ASSESSING HABITAT AVAILABILITY AND USE BY BUFF-BREASTED SANDPIPERS (*TRYNGITES SUBRUFICOLLIS*) WINTERING IN SOUTH AMERICA

Richard B. Lanctot[1,5], Daniel E. Blanco[2], Martín Oesterheld[3], Rodrigo A. Balbueno[4], Juan P. Guerschman[3], & Gervasio Piñeiro[3]

[1]U.S. Geological Survey, Alaska Science Center, 1011 East Tudor Rd, MS 701, Anchorage, Alaska 99503, USA.

[2]Wetlands International, 25 de Mayo 758 10º I, (1002) Buenos Aires, Argentina.

[3]FAUBA, Cátedra de Ecología, Facultad de Agronomía, Universidad de Buenos Aires, Av. San Martín 4453, 1417 Buenos Aires, Argentina.

[4]Biolaw Consultoria Ambiental, Av. Lavras 141/204, 90460-040, Porto Alegre, Rio Grande do Sul, Brasil.

Resumen. – Evaluación de la disponibilidad y uso de hábitat del Playerito Canela *(Tryngites subruficollis)* durante la estación no reproductiva en América del Sur. – El Playerito Canela (*Tryngites subruficollis*) es una especie de interés para la conservación en EE.UU., Canadá, Argentina y Brasil. En el pasado, su tamaño poblacional alcanzó los cientos de miles de ejemplares, mientras que, en la actualidad, ha sido estimado en menos de 15.000–20.000 individuos. En este estudio, se censaron Playeritos Canela en 285, 128 y 171 localidades de Argentina, Uruguay y Brasil, respectivamente, en 1999 y 2001. Luego, se asoció la densidad de Playeritos Canela con la heterogeneidad de la vegetación y con la clasificación no supervisada de imágenes satelitales. Las densidades (ind/ha) resultantes fueron 0,11 en Argentina, 1,08 en Uruguay y 2,18 en Brasil. Los playeritos fueron registrados principalmente en pastizales fuertemente pastoreados por ganado. La especie se asoció positivamente con estepas de halófitas en los tres países, y negativamente con pastizales mesofíticos húmedos, praderas de mesófitas y cultivos de arroz. El análisis basado en imágenes satelitales mostró que el 38% (Brasil), 53% (Uruguay) y el 64% (Argentina) del área de distribución no reproductiva reunía condiciones de hábitat adecuadas para la especie. Estas estimaciones seguramente sobrestiman el área realmente utilizada por la especie, debido a asociaciones débiles especie-hábitat , a que el grano de la clasificación fue demasiado grueso o demasiado fino, y/o a que no todas las clases fueron muestreadas en relación a su disponibilidad en el terreno. Los esfuerzos futuros para estimar el uso de hábitat del Playerito Canela deberían enfocarse en una mejor separación de tipos de hábitat, de forma tal que, por ejemplo, sea posible diferenciar pastizales con pasto alto y corto. La notable declinación poblacional de la especie durante el siglo pasado sugiere la no utilización de todas las áreas con hábitat adecuado.Son necesarios estudios adicionales para determinarla distribución de la especie y estudiar sus desplazamientos durante el verano austral. Además, es necesario realizar trabajos de campo adicionales en aquellas unidades de vegetación y clases que fueron pobremente muestreadas, para evaluar adecuadamente su uso por parte del Playerito Canela.

Abstract. – Buff-breasted Sandpiper (*Tryngites subruficollis*) is a species of high conservation concern within the United States, Canada, Argentina and Brazil. Once numbering in the hundreds of thousands, the

[5]*Current address:* U.S. Fish and Wildlife Service, Migratory Bird Management, 1011 East Tudor Road, MS 201, Anchorage, Alaska 99503, USA. *E-mail:* Richard_lanctot@fws.gov.

population size of the species is now estimated to be as low as 15–20,000. We surveyed Buff-breasted Sandpipers at 285, 128 and 171 locations in Argentina, Uruguay and Brazil, respectively, during 1999 and 2001. Then, we associated bird distribution with both vegetation heterogeneity and unsupervised classifications of satellite imagery. Densities ranged from 0.11 individuals/ha in Argentina to 1.08 in Uruguay, and 2.18 in Brazil. Buff-breasted Sandpipers were found primarily in pasturelands that were heavily grazed by livestock. The species was positively associated with halophytic steppes in all three countries, and negatively associated with humid mesophytic meadows, mesophytic prairies, and rice fields in at least one country. Satellite image analysis indicated that 38% (Brazil), 53% (Uruguay), and 64% (Argentina) of the main wintering range was suitable for the species. These estimates surely overestimate the real area used by the species as the habitat-bird associations were weak, the heterogeneity of unsupervised image classes were either too fine or too coarse, and not all unsupervised classes were sampled relative to their availability. Future efforts to estimate habitats used by Buff-breasted Sandpipers need to more finely divide habitat types so that, for example, tall and short grass pastures can be differentiated. The large population decline during the past century also makes it likely that Buff-breasted Sandpipers do not use all the areas that are suitable. Additional study is needed to determine how the species distributes itself and moves throughout their winter range during the austral summer. Also, additional ground surveys are needed in vegetation units and unsupervised satellite imagery classes that were poorly sampled to adequately test their use by Buff-breasted Sandpipers. Accepted 8 January 2004.

INTRODUCTION

At the turn of the 20th century, Buff-breasted Sandpipers (*Tryngites subruficollis*) probably numbered in the hundreds of thousands (Forbush 1912, Hudson 1920). Shorebird surveys in central and eastern Canada indicate that the population size may be as low as 15,000–20,000 today (Brown *et al.* 2001, Morrison *et al.* 2001). This decline is attributed to commercial hunting in the late 1800s and early 1900s in the central United States, and to a lesser degree in southern South America (McIlhenny 1943, Myers 1980, Canevari & Blanco 1994), and the widespread conversion of short grass prairies to agriculture in the United States plains (Wetmore 1927, Lanctot & Laredo 1994). In 1999, the Buff-breasted Sandpiper was added to Appendix I of the Convention on the Conservation of Migratory Species of Wild Animals (CMS-UNEP 1999) at the request of Argentina. The species is also ranked as one of high concern in the United States (Brown *et al.* 2001) and Canadian (Donaldson *et al.* 2001) shorebird conservation plans, and is listed as "nearly vulnerable" in the Red Data Book and the Official Endangered Species List of Rio Grande do Sul State (Fontana *et al.* 2003, Decreto Estadual 41.672, 11 de junho de 2002). Factors that led to these designations were a small and declining population, and a relatively small wintering area within which birds concentrate (Brown *et al.* 2001, CMS-UNEP 1999). These certifications encourage the study, management, and conservation of the species.

Within this framework, we conducted the first population-wide survey of the species in South America. The natural history of the Buff-breasted Sandpiper required that such a survey be conducted on the wintering grounds. During the breeding season, individuals occur sporadically and in unpredictable numbers throughout the high Arctic (Troy & Wickliffe 1990, Lanctot & Laredo 1994, Lanctot & Weatherhead 1997). Similarly, Buff-breasted Sandpipers are broadly dis-

FIG. 1. Area (dark gray) in Argentina, Uruguay and Brazil where Buff-breasted Sandpipers were surveyed and satellite imagery and vegetation analyses were conducted in 1999 and 2001. Medium gray indicates water not included in study.

persed and are unpredictable in distribution during spring and fall migration in the central plains of the United States & Canada (Skagen 1997, J. G. Strauch Jr. unpubl.). In contrast, Buff-breasted Sandpipers winter in a relatively small region of Argentina, Uruguay, and Brazil (Belton 1994, Blanco *et al.* 1993, Lanctot & Laredo 1994) where they are restricted to coastal areas that provide a sanctuary for the species because flooding and soil salinity limit agricultural development and promote cattle grazing (Soriano 1991). Buff-breasted Sand-

pipers, in turn, benefit from animal husbandry because of their dependence on short grass pastures for winter habitat.

This paper summarizes the results of a multi-year, international effort to survey Buff-breasted Sandpipers and document habitat availability on their wintering grounds in Argentina, Uruguay and Brazil. Numbers and distribution of birds are briefly described here with additional details presented in Lanctot *et al.* (2002). We describe several procedures used to document habitat use and availability,

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and outline future efforts that are needed to estimate habitat use by the species.

METHODS

Ground surveys. Buff-breasted Sandpipers were surveyed on their wintering range in Argentina (1999), Uruguay (1999 and 2001), and Brazil (2001; Fig. 1). The wintering range was outlined using the distribution and timing (November through February sightings) of historic observations, previous knowledge of the species' habitat use (Blanco *et al.* 1993), and the distribution of habitat types in the Río de La Plata grasslands (see maps in León *et al.* 1984, Soriano 1991). Selection and number of sample sites, and survey methods are described in Lanctot *et al.* (2002). Briefly, surveys were conducted at random sites within the wintering range and Buff-breasted Sandpipers were surveyed using variable circular plot sampling (Reynolds *et al.* 1980, Buckland *et al.* 1993). The total number of survey locations (i.e., points) per locality varied from 1 to 16 depending upon the amount of suitable habitat (most had at least five points). At each point, one or two observers recorded the number, the behavior, and the radial distance from detected birds to the observation point (to the nearest meter) for a 5-min period. We noted whether birds were observed within 250 m of the survey point. We used the program DISTANCE (ver. 3.5, Thomas *et al.* 1998, Web site: http://www.ruwpa.st-and.ac.uk/distance/) to determine densities and confidence intervals for Buff-breasted Sandpipers detected in each country. Hand-held GPS units were used to determine geographical coordinates for each survey point (accurate to within 50 m). At each location, we also recorded the cover type (e.g., pasture, marsh, rice fields), whether the area had been or was being grazed by livestock, and the height of vegetation (e.g., 2–5, 6–10, 11–20, and >20 cm).

Habitat – bird associations. During the spring 2001 (November–December), we described the vegetation within 250 m of survey points. In Argentina, this work was restricted to 45 locations where Buff-breasted Sandpipers had been surveyed in 1999, plus an additional five points at new locations. Here, vegetation descriptions were matched to the most similar vegetation unit described in Perelman *et al.* (2001). In Brazil and Uruguay, we described vegetation at 171 and 109 locations, respectively, all of which were associated with simultaneous surveys for Buff-breasted Sandpipers. Within Brazil and Uruguay, vegetation descriptions were then used to create eleven vegetation units, some of which were subsequently pooled to form six synthetic vegetation units, based on shared plant species. Next, we explored the association between Buff-breasted Sandpiper presence and vegetation units identified during ground surveys in each country. We used the Log-likelihood ratio test (Zar 1999: 505) to conduct an overall analysis, and a simulated χ^2 test, that accounts for low sample size, to investigate the probability that individual vegetation units were used or avoided more than expected, based on the remaining units.

To determine the potential amount of habitat suitable for Buff-breasted Sandpipers, we performed an unsupervised classification of LANDSAT 5 and 7 images of the main wintering area of each country, and associated this classification with the presence of Buff-breasted Sandpipers using contingency table analyses as described above. These analyses were done separately for each country due to differences in landcover classes. We extracted image values from areas within 250 m radius of each survey point. Pixel size was 30 x 30 m, so each area was represented by 218 pixels. The classifications performed in all three countries differentiated between 20 and 30 spectral classes, but most of them corre-

TABLE 1. Association between Buff-breasted Sandpipers and vegetation units at survey points in Argentina, Uruguay and Brazil. The numbers inside the table indicate the number of survey points in which Buff-breasted Sandpipers were (Yes) or were not (No) recorded.

Vegetation units	Presence of Buff-breasted Sandpipers					
	Argentina[1]		Uruguay[2]		Brazil[3]	
	Yes	No	Yes	No	Yes	No
Mesophytic prairie	1	14	1	22	10	37
Humid mesophytic meadow	0	13	–	–	–	–
Humid prairie	2	5	11	18	16	33
Halophytic steppe	5	5	9	10	14	4
Rice	–	–	3	26	8	42
Sown pasture	–	–	0	9	0	5
Other	–	–	–	–	0	2
Total	8	37	24	85	48	123

[1]Likelihood ratio test = 12.5, df = 3, $P = 0.006$
[2]Likelihood ratio test = 22.6, df = 4, $P < 0.001$
[3]Likelihood ratio test = 29.4, df = 5, $P < 0.001$

sponded to water surfaces, which were pooled into a single class.

RESULTS

Distribution and abundance. Information on the distribution and abundance of Buff-breasted Sandpipers on their wintering grounds is presented in more detail in Lanctot *et al.* (2002). In brief, we surveyed 32, 14, and 18 localities (including 285, 128, and 171 survey points) in Argentina, Uruguay, and Brazil, respectively. In Argentina, 10 of the 32 localities surveyed had Buff-breasted Sandpipers present, and 360 individuals were observed. In Uruguay, nine of the 14 localities surveyed had Buff-breasted Sandpipers present, and 1393 individuals were observed. In Brazil, 10 of the 18 localities surveyed had Buff-breasted Sandpipers present, and 2081 individuals were observed. Densities were 0.11 (95% C.I. = 0.04–0.31), 1.08 (C.I. = 0.37 to 3.18), and 2.18 individuals/ha (C.I. = 0.89–5.31) in Argentina, Uruguay, and Brazil, respectively.

Habitat features at sites with Buff-breasted Sandpipers. After excluding plots that were non-randomly selected (plots from Uruguay in 1999), or repeatedly surveyed within a year (Estancia Medaland in Argentina), we were left with 122 survey points (20.9% of 584 points) where Buff-breasted Sandpipers had been detected. These points were distributed in 28 localities (44.4% of 63 total localities). Most Buff-breasted Sandpipers were detected in pasturelands (85.8%), whereas a smaller percentage were found in agriculture (6.7%) and abandoned (7.5%) fields. Most survey points where Buff-breasted Sandpipers were detected had livestock present (90%), and most points were intensively grazed (62% of points had vegetation 2–5 cm tall as the dominant cover type).

Vegetation type and Buff-breasted Sandpipers. In Argentina, the presence of Buff-breasted Sandpipers was associated with vegetation units described at survey points ($P = 0.006$, Table 1). Buff-breasted Sandpipers were

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TABLE 2. The relationship between Buff-breasted Sandpipers (BBSA) and the unsupervised image classification for the main wintering area in Argentina, Uruguay and Brazil. Survey points with classes that correspond to various types of water (A9, U8, and B10) are not included in the table. Sample sizes were too low to be meaningful for classes A1, A2, A4, and A8 in Argentina, U1, U2, U3, and U5 in Uruguay, and B3, B4, B8, and B11 in Brazil.

Country and classes ID	Survey points with BBSA	Survey points without BBSA	Total survey points (% of all points)	Percentage of survey points with BBSA	Area (ha)	Percentage of area
Argentina[1]						
A1	0	1	1 (0.5)	0	18,733	3.9
A2	0	6	6 (2.7)	0	78,772	16.5
A3	1	24	25 (11.3)	4	91,156	19.1
A4	0	8	8 (3.6)	0	69,158	14.5
A5	5	25	30 (13.5)	16.7	80,811	16.9
A6	8	74	82 (36.9)	9.8	97,788	20.5
A7	4	62	66 (29.7)	6.1	35,151	7.4
A8	0	4	4 (1.8)	0	6,462	1.4
Total	18	204	222 (100)	8.1	478,031	100
Uruguay[2]						
U1	0	1	1 (0.8)	0	35,012	3.3
U2	0	3	3 (2.4)	0	12,194	1.1
U3	2	1	3 (2.4)	66	32,199	3.0
U4	10	13	23 (18.1)	44	102,323	9.6
U5	1	2	3 (2.4)	33	76,049	7.2
U6	22	40	62 (48.8)	36	461,140	43.4
U7	3	29	32 (25.2)	9	343,811	32.4
Total	38	89	127 (100)	30	1,062,728	100
Brazil[3]						
B1	2	12	14 (8.2)	14	103,505	5.7
B2	2	16	18 (10.5)	11	210,877	11.5
B3	0	0	0	Not applicable	73,522	4.0
B4	0	0	0	Not applicable	106,997	5.9
B5	14	11	25 (14.6)	56	346,409	19.0
B6	26	25	51 (29.8)	51	354,051	19.4
B7	4	49	53 (31.0)	7.6	328,088	18.0
B8	0	0	0	Not applicable	172,538	9.4
B9	0	8	8 (4.7)	0	47,214	2.6
B11	0	1	1 (0.6)	0	74,430	4.1
B12	0	0	0	Not applicable	8,768	0.5
Total	48	122	170	28.2	1,826,399	100

[1]Likelihood ratio test = 6.90, df = 7, P = 0.44
[2]Likelihood ratio test = 15.29, df = 6, P = 0.02
[3]Likelihood ratio test = 44.97, df = 6, P < 0.001

found to be positively associated with halophytic steppes (simulated χ^2 test, halophytic steppe vs remaining units, P = 0.002) and negatively associated with humid mesophytic

meadows ($P = 0.041$).

In Uruguay, Buff-breasted Sandpiper presence was strongly associated with the synthetic vegetation units ($P < 0.001$, Table 1). The presence of Buff-breasted Sandpipers was positively associated with humid prairies ($P = 0.014$) and halophytic steppes ($P < 0.001$), and negatively associated with the mesophytic prairies ($P = 0.015$). Agricultural conversion of mesophytic prairies typically results in rice fields or sown pasture (MGAP 1999).

In Brazil, the presence of Buff-breasted Sandpipers was also associated with vegetation units ($P < 0.001$, Table 1). Buff-breasted Sandpipers observed at survey points were positively associated with halophytic steppes ($P < 0.001$) and negatively associated with rice fields ($P = 0.011$).

Unsupervised satellite image classification and Buff-breasted Sandpipers. In Argentina, there were nine spectral classes identified in the unsupervised classification including class A9 that represented a variety of water types. Classes A2 and A3 dominate the northern portion of the study area, and correspond to the "costero" landscape (coastal zone composed of various types of salt marshes) defined by Movia (1975). Classes A4 through A6 dominate the southern portion, which correspond to the "albufera" landscape (Movia 1975), and are composed of salt marshes, old tide canals (currently ponds), plains, and uplands. Our analysis failed to find any clear association between unsupervised image classes and Buff-breasted Sandpiper presence ($P = 0.44$, Table 2). However, our survey failed to sample all the classes in proportion to their availability, and some classes were sampled too little to make any definite conclusions. Classes A3 and A5–A7 had Buff-breasted Sandpipers present on 4–17% of the survey points, but these proportions were not higher than that expected by chance. The central portion of the Argentine study area is composed of many classes, indicative of a fine-scaled heterogeneity within the area, whereas only a few classes dominated the peripheral area. This fine-grained heterogeneity made it difficult to find an association between Buff-breasted Sandpiper presence and spectral classes. Considering classes A3 and A5–A7 as favorable Buff-breasted Sandpiper areas, the surveyed area has nearly 305,000 ha (64%) suitable for the studied species. The remaining 173,000 ha will require further research to be classified either way.

In Uruguay, there were eight spectral classes including class U8 that corresponded to various types of water. A comparison of these classes to an environmental classification created by PROBIDES (1999) indicated U4 and U6 closely matched the "bañados" (wetlands), U5 the "ríos y arroyos" (rivers and streams), and U7 the "llanuras altas" (high plains). Unlike Argentina, the unsupervised classification of the satellite image data was associated with Buff-breasted Sandpiper presence ($P = 0.02$, Table 2). In addition, the survey roughly sampled all classes according to their proportional area. Buff-breasted Sandpipers frequently occupied classes U4 and U6 (although not significantly, $P = 0.1$ to 0.2), whereas Buff-breasted Sandpipers avoided class U7 ($P = 0.002$). The other four classes represented a low proportion of the total area and had too few samples to make any definitive conclusions about their habitat suitability. Much of unsupervised classes in Uruguay were distributed coarsely, making it difficult to find an association between Buff-breasted Sandpiper presence and spectral classes. If classes U4 and U6 are considered to represent favorable Buff-breasted Sandpiper habitat, the surveyed area has nearly 563,000 ha (53% of main wintering range) suitable for the species. If class U7 is considered unsuitable habitat,

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the survey area has nearly 344,000 ha (32%) unsuitable for Buff-breasted Sandpipers. The remaining 155,000 ha will require further research to be classified as suitable or unsuitable.

In Brazil, there were 12 spectral classes including class B10 that corresponded to various types of water. Personal experience on the ground by R. Balbueno (unpubl.) indicated B1 closely matched the dry pasture, B2 the exposed ground, B3 the forest, B4 the humid field/pine trees, B5 the marsh, B6 the pasture, B7 the rice fields, B8 the sand areas, B9 the unknown areas covered by clouds or shade from clouds, B11 the abandoned rice fields, and B12 the sand areas or unknown areas covered by clouds. Like Uruguay, the unsupervised classification of the satellite image data was associated with Buff-breasted Sandpiper presence ($P < 0.001$; Table 2), with B5 ($P = 0.001$) and B6 ($P < 0.001$) classes positively associated and the B7 ($P < 0.001$) class negatively associated. We suspect the positive association with marsh (B5) represents areas near lagoons that have been heavily grazed by livestock. There was no clear affinity by Buff-breasted Sandpipers for B1 or B2 classes and the remaining classes were sampled too poorly to determine any association. Unfortunately, the survey did not sample all classes according to their proportional area (B6 and B7 were over sampled, and there were no sites in B3, B4, B8 and B12). If we assume this analysis is correct, the surveyed area has over 700,000 ha (38.4%) suitable for the species, 328,000 ha (18.0%) unsuitable, and 313,000 ha (17.2%) where no preference is shown. The remaining 483,400 ha will require further study to determine its suitability.

DISCUSSION

Ground surveys revealed several interesting aspects about Buff-breasted Sandpiper winter ecology: 1) the mean density of Buff-breasted Sandpipers was much higher in Brazil (2.18/ha) than in Argentina (0.11/ha) or Uruguay (1.08/ha); 2) no matter which country was visited, Buff-breasted Sandpipers were found primarily in pastures that were either being or had been grazed intensively by livestock; and 3) that Buff-breasted Sandpipers tended to be found in halophytic steppe vegetation units in all three countries. Such salt-inundated areas tended to be along the coast or adjacent to canals that allowed saltwater access to inland sites.

Satellite imagery analysis allowed us to estimate the potential area suitable for Buff-breasted Sandpipers. Our initial outline of the main wintering area indicated that Brazil (c. 2,800,000 ha), followed by Uruguay (c. 1,000,000 ha) and then Argentina (c. 478,000 ha), had the largest potential area for the species. The area deemed useable for Buff-breasted Sandpipers was much smaller, however. Indeed, only a fraction (38% in Brazil, 53% in Uruguay, and 64% in Argentina) of the main wintering area in each country had unsupervised image classes that were positively associated with Buff-breasted Sandpiper presence. These percentages probably overestimate the area actually used by the species. Associations were typically weak with many survey points lacking Buff-breasted Sandpipers despite a positive association with an unsupervised class. Similar, some survey points had Buff-breasted Sandpipers recorded despite a negative association with an unsupervised image class. Attempts to use the unsupervised classification also had problems with the scale at which classes were distributed – fine and coarse-scale heterogeneity effectively prevented us from differentiating levels of usability. Another problem encountered was either inadequate or lack of sampling in the available image classes.

Future efforts to estimate habitats used by Buff-breasted Sandpipers need to include

additional factors that might reduce the amount of habitat thought to be suitable. For example, the unsupervised image classification simply separated the main wintering range into large classes of habitats (e.g., agriculture vs pastureland). This process could not, therefore, differentiate among pastures that had tall and short vegetation. Unfortunately, grass height is very dynamic and fluctuates with the presence of livestock and rainfall throughout the austral summer. We believe it is also quite likely that Buff-breasted Sandpipers do not use the entire area that is suitable. The large decline in population size during the past century almost assures that some areas that are appropriate are not used. Further, repeated surveys at wintering sites in Argentina and Brazil (J. Almeida & J. Isacch pers. comm) indicate Buff-breasted Sandpipers vary in their use of an area through time – even though the area apparently is suitable throughout the sampling period. Additional study is needed to determine how the species distributes itself and moves throughout their winter range during the austral summer. Thus, there appears to be either an overabundant amount of suitable habitat or other criteria that is limiting habitat use by Buff-breasted Sandpipers.

Beside these methodological issues, additional ground surveys are needed in vegetation units and unsupervised satellite image classes that were poorly sampled in 1999 and 2001. Indeed we did not survey all classes in proportion to their availability, and several classes were sampled too seldom to conclude anything about their suitability as Buff-breasted Sandpiper habitat. Further, our imagery analysis was constrained by the size of the original survey sites (c. 20 ha for a 250-m radius area). The fine-grained heterogeneity, especially of the Argentina landscape, may require more defined locations so that bird use can be matched to specific landcover classes.

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