995, Goldstein et al. 1996, Goldstein 1997). We chose this area because two study teams could cover it during one survey day, which minimized double counting of hawks for estimation of population abundances. In 1998, a 900 km^2 sampling area (45 × 20 km) was selected in the central portion of Santa Fe province, on the border with Córdoba province (Fig. 1). Fieldwork was carried out in this area between 7 January and 14 March 1998.

Both study areas were dominated by agricultural fields. The La Pampa area contained a mosaic of crops including sunflowers, corn, sorghum, millet, and soybeans, as well as patches of natural habitats such as *Poa* spp. and *Stipa* spp. grasslands. The Santa Fe study area was dominated (74%) by continuous cropland (mostly soybean), with the remaining of the surface (26%) dedicated to livestock and milk production over non-native pastures. La Pampa area had lower rainfall and slightly lower mean annual temperature than Santa Fe area (600–700 mm, 16°C and 800–900 mm, 17°C, respectively; Canavelli 2000).

METHODS

Individual Patterns of Daily Activity and Habitat Use. Between 16 December 1996 and 13 March 1997, focal observations of individuals were recorded to describe patterns of daily activity and habitat use within La Pampa study area. The day was divided into three equal periods: morning (0600–1040 H), midday (1041–1520 H), and afternoon (1521–2000 H) based on the length of the day during December (sunshine equal to 14 hr 35 min between 0604 and 2025 H, R. Rodriguez pers. comm.). We randomly assigned these periods to three different days each week. Locations for focal observation points were randomly selected among locations of flocks observed in the area on previous surveys (Canavelli 2000).

When a flock of hawks was found, we began a scan with binoculars starting on a randomly selected horizontal angle (at 10° intervals) and vertical section (air/ground) in which the group was previously divided, until one individual was identified. Then, we began an observation bout of 5-min conducted on that individual using 10× binoculars and a 20–60× spotting scope. A 5-min rest bout followed and then a new individual was randomly selected and observed. This procedure was repeated during the entire 280-min observation period for a total of 29 observation bouts/observation period. Observations recorded during each observation bout were: general weather conditions (cloud cover, wind speed and direction, and temperature); cover type (wheat, corn, sunflower, alfalfa, other improved pasture, native-plant pastures, fallow field, plowed field, woodland, and other); behavior of the individual hawk (soaring, active flight, and perching on the ground, fence post, light pole, and in a tree); and bird activity (preening, foraging, short runs, short flights, pecking on the ground, extension of feet while soaring, and movement of feet to the bill while soaring). Individuals were considered to be foraging on the ground if they made short runs, walks, jumps or flights usually followed by pecks to the ground to catch prey (without necessarily using talons). While soaring, hawks were considered to be foraging when they dove, extended one or both feet to catch prey and then transferred it to the bill (Woffinden 1986).

The relative frequencies and mean frequencies of behavioral observations were analyzed using SAS System for Windows (v6.12, 1998). In order to pool all the observations for an estimation of hourly-activity budget per day, the number of observations for each behavior during each hour was scaled based on how much of the hour was completely covered on the observation periods. In this way, a balance was achieved among the unequal number of observations obtained for each hour (as result of the differences in detectability of Swainson's Hawks at different times of the day). Then, the percentage of time devoted to each activity was estimated on an hourly basis

Habitat Selection at Population Level. Our characterization of habitat use at the population level (population is defined as the group of Swainson's Hawks sharing the study area at the same time) was based on systematic surveys conducted every 3–4 d along roadways regularly spaced over the two study areas. Twenty-two surveys were conducted in La Pampa between 21 December 1996 and 16 March 1997, and 21 were conducted in Santa Fe between 7 January and 14 March 1998. Eight surveys in La Pampa were conducted using strip transects (bandwidth of 200 and 300 m on each side, five and three surveys, respectively), while 14 surveys in this area and all the surveys in Santa Fe study area were conducted using point counts (variable circular plots; Buckland et al 1993). In the latter case, routes were 45 km long regularly spaced every 10 km, with ten 5-min point-count stations spaced at 5 km intervals on each route, totaling 60 point-count stations in La Pampa (six routes) and 30 stations in Santa Fe (three routes; Canavelli 2000).

One or two groups of two people conducted the surveys in a vehicle driving at 40–60 km/hr during the morning (0600–1200 H) and in the afternoon (1400–2000 H). In the case of two groups (La Pampa), each group was randomly assigned to cover three routes each day, in order to reduce observer bias on different areas. Additionally, both in La Pampa and in Santa Fe, the starting point and route for the survey were randomly established, but considering each route was equivalently covered on different time periods (morning, midday, and afternoon) in order to standardize the influence of time of the day on the counts (Watson et al. 1996).

All hawks detected during each survey were recorded. Data included percent cloud cover and wind speed in qualitative categories; time of day; location using the truck odometer; and distance to the hawks from the observer estimated in intervals of 0–10, 11–50, 51–100, and 101–500 m. We also recorded land cover type, including field crops (such a corn, sunflowers, wheat, or sorghum), annual pastures (such as millet), permanent pastures (such as alfalfa), native plant pastures, fallow fields, plowed fields, and woodlands. We recorded the number of hawks (which were counted if there were individual hawks or small groups or estimated a range of numbers for large flocks); behaviors included: soaring, active flight, perched on the ground, on fence posts, on electric light posts, or in trees; bird activities: feeding in the air; feeding on the ground, preening; and resting/sunning Two behaviors could be recorded for an individual hawk

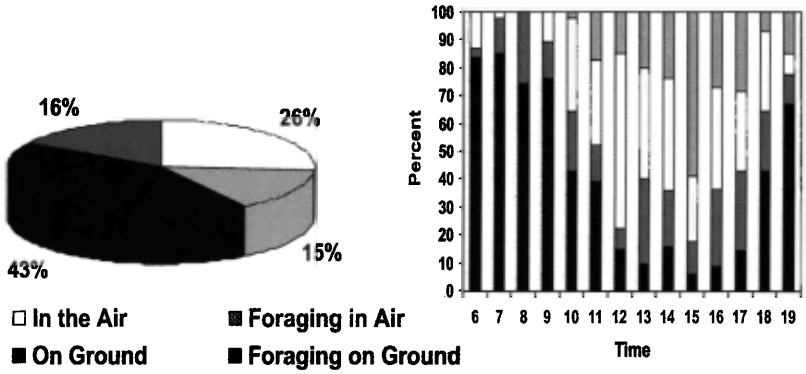

Figure 2. Daily activity pattern of Swainson's Hawks in La Pampa, Argentina (N = 416 observations). A. Activity budget (as percent of observations for each behavior in a day); B. Distribution of activities at different hours (as percent of observations made each hour).

(e.g., a hawk could be recorded preening and perched on a fence post).

Only counts of hawks observed on the ground were included in the habitat-use analysis because it was clear that they were using a particular cover type. We later reassigned these counts to five cover types: cropland (sunflower, wheat, and sorghum), annual pastures (millet), permanent pastures (alfalfa and pastures >2 yr-old, natural, fallow and short-grass fields), plowed fields, and woodlands. Because the hawks usually moved in flocks (not independent individuals), habitat use was analyzed using the number of observations and not the number of hawks observed in each cover type (Thomas and Taylor 1990, Alldredge and Ratti 1992). Although we made sporadic observations of hawks using native woodlands and lowlands outside the study area in La Pampa and hawks soaring over urban areas, we made no observations of Swainson's Hawks on the ground in these areas during surveys. For this reason, these cover types were not included in the analysis of habitat use.

Habitat availability in both areas was obtained from satellite image analysis using remote sensing methodology. The National Institute of Agricultural Technology (INTA) at Castelar (Buenos Aires, Argentina) provided satellite images for both study areas (Mosaic Landsat TM, Path/Rows 228–84 and 228–85 for La Pampa and Path/Rows 228–82 and 227–82 for Santa Fe). Images included bands three (red), four (near infrared), and five (middle-infrared) and they were georeferenced to latitude and longitude. Unsupervised and supervised classifications were carried out on each area using IDRISI for Windows (v.2.008, Clark University, Eastman 1997). Eighteen land use classes were initially considered in La Pampa and 16 in Santa Fe. Later, we grouped these into six new classes: permanent pastures (alfalfa fields, native-plant pastures, short-grass fields, and fallow fields), cropland (sunflower, sorghum, corn, oat, wheat, stubble wheat, plowed fields, and annual pastures), native woodlands, *Eucalyptus* spp. woodlands, lowlands, and urban areas.

Habitat selection was estimated following Neu et al. (1974) and using the program HABUSE (Byers et al. 1984). In addition to Bonferroni's confidence intervals estimated by this method, Bailey's intervals were estimated in order to complement those intervals obtained by the program HABUSE (Cherry 1996). Bailey's intervals are more robust for small sample sizes and provide the best combination of low error rates and interval length on the estimation of confidence intervals (Cherry 1996).

RESULTS

Individual Patterns of Daily Activity and Habitat Use. We recorded 416 activity and habitat use observations over 22 d. In the morning (0600–1040 H), we obtained 204 observations on 10 different days, 139 observations were obtained at midday (1041–1520 H) on 8 d, and 73 were obtained in the afternoon (1520–2000 H) on 7 d. Observations were made in more than one time block in the same day on only 3 d (16 December 1996, 8 and 17 January 1997).

Hawks spent most of the day (59%) sunning/resting, preening, and foraging on the ground (Fig. 2A), mainly in the morning and late afternoon (Fig. 2B). The remainder 41% of the day was spent soaring, gliding, and foraging in the air, particularly at midday. Most hawks (64–100%) stayed on the ground until 0900–1000 H, with temperatures 11–29°C (Fig. 2B). At 1100 H, hawks were observed in nearly equal proportions in the air (48%) and on the ground (52%). Between 1200–1600 H (temperatures 20–38°C), hawks were observed mostly soaring (77–82%). When the highest temperatures were registered (midday, 35–38°C), only soaring hawks were observed. At 1700 H, hawks were again observed in nearly equal proportions in the air (57%) and on the ground (43%). Finally, between 1800–2000 H (tempera-

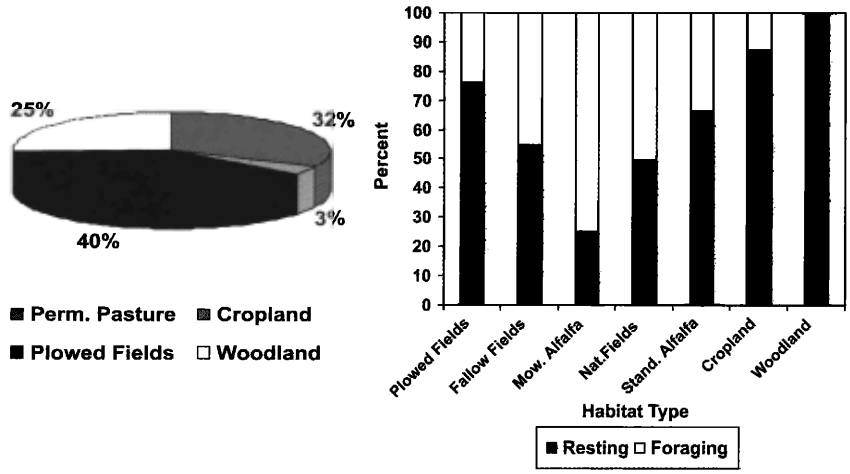

Figure 3. Cover types used by Swainson's Hawks on the ground during focal observations (N = 279 observations) A. Percentage of observations related to cover type; B. Percentage of observations by behavior in each cover type. Permanent pastures in A include fallow fields, mowed alfalfa, natural fields, and standing alfalfa.

tures 20–35°C), hawks were again mainly observed on the ground (67–78%, Fig. 2B).

Swainson's Hawks used various cover types for different activities at different times during the day. They mainly used plowed fields (N = 100 observations) and permanent pastures (N = 84) to sun, rest, and preen on the ground (Fig. 3A and 3B) during the day. Additionally, they used plowed fields (N = 29) and permanent pastures (fallow, natural, mowed, and standing alfalfa fields; N = 38) to forage on the ground (Fig. 3B). Plowed fields were used for foraging on the ground early in the morning (N = 21), while permanent pastures were used more at midday and afternoon (N = 20 and 10, respectively). Hawks were observed soaring and foraging in the air over several cover types (N = 92 and 45 observations, respectively), including permanent pastures (N = 36), annual crops (N = 31), plowed fields (N = 28) and annual pastures (N = 3), especially at midday (N = 85) and in the afternoon (N = 26). In woodlands (N = 66 observations), most (76%) of hawks observed were either resting or preening in trees, early in the morning or late in the afternoon (N = 44 and 6, respectively).

Based on our observations, a typical day for a Swainson's Hawk on its wintering grounds was divided into three periods: (1) morning, when hawks stayed mostly on the ground, in roosts, or in plowed fields located next to roosts either sunning, resting, preening, and foraging; (2) midday and afternoon, when some hawks still remained on the ground, mostly foraging on permanent pastures, but increasingly left the ground and soared while feeding in the air over crops and pastures; and (3) late afternoon prior to roosting, when hawks are again on the ground in plowed fields and pastures preening and foraging. Hawks were usually observed using crop and pasture fields without any disturbance, but on seven sampling occasions, hawks were observed on crop and pasture fields while farm operations such as plowing, mowing or baling, and burning were conducted (four, two, and one occasions, respectively), or cattle were grazing on the fields (one occasion).

Habitat Use at the Population Level. Observations from both study areas showed that Swainson's Hawks primarily used permanent pastures which were not plowed on an annual basis (159 observations, 6265 hawks in La Pampa; 240 observations, 6885 hawks in Santa Fe; Fig. 4). In La Pampa, plowed fields followed permanent pastures in importance of use (77 observations, 3793 hawks) while in Santa Fe, annual pastures were the second most used cover type (72 observations, 1511 hawks). Cropland was more used in La Pampa than in Santa Fe, but in both study areas, observations were less than 15% of the total (36 observations, 3039 hawks and 23 observations, 141 hawks in La Pampa and Santa Fe, respectively). Less than 10% of our observations on both areas (15 observations, 329 hawks in La Pampa and 36 observations,

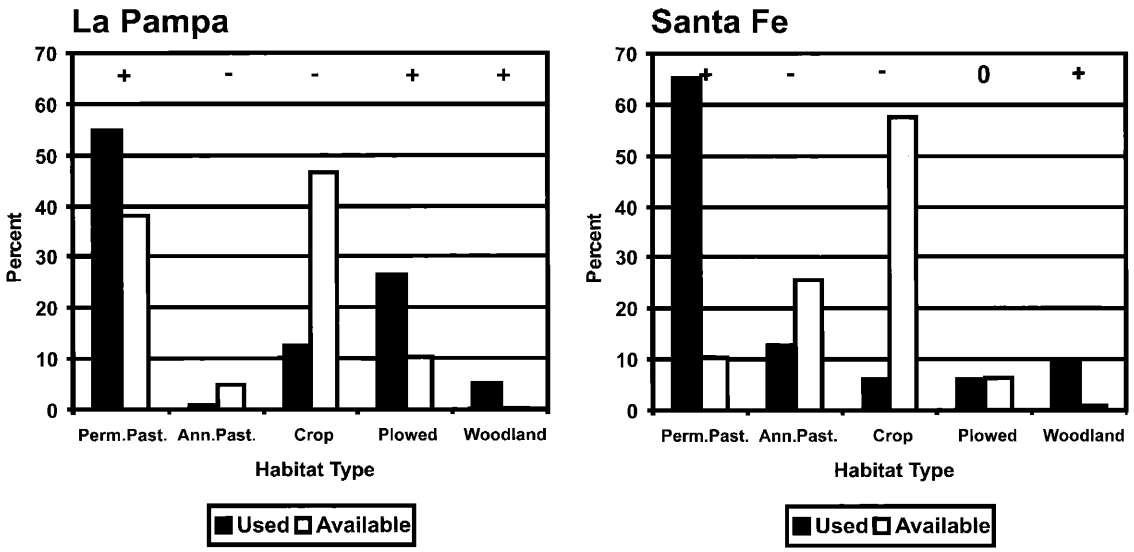

Figure 4. Habitat use vs. availability in La Pampa and Santa Fe study areas, Argentina. Habitat use is expressed as percent of observations with hawks on the ground, $N = 290$ observations in La Pampa and $N = 393$ observations in Santa Fe), and habitat availability is expressed as percent of each habitat type determined from satellite images. (+) = used more than available, (−) = used less than available, and (0) = used as available (Table 1).

844 hawks in Santa Fe) were on hawks using woodlands (Fig. 4).

Among permanent pastures, fallow, native-plant, and alfalfa fields were the most commonly used in La Pampa (70, 41, and 40 observations; 1715, 1671, and 2640 hawks, respectively). In alfalfa fields, more observations were made on standing than on mowed alfalfa (23 and 17, respectively), although fewer hawks were observed on standing alfalfa compared to mowed fields (855 and 1785 hawks, respectively). In Santa Fe, 83% (200) of observations made on permanent pastures were in fallow and short-grass fields (129 observations, 2538 hawks and 71 observations, 2456 hawks, respectively). In this case, both number of observations and hawks were greater in mowed than in standing alfalfa (23 observations, 1287 hawks and 16 observations, 603 hawks, respectively). Sixty-one percent and 77% of observations made on hawks foraging on the ground in La Pampa (14 observations, 2525 hawks) and Santa Fe (23 observations, 2069 hawks), respectively, were on permanent pastures, followed in importance by plowed fields (La Pampa: 6 observations, 1524 hawks and Santa Fe: 4 observations, 280 hawks). Fallow (26% of observations with hawks foraging on the ground in La Pampa and 27% in Santa Fe), native-plant (9% in La Pampa), short-grass (43% in Santa Fe), and alfalfa fields (22% in La Pampa and 7% in Santa Fe) were the main permanent pastures used for foraging on the ground. Groups of hawks foraging on the ground varied between 207 (SE = 65) and 86 (SE = 37) individuals in La Pampa and Santa Fe, respectively.

In La Pampa, annual crops and pastures were mostly used when plowed than in other crop stages (65% of observations in these cover types, $N = 77$, 3793 hawks). Wheat was used when in stubble (8 observations, 1232 hawks), and corn and sunflower were used principally when emerged (cover height <40 cm; 12 observations, 1466 hawks and 15 observations, 340 hawks, respectively). In Santa Fe, 41% of 91 observations made on crops and annual pastures were on mowed millet followed by plowed and soybean fields (24% and 24%, respectively). On both areas, hawks were observed with working farm machinery, both while mowing or baling alfalfa and annual pastures (such as millet, 11 observations, 774 hawks) and plowing fields (7 observations, 333 hawks). Additionally, on six occasions (188 hawks), hawks were observed on fields being grazed by cattle.

Cropland and annual pastures comprised most of the agricultural landscape in both study areas, followed by permanent pastures (Fig. 4). Woodlands contributed little to the general land cover.

Table 1. Analysis of habitat use versus availability for La Pampa and Santa Fe study areas, Argentina. Probability of disproportional use ≤0.05. (+) = used more than expected, (0) = used as expected, and (−) = used less than expected (Byers et al. 1984 and Cherry 1996).

HABITAT	OBSERVED USE (PERCENT)[a]	USE INTERVAL BYERS' INTERVALS	BAILEY'S INTERVALS	EXPECTED USE (PERCENT)[b]
La Pampa				
Permanent pasture	0.548	0.473–0.624 (+)	0.439–0.646 (+)	0.380
Annual pasture	0.010	0.000–0.026 (−)	0.000–0.047 (−)	0.049
Crops	0.124	0.074–0.174 (−)	0.063–0.201 (−)	0.465
Plowed	0.266	0.199–0.332 (+)	0.177–0.361 (+)	0.105
Woodland	0.052	0.018–0.085 (+)	0.015–0.110 (+)	0.002
Santa Fe				
Permanent pasture	0.611	0.547–0.674 (+)	0.530–0.683 (+)	0.102
Annual pasture	0.183	0.133–0.233 (−)	0.126–0.248 (−)	0.257
Crops	0.059	0.028–0.089 (−)	0.027–0.102 (−)	0.575
Plowed	0.056	0.026–0.086 (0)	0.025–0.099 (0)	0.065
Woodland	0.092	0.054–0.129 (+)	0.051–0.143 (+)	0.005

[a] Percent of observations of hawks on the ground/cover type.
[b] Percent values based on classified satellite image.

Swainson's Hawks used permanent pastures and plowed fields for foraging and woodlands for roosting disproportionately with respect to their availability in each study area ($\chi^2 = 531.8$, $P < 0.001$ in La Pampa; $\chi^2 = 625.6$, $P < 0.001$ in Santa Fe). Byers' and Bailey's intervals indicated that, in addition to these cover types, the hawks used plowed fields more than available in La Pampa, but in the same proportion as expected based on availability in Santa Fe (Table 1). Cropland and annual pastures were used less than expected based on their availability.

DISCUSSION

Our data indicated that Swainson's Hawks relied heavily on plowed fields and permanent pastures (Fig. 3), with the former cover type being used primarily for sunning and resting early in the morning and afternoon, and the latter one being used for foraging during midday (Fig. 2). This pattern of habitat use was probably associated with differences in physical attributes and food availability provided by each habitat type. Plowed and recently-harvested fields usually offer the best conditions for the development of thermals during the morning (R. Rodriguez pers. comm.). Swainson's Hawks spent their time sunning and resting in these fields until thermals developed in the morning and after they subsided in the afternoon. In addition, open fields may provide a greater availability of insects (such as insect larvae) and worms early in the morning and late in the afternoon, given their movements to the upper layers to feed on vegetal matter. Coleoptera larvae and earthworms move on the soil in response to food availability, temperature, moisture and soil type (Murton 1973, Braga da Silva 1995). Finally, farm operations such as plowing and discing expose soil insects to birds, which usually forage around working farm machinery, acting as natural insect larvae control (Frana and Imwinkelried 1996). Therefore, insect larvae and worms in plowed fields and cropland would have been more abundant in the upper layers of soil when temperatures were low and moisture was high (early in the morning and late in the afternoon) or when tillage operations (such as plowing and discing) exposed them to the surface. Conversely, flying insects such as grasshoppers are more active as temperatures rise, becoming most active at midday (Liebermann and Schiuma 1946, Capinera and Sechrist 1982, Salto and Beltrame 1999), the time when we observed the hawks mainly foraging in permanent pastures.

Differences in prey availability in different habitats were also indicated by the foraging behaviors we observed while the hawks were on the ground. Swainson's Hawks are adapted to pursue mobile and exposed species such as rodents and swarms of insects, both on the ground and in the air (Eng-

land et al. 1997). The hawks we observed in plowed fields usually foraged by standing on the ground until they saw grasshoppers and other insects. Then, they used short walks, runs, and pecks to catch prey (without necessarily capturing prey with their talons first), pouncing at and running down the insects ("like domestic turkeys do," England et al. 1997). Swainson's Hawks also foraged this way in permanent pastures, but they typically made short flights and jumps in addition to short runs, apparently to flush grasshoppers.

Our observations of activity and behavior are consistent with that of a hawk with an insectivorous diet. Swainson's Hawks mainly feed on grasshoppers while wintering, although they also prey on other insects such as insect larvae, beetles, and dragonflies according to their availability (Liebermann 1935, Pereyra 1937, Liebermann 1944, White et al. 1989, Jaramillo 1993, Rudolph and Fisher 1993, Woodbridge et al. 1995, Goldstein et al. 1996, Serracin Araujo and Tiranti 1996, Goldstein 1997, Canavelli et al. 2001). Grasshoppers are usually the dominant aboveground invertebrate in pastures and natural grasslands based on biomass (Capinera et al. 1997). Additionally, agricultural practices, such as plowing, discing, mowing, harvesting, and burning of grasses and stubble are expected to increase the availability of insect prey in annual crops and pastures, as it happens with mammals, given the modification or removal of cover and prey movement generated by these operations (Bechard 1982, Tewes 1984, Caldwell 1986). In fact, both in Santa Fe and La Pampa provinces, Swainson's Hawks were observed on pasture and crop fields when operations such as mowing, baling and plowing were conducted. Therefore, the observed pattern of habitat use was as expected for an insectivorous bird preying on temporarily abundant, easily captured, and often spatially-unpredictable insect prey (Alerstam 1990, Sherry and Holmes 1995).

Food availability, as determined by prey abundance and vegetative structure, could be the key factor that determines the selection of permanent pastures as foraging sites by Swainson's Hawks during winter. On their breeding grounds, hawks usually forage on fields that offer less overall vegetative cover and greater prey availability (such as mowed or irrigated alfalfa and harvested cropland, Bechard 1982, Estep 1989, Woodbridge 1991). Observations made on different fields in Santa Fe province (Argentina) shown that fallow fields, such as old pastures, alfalfa and short-grass fields had the highest grasshopper abundances, the lowest vegetative cover, and the greatest grasshopper availability of all the cover types used by foraging hawks (Canavelli and Salto unpubl. data).

The relationship between food availability and habitat selection by this species helps also to explain the significant mortalities of Swainson's Hawks that have been reported on the wintering grounds (Woodbridge et al. 1995, Goldstein et al. 1996). At least 5000 Swainson's Hawks were killed in pasture and crop fields by the misuse of organophosphorous pesticides (Goldstein et al. 1999), probably after they were drawn to the fields by the abundance and availability of grasshopper prey. Twelve of 19 mortality incidents occurred on alfalfa fields, with individual reports on corn, wheat, and sorghum fields (Canavelli and Zaccagnini 1996, Goldstein 1997, Goldstein et al. 1999). Although in this study, crop fields were sporadically used and not selected as foraging habitats, the combination of insect outbreaks and pesticide applications (increase on food availability of flushed prey caused by the spraying machine on the plot) could have favored the congregations of hawks on these plots, resulting in the massive mortality incidents. Additionally, applications of organophosphorous pesticides on summer crops and pastures in the region mostly occurred between December and February (Canavelli and Zaccagnini 1996), the time when Swainson's Hawks were wintering in Argentina (Woodbridge et al. 1995, England et al. 1997), and during the morning or late in the afternoon (Grue et al. 1983, R. Bogino pers. comm.), when hawks were mainly sunbathing and foraging on the ground (Fig. 2). Therefore, behavioral traits of Swainson's Hawks and the current practice of pesticide applications may synergistically increase the potential exposure of hawks to the chemicals, making these raptors particularly vulnerable to such operations.

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