HABITAT LOSS AND ITS IMPACT ON AVIAN DIVERSITY OF HIGHLAND MOUNTAINS OF CORDOBA, ARGENTINA

Final Report

April 2009

Dr. Laura M. Bellis
Facultad de Ciencias Exactas Físicas y Naturales.
Universidad Nacional de Córdoba.
Córdoba, Argentina

Habitat problem

The loss of biological diversity is closely related to economic progress, which is currently reaching dramatic proportions. In mountain ecosystems, domestic livestock is one of the major threats to global biodiversity, and habitat protection is the most important means of conserving wildlife. Both historic and present-day vegetation dynamics are mediated by variation in disturbance intensity and frequency of fire and ungulate grazing (Coppedge et al. 2008). This in turn influences the avian community via the resulting heterogeneity of vegetation (Willson 1974).

Highland mountains of central Argentina are a good example to study the effect of overgrazing on biodiversity. In the region the main economic activity is the rearing of livestock (cattle, sheep, horses and goats), which began in the early seventeenth century (Cingolani et al. 2004, 2008). Livestock is an important factor structuring the landscape and have important consequences for the integrity of the ecosystem. Thus 400 years of domestic grazing without an adequate management provoked serious problems of erosion and vegetation degradation (Cingolani et al. 2003, 2004, Renison et al. 2006). Heavy grazing and associated activities like vegetation burning produced a trend of transformation from woodlands to grasslands to eroded rocky surfaces (Cingolani et al. 2008), which in the long-term can reduce habitat heterogeneity by eliminating little represented habitats (e.g. woodlands); hence, reducing bird diversity (García et al. 2008). These problems are especially alarming in central Argentina because rivers formed there provide the lowlands with water and, since these mountains constitute a biogeographical island harbouring 41 endemic plant and animal species, including 12 subspecies of endemic birds. Also, the region shares environments with other South American regions located at different latitudes, such as forest of *Polylepis sp*., which is considered one of the most endangered ecosystems of the world (Renison et al. 2006).

In 1997, 26,000 ha of the best preserved areas were set aside to create the 'Quebrada del Condorito' National Park. A further buffer area of 129,000 ha of private land surrounding the Park were declared National and Provincial Water Reserves, but continued under private ownership and traditional livestock management, i.e, high livestock stocking rates. Although domestic grazing pressure and fire are now restricted in the national park, soil erosion remains a severe problem, becoming aggravated in the privately owned areas

used for domestic animals rearing (Cingolani et al. 2004, Renison et al. 2006, Cingolani et al. 2008). Consequently, there is an urgent need to study the impact of domestic livestock on biodiversity. Due to the impossibility to perform complete species inventories, here we propose birds as indicators of habitat quality. Avifaunal communities are highly sensitive to changes in habitat caused by human disturbance (Watson et al. 2004, Pidgeon et al. 2007) hence they have been used effectively as bio-indicators in many ecosystems (Gottschalk et al. 2005).

The main aim of this project was to investigate the impact of domestic grazing on avian diversity in the highland mountains of central Argentina. Specific objectives were to: (1) compare bird richness between areas under traditional livestock management, moderate grazing and livestock exclusion, and (2) characterize the vegetation of each habitat type under different grazing intensities, which are in part the result of long-term livestock pressure (Cingolani et al. 2004).

Activities performed

Fieldwork was carried out in the Sierras Grandes of Cordoba (1200–2800 m a.s.l.) in central Argentina. The vegetation was classified into eight vegetation units that belong to three habitat types: woodlands, grasslands, and rock habitats (Figure 1). Vegetation units are mainly the product of a combination of physiographic characteristics and long-term ranching activities (Cingolani et al. 2003, 2004).

In each habitat types sample sites were randomly located in zones under different grazing situations: (1) traditional grazing: livestock management within privately owned lands (129,000 ha) where livestock activities have been fairly intense during the last 400 years and effective stocking rate generally ranges from 0.4 to more than 1.5; (2) grazing exclusion: traditional grazing until 1998 when the National Park administration took over 26,000 ha of land and livestock was completely excluded four years before our field surveys and (3) moderate grazing: livestock is maintained at low stocking densities.

Bird data

126 widely distributed sampling points were located in each of sampling sites, 14 points per environmental condition which is defined as a combination among different

habitat types and grazing situations. Each point was surveyed for 10 min to maximize count efficiency and efforts were made to avoid double-counting of individuals moving among points (Sutherland 2004). Points were visited in the spring-summer (September-March) seasons; twice in 2007-2008 and twice in 2008-2009. Bird richness and abundance was recorded. The location of each sample point was recorded with a GPS.

Richness of bird communities was calculated using EstimateS v.8.0 software (Colwell 2006). Sample species richness was estimated from the sample-based rarefaction curves (Mau Tau; Sobs; Mao et al. 2005). Sample was randomised 50 times for each dataset. To examine changes in species composition among habitat types, the robust bootstrap estimator (Sboot; Colwell and Coddington 1994) was used as a richness measure.

We tested changes on bird richness and grazing intensities among habitats using a ANOVA test (Underwood 1997).

Vegetation data

In each of 126 bird sampling sites we recorded a group of vegetation variables that represent the accumulated grazing impact at local scale. Using 16 quadrates (1 m^2) per site we totalized a sampling efforts of 2016 quadrates. In each of them we measured: (a) % of vegetation cover (monocotyledonous and dicotyledonous species), (b) % bare rock exposed by erosion, (c) vegetation height at three strata: herbs, shrubs and trees and, (d) % of rock outcrops. Vegetation data were recorded in the 2008-2009 spring-summer (September-March) seasons. The location of each sample points was recorded with a GPS.

Differences among vegetation characteristics per environmental condition; defined as a combination among different habitat types and grazing situations, were tested with ANOVA and Duncan post-hoc multiple comparison tests (Underwood 1997).

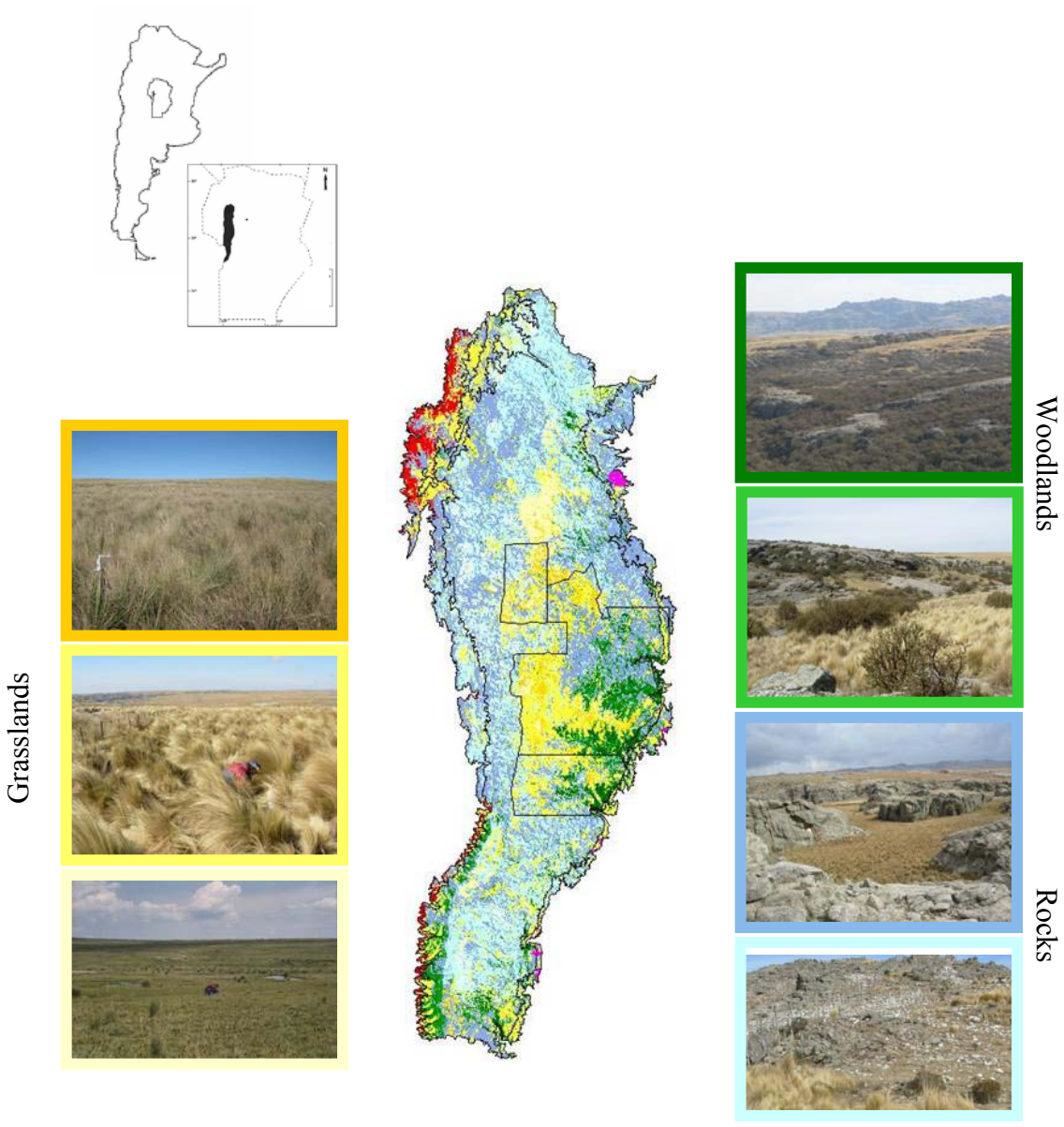


Figure 1. Sierras Grandes of Cordoba, Argentina. Each picture represents the different vegetation units included in the three habitat types of the region. Dark line shows the location of Quebrada del Condorito National Park. (Map adapted from GIS of Sierras Grandes; Cingolani et al. 2003b).

RESULTS

Bird richness

1-Traditional grazing situation:

Table 1 shows the avian richness (as a list of bird species) and the total abundance recorded in each habitat types under high densities of livestock.

Woodlands	Grasslands	Rock habitat
Aeronautes andecolus	*Anairetes flavirostris*	*Aeronautes andecolus*
Anairetes flavirostris	*Anthus furcatus*	*Anthus hellmayri*
Anairetes parulus	*Anthus hellmayri*	*Asthenes modesta cordobae*
Asthenes modesta cordobae	*Asthenes modesta cordobae*	*Asthenes sclateri sclateri*
		Cinclodes atacamensis schocolatinus
Asthenes sclateri sclateri	*Asthenes sclateri sclateri*	
Bolborhynchus aymara	*Cinclodes comechingonus*	*Cinclodes comechingonus*
Carduelis magellanica	*Cinclodes fuscus*	*Cinclodes fuscus*
Cathartes aura		
	Cincodes oustaleti olrogi	*Hymenops perspicillata*
Cinclodes atacamensis schocolatinus	*Cistothorus platensis*	*Muscisaxicola rufivertex achalensis*
Cinclodes comechingonus	*Colaptes campestris*	*Nothiochelidon cyanoleuca*
Cincodes oustaleti olrogi	*Hymenops perspicillata*	*Phrygilus unicolor cyaneus*
Cistothorus platensis	*Idiopsar brachyurus*	*Sturnella loica obscura*
Colaptes melanolaimus	*Muscisaxicola rufivertex achalensis*	*Vanellus Chilensis*
Geranoaetus melanoleucus	*Nothiochelidon cyanoleuca*	*Zonotrichia capensis*
	Phrygilus plebejus naroskyi	
Leptasthenura fuliginiceps	*Phrygilus unicolor cyaneus*	
Muscisaxicola rufivertex achalensis	*Sturnella loica obscura*	
Turdus chiguanco	*Theristicus caudatus*	
	Turdus chiguanco	
	Vanellus chilensis	
	Zonotrichia capensis	
Individuals: 89	Individuals: 87	Individuals 56
Species: 17	Species: 21	Species: 14

2-Moderate grazing situation:

Table 2 shows the avian richness and total abundance recorded in each habitat types under moderate densities of livestock.

Woodlands	Grasslands	Rock habitat
Agriornis montana fumosus	*Anthus furcatus*	*Agriornis montana fumosus*
Anairetes parulus	*Anthus hellmayri*	*Anthus furcatus*
Asthenes sclateri sclateri	*Asthenes modesta cordobae*	*Anthus hellmayri*
Buteo albicaudatus	*Asthenes sclateri sclateri*	*Asthenes modesta cordobae*
Cinclodes atacamensis schocolatinus	*Catamenia analis*	*Asthenes sclateri sclateri*
Falco sparverius	*Cinclodes atacamensis schocolatinus*	*Cinclodes fuscus*
Turdus chiguanco	*Cinclodes comechingonus*	*Cincodes oustaleti olrogi*
Zonotrichia capensis	*Cinclodes fuscus*	*Cistothorus platensis*
	Cincodes oustaleti olrogi	*Falco sparverius*
	Cistothorus platensis	*Geranoaetus melanoleucus*
	Hymenops perspicillata	*Hymenops perspicillata*
	Phrygilus alaudinus	*Phrygilus unicolor cyaneus*
	Polyborus plancus	*Sturnella loica obscura*
	Sturnella loica obscura	*Zonotrichia capensis*
	Turdus chiguanco	
	Vanellus chilensis	
	Zonotrichia capensis	
Individuals: 13	Individuals: 72	Individuals: 46
Species: 8	Species: 17	Species: 14

3-Exclusion grazing situation:

Table 3 shows the avian richness and total abundance recorded in each habitat types under livestock exclusion.

Woodlands	Grasslands	Rock habitat
	Anthus furcatus	
Aeronautes andecolus	*Anthus hellmayri*	*Agriornis montana fumosus*
Agriornis montana fumosus	*Asthenes modesta cordobae*	*Aimophila strigiceps*
Aimophila strigiceps	*Asthenes sclateri sclateri*	*Anthus furcatus*
Anairetes flavirostris	*Buteo polyosoma*	*Anthus hellmayri*
Anairetes parulus	*Carduelis magellanica*	*Asthenes modesta cordobae*
Asthenes sclateri sclateri	*Catamenia inornata cordobensis*	*Asthenes sclateri sclateri*
Bolborhynchus aymara	*Cathartes aura*	*Bolborhynchus aymara*

Carduelis magellanica	*Cinclodes comechingonus*	*Carduelis magellanica*
Cathartes aura	*Cistothorus platensis*	*Cinclodes comechingonus*
Cistothorus platensis	*Embernagra platensis*	*Cinclodes fuscus*
Colaptes melanolaimus	*Geositta cunnicularia contrerasi*	*Cistothorus platensis*
Columba maculosa	*Hymenops perspicillata*	*Embernagra platensis*
Coragyps atratus	*Leptasthenura fuliginiceps*	*Geositta cunnicularia contrerasi*
Falco sparverius	*Melanopareia maximiliani*	*Hymenops perspicillata*
Geranoaetus melanoleucus	*Nothoprocta pentlandii*	*Leptasthenura fuliginiceps*
Leptasthenura fuliginiceps	*Nothura maculosa*	*Milvago chimango*
Myioborus brunniceps	*Phrygilus plebejus naroskyi*	*Muscisaxicola rufivertex achalensis*
Pheucticus aureoventris	*Phrygilus unicolor cyaneus*	*Nothura maculosa*
Sappho sparganura	*Sturnella loica obscura*	*Phrygilus plebejus naroskyi*
Thraupis bonariensis	*Turdus chiguanco*	*Phrygilus unicolor cyaneus*
Troglodytes aedon	*Upucerthia dumetaria*	*Sturnella loica obscura*
Turdus chiguanco	*Vultur gryphus*	*Turdus chiguanco*
Zonotrichia capensis	*Zonotrichia capensis*	*Zonotrichia capensis*
Individuals: 93	Individuals: 103	Individuals: 94
Species: 23	Species: 24	Richness: 23

Bird richness was different among habitats ($F = 19.69$; $P < 0.0001$) and grazing situations ($F= 10.86$; $P < 0.0001$) Figure2.

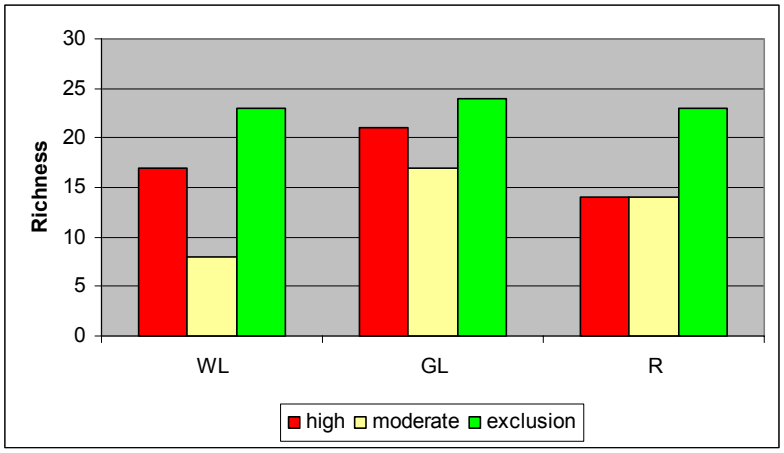
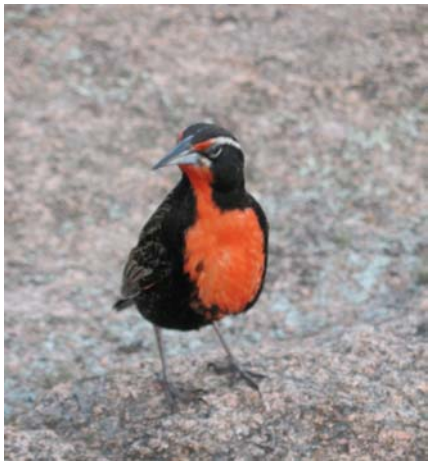


Figure 2. Bird richness comparisons among the different environmental conditions (i.e. the combination of habitat types and grazing situations). WL: woodlands, GL: grasslands R: rock habitats. Colours show the 3 grazing situations.

The grassland had the highest species richness (R_{boot}= 21.10 ± 8.41) and the rock habitat the lowest one (R_{boot}= 13.45 ± 5.53) since rock habitat include the most eroded and impoverished areas of the region. Considering the grazing situation, the habitat with livestock exclusion showed the highest values of avian richness (R_{boot}= 21.92 ± 8.96).

4-Endemic birds

We recorded 11 endemic subspecies birds in the study area: *Asthenes modesta cordobae, Cinclodes atacamensis schocolatinus, Cincodes oustaleti olrogi, Sturnella loica obscura, Asthenes sclateri sclateri, Agriornis montana fumosu, Phrygilus unicolor cyaneus, Phrygilus plebejus naroskyi, Muscisaxicola rufivertex achalensis, Catamenia inornata cordobensis* and *Geositta cunnicularia contrerasi.* We did not detect differences on endemic bird occurrence through grazing situations.



Sturnella loyca obscura

Muscisaxicola rufivertex achalensis

Figure 3. Some endemic birds of the study area. Photo credit: L. Heil.

Vegetation characteristic

Environmental conditions showed significant differences with respect to their structural vegetation attributes and erosion condition (F: 77.49, P < 0.0001), recording variations in the vegetation characteristics of each habitat type and grazing intensities (Table 4).

Table 4. Mean values of vegetation characteristics of different environmental conditions of the mountains of central Argentina. Different letters indicate significant difference of Duncan test (P < 0.05).

Habitat	Grazing intensities		
GRASSLAND	**High**	**Moderate**	**Exclusion**
Monocotyledonous (%)	45.76a	73.81b	71.33b
Dicotyledonous (%)	42.81a	12.15b	16.33c
Height of herbs stratum (m)	0.38a	0.58b	0.44c
Height of shrub stratum (m)	0.2a	0.02b	0.02b
Height of tree stratum (m)	0	0	0
Rock outcrops (%)	5.98a	14.29b	12.89b
Soil exposed by erosion (%)	4.43a	7.15a	4.77a
FOREST			
Monocotyledonous. (%)	8.06a	25.63b	21.63b
Dicotyledonous (%)	73.92b	25a	75.04b
Height of herbs stratum (m)	0.42a	0.58a	0.38a
Height of shrub stratum (m)	0.22a	2.66a	0.58a
Height of tree stratum (m)	2.66b	0.4a	2.18b
Rock outcrops (%)	14.11b	80a	13.04b
Soil exposed by erosion (%)	0b	17.5a	0.86b
ROCKS			
Monocotyledonous (%)	5.52a	50.88b	30.3c
Dicotyledonous (%)	9.05b	15.36a	8.76b
Height of herbs stratum (m)	0.06a	0.44b	0.18c
Height of shrub stratum (m)	0.04a	0.07a	0.03a
Height of tree stratum (m)	0a	0.01a	0a
Rock outcrops (%)	88.43a	48.69b	56.16c
Soil exposed by erosion (%)	61.62a	17.93b	35.55c

General Conclusion

Our results show that livestock exclusion increased the avian richness in all habitat types, however did not show a strong differentiation on vegetation structure respect to areas

under grazing situations. In Cordoba mountains the effects of livestock exclusion on avifauna has both positive and negative effects for conservation, depending on time scale. Short-term (< 6 years) livestock exclusion has caused, in all habitats, significant reductions in observed bird richness (García et al. 2008). However at medium term (6 years to present) bird richness is favoured by grazing exclusion. This information is specially important in habitat such as woodlands (Figure 4) which are the special conservation concern since their limited extent and patchy distribution and because the livestock grazing alters or prevents their natural recovery (Teich et al. 2005). Despite of these conservation problems woodlands still harbour a high biodiversity such as: birds, insects, fungi, ferns, epiphytes among others (Fjedsa and Kessler, 1996, Bellis et al. 2009).

Overall, data obtained here allow us to have a more detailed appreciation of the livestock effect for the conservation of biodiversity and they constitute a starting point for more comprehensive studies. This information results important and necessary in order to perform long term studies, in an effort to define conservation strategies of this mountain ecosystem. Specially in habitats as woodlands where its recovery, a highly desirable conservation objective, seem to be difficult to achieve without long term livestock exclusion (Teich et al. 2005; Renison et al. 2006).

A

B

Figure 4. A: View of a *Polylepis* woodland of Sierras Grandes of Cordoba, Argentina. Photo credit: L. Heil. B: Group member in the study area.

Activities performed

1-PhD Thesis entitled "Comunidades de aves de las Sierras Grandes de Córdoba. Erosión, fragmentación y heterogeneidad: incidencia antrópico-ambiental"**.** Lisandro Heil. Universidad Nacional de Córdoba. Phase of progress : Intermediate

2-Undergraduate thesis entitled "Uso de hábitat de la Loica Común (*Sturnella loyca obscura*) en relación a la intensidad de pastoreo en las Sierras Grandes de Córdoba, Argentina". Nadia Muriel. Facultad de Ciencias Exactas Físicas y Naturales Universidad Nacional de Córdoba. Phase of progress: writing final manuscript.

3-Presentation of preliminary results a the **II Jornadas Argentinas de Ecología de Paisajes**. May 2009. Abstract accepted entitled "Comunidades de aves de las Sierras Grandes de Córdoba. Incidencia de la ganadería sobre la heterogeneidad del paisaje".

4-Presentation of preliminary results a the **II Jornadas Argentinas de Ecología de Paisajes**. May 2009. Abstract accepted entitled "Uso de la percepción remota como predictor de la riqueza de aves en bosques de tabaquillo (*Polylepis australis*) de la provincia de Córdoba con diferente hábito de crecimiento".

References

BELLIS, L. M., RIVERA, L. , POLITI, N., MARTÍN, E. , PERASSO, M. L. CORNELL, F. & RENISON D. 2009. Latitudinal patterns of bird richness, diversity and abundance in *Polylepis australis* mountain forest of Argentina. *Bird Conservation International*, in press.

CINGOLANI A. M., M. R. CABIDO, D. RENISON & V. SOLÍS NEFFA. 2003a. Combined effects of environment and grazing on vegetation structure in Argentine granite grasslands. *Journal of Vegetation Science* 14: 223-232.

CINGOLANI A. M., RENISON D., SCHINNER D., CABIDO M., ENRICO L., GALLI E., FALCZUK V., ZAK M. & RENISON R. 2003b. Sistema de Información Geográfica de la Reserva Hídrica Provincial de Achala y Parque Nacional Quebrada del Condorito. En: Flores A. y Cabido D. (eds.). Primer Congreso Nacional de Áreas Naturales Protegidas. Resumen de presentaciones pp 104-105. Córdoba:

Agencia Cordoba DACyT, Dirección de Ambiente, Administración de Parques Nacionales.

CINGOLANI A. M., D. RENISON, M. R. ZAK & M. R. CABIDO. 2004. Mapping vegetation in a heterogeneous mountain rangeland using Landsat data: an alternative method to define and classify land-cover units. *Remote Sensing of Environment* 92: 84-97.

CINGOLANI A. M., D. RENISON, P. TECCO, D. GURVICH, & M. CABIDO. 2008. Predicting cover types in a mountain range with long evolutionary grazing history: a GIS approach. *Journal of Biogeography*, 35: 538-551.

COLWELL, R. K. 2006 EstimateS: Statistical estimation of species richness and shared species from samples. Version 8.0, ,http://viceroy.eeb.uconn.edu/EstimateS.

COLWELL R. K. & CODDINGTON J. A. 1994. Estimating terrestrial biodiversity through extrapolation. *Phil. Trans. R. Soc*. 345: 101–118.

COPPEDGE B. R., FUHLENDORF S. D., HARRELL W. C. & ENGLE, D. V. 2008. Avian community response to vegetation and structural features in grasslands managed with fire and grazing. *Biological Conservation* 141:1196-1203.

FJELDSA, J. & KESSLER, M. 1996. Conserving the biological diversity of Polylepis woodlands of the highland of Peru and Bolivia. A contribution to sustainable natural resource management in the Andes. Copenhagen, Denmark: NORDECO.

GARCIA, C., RENISON, D., CINGOLANI, A. M. & FERNA´NDEZ-JURICIC, E. 2008. Avifaunal changes as a consequence of large scale livestock exclusion in the mountains of Central Argentina. *J. Appl. Ecol*. 45: 351– 360.

GOTTSCHALK, T. K., F. HUETTMANN, & M. EHLERS. 2005. Thirty years of analyzing and modeling avian habitat relationships using satellite imagery data: a review. *International Journal of Remote Sensing* 26: 2631–2656.

MAO, C. X., COLWELL, R. K. & CHANG, J. 2005. Estimating the species–accumulation curve using mixtures. *Biometrics* 61: 433–441.

PIDGEON, A.M., V.C. RADELOFF, C. H. FLATHER, C.A. LEPCZYK, T.J. HAWBAKER, M.K. CLAYTON, & R. B. HAMMER. 2007. Associations of Forest Bird Species Richness with Housing and Landscape Patterns across the USA. *Ecological Applications* 17 (7): 1989-2010

RENISON D., HENSEN I., SUAREZ R. & CINGOLANI A. 2006. Cover and Growth Habit of *Polylepis* Woodlands and Shrublands in the Mountains of Central Argentina: Human or Environmental Influence? *Journal of Biogeography* 33: 876-887.

SUTHERLAND, W.J., 2004. Ecological Census Techniques. A Handbook. Cambridge University Press, Cambridge.

TEICH, I., CINGOLANI, A. M., RENISON, D., HENSEN, I. & GIORGIS, M. A. 2005. Do domestic herbivores retard *Polylepis australis* Bitt. woodland recovery in the mountains of Cordoba, Argentina? *For. Ecol. Manage*. 219: 229–241.

UNDERWOOD, A.J. 1997. Experiments in ecology: their logical design and interpretation using analysis of variance. Cambridge University press. UK.

WATSON, J. E., WHITTTAKER, R. J. & DAWSON, T. P. 2004. Habitat structure and proximity to forest edge affect the abundance and distribution of forest-dependent birds in tropical coastal forest of southeastern Madagascar. Biol. Conserv. 120: 311–327.

WILLSON, M. F. 1974. Avian Community Organization and Habitat Structure. *Ecology*, 55 (5): 1017-1029.

Financial report

Rufford Grant : US $ 4372

ITEM	Quantity	TOTAL (US Dollars)
Camping gear		
Backpack cover	1	8.97
Sleeping bags	2	288.14
Gas bottle for cooking	3	18.08
Insulating mats	2	16.03
GPS cover	1	9.62
Heater	1	20.93
Batteries		32.47
Field expenses		
Food & transportation (140 days)		
2 people (bus, taxies, etc)	280 men-days	1858.58
Local guides and support		294.49
Results presentation		
Congress fees		595.51
Posters		68.67
Office and computer supplies		
Printer ink, CDs, DVDs, papers, etc		214.94
Copies		88.91
Voltage-stabilizer	1	25.00
Pen drive	1	11.86
Mouse	1	5.45
UPS	1	163.46
Notebook battery	1	416.67
Others		
Mail		20.35
Telephone		16.35
Contingencies		203.46
TOTAL (US Dollars)		**4377.92**