Darwin Fellowship - Final Report

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Darwin Project Title	**High Andes Conservation Without Borders**
Name of Darwin Fellow	Magdalena Bennett
UK Organisation	Wildlife Conservation Research Unit, Oxford University
Your Organisation	Wildlife Conservation Research Unit, Oxford University
Your role in your Organisation	DPhil student
Start/end date of Fellowship	September 2010/ August 2011
Location	Oxford
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Type of work (e.g. research, training, other, please specify)	Research
Main contact in UK Organisation	Dr Claudio Sillero-Zubiri
Author(s), date	Magdalena Bennett 20th October 2011

1. Background

I was involved in the Darwin Project “Conservation of Puna´s Andean cats across national borders” (project 14 028, 2005-2008), centred around the triple frontier of Argentina, Bolivia and Chile, from its inception. Collaborating with Oxford partners I conducted studies of the spatial ecology of Andean carnivores, including collation of sighting databases and of a Geographic Information System of the area, and spatial analyses including the use of remote sensing data. I also contributed to develop and implement the off-road driving mitigation campaign in Chile. Since April 2010 I became involved with the Darwin initiative post project grant entitled "High Andes conservation without borders" (EIDPO038).

The Darwin Fellowship has enabled me to undertake biogeographical research that will contribute to the conservation of High Andes biodiversity in the triple frontier between Argentina, Bolivia and Chile. During my involvement with the original Darwin project we identified key areas for conservation of carnivores in the region (particularly Andean cats), the critical resources on which they depend (mainly highland wetlands, and rodent prey), and threats from unregulated off-road tourism. As a follow up of the original research, the research focus of my fellowship work shifted towards measuring and understanding the threats for the conservation of biodiversity and natural resources in the High Andes, including climatic change and land use changes. The overall work plan involves temporal analysis of variations in rainfall, water extraction, and concurrent changes in vegetation associated to wetlands, peatlands, salt pans and lagoons, since the year 1975.

Since October 2010 I am enrolled in a Doctoral Degree at the University of Oxford Zoology Department (www.zoo.ox.ac.uk). WildCRU (www.wildcru.org), the UK host organization,

provides me with academic expertise in conservation and tools that are otherwise not available in my country. Through WildCRU I established a collaboration with the University of Oxford 's School of Geography and the Environment (SGE) to develop work on remote sensing in high mountains and regional climate modelling in the Andes.

Additionally I took a course on Climate and Catchment Processes with Dr Mark New (MSc in Water Science, SGE Policy and Management, www.geog.ox.ac.uk/graduate/msc-wspm/structure.html). I also attended courses on Rhetorical Functions in Academic Writing and Communication Skills (Language Centre, University of Oxford, www.lang.ox.ac.uk/courses/english.html), Introduction to End Note in the Computing Services from the University www.oucs.ox.ac.uk, and First Aid in Fieldwork (Wildlife Conservation Research Unit). Also, I attended to the workshop “Research ethics, practice and dissemination in biogeography: A workshop focused on preparation, writing and peer review” with Dr Robert Whittaker in the Oxford University Centre for the Environment www.biogeography.org/html/Meetings/2011Oxford/index.html and several seminars at WildCRU, the Zoology Department and the School of Geography and the Environment.

2. Achievements

I started the fellowship in September 2010 due to difficulties with my visa, because after been accepted by Oxford for my DPhil student I required a graduate student visa. One the visa was secured I was able to travel to the UK to start my fellowship and doctoral studies, starting my graduate work in earnest in October 2010 under the supervision of Dr Claudio Sillero-Zubiri (WildCRU), joint supervision by Dr Mark New (SGE), and in close collaboration with Dr Jorgelina Marino at WildCRU, the UK ecologist with the new Darwin project. Jorgelina has now become my joint supervisor, after Mark New's departure to take up a new position elsewhere.

I spent two months in the field in the triple frontier of Argentina, Bolivia and Chile. During this trip I visited all the Darwin project study areas, met with the Argentine and Bolivian members of the Darwin team, and contacted Protected Area managers in the three countries.

One main objective was to collect extensive ground truth data for subsequent analyses of satellite images, targeting major key components of the landscape, such as lakes, wetlands, vegetation types and specific topographic features. The extensive surveys also helped to collect information on the distribution of key species of fauna, the condition and grazing activities in pastures associated to wetlands, and to measure lagoons and salty pans in Argentina affected by an extreme dry year. In Bolivia I surveyed the site of a geothermic power plant soon to be installed near Colorada Lagoon in Eduardo Avaroa National Park, a key area for breeding colonies of flamingos. In Chile I surveyed the areas most affected by water extraction for mining and urban uses, registering deteriorated wetlands and peatlands, some of them much drier than in previous years.

As a result of this field I was able to develop a complete database of spatial information regarding key natural resources and threats across the triple frontier, which I am currently analysing for my Doctoral thesis. The cartographic (GIS) database includes human settlements, roads, mining operations, tourism infrastructure and sites of interest, limits of existing and proposed protected areas, topography, hydrography, locations of records of fauna and vegetation maps. This database will be used to study the natural resources and the threats that are affecting the study area. The database was developed from field data,

Landsat and Quickbird satellite images, and the government cartography available for each country (Appendix 1).

In Chile I visited government offices in Santiago to collected information on water extraction, data from climate weather stations, vegetation, and population census data, including the *Direccion General de Aguas (*DGA), *Instituto Nacional de Estadisticas* (INE) and *Servicio Agricola y Ganadero (*SAG). I have now identified all important wetlands affected by water extraction for mining and urban use since 1960 in Chile.

In order to assess evidence of climate change and its effects upon the High Andes ecosystem in Chile, I first collated climatic information from 27 meteorological stations in the study area. The data include temperature, precipitation, humidity and wind between 1970 and 2010. Analyses of precipitation patterns and trends over the past 40 years indicated that rainfall is decreasing in some localities, but not consistently across weather stations. Rainfall instead was markedly affected by the Southern Oscillation Index (El Nino- La Nina Phenomenon). Complementarily, I am investigating changes in vegetation since 1981 to 2006, and how these relate to climatic variations. For this I used the Normalized Difference Vegetation Index As a proxy for green vegetation, compiled from NOAA/AVHRR satellite data by Global Inventory Monitoring and Modeling Studies (GIMMS). I have also acquired 12 Landsat TM satellites images to investigate changes in this vegetation index in the Chilean side of the triple frontier, between the driest and wettest years over the last three decades. The preliminary results show that changes in precipitation produce changes in grasslands and scrublands, but not so clearly in the vegetation associated to wetlands. My hypothesis is groundwater is continually feeding these wetlands, many of which are peat-like formations with capacity retain water longer than grasslands and scrublands (Appendix 2). I have focused my work on the climatic analyses in order to complete first my collaboration with Dr Mark New, who left Oxford at the end of August 2011 to work in South Africa. Because of this change of plans, I modified my plans and delayed my second field trip. I will now be going back to do fieldwork in Chile's High Andes during December and January.

In collaboration with CONAF (the organization in charge of Chile’s protected areas) I also extended the implementation of the off-road information campaign (meetings with tourism agencies, disseminating of education material).

Other achievements of the fellowship include three conference presentations:

- First Latin American Congress (4TH Argentina) for the Conservation of Biodiversity in Tucumán, Argentina (22 – 26 November 2010). “High Andes Conservation Without Borders, Darwin Initiative Project” (Appendix 3).
- Spatial Ecology & Conservation, International Conference. 5th to 7th September 2011. Birmingham University, UK. Presentation “Spatial analyses in support of wildlife conservation across frontiers in the High Andes”.
- Advances in Biogeography Conference. 23rd to 25th September 2011. Oxford University, UK. Presentation “Andean cat biogeography and conservation: an application of a niche model” (Appendix 4).

and one publication:

Marino J, Bennett M, et al. 2011. Bioclimatic constraints to Andean cat distribution: a modelling application for rare species. Diversity and Distributions, 17:311–322. Article first published: 16 Feb 2011.

3. Outcomes, lessons and Impact

The Darwin Fellowship has been instrumental to developing my research skills and to maximize my contribution to the High Andes Conservation without Borders Darwin Initiative project. During my time at WildCRU and the School of Geography, I have learnt many skills and tools that are relevant for my professional development as a geographer with interest in conservation of biodiversity and natural resources. The various courses, seminars and conferences I attended helped me generate new ideas for my research and to develop new ways to contribute to the conservation of High Andes ecosystems in Chile.

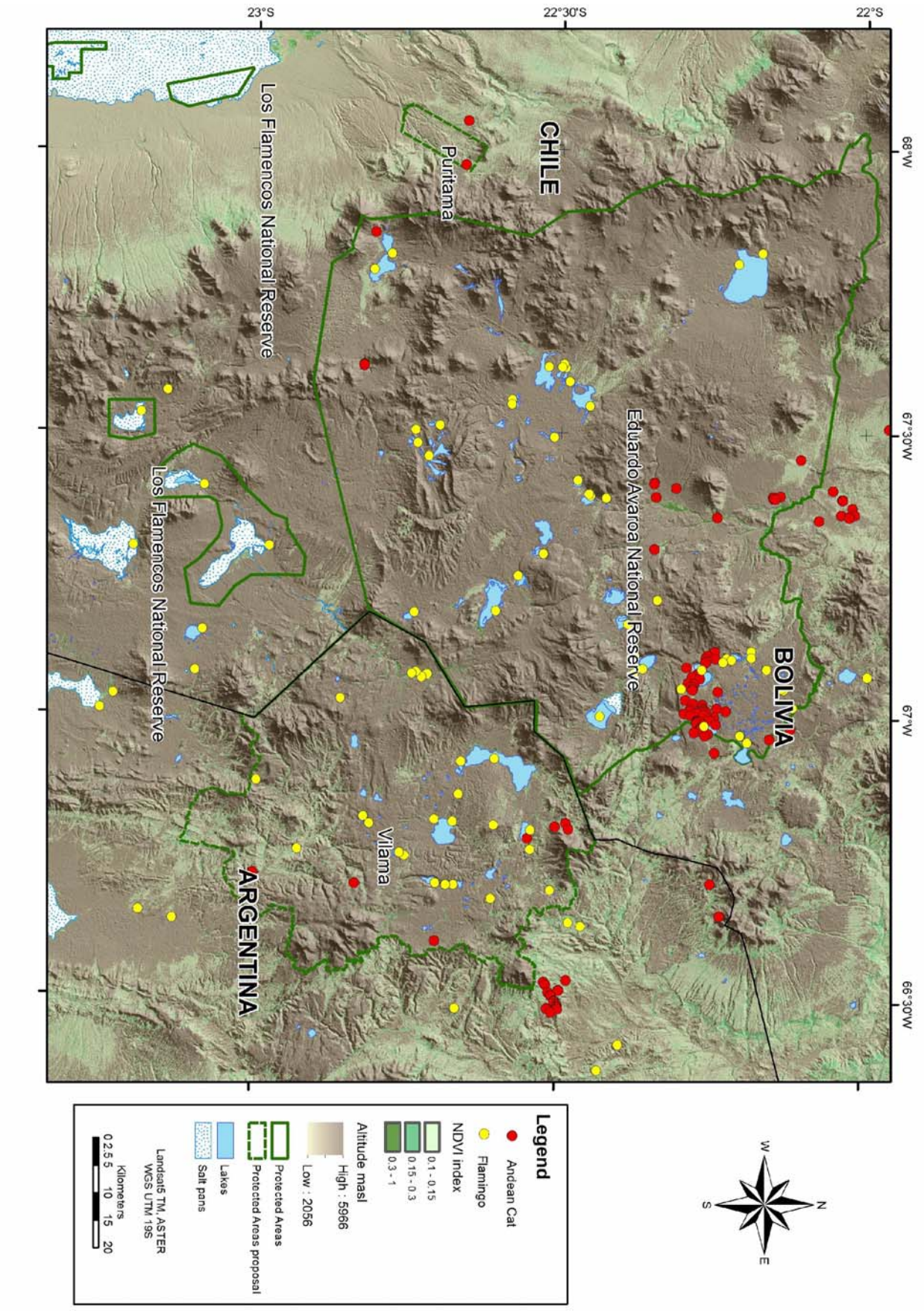
The experience that I gained in the field and during my time in Oxford is going to be crucial for the next three years of my doctoral research at WildCRU. The academic writing lessons, and the close collaboration with my supervisors, have helped me to improve my capacity to write scientific papers, with two papers currently in preparation.

Through my involvement with the Darwin Initiative project over the next few months I will have many opportunities to improve and apply my experience with applied conservation in the triple frontier of Argentina, Bolivia and Chile. This project has allowed me to understand the various levels at which conservation operates, giving me the opportunity to participate of conservation activities that involved researchers as well as protected areas managers, and local communities.

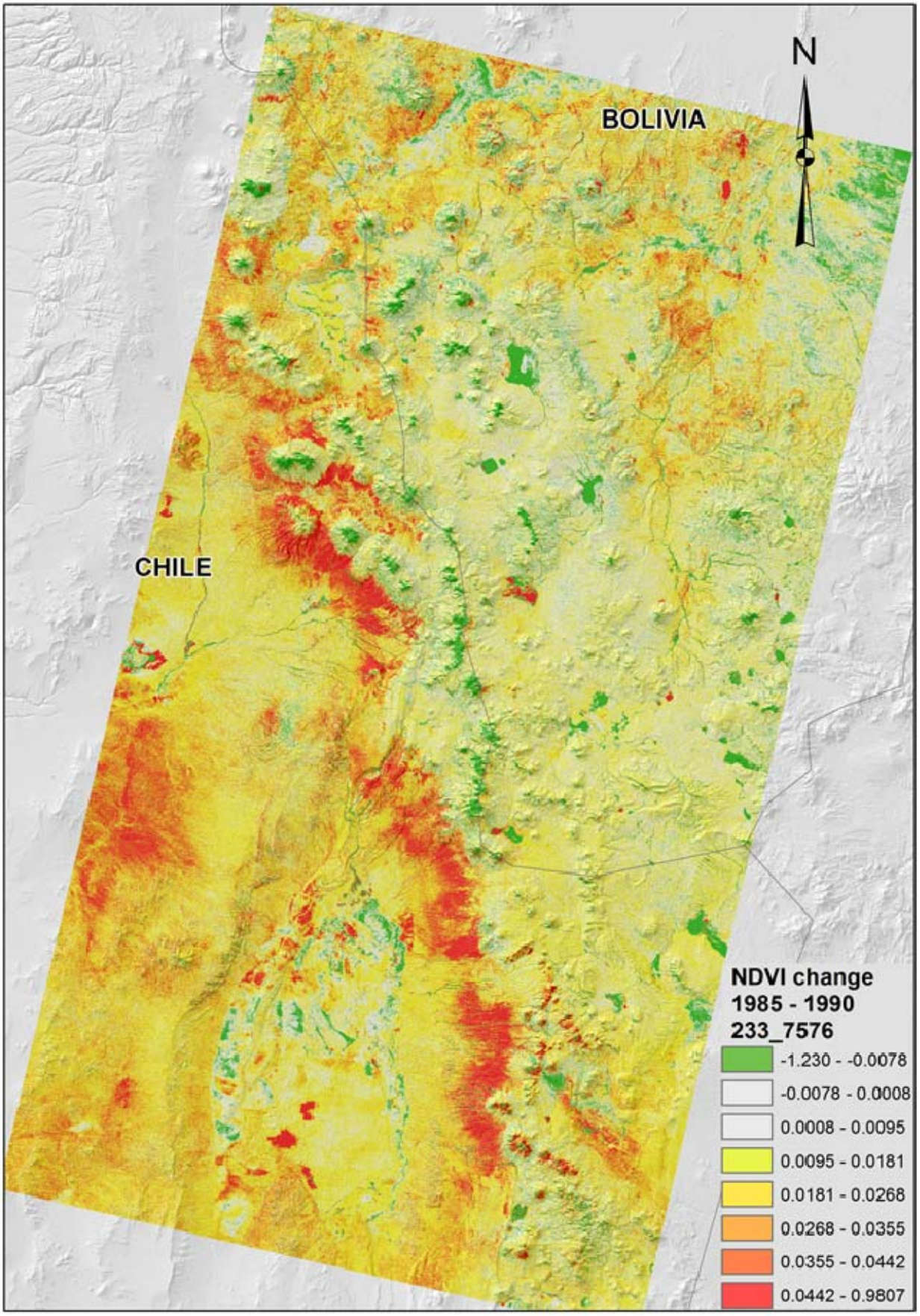
Over the last year I had opportunities to contact other UK biodiversity institutions, intergovernmental organisations and NGOs during conferences and seminars in Oxford and Birmingham. I made contacts with people in various different groups such as the European Environment Agency or Nature Server, of relevance for my present research and for future work in Chile. I maintain contact using email and social networks like LinkedIn and Facebook.

My experience as a Darwin Fellow has been very rewarding. I received excellent support from my colleagues at WildCRU. This institution has many experienced scientists willing to share their knowledge with the younger colleagues, and have helped me with my conservation work. Also, the chance of working as a team member in this research centre allowed me to learn other skills not directly related to my research. Moreover, the spirit of the people on this institution gave me more strength to continue working with my conservation topic.

Appendix 1. Study area with vegetation index (NDVI), Andean cat and flamingo presence.



Appendix 2. NDVI change between the end of the rainy season of 1985 and 2009.



Appendix 3. Oral presentation at the "First Latin American Congress (4TH Argentina) for the Conservation of Biodiversity" in Tucumán, Argentina.

Appendix 4. Poster presentation at the “Advances in Biogeography Conference”. Oxford University,UK.

Biogeographical and conservation applications of a niche model for Andean cats

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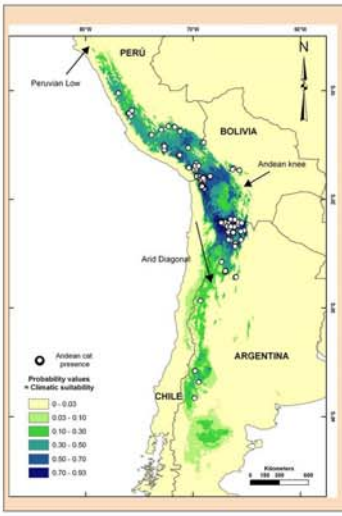
Wildlife Conservation Research Unit

Models of species' responses to their environment provide operational applications of their ecological niches. These are especially useful for threatened species that are rare and difficult to sample, or for which few data are available such as the Andean cat (*Leopardus jacobita*), one of rarest and least known felids in the world. We explore the conservation implications of a bioclimatic model developed from occurrence data, taking into account biogeographical barriers, gaps in knowledge, human pressure and level of protection within Protected Areas.

METHODS

- A climatic model was developed using Maxent software (n=237 presence locations) (Marino et al., 2011). The lowest presence probability was used as threshold between suitable and unsuitable habitat (Pearson et al., 2007) and 0.5 as the threshold for *best habitat*.
- Gap analysis: IUCN World Database of Protected Areas 2009 (WDPA, 2009).
- Threat analysis: *Human Footprint* layer (Sanderson et al., 2009).

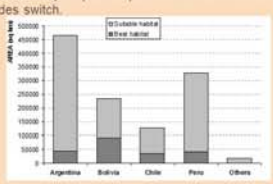
RESULTS

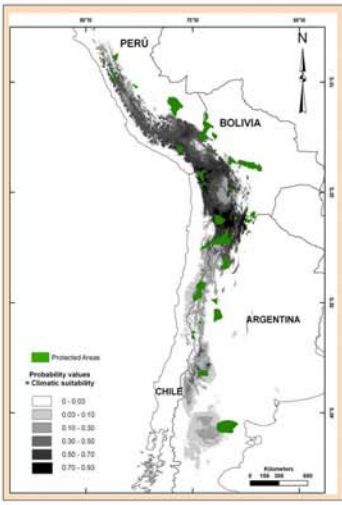


HABITAT QUALITY, DISTRIBUTION AND BIOGEOGRAPHICAL BARRIERS

Suitable climatic conditions for Andean cats are found along the High Andes in Peru, Bolivia, Chile and Argentina, and at lower elevations in the steppes of Argentina's northern Patagonia. Argentina contains the largest area of suitable habitat, followed by Peru. Bolivia contains more of the *best habitat*.
Low suitability coincides with biogeographical barriers also recognized as important boundaries for other species (marked with arrows in the map):

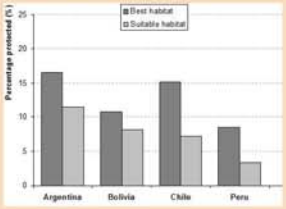
- the Peruvian Low, an arid, east-west valley dropping to about 500m;
- the 'Andean knee' in Bolivia, an hyper-arid transition zone between Wet Puna and Dry Puna;
- the South American Arid Diagonal, a hyper-arid zone where precipitation patterns at each side of the Andes switch.





REPRESENTATIVENESS OF ANDEAN CAT HABITATS INSIDE PROTECTED AREAS

- Protected areas (PAs) across South America encompass 8% of all suitable habitat.
- Of the 58 PAs with at least 100km^2 of suitable habitat, only 14 had confirmed records of Andean cats, and only 21 contained some *best habitat*.
- Andean cat habitats are proportionally less well represented within the PA network in Peru.
- Argentina is the country with the greatest representation within PAs.
- Bolivia contains the largest extent of *best habitat*, both inside and outside PAs.



HUMAN PRESSURE UPON ANDEAN CAT HABITAT

The *Human Footprint* expresses, as a percentage, human influence as a function of population density, land transformation, accessibility, and electrical power infrastructure. Suitable Andean cat habitat is under relatively higher human pressure in Peru, both inside and outside protected areas. Human pressure is lowest in Argentina.

Andean cat suitable habitat					
	area (km^2)	human footprint (mean, CV)	% protected	number of PA	PA Human Footprint (mean, CV)
*Total**	*1,172,320*	*16.5 (0.66)*	*8*	*58*	*12.2 (0.79)*
Argentina	466,260	9.9 (0.73)	11	16	7.5 (0.76)
Bolivia	233,270	17.2 (0.60)	8	14	14.5 (0.70)
Chile	127,560	15.0 (0.60)	7	7	14.2 (0.60)
Perú	326,720	23.1 (0.44)	3	10	19.0 (0.51)

PRIORITY AREAS FOR CONSERVATION AND RESEARCH

Taking into account Andean cat presence, potential corridors, human pressure and genetic structure of known populations, we prioritized conservation actions across regions and existing protected areas.

Actions	Priority targets		Priority criteria					
	Rank	Region or protected area	Contains *best habitat*	Potential corridor	Poorly represented in PAs	High human footprint	Range edge (more vulnerable)	Unique genotypes
a) Regional priorities								
Presence surveys in suitable areas with few or no records	1	(Bol & Chi) along the High Andes bt 19-21°S	x	x	x			
	2	(Arg) central Andes of Argentina	(patches only)		x			x
	3	(Arg & Chi) Arid Diagonal along the Andes bt. 27- 32°S		x				
	4	(Bol) around 67°W and 17-20°S				?		
	5	(Peru) around 70-71°W and 14-16°S				x		
	6	(Arg) northern Patagonia steppe			x		x	
	7	(Peru) northernmost range (above 10°S 77°W)				x	x	
b) Priorities in protected areas								
Promote effective protection of PA with Andean cat records	1	(Peru) PAs: Aguada Blanca	x			x		
	2	(Bol) PAs: Eduardo Avaroa, Sajama, Tunari, Madidi, Cotapata	x			x		
	3	(Arg) PAs: Otroz -Cauchari, Laguna de los Pozuelos, Campo de los Aliscos, Laguna Blanca, "San Guillermo		(*)				
	4	(Chi) Las Vicuñas, Lauca, Surire						
Promote effective protection & surveys in PA without records	1	(Arg) PA: Los Andes	x					x
	2	(Bol) PAs: Yura, Llica, Huancaroma, Cordillera de Sama, Cerro Tapilla, Minkiri	x					
	2	(Chi) PAs: Volcán Isluga, Los Flamencos en Chile	x					

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CONSERVATION IMPLICATIONS

- Climatic barriers affect the quality and connectivity of Andean cats habitat across the species distribution; and mitochondrial DNA studies have revealed genetic structuring consistent with these barriers. Surveys to determine the presence of Andean cats and of habitat corridors connecting Andean cat populations are a priority.
- Only 8% of the suitable habitat is protected, but the level of protection in many of these PAs remains inadequate. Promoting effective protection in PAs with Andean cats is a global priority. New PAs would contribute to increase representation of suitable Andean cat habitat in Peru.
- Human pressure is relatively higher in the Wet Puna of Peru and Bolivia, therefore protecting good quality Andean cat habitat is a priority.
- Finer resolution models would enable the inclusion of more direct variables and resources, and capture the characteristically patchy distribution of anthropogenic effects from water extraction, mining, tourism and hunting.

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