Avian communities as affected by the heterogeneity of the agricultural landscape of the Rolling Pampas, Argentina: dynamics between cultivated and non-cultivated environments

Final Report

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PROJECT TITLE: Avian communities as affected by the heterogeneity of the agricultural landscape of the Rolling Pampas, Argentina: dynamics between cultivated and non-cultivated environments.

I. INTRODUCTION

Very few truly pristine natural prairies remain in any part of the New World Tropics, and all are threatened to a certain degree. The great prairies of Mexico, Venezuela, Brazil, Argentina and the Andean countries have been used for agriculture during centuries. In Brazil and the northern extreme of Bolivia, extensive areas of upland Campo grasslands (open prairies similar to the dry prairies of the Mid West in North America) have been lost to mechanized agriculture at a large scale. The total destruction of this vegetation type is imminent outside very few protected areas. The prairies of Northern Mexico and southern Argentina have been degraded during a much longer period than the Brazilian Campo, where extensive areas have been replaced by shrubby vegetation (Stotz et al. 1996).

The adoption of agriculture and livestock production in the Argentine Pampas during the last 200 years has enormously modified the ecology and landscape of the region (Solbrig and Morello 1997). At the beginning of the 20th century, the agricultural and livestock activities consisted of an alternating cycle between cattle and alfalfa, with periods of alternation of 3 to 6 years of length. Both cattle farming and alfalfa restituted the soil organic matter and returned consumed nutrients by the corn and wheat crops. These relatively long cycles also permitted the existence of large extensions of natural prairies, as abandoned pastures (Solbrig 1997). Since the 1950´s, when more intense agricultural systems are introduced in the region, the situation has radically changed (Senagliesi et al. 1997). Towards 1975, the process of substitution of livestock by agriculture takes on a new dimension with the incorporation of green revolution, short-cycle wheat, which permitted a double harvest together with soybean. Continued agriculture in the "Nucleo Maicero" ("Corn Nucleus") leads to the elimination of cattle and the pasture-crop cycle. Furthermore, agricultural area was recently increased by removing wire-rows and by cultivating road set-a-side, which additionally reduced habitat for birds and other faunal taxa (Morello and Matteucci 1997, Solbrig 1999). The environmental consequences are the loss of natural biodiversity through habitat destruction, the overuse or misuse of pesticides, fertility loss through poor or insufficient use of fertilizers, and a slow but persistent loss of soil and water retention capabilities of the environment (Morello and Matteucci 2000).

With respect to the loss of biodiversity, the process of more intensive agricultural use has caused the disappearance of natural ecosystems over huge areas in the humid Pampas (Chiozza y Figueira 1985, in Morello and Matteucci 2000, Solbrig 1999). Besides habitat loss, another one of the main environmental problems associated with the Pampas, according to Morello and Matteucci (2000), is ecosystem fragmentation. Habitat fragmentation is a process through which a particular type of habitat is partially or totally eliminated, altering in a perpetual form its original configuration. Habitat loss, changes in the configuration of habitat patches, and a simultaneous combination of these phenomena may potentially reduce a species´ population persistence across a landscape (Villard et al 1999, Bender et al. 1998, Wilcox and Murphy et al 1991). In the Pampas, the landscape has been fragmented by human activities and anthropogenic spaces are bordered with fragments of different habitat types: relict (relatively intact fragments of probably original vegetation), residual (natural pasture fragments which form a web in the more man-altered landscapes and are under intermittent disturbance), semi-natural (natural vegetation fragments under heavy grazing pressure, without impacts from tilling and low impact from agrochemicals) and neoecosystems (small areas of high vegetation cover and atypical architecture, dominated by exotic, woody species). The anthropic space is composed of lands in different stages of the agricultural calendar, according to crops grown at particular times of the year and different levels of deterioration, according the soil types, topography and history of use. The combination of the different cover types with the agricultural stages produce a wide variety of environments which characterize the patchiness of the agricultural landscape (Morello y Mateucci 1997).

Additionally, the influence of spatial patterns over the characteristics of the biotic communities have long been the interests of biogeographers and, more recently, landscape ecologists (Turner 1989, Flather and Sauer 1996, Fahrig 2006). The effects of substitution of pasture by agriculture and habitat fragmentation in the Humid Pampas on animal populations has not been well documented and studied, beyond anecdotal registers on the apparent reduction of some animal species used for human consumption (Morello and Mateucci 1997, 2000). Although it is known that relict fragments of greater size (of any particular habitat) show a greater specific species richness and birds as well as mammals prefer these (Turner 1989), the relationships between patch characteristics of natural, semi-natural and agricultural habitats, and the interactions between agricultural lots, and animal communities in particular, are not known, except for small mammals (rodents) studies because of Argentine Hemorrhagic Fever (Morello and Matteucci 1997). A landscape perspective in the study of these interactions extends the traditional homogeneous patch study to the general consideration of the patch mosaic (Hobbs 1993). Morello and Mateucci (1997) affirm that "to understand and predict the changes of the Pampas natural subsystem in relation to the productive agricultural subsystem, we must apply a landscape ecology perspective, considering the development and dynamics of spatial heterogeneity… because of this, the structure of the landscape as well as the internal patch dynamics are of interest". With regard to the study carried out by Turner (1989) regarding rodents in agricultural patches (soybean, corn, wheat and natural pasture) in the Pampas, they ascertain that "it is highly probable that other animal species exist, above all insects and birds, which show a spatial and temporal dynamic dependent on the type of landscape mosaic".

With respect to birds, the effect of landscape structure and composition on the presence and abundance of species belonging to this taxonomic group is not known. Additionally, the species that are pasture specialists avoid other habitats, especially those modified by humans. In their totality, the American natural grasslands maintain an avifauna as specialized as that of Neotropical humid forests, and much more specialized than that of dry forests and shrublands (Stotz et al. 1996). The zoogeographic zone correspondent to the Argentinean Pampas harbors a total of 265 species, of which 109 (41%) depend on natural prairies has primary habitats. Eight (8) of these (*Numenius borealis*, *Guira guira*, *Asthenes baeri*, *Asthenes hudsoni*, *Coryphistera alaudina*, *Knipolegus hudsoni*, *Anthus nattereri* y *Sporophila zelichi*) depend on a single type of natural grassland. Five (5) species depend exclusively on a combination of natural grassland types (*Rhynchotus rufescens*, *Buteo albicaudatus*, *Caracara plancus*, *Falco femoralis*, y *Speotyto canicularia*). Eigth (8) spefies are endemic to the Pampas, and four of these (*Sporophila cinnamomea*, *S. palustris*, *S. zelichi* y *Sturnella defilippi*) depend on natural prairies. These four species are also considered vulnerable, that is, face a risk of extinction in the medium term (IUCN 1996, 2006). Another 11 species are under some category of risk, according to IUCN (1996, 2006) and Birdlife International (2000). Of these, 8 depend directly on one or various types of natural prairies of the Argentinian Pampas, and although not endemic to the zoogeographic region, are restricted to no more than 3 o 22 zoogeographic regions existent in the Neotropics (with one exception, Rhea americana, restricted to 4 regions) (Stotz et al. 1996).

Taking into consideration the degree of specialization of Pampas birds, the degree of destruction that this ecosystem has been subject to, there is a great concern regarding the persistence of these species in the medium and long term. For this reason, conservation efforts are being carried out in the region, through the Important Bird Areas program of the Argentinian Ornithological Society (Asociación Ornitológica del Plata, AOP), the establishment of a series of private reserves by the Wildlife Foundation (Fundación Vida Silvestre) and political and scientific lobbying for the establishment of more public national and international reserves (also carried out by the Wildlife Foundation). Nonetheless, only 0.3% of natural prairies still existent in the Pampas are currently under some protection regime (DiGiacomo 2003). The high degree of fragmentation of the natural ecosystem also casts a shadow on the survival of these species in smaller fragments (even though they might be high-quality patches), isolated from each other.

Thus, taking into account the present scenario, the preservation of these bird species must not depend exclusively of areas identified for this purpose, but also on areas surrounding reserves. The importance of the surrounding landscape, in particular of the structure and disposition of landscape elements, on the conservation and preservation of these species, must be evaluated. The present study has as a principal objective to evaluate the effect of landscape structure on the bird community of birds dependent on natural grasslands of the Argentinian Pampas.

II. PROJECT OBJECTIVES

The main objective is to determine the effect of agricultural landscape heterogeneity on local bird communities and define landscape scenarios that enhance their conservation in the Rolling Pampas, Argentina. Specific objectives are to: 1) characterize the agricultural landscape heterogeneity of the region; 2) study the avifaunal and the floristic composition of terrestrial/riparian corridors, agricultural/non-agricultural patches, and fences/hedgerows 3) establish relationships between both the avifaunal and floristic composition of the study plots and the heterogeneity of the surrounding landscape; 4) relate changes in avifaunal and floristic composition of agricultural sites and their margins as a function of disturbance regime and agricultural-use history. In this particular research, we concentrated on specific objectives 1, 2 and 3.

III. METHODS

A. Study Area

The study area is located in the central portion of the Rolling Pampas, one of the subregions of the Pampas phytogeographic region (Soriano 1991). The Rolling Pampas is found in the northeast of the Pampas region, extending along the Paraná river from northeast to southeast, and finding its southward limit with the Flooding Pampas. The subregion´s climate is defined as template and humid, with a marked dry season and a hot summer (Hall et al. 1992). The subregion is delimited climatically by the 17°C isotherm to the north and the 14ºC y 15ºC isotherms to the south. Mean annual precipitations oscilate from 1000 mm to the northeast to 600 mm to the southeast (Hall et al. 1992). The study region is located in the northern portion of Buenos Aires Province, Argentina, and totally or partially includes 32 Municipalities (“Partidos”, see figure 1).

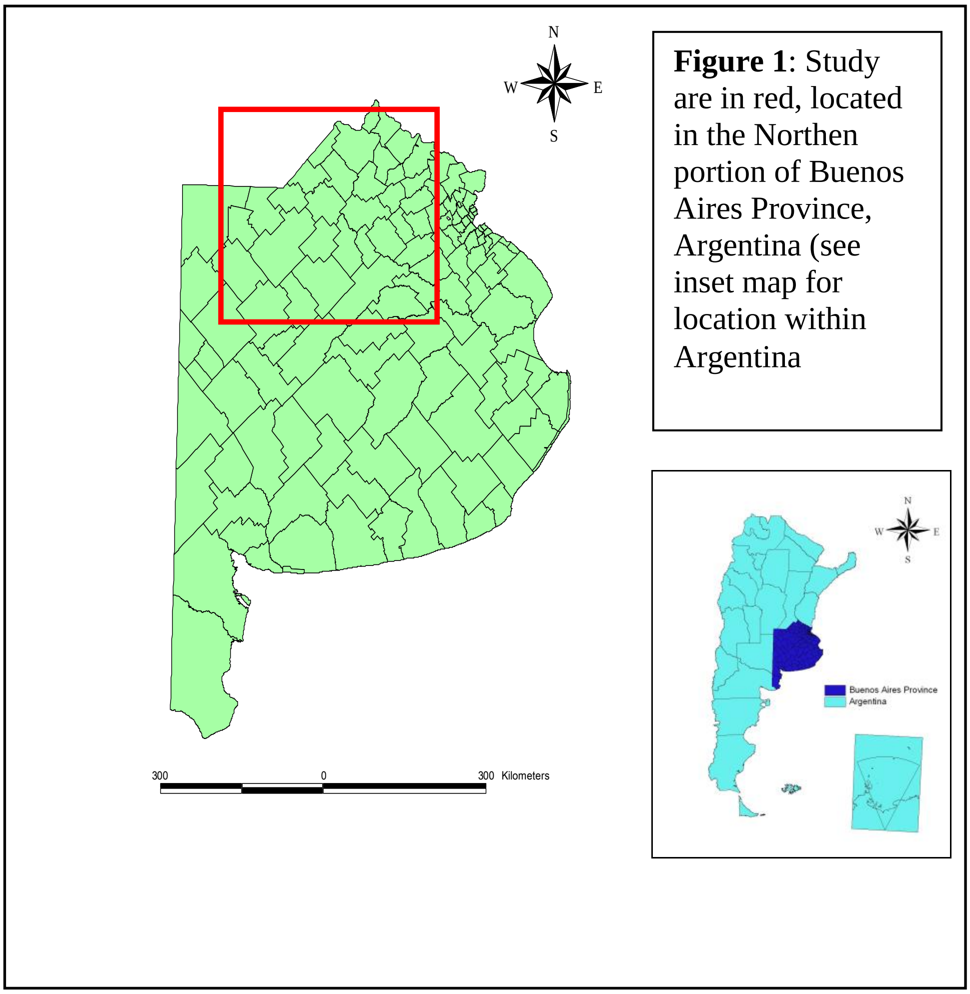
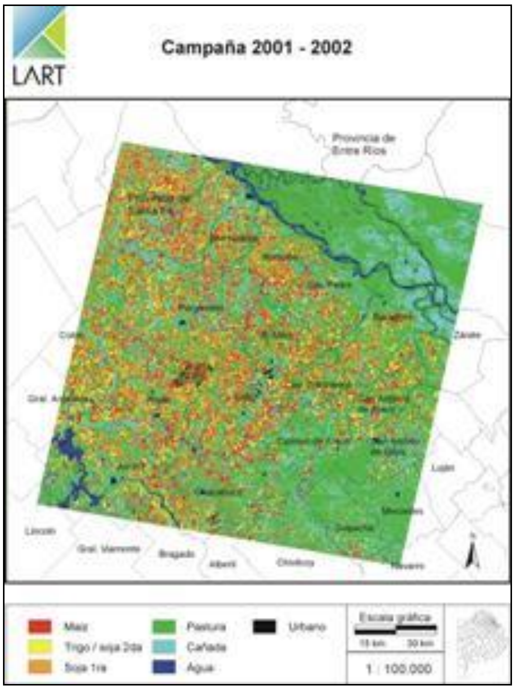


Figure 1: Study are in red, located in the Northen portion of Buenos Aires Province, Argentina (see inset map for location within Argentina

B. Land use/land cover classification

The first step to achieve project objectives was to create a land use/land cover map for the region, from where we will identify landscape types. For this purpose, a LANDSAT 5 TM and 7 ETM+ images from 2001-2002 was used (path 226-row 84 central latitude (34º02`)). The classification was carried out by the Regional and Teledetection Analysis Laboratory of the Faculty of Agronomy, University of Buenos Aires (Laboratorio de Análisis Regional y Teledetección-LART). Three different images from the same crop cycle (September and December of 2001 and February 2002). This particular methodology permits the discrimination of the different types of crops according the their phenologic characteristics. Details for the classification are given in Guershman et al. (2003). The result of the classification can be seen in figure 2.



C. Identification of major landscape types

Our method for identifying major landscape types first consisted in creating a grid of 8 km² for the whole study region and intersecting the land use/land cover map with this grid. We originally intended to use a 1 km^2 grid, but this was not possible because of limited analytical capacities of our GIS system. Once each 8 km grid cell could be treated independently as a landscape unit, with its unique subset of landscape patches, indices that quantify landscape composition and configuration were calculated for each square, using FRAGSTATS software (McGarigal and Marks 1995). These indices quantified land use area, number of patches, coefficient of variation in patch size, total edge and mean patch shape (through the mean patch shape index). Again, we calculated all these indices for each land use class in each square. The squares where then classified by cluster analysis, which groups elements (landscape units or squares) based on a previous calculation of their similarities (a similarity index for each landscape index and each habitat class). This methodology then permitted us to create a bird sampling protocol that would adequately sample all landscape types with an equal effort in each.

D. Bird sampling

Bird sampling was carried out with the point count methodology (Ralph et al. 1994). At each point, during five minutes, all bird species and number of individuals were recorded at two radii, within and beyond 50 m. Point counts were carried out along secondary roads, and in series of 30 point counts. In each one of the major landscape types identified in the region, we carried out 3 replicas of 30 point counts (henceforth, “routes”), for a total of 12 routes (4 major landscape types) and 360 sampled points. Figure 3 shows the four major landscape types and the location of routes in each type. Sampling took place between November 2005 and January 2006. Additionally, we characterized cover.

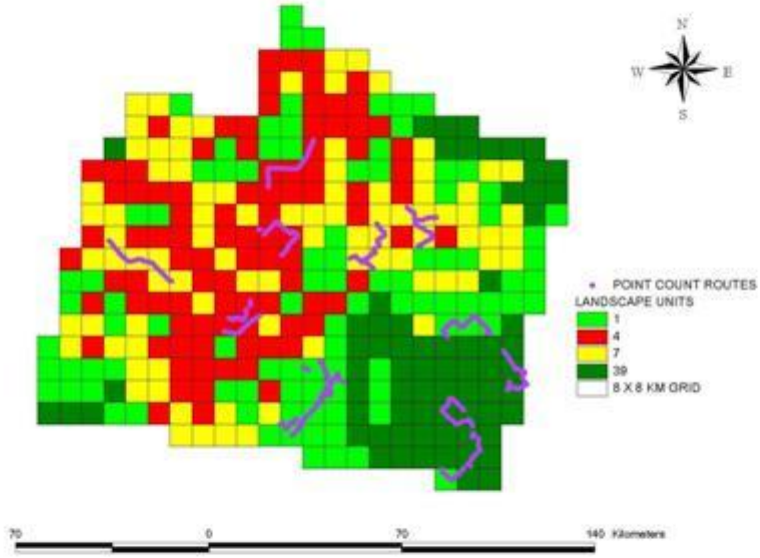


Figure 3: Major Landscape units and location of bird point count routes

E. Landscape characterization in the vicinity of points

To characterize the landscape context of each point, we created a 1 km^2 buffer around each one. When then used a similar methodology for the identification of major landscape types: 1) we calculated the aforementioned landscape indices within the 1 km^2 buffer of each point; 2) points were classified in groups using cluster analysis, according to their landscape context. In this manner, we obtained groups of points with a very similar landscape context, which would then be compared according to their avifaunal assemblages.

In addition to this landscape characterization, the immediate vicinity (within a 50 m radius) of points was characterized as percent coverage of different habitat classes. This method provided a measure of habitat coverage in roadsides and set-a-sides.

F. Statistical Analysis

To compare species richness between groups of points with similar landscape context, we used the Kruskall-Wallis test for the comparison of medians. We also carried out multiple comparisons to determine which particular landscapes were different from each other. We compared total species richness, and particularly grassland species richness (i.e., species that depend completely or partially on grasslands). We also compared total species and grassland species richness of those individuals detected only within 50 m, to evaluate the importance of roadsides and set-a-sides, in particular, for grassland bird conservation. Habitat affinities were taken from Stotz et al. (1996).

To evaluate the relationships between bird species composition and the structure of the landscape, we used canonical correspondence analysis (Ter Braak 1986). This multivariate technique permits the direct relationship of the set of bird species to the set of landscape variables by detecting the patterns of variation in community composition that can be explained best by the environmental variables (Ter Braak 1986). In particular, this technique permits the estimation of a species-environment correlation, which is a measure of how well the extracted variation in community composition can be explained by the environmental variables. It also provides what are called "intraset correlations", and by looking at the signs and relative magnitudes of these, we may infer the relative importance of each environmental variable for predicting community composition (Ter Braak 1986). As in other ordination techniques, variability in community composition is summarized in several independent (orthogonal) axes (Legendre and Legendre 1983). Thus, there is a species-environment correlation and intraset correlations for each axis.

IV. RESULTS AND DISCUSSION

A total of 103 species were detected during the study, belonging to 39 families and 14 orders. The family with the greatest number of species was Tyrannidae (new world flycatchers), with 9 species. Other well-represented families, with more than 5 species, where Anatidae (ducks, geese and swans), with 9 species; Furnariidae (ovenbirds), with 7 species; and Columbidae (doves and pigeons), Emberizidae (sparrows and seedeaters), and Icteridae (blackbirds) with 6 species each. Of the species total (103), 54 species were completely or partially dependent on grassland, and 24 were considered grassland specialists. Of the remaining 49 species, 22 species were typical of aquatic habitats and 27 species forest specialists. We did not find any species that were endemic to the Pampas region or under any category of risk, according to IUCN (2006) standards.

A. Description of landscape groups

Six different groups of points were identified, according to their landscape context at a 1 km radius (figure 4). Figure 5 provides an example of one point for each group (points which had approximate mean values for all landscape indices and habitat classes), and a table giving mean values for landscape indices for each class.

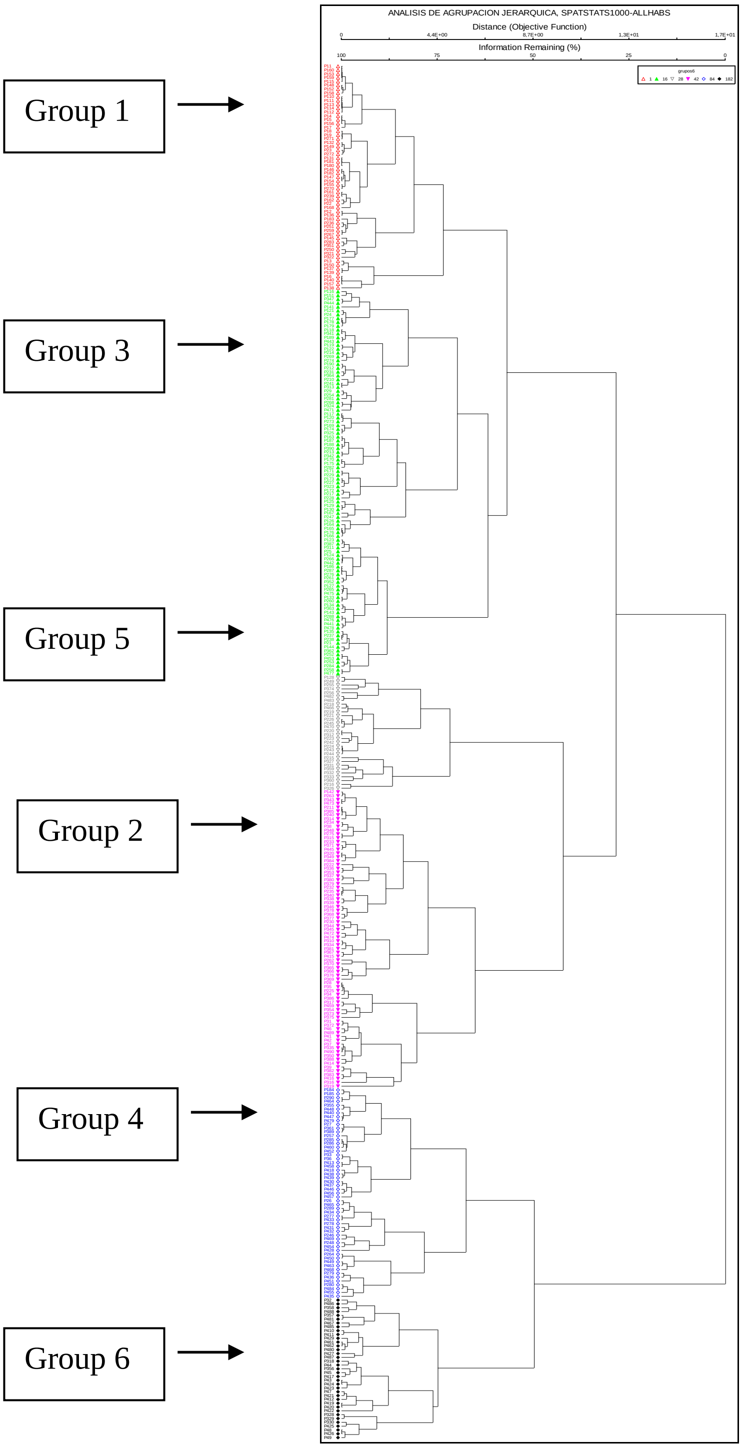


Figure 4: Cluster analysis of points, according to 5 landscape indices (class area, number of patches, patch size coefficient of variation, total edge and mean shape index) calculated for all habitat classes. Different colors indicate members of 6 different groups.

Groups are ordered in decreasing grassland cover. A general pattern for all groups can be described: 1) the number of patches and total edge increase with decreasing area, especially for the two natural classes (pasture and flooded pasture); 2) the patch size coefficient of variation and mean shape index increase with area.

Group 1 is clearly dominated by pasture, and has a relatively large proportion of flooded pasture; thus, it has a nearly complete cover of natural landscapes. Group 2 is also dominated by pasture, but agricultural classes supercede flooded pasture. Group 3 has approximately equal proportions of pasture and flooded pasture, which account for approximately 70% of total area. Group 4 has pasture, flooded pasture and corn in approximately equal proportions, and these three classes account for 78% of total area. Both groups 5 and 6 are dominated by agricultural habitat classes; group 5 is dominated by wheat/soybean, and group 6 by soybean. These two groups have the lowest proportion of natural habitat classes; group 5 has approximately 35% natural cover and group 6 only 15% natural cover.

Percent cover of different habitat classes in the immediate vicinity of points (within a circle with 50 m radius) can be seen in figure 6. Cover data corroborated a decrease in pasture according to group, as well as a general increase in area of agricultural classes. Otherwise, landscape patterns in coverage were not confirmed, indicating that at the local scale, roadsides have particular habitat coverages associated to them. These will be analyzed later in light of bird data taken within a radius of 50 m.

B. Comparison of species richness and number of individuals among groups of points representing different landscapes

VARIABLE	H	p
TOTAL SPECIES RICHNESS	32.82	<0.0001
NUMBER OF INDIVIDUALS-ALL SPECIES	34.14	<0.0001
GRASSLAND SPECIES RICHNESS	26.34	0.0001
NUMBER OF INDIVIDUALS-GRASSLAND SPECIES	41.4	<0.0001
TOTAL SPECIES RICHNESS WITHIN 50M	20.86	0.0008
NUMBER OF INDIVIDUALS-ALL SPECIES WITHIN 50 M	22.23	0.0005
GRASSLAND SPECIES RICHNESS WITHIN 50 METERS	15.59	0.0073
NUMBER OF INDIVIDUALS-GRASSLAND SPECIES WITHIN 50 M	16.22	0.0061

Table 1: comparisons among groups for different community-scale variables using the Kruskall-Wallis non-parametric test; differences are significant for all variables.

Comparisons among groups for average species richness and average number of individuals (for all species and for grassland-dependent species) are shown in table 1 and figures 7-14. All comparisons among groups for all variables were significant at $\alpha < 0.001$. With respect to total species richness, significant differences can be observed mainly between groups 1 to 3 and groups 5 and 6 (figure 7). With respect to grassland species richness, differences can be observed between groups 2 and 3, and 5 and 6 (figure 8). Clearly, species richness is significantly higher in habitats dominated by natural habitats (pasture and flooded pasture). Nonetheless, differences are not large in magnitude: the highest total species richness is registered in group 2, with an average of 16.21 ($\pm$ 0.88) species, compared to group 5 with the lowest mean number of species, 12.27 ($\pm$ 1.06) species. For grasslands species, group 2 again had the highest species richness.

With regard to the number of individuals for all species, differences among groups are mainly between groups 1 and 2, and 5 and 6 (figure 9). Although this pattern is similar to the case of total species richness, the difference in magnitude is much larger: the highest mean numbers of individuals was for group 2, 108.06 (± 21.48), nearly twice as much as the mean number of individuals for group 5, with a value of 56.84 ± 19.38. With regard to the mean number of individuals for grassland species, the main differences were among groups 1 and 4, and groups 5 and 6 (figure 10). Here, a steady increment of mean number of grassland species individuals between groups 2 and 4 was observed, contrary to what could be expected from a concurrent decrease in pasture. This can be explained, nonetheless, by an increment in flooded pasture between group 2 and groups 3 and 4, both having a large proportion of this habitat class. Additionally, after group 1, group 4 has the highest mean number of individuals of grassland species. This group has a high proportion of natural habitats (pasture, 23%, and flooded pasture, 25%, for a total of 48%), as well as a relatively high proportion of corn (31%). This particular mixture of natural habitats and a high proportion of corn seem to be beneficial for this particular group of species, and will probably conserve grassland birds, especially in terms of total biomass. Differences among the first four groups and groups 5 and 6 are notorious, and it is clear that landscapes dominated by soybean or the wheat/soybean alternating combination is deleterious for birds, especially in terms of number of individuals. This is also important in terms of the elimination of roadsides and set-a-sides, which as will be discussed, are also being eliminated in landscapes dominated by the soybean crop.

As mentioned before, it has been said that in this particular region, roadsides and set-a-sides could play an important role in conserving biodiversity (Morello and Matteucci 1997). Our following discussion of results is related to phenomenon. We quantified birds within 50 m of the census point, as well as the vegetation (% cover) within this circle. When considering only those birds detected within 50 meters of the census point, patterns were similar to those for total species richness and grassland species richness (all species detected within and beyond 50 m), but differences were less significant. Stronger differences among groups would be indicated by groups with letters exclusive to them, and less marked differences are indicated by groups with several letters. This general pattern of more similarity when only considering those species detected within 50 m is also observed for grassland species (figures 8 and 12). In this case, as a generality it can be said that the only group where grassland species richness was significantly lower than in the other groups is number 6. We also observed that in this group, many roadsides where being eliminated and the soybean crop literally reached the edge of the road. This meant that wire fences were also eliminated, which also were observed to be important perches for displaying and feeding for many species.

With regard to the mean number of individuals for all species detected within 50 m, a very similar pattern to the one found for the mean number of individuals within and beyond 50 m (figures 9 and 11) can be observed. Nonetheless, upon comparison of grassland species individuals detected within 50 m and at both radii, it is clear that differences are less marked when only considering individuals within 50 m (less significant differences are marked by group columns with more than one letter). Groups that had very low mean numbers of individuals for grassland species when considering all detections (within and beyond 50 m) had much higher numbers when only considering those individuals detected within 50m.

If we consider the proportion of all birds detected within 50 m, this proportion was negatively related to the amount of pasture cover in the landscape: In other words, as pasture cover decreased, more birds were detected within 50 m (Pearson correlation coefficient r = 0.46). Thus, we conclude that at this (local) scale, the roadsides, which are usually grassland relicts, are providing important habitat for grassland bird species, especially in those landscapes dominated by agriculture (groups 5 and 6).

C. Influence of landscape composition and configuration in determining bird community composition

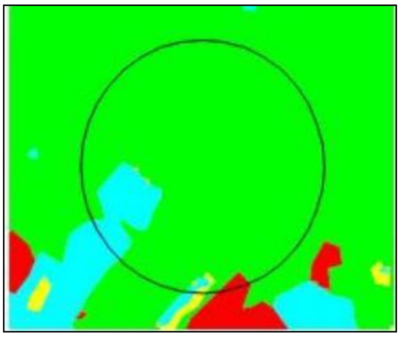
As mentioned in the methods section, we used canonical correlation analysis to investigate the influence of landscape composition and configuration in determining bird community composition, using the species-environment correlation, which is a measure of how well the extracted variation in community composition can be explained by the environmental variables, and intraset correlations, which allowed us to infer the relative importance of each environmental variable for predicting community composition (Ter Braak 1986). In tables 2 and 3, we can observe the species-environment correlations, which in this case are correlations between species composition and landscape variables for the different habitat classes. As in other ordination techniques, the variability in an n-dimensional species space where census points are located is summarized in axes, and the first axes usually summarize most of the variability in species composition among census points. Another important point is that the variability summarized in one axis is completely independent of the variability summarized by other axes (i.e., axes are orthogonal).

	LANDSCAPE ALL SPECIES		LANDSCAPE GRASSLAND SPECIES	
	r	p-value	r	p-value
AXIS 1	0.577	0.01	0.569	0.04
AXIS 2	0.436	0.02	0.440	0.16

Table 2: Species environment correlations for the first two axes of canonical correspondence analysis, for all species and grassland species, and landscape variables.

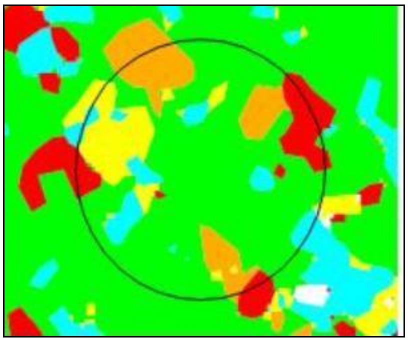
	LOCAL ALL SPECIES		LOCAL GRASSLAND SPECIES		LOCAL GRASSLAND SPECIES <50M	
	r	p-value	r	p-value	r	p-value
AXIS 1	0.45	0.02	0.518	0.02	0.58	0.04
AXIS 2	0.31	0.02	0.392	0.03	0.57	0.02

Table 3: Species environment correlations for the first two axes of canonical correspondence analysis, for all species and grassland species and percent cover values within 50 m of census point. For the case to the far right, only bird data within 50 m of census points was used (grassland species < 50 m).



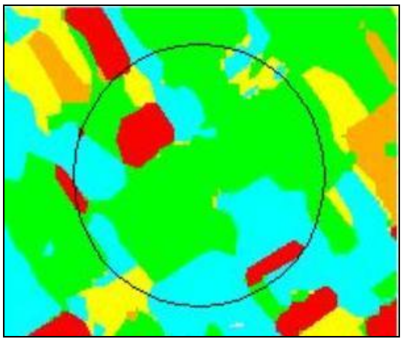
Group 1 (n = 59 points):

HABITAT	CA	NUMP	PSCOV	TE	MSI
PASTURE	214.87	4.46	134.38	12790.96	1.67
FLOODED	78.03	5.69	128.94	9208.36	1.50
CORN	5.63	6.22	102.45	1892.96	1.01
SOYBEAN	3.95	1.27	29.61	745.17	1.00
WHEAT/SOY	8.25	2.54	51.24	1604.84	1.05



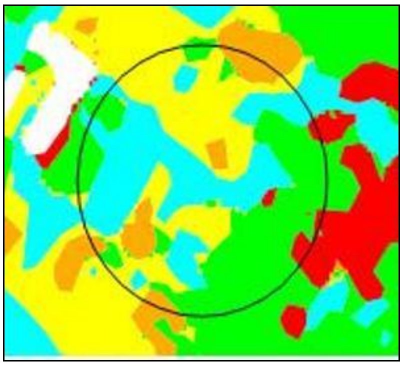
Group 2 (n = 78 points):

HABITAT	CA	NUMP	PSCOV	TE	MSI
PASTURE	157.61	9.40	218.58	13924.21	1.57
FLOODED	31.24	6.04	122.15	5164.57	1.40
CORN	37.46	11.44	199.92	6066.23	1.33
SOYBEAN	36.47	6.71	74.72	4890.48	1.32
WHEAT/SOY	49.26	3.78	81.64	5045.34	1.41



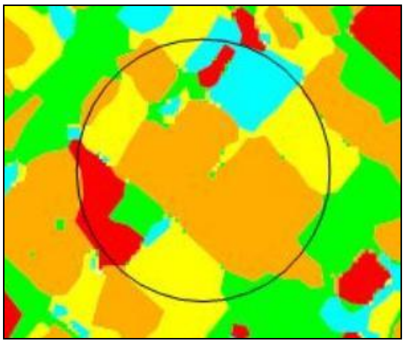
Group 3 (n = 101 points):

HABITAT	CA	NUMP	PSCOV	TE	MSI
PASTURE	129.74	11.33	231.58	12877.03	1.46
FLOODED	96.52	6.54	144.13	11631.86	1.64
CORN	28.09	12.92	184.08	5632.71	1.25
SOYBEAN	4.95	2.31	92.16	1090.61	1.00
WHEAT/SOY	46.47	5.05	113.57	5258.70	1.38



Group 4 (n=55 points):

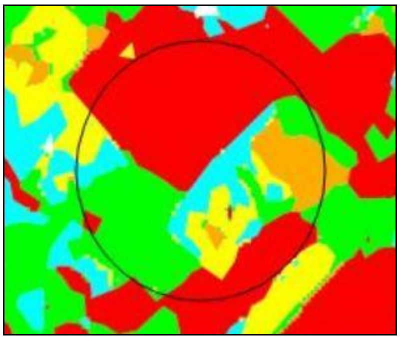
HABITAT	CA	NUMP	PSCOV	TE	MSI
PASTURE	71.91	14.85	230.20	10304.69	1.36
FLOODED	75.93	6.98	140.42	10131.13	1.53
CORN	94.26	16.76	254.01	13122.12	1.39
SOYBEAN	40.34	5.91	82.99	5376.47	1.38
WHEAT/SOY	25.93	2.40	60.37	2627.55	1.27



Group 5 (n=30 points):

HABITAT	CA	NUMP	PSCOV	TE	MSI
PASTURE	48.82	15.17	228.67	8323.79	1.33
FLOODED	62.60	5.67	131.92	7869.78	1.49
CORN	36.80	11.73	184.38	5822.72	1.31
SOYBEAN	16.62	4.17	58.29	2397.01	1.15
WHEAT/SOY	144.01	3.97	107.51	9253.47	1.52

Figure 5: Configuration of an exemplary sample unit (point) belonging to each group; groups were defined according to their landscape context at a radius of 1000 m (buffer shown); tables show mean values for class area (CA, in hectares), number of patches (NUMP), patch size coefficient of variation (PSCOV), total edge (TE, in meters) and the mean shape index, for each habitat class. Color legend: Pasture-Green; Flooded Pasture-Light Blue; Corn-Yellow; Soybean-Orange; Wheat/Soybean-Red.



Group 6 (n= 37 points):

HABITAT	CA	NUMP	PSCOV	TE	MSI
PASTURE	31.80	19.76	254.10	7699.23	1.29
FLOODED	17.80	4.70	98.65	3535.64	1.33
CORN	86.14	11.32	213.66	9836.38	1.40
SOYBEAN	102.28	8.14	54.11	8986.87	1.37
WHEAT/SOY	72.92	2.11	54.92	4756.23	1.33

Figure 5 (cont.): Configuration of an exemplary sample unit (point) belonging to each group; groups were defined according to their landscape context at a radius of 1000 m (buffer shown); tables show mean values for class area (CA, in hectares), number of patches (NUMP), patch size coefficient of variation (PSCOV), total edge (TE, in meters) and the mean shape index, for each habitat class. Color legend: Pasture-Green; Flooded Pasture-Light Blue; Corn-Yellow; Soybean-Orange; Wheat/Soybean-Red.

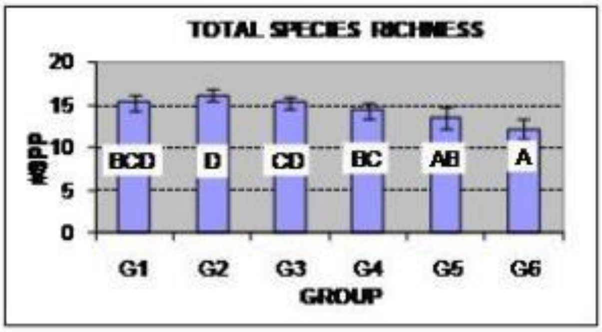


Figure 7

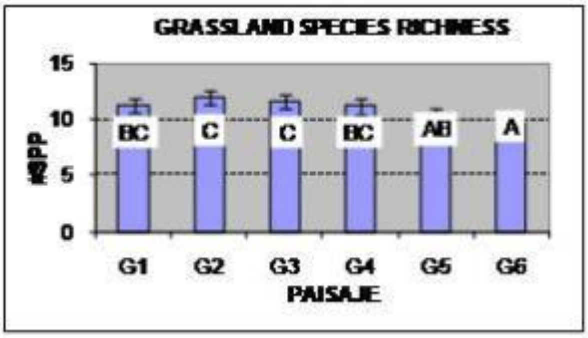
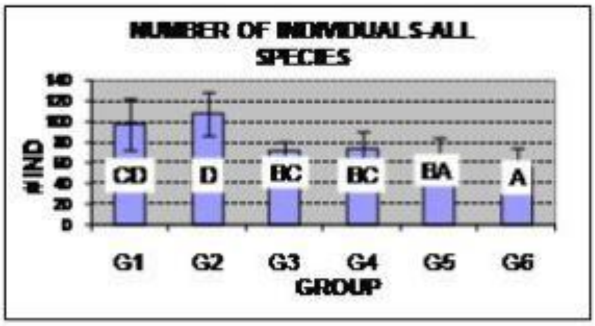


Figure 8



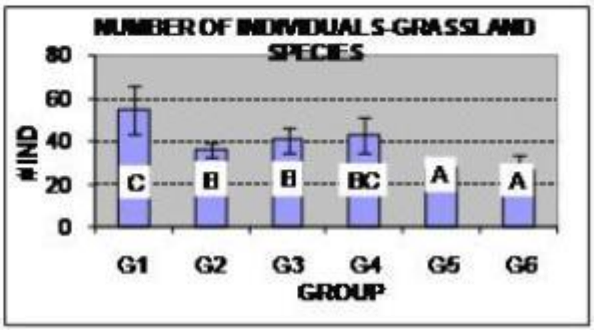
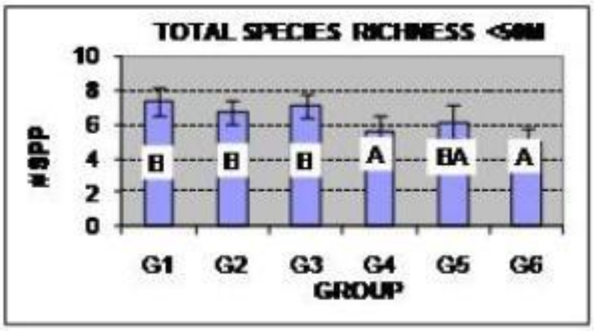


Figure 9

Figure 10

Figures 1-4: Comparison among groups in mean species richness for all species (total) and grassland species (Fig. 7 and 8, respectively) and number of individuals for all species and grassland species (Fig. 9 and 10, respectively). Different letters indicate significant differences between pairs of groups, at $\alpha \leq 0.05$.



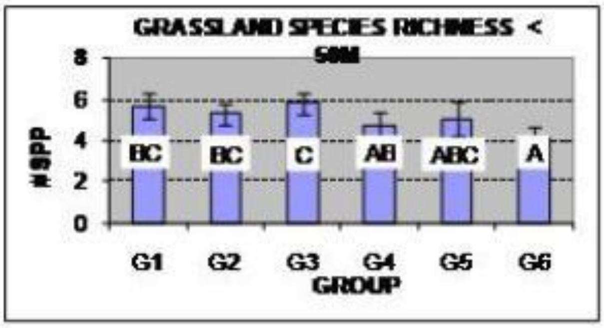
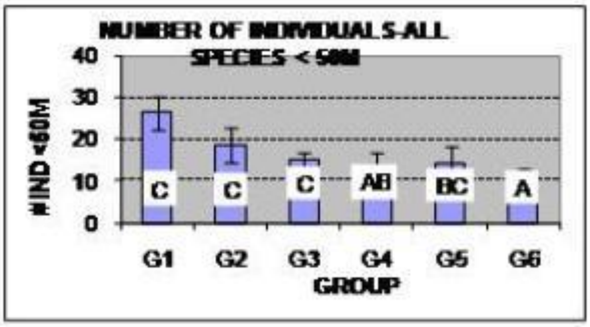


Figure 11

Figure 12



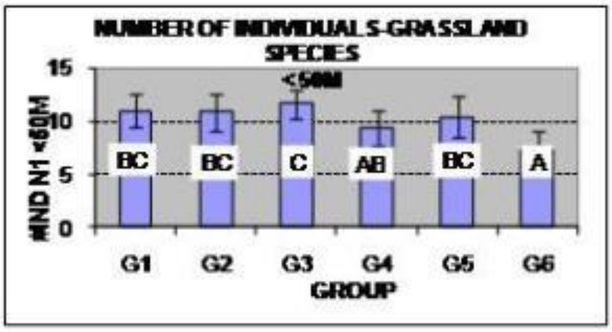


Figure 13

Figure 14

Figures 1-4 (cont.): Comparison among groups in mean species richness for all species (total) and grassland species (Fig. 7 and 8, respectively) and number of individuals for all species and grassland species (Fig. 9 and 10, respectively), detected within a 50 m radius of points. Different letters indicate significant differences between pairs of groups, at $\alpha \leq 0.05$.

As seen in table 2, species-environment correlations between both axes and community composition including all species were significant (at $\alpha = 0.05$). This means that community composition can be significantly explained by landscape composition and configuration, or alternatively that species composition is significantly influenced by landscape heterogeneity. For grassland species, this affirmation can only be said for the correlation between axis 1 and species composition.

Intraset correlations between axes 1 and 2 (both significant) and landscape variables are shown in table 4 when all species are considered, and between axis 1 and landscape variables are shown in table 5, for grassland species. Again, intraset correlations allow us to infer the relative importance of each landscape variable for predicting community composition, according to their magnitude and sign. When observing the results in table 4, for axis 1, from the magnitude of the correlations, we can observe that both area of flooded pasture and area of wheat/soybean are the most important landscape variables in predicting species composition (here, we highlight results for correlation values higher than 0.3). We may also observe that these two variables are found at both extremes of the axis: signs in this case indicate that those sites that had very large cover values of flooded pasture and a very small area covered by soybean. This interpretation can also be made for other landscape variables. Following the area variables on this axis, in relative importance, are the mean shape index values for all habitat areas. The number of patches of wheat/soybean is also important, although less important in a relative sense, since all mean shape indeed values for all classes have high values, and only one for the "number of patches" variable.

The intraset correlations for the second axis highlight the importance of pasture and corn area in predicting species composition, followed by the number of patches of pasture and wheat/soybean, and finally the shape of corn patches. In general, the landscape variables that were most important in predicting species composition were (in order of importance): area, patch shape, and the number of patches.

As mentioned before, when observing the results of canonical correspondence analysis for grassland species, only the species-environment correlation for axis 1 was significant (table 2). Thus, only the intraset correlations for this axis 1 are shown in table 5. As expected, the most important landscape variable in predicting grassland species composition are, on one extreme, the two pasture cover variables, and on the other extreme, the wheat/soybean variable. This, in turn means that those sites that had high pasture cover at a 1000 m radius had low wheat/soybean cover. Following the area variable for wheat/soybean are the patch shape variables for agricultural classes (corn, wheat/soybean and soybean) and the area variable for corn. Thus, especially when considering the agricultural classes, configuration variables and particularly patch shape, are important in determining grassland species composition.

We were also interested in determining the relative importance of landscape and local (percent cover) variables in determining species composition. To investigate this phenomenon we also conducted canonical correlation analyses for total species and grassland species, and local variables. The results can be seen in table 3. When comparing the species-environment correlations with local habitat variables to species-environment correlations with landscape variables (table 2), the former are significantly lower in the case of all species, and similar but also lower for grassland species. Thus, in both cases, we conclude that landscape variables are better predictors of species composition than local habitat cover variables, and particularly when all bird species are considered. Intraset correlations are shown for all species and local habitat cover variables in table 6 and for grassland species and local habitat cover variables in table 7. As it can be observed, habitat classes are slightly different than for landscape variables, and woodland is added. For all species, the most important habitat classes in determining species composition where natural pasture, woodland and corn on axis 1, and woodland, wheat and corn on the second axis. For grassland species, the most important classes where natural pasture, woodland and corn for axis 1, and woodland, bare soil and soybean for axis 2.

We also used canonical correspondence analysis to investigate the importance of roadside grassland vegetation for grassland species. For this particular case, we only used bird records within 50 m of census points, and local habitat cover variables. Species-environment correlations are shown in table 3 (grassland species < 50m), and intraset correlations are shown in table 8. The species-environment correlations for this case are very similar to the correlation for grassland species and landscape variables (table 1) for axis 1.

By looking at the correlations for axis 1, it is clear that species composition within 50 m of the census point is determined by percent pasture cover, from the magnitude of the correlation of natural pasture to axis 1 (0.80), nearly twice as much as correlations of other habitat classes. Pasture (both flooded and non-flooded) cover is also important in determing species composition at the landscape scale (table 4). Thus, for grassland species, we conclude that the main factor influencing species composition both at the local and landscape scale is natural pasture cover. At the local scale, pasture cover is a much more important determinant of species composition than at the landscape scale, evidenced by intraset correlations for flooded and non-flooded pasture with axis 1 for grassland species and landscape variables (-0.32 and -0.37, respectively, table 5), much lower than the intraset correlation of natural pasture to axis 1 (0.80) for grassland species and local variables (table 8). We believe these results support our conclusion of the importance of roadside grassland vegetation for the conservation of grassland species, particularly in landscapes with a large proportion of cultivated land.

V. CONCLUSIONS

1) A total of 103 species were detected during the study, belonging to 39 families and 14 orders. Of the species total (103), 54 species were completely or partially dependent on grassland, and 24 were considered grassland specialists. Of the remaining 49 species, 22 species were typical of aquatic habitats and 27 species forest specialists. We did not find any species that were endemic to the Pampas region or under any category of risk, according to IUCN (2006) standards.

2) Six different groups of points were identified, according to their landscape context at a 1 km radius. A general pattern for all groups can be described: 1) the number of patches and total edge increase with decreasing area, especially for the two natural classes (pasture and flooded pasture); 2) the patch size coefficient of variation and mean shape index increase with area. Groups 1, 2 and 3 were dominated by either non-flooded or flooded pasture, group 4 was more heterogeneous but dominated by a mix of corn and flooded pasture, and groups 5 and 6 were dominated by soybean and soybean/wheat, respectively.

3) All comparisons among groups for average species richness and average number of individuals, for all species and for grassland-dependent species, were significant. Clearly, species richness is significantly higher in habitats dominated by natural habitats (pasture and flooded pasture), that is, in groups 1 to 3. Nonetheless, differences were not large in magnitude.

4) With regard to number of individuals, the pattern in similarities and differences among groups were similar to the case of species richness, but differences in magnitudes were much greater. Groups 1 and 2 supported nearly twice as many numbers of individuals of all species and grassland species than groups 5 and 6, dominated by soybean. Additionally, group 4, which was not clearly dominated by any habitat class, but had similar proportions of flooded pasture and corn and a relatively high proportion of non-flooded pasture, had a high number of grassland species individuals, indicating that this particular mix of habitats in fairly equal proportions, maintains a high number of individuals, and particularly of grassland species. It is also clear that landscapes dominated by soybean or the wheat/soybean combination are deleterious for birds, especially in terms of number of individuals.

5) At the local scale, the roadsides, which are usually grassland relicts, are providing important habitat for grassland bird species, especially in those landscapes dominated by agriculture (groups 5 and 6). In group 6, we observed that wire fences and roadsides were being eliminated, and the soybean crop literally reached the edge of the road. These roadsides had very low species richness and supported very few individuals of grassland species.

6) Species-environment correlations and community composition for all species and grassland species were significant, indicating that community composition can be

significantly explained by landscape composition and configuration, or alternatively that species composition is significantly influenced by landscape heterogeneity.

7) In general, the landscape variables that were most important in predicting species composition were (in order of importance): area, patch shape, and the number of patches. When considering all species, both area of flooded pasture and area of wheat/soybean, followed by patch shape variables for flooded pasture, wheat/soybean, soybean and corn are the most important landscape variables in predicting species composition on the first axis, and on the second axis, area of non-flooded pasture and corn, followed by the number of patches of pasture and wheat/soybean. In the case of grassland species, area of non-flooded and flooded pasture and wheat/soybean where the most important variables, followed by patch shape variables for the agricultural classes.

8) Landscape variables are better predictors of species composition than local habitat cover variables, and particularly when all bird species are considered. For all species, the most important habitat classes in determining species composition where natural pasture, woodland and corn on axis 1, and woodland, wheat and corn on the second axis. For grassland species, the most important classes where natural pasture, woodland and corn for axis 1, and woodland, bare soil and soybean for axis 2.

9) At the local scale, pasture cover is a much more important determinant of species composition than at the landscape scale, evidenced by intraset correlations for flooded and non-flooded pasture with axis 1 for grassland species and landscape variables. These results support our conclusion of the importance of roadside grassland vegetation for the conservation of grassland species, particularly in landscapes with a large proportion of cultivated land.

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APPENDIX 1: Details of expenditures

DETAIL	RUFFORD SMALL GRANT	OTHER FUNDING SOURCES	TOTAL
Hiring of bird expert for censuses	£260.00	£100.00	**£360.00**
Per-diem for regional work (40 work days, £12.00/day, 3 persons)	£710.00	£440.00	**£1,150.00**
Travel Costs (includes travel to/Buenos Aires and Montevideo of bird expert)	£120.00	£0.00	**£120.00**
Vehicle rental	£250.00	£150.00	**£400.00**
Vehicle maintenance and fuel (vehicle necessary for field trips)	£130.00	£134.00	**£264.00**
G.I.S. consultancy	£60.00	£55.00	**£115.00**
Materials (Binoculars, GPS, data forms, etc.)	£0.00	£440.00	**£440.00**
Socialization of results in Argentinian Reunion of Ecology	£0.00	£70.00	**£70.00**
TOTAL PER FUNDING SOURCE	**£1,530.00**	**£879.00**	**£2,409.00**

Description of expenditures

Due to our lack of experience in knowledge of the local birds, we hired a local expert and associate from Uruguay to carry out censuses with us. His name is Gabriel Rocha. Since he lives in Uruguay, we had to cover his travel costs to and from Montevideo (capital of Uruguay) and Buenos Aires. This description would entail costs for his salary and travel costs. Also, we were not able to obtain a vehicle from the Faculty of Agronomy for every census period. Thus, we had to rent a vehicle. This would entail costs for vehicle rental.   We also had some expenses related to a GIS consultancy which we could not cover with other funds. Due to these differences concerning the original budget and the one we present here, we were not able to save money for publishing costs. Nonetheless, we were able to socialize our results in the 22nd Argentinean Reunion of Ecology, held between the 22 and 25 of August, 2006 in the city of Córdoba. Details of this conference can be consulted in: http://www.rae2006.com.ar . We also include a copy of the session in which our work was presented. We are now preparing our first publication, which will be sent when finished.

Appendix 2: detail of chronogram where our Project results (highlighted in yellow) where related in the 22nd Argentinean Reunion of Ecology, held between the 22 and 25 of August 2006

PRESENTACIONES ORALES

Martes 22 de Agosto

DINAMICA DE POBLACIONES Y COMUNIDADES

Sala: Amerian A (Patio Olmos)
Horario: 8:30 a 11:15 hs

8:30 hs. Heinemann, K. y Kitzberger, T. **Patrones temporales de establecimiento de *Nothofagus pumilio* (lenga) en bosques maduros del noroeste de la Patagonia.**

8:45 hs. Suarez, M. L. y Kitzberger, T. **Supervivencia de plántulas de *Nothofagus dombeyi* y *Austrocedrus chilensis* en claros producidos por un evento de sequía.**

9:00 hs. Ribas-Fernandez, Y. A.; Hadad, M. A. y Pucheta, E. **Destino post-dispersión de propágulos de *Bulnesia retama*: heterogeneidad espacial del banco de semillas y tasa de germinación a campo.**

9:15 hs. Biganzoli, F. y Batista, W. B. **Dinámica de poblaciones de *Baccharis dracunculifolia* en el paisaje del Parque Nacional El Palmar.**

9:30 hs. Blendinger, P. G. **Reclutamiento de Pino del Cerro (*Podocarpus parlatorei*) en Yungas: limitaciones en la dispersión por aves y en el establecimiento.**

9:45 hs. Leva, P. E. y Aguiar, M. R. **Diversidad y velocidad de la colonización del suelo por gramíneas en comunidades patagónicas.**

10:00 hs. Torres, C.; Galetto, L.; Ferreras, A. y Anton, A. **Biodiversidad y fragmentación de hábitats: variación de la riqueza y composición de especies vegetales en fragmentos de Bosque Chaqueño.**

10:15 hs. Dardanelli, S. y Nores, M. **Pérdida de especies de aves post-fragmentación en pequeños fragmentos de bosque en Córdoba, Argentina.**

10:30 hs. Lantschner, M. V. y Rusch, V. E. **Influencia de la matriz de paisaje en las comunidades de aves de plantaciones forestales en el NO de la Patagonia.**

10:45 hs. Ruete, A. **Análisis de estabilidad de comunidades: un sistema complejo del Bosque Valdiviano como ejemplo.**

11:00 hs. Cerezo, A.; Poggio, S.; Rocha, G. y Perelman, S. **Comunidades de aves y heterogeneidad del paisaje en el norte de la Provincia de Buenos Aires, Argentina.**