A research project to help preserve the endangered jaguar population of the Green Corridor of Misiones, Argentina

Annual report

January 2008 to July 2009

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REPORT SUMMARY

For the last five years we have been conducting research and conservation activities on jaguars and other felids in the Green Corridor of Misiones, Argentina, one of the biggest remnants of Atlantic Forest. Our research efforts have been focused primarily at obtaining an accurate estimate of the size of this jaguar population and at understanding what factors are threatening it. We assessed the current distribution of jaguars in the Upper Paraná Atlantic Forest establishing a network of volunteers (about 150 people) to obtain information on the presence of this species in the different forest remnants of this ecoregion in Argentina, Brazil and Paraguay. The volunteers collect data on sightings, plaster molds of tracks and feces of large carnivores with associated geographic information. Simultaneously, we obtain reliable density estimates for jaguars at three different sites using camera traps in combination with population models and evaluate how the availability of prey, hunting pressure and the abundance of the puma affects the abundance of jaguars. With this information we estimate a total jaguar population of between 25-53 individuals in the Green Corridor (Paviolo *et al.* 2008). With these results and in collaboration with scientists from the Alexander Center for Applied Population Biology at Lincoln Park Zoo (USA), we conducted a spatially explicit population and habitat viability analysis (PHVA) for the jaguars of the Green Corridor. The results of this PHVA suggest that poaching is the most important factor that affects jaguars and that this population has a high probability of extinction within the next 50 years if this situation is not reversed (Lonsdorf *et al.* in prep.). Simultaneously, in collaboration with government and nongovernment institutions we are developing a Conservation Plan for this population and we have conducted large-scale communication campaigns and education programs promoting jaguar conservation. Despite our important advances in knowledge about this jaguar population, several research questions remain to be answered that are critical to understand how to manage this population and save it from extinction. Currently we are conducting conservation-oriented research aimed at: 1) monitoring this jaguar population and estimating population trends and turnover rates with camera-trap surveys carried out at regular intervals, 2) fitting jaguars with GPS-collars to learn how they use their habitat, 3) evaluating the health status of this population and the potential of disease transmission by domestic carnivores, 4) studying the diets of jaguars, pumas and ocelots under different conservation regimes to understand the interaction of poaching (prey depletion) and intra-guild competition in jaguar conservation 5) understanding how landscape features affect jaguar persistence and its genetic variability. During 2008 we developed the third camera trap survey at the northern part of the Green Corridor. The density estimate is similar of that obtained in 2006 but slightly higher than the one obtained in 2004. Although our sample size is relatively small (N=13 individuals), survivorship of the adult individuals is relatively high compared with a previous study in the area (Crawshaw, 1995). According to these results the abundance of jaguars appears to be stable or increasing slowly during the last five years. This might be the result of recent conservation efforts that include better measures of habitat protection, as well as communication and education campaigns. During February and March of 2009 we have been working on attempts to capture jaguars. On February 26 we captured and fixed with a GPS collar our first jaguar. We collected biomedical samples for the evaluation of his health status and we are monitoring this jaguar periodically by land and aircraft flights. During the same period in collaboration of the Field Veterinary Program of Wildlife Conservation Society we were collecting samples of domestic carnivores of the neighborhood of the protected areas of the North of the Green

Corridor to evaluate the potential of disease transmission to jaguars. We also started to analyze felid feces to understand if there is an interaction between prey availability and intra-guild competition that could potentially affect jaguar conservation. In the same period we finished some of the analysis, at a regional scale, of the effects of fragmentation and land use patterns on jaguar and pumas distribution and population structure. During the next years we will continue with camera traps surveys to describe the population dynamics and monitor the effectiveness of conservation actions. We also will continue with jaguar captures to fix jaguars with GPS collars and collect biomedical samples. The information provided by collared jaguars will allow us understand how jaguars use the landscape in the Green Corridor, how the pattern of habitat use may impose risks on jaguars, depending on differential human impacts, and what characteristics corridors should have to be effective for jaguar movements across different portions of the landscape. The results of our research will be used to improve the ongoing Conservation Plan for this endangered jaguar population.

PROJECT LEADERS

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OTHER STAFF

-Veterinary Marcela Uhart, Veterinary team of Wildlife Conservation Society. (part time). Team role: Lead the jaguar immobilizations during captures, collection and analysis of biomedical samples of jaguars and domestic carnivores.
- Veterinary Virgina Rago, Veterinary team of Wildlife Conservation Society. (part time). Team role: Lead the jaguar immobilizations during captures, collection and analysis of biomedical samples of jaguars and domestic carnivores.
- Veterinary Hebe Ferreira, Veterinary team of Wildlife Conservation Society. (part time). Team role: Lead the jaguar immobilizations during captures, collection and analysis of biomedical samples of jaguars and domestic carnivores.
-Esteban Pizzio (Park ranger, part-time). Team role: Co-coordinator of the volunteer's network, samples process, local communication of the results, field assistant.
-Ricardo Melzew (Park ranger, part-time). Team role: Co-coordinator of the volunteers' network, samples process, local communication of the results, field assistant
-Lucia Palacio (undergraduate student, part-time). Team role: Diet analysis, samples process, data analysis, field assistant.
-Paula Cruz (undergraduate student, part-time). Team role: samples process, field assistant.
-Biol. Veronica Quiroga (part-time). Team role: field assistant.

PARTNERS AND OTHER INSTITUTIONAL AFFILIATIONS

National Parks Administration of Argentina (NPA) has provided assistance to this project, which is partly undertaken within the Iguazú National Park. The NPA has special interest in this project since this institution, along with the Secretary of Fauna and Flora of Argentina, has to implement (by national law that declared the jaguar a National Monument) a Conservation Plan for this species. The knowledge generated by this project is one of the main sources of information used to develop the Conservation Plan for the species.

Ministry of Ecology of Misiones Province of Argentina (MEM) has also provided support to this project. Our team participates in the Jaguar Committee, a consultant body to the government of Misiones. The MEM is also participating, along with staff from the NPA and NGOs in the development of the Conservation Plan for this jaguar population.

Fundación Vida Silvestre Argentina (FVSA) is an important national NGO and it has provided critical support to our research and conservation efforts in the Atlantic Forest. Both, Carlos De Angelo and I received small fellowships in 2003 to start up jaguar research in the Green Corridor. FVSA has a regional Atlantic Forest Program in Puerto Iguazú, Misiones, and has been providing funds, technical and field assistance to the project. This program has special interest in monitoring this jaguar population. FVSA has frequent contact with the media, and our jaguar project has been featured in national and local newspapers, TVs and radio stations. We are working with this institution in an education program related to jaguar conservation.

Lincoln Park Zoo (LPZ) has provided support to this project through grants to Dr. Di Bitetti. Our team is working in collaboration with its scientific staff in the development and improvement of a Population Viability Analysis for jaguars in the Atlantic Forest.

Wildlife Conservation Society (WCS): This institution funded our work with camera traps twice by a Jaguar Small Grant. In 2009, in collaboration with the Field Veterinary Program of Argentina of this institution, we started an evaluation of the potential impact of diseases in the conservation of this jaguar population and the identification of health threats from domestic carnivores in the area. The veterinary team is also assisting us in the immobilization process during the jaguar captures.

Brazilian Genetic team: we are working in collaboration with a team of researchers of the Pontificia University of Porto Alegre lead by Dr. Eduardo Eizirik. The main research topics are the development of genetic techniques to study felids on the wild and the evaluation of the genetic structure of jaguar populations of the Atlantic Forest.

STUDY AREA

The focal area of this project is located in the most interior portion of the Atlantic Forests of South America, usually referred to as the Upper Paraná Atlantic Forest eco-region. The region comprises the East of Paraguay, South West of Brazil and North East of Argentina (Figure 1). The Atlantic Forests of South America constitute a dramatic example of habitat loss and degradation. Considered one of the World´s hotspots for biodiversity (Myers *et al.* 2000), only less of 7% of the original forest cover remains as isolated forest fragments (Figure 2, De Angelo, 2009). The jaguar is being used as a focal species to guide conservation efforts and implement a biodiversity conservation landscape in the region (Di Bitetti *et al.* 2003).

The Green Corridor, located in the Misiones province of Argentina and adjacent areas of Brazil and Paraguay, is one of the biggest fragments of the Atlantic Forest (Figure 2). This area supports the southernmost jaguar population in the world (Sanderson *et al.* 2002, Paviolo *et al*. 2006) that is critically endangered (Paviolo et al. 2008). This population has been identified by a group of jaguar conservation experts as a "Jaguar Conservation Unit" as a result of its long-term conservation potential and its ecological uniqueness (Sanderson *et al*. 2002, Marieb, 2006). These authors suggest that scientific and conservation efforts should focus on this population.

In Argentina, the jaguar has been eliminated from most of its former range, and only three relatively isolated populations remain in the subtropical forests of the Northern portion of this country (Di Bitetti et al. 2006). The extinction of the population of Misiones province would mean one of the last steps towards the extinction of the species in Argentina, since the other populations are also threatened (Di Bitetti *et al.* 2006, Paviolo et al. 2008). Despite the critical situation of this population, if present conditions are reverted, the population of jaguars of the Green Corridor is still the one with the largest potential for long-term persistence in the Atlantic Forests (Sanderson *et al.* 2002, Marieb, 2006, Paviolo *et al.* 2008. Lonsdorf *et al.* in prep.).

Figure 1. Location of the Upper Parana Atlantic Forest in South America

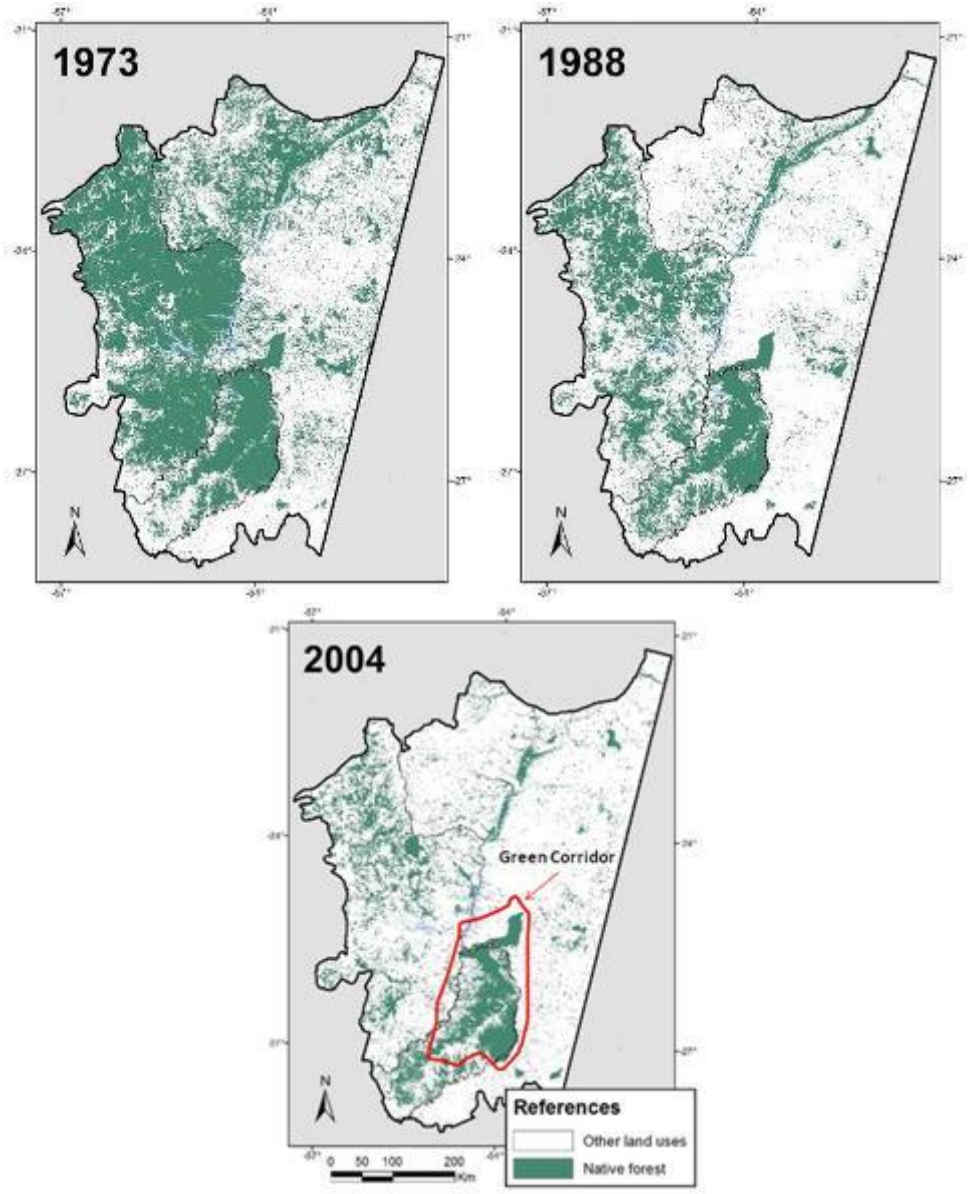

Figure 2. Large scale landscape analysis. Forest fragmentation process in the Upper Parana Atlantic Forest (De Angelo, 2009).

APPROVED BUDGET

Item	Amount	Status
Field equipment (including camera traps and GPS collars)	1,200	spent
Supplies	800	spent
Field expenses	1,000	spent
Gasoline and vehicle maintenance	2,000	spent
Total	5,000	

ACTIVITIES/PROGRESS

Goals

1-Estimate population dynamic parameters and monitor population trends for the jaguar population of the Green Corridor.

To study population turn-over rates and survivorships of jaguars we are conducting longitudinal camera-trap surveys at study sites we have already surveyed (in 2004 and 2006) in the North of the Misiones Province. The area includes the Iguazú National Parks of Argentina, the adjoining San Jorge Forest Reserve and Urugua-í area (see Paviolo *et al.* 2008 for description of the study sites and methods). This region was also part of the research area of Peter Crawshaw study (1995). Between April and July 2008 we developed a camera-trap survey that included all the areas previously surveyed and new areas such as Puerto Península Provincial Park.

At the study site we deployed 47 camera-trap stations, with two camera traps each, and placed at both sides of unpaved roads or trails. Total survey effort was 2327 trap/days and the estimated surveyed area was 1700 km^2 (Table 1). We photographed 16 individuals and estimated a density of between 0,95 and 1,3 ind/100km^2 (Table 1). The density is similar of that obtained in 2006 but slightly higher than the estimated in 2004. According to these results the abundance of jaguars appears to be stable or increasing slowly during the last years (Table 1). This might be the result of recent efforts of conservation that include better measures of protection of habitat (e.g., more park rangers, new protected areas), as well as of communication and education campaigns. However the density estimates are still lower than the 3,7 ind/100 km^2 estimated by Peter Crawshaw (1995) in early nineties.

Figure 3. Jaguar female photographed by a camera trap at the Iguazú National Park during the 2008 survey.

Table 1. Results of the camera traps surveys developed in the North of the Green Corridor. The population estimate was obtained using capture-recapture models (Mh) and the surveyed area was estimated using ½ of the mean maximum distance moved of the jaguars photographed in all the surveys.

Survey	Photograph /1000 days	Nº of animals	Population estimate	Area	Density (ind/100Km^2)
Iguazú 2004	6.131	4	5	661.05 Km^2	0,75 ± 0,24
Iguazú 2006	13,645	11	14	1065.6 Km^2	1,31± 0,26
Iguazú 2008	29,222	16	22	1698.5 Km^2	1,3± 0,28

The minimum survivorship of the individuals recorded by the cameras between 2004 and 2008 was 57% and was more than 70% between successive surveys (2004-2006 and 2006-2008). These values are relatively high if we consider that some individuals not recorded by the cameras in the 2008 survey could be still in the area (but could not be recorded by the cameras) or could have emigrated to other areas. These survivorship rates are relatively high if we compare them with the one obtained by Peter Crawshaw (1995) in the period 1990-1995 in the same area. None of the 8 individuals he monitored survived more than 3 years, and all were dead by the end of his study as a result of poaching and road kills (Crawshaw, 1995).

Figure 4. This jaguar named Mbareté (strong in Guaraní language) was photographed by our cameras in 2004, 2006 and 2008 surveys.

We are planning to developed new camera traps surveys in the area during the next years to develop population dynamic analysis using capture-recapture models

(Karanth *et al.* 2006). These activities will be part of the Post-doc research work of the PI in collaboration with Dr. James Nichols. Dr. Nichols is a researcher of the US Geological and has broad experience on population modeling. He has lead, in collaboration with Dr. Ullas Karanth, the development of the methodology that combines capture-recapture models with camera traps data to study the abundance and population dynamics of felids.

2- Study the landscape use by jaguars in the Green Corridor.

During February and March of 2009 we made attempts to capture jaguars. We used cage traps with live pig as bait (Figure 5). A removable compartment separated from the main trap with a strong steel mesh partition was utilized to house the bait. Previously, pigs used were dewormed and quarantined, to avoid introducing pathogens to the environment. Traps were checked daily, in the morning, and at this time the pigs were provided with fresh food and water. We used seven cage traps totalizing 324 trap-days. Traps were located in the Iguazú National Park (5) and Península Provincial Park (2), in the areas most frequently used by jaguars according our information provided by camera-traps.

Figure 5. The veterinary team and Agustin Paviolo checking a cage trap used to capture jaguars.

On February 26, we capture our first jaguar near Iguazú River at the Iguazú National Park (Figure 6). This individual was an adult male of 71 kg in very good condition, and named Guacurarí (the name of hero of Mbya-Guarani Indians of the region). This animal was previously recorded by our camera-traps in our surveys in the area in 2006 and 2008. Chemical immobilization and samples collection for health and genetic analysis were successful and we fixed the jaguar with a GPS collar (model Tellus, for more details see http://www.followit.se/wildlife/). The collar was programmed to fix a position every 30 minutes and emit VHF signal during light ours. The data can be recovered by a UHF receiver every time. We release the jaguar in the same place of capture and follow him by the VHF signal of the collar until the evening. The animal remains in the area the first hours. He apparently moved during the night because when we returned to the area in the next day we couldn´t listen the VHF signal.

Figure 6. Hebe Ferreira and Virginia Rago (Veterinary team) and Agustin Paviolo collecting biomedical samples and fixing the GPS collar to Guacurarí. This jaguar was photographed before during the camera traps surveys in 2006 and 2008.

On March 15 we located the jaguar near an intern road of Iguazú National Park at 8 km of the capture site and during this night we photographed him with a camera traps in the capture site (Figure 7). We located the jaguar several times during April and on day 25 we made our first flight to download the data in a helicopter, but we couldn´t find the VHF signal. On June 11 we made another flight in an aircraft and we located the jaguar but we download the data partially (48 localizations) because we had problems with the reception of the signal (Figure 8).

Figure 7. Guacurarí with the GPS collar photographed by a camera-trap 18 days after capture.

At present, we are buying a special UHF antenna to be mounted in the aircraft to have a better reception. We are planning another flight to the next month to download the data using the new antenna. During the next year we will restart our jaguar capture attempts increasing the effort (using at least 15 traps during more time) to increase the chances of jaguar captures.

Figure 8. View of the Iguazú Falls during one of our flights to locate the captured jaguar and download the GPS data.

3- To evaluate the potential impact of diseases in the conservation of this jaguar population and identify health threats from domestic carnivores in the area.

During February and March of 2009 we were collecting samples of the captured jaguar, domestic dogs and cats of neighborhood of the protected areas of the Green Corridor. The surveyed areas were Andresito (E of Iguazú National Park), the 2000 ha area of Puerto Iguazú (NW of Puerto Peninsula Provincial Park) and the Iguazú National Park, where Park Rangers have some domestic cats and dogs. We obtained blood samples and fecal swabs of 1 jaguar, 27 dogs and 12 domestic cats (Figure 9).

The blood was centrifuged (using a portable 3000 rpm centrifuge) and the serum obtained was conserved in liquid nitrogen for analysis of infectious diseases and blood biochemistry. When possible fresh fecal material was collected and preserved in saline solution with formaline, for posterior parasitological analyses. In case of presence of skin lesions they were scraped and samples stored in plastic vials with Vaseline for parasitological analysis.

Jaguar samples were recently sent to the Cornell Veterinary Diagnostic Laboratory to make serological test to evaluate the exposition of jaguars to infectious diseases (Feline leukemia, feline panleukopaenia, feline immunodeficiency, feline coronavirus, feline herpes virus, calicivirus, canine distemper, toxoplasma, heart worm, leptospirosis and rabies). Fecal swabs and cellular package of blood of the jaguar and domestic cats and dogs were sent to the University of Buenos Aires to make molecular analysis (PCR) and test the presence of pathogenic virus in the animals (FeLV, FIV, Fel. Panleukopenia, Canine parvovirus type 2). The samples for parasitological analysis have been sent to Dr. Pablo Baldomenico of the Universidad Nacional del Litoral. The results of all these analyses will be available in the next months. We still don´t sent the domestic carnivores samples for serological test because we don´t have funds to cover these analysis.

Figure 9. Veterinary Virginia Rago collecting samples of domestic carnivores of the neighborhood of forest areas where jaguars live.

4- Evaluate the diet of jaguar, pumas and ocelots in areas with different hunting pressure

Since July of 2008 we are working in the evaluation of the diet of these cat species. We prepared a reference collection of hairs, skins and skeletons of the mammals of the region available at Iguazú National Park that is helping in the identification of the prey items. We took pictures of hairs under different treatments in a microscope and described the hair morphology of most of the mammal preys of these cat species. With this information we developed a digital Guide of Hairs of Misiones Mammals (Palacio, 2009). Most of this work is being developed by Lucia Palacio, a student at the University of Mar del Plata. These activities are part of her degree thesis in biology that will be defended next August.

We have already analyzed more than 60 fecal samples from different places and cat species (Figure 10). Our preliminary analysis shows that jaguar diet is the least diverse of the three cat species. Jaguar diet is composed mainly for collared peccaries (*Pecari tajacu*) that constitute more than 70% of consumed biomass (Palacio, 2009). It is important note that white lipped peccaries (*Tayassu pecari*) were not founded in the jaguar feces. This species was the most important prey of jaguars in the region (Crawshaw, 1995), but suffered a population decline in the Northern part of the Green Corridor after the nineties (Paviolo *et al.* 2008). Pumas have the most diverse diet comprising 15 species. The most important prey according to the biomass consumed were also the collared peccaries (47%), white lipped peccaries (16%) and brocket deer (9% *Mazama americana* and 6% *Mazama nana).* The records of white lipped peccaries correspond to feces founded at Yabotí Biosphere Reserve where this peccary is abundant (Paviolo *et al.* in press). The ocelot showed diet diversity levels between the jaguars and pumas. The most important prey for this species in the region was the dwarf brocket deer (*Mazama nana)* comprising more than 50% of the

consumed biomass. Other important prey were agouties (*Dasyprocta azarae*) and coatis (*Nasua nasua*) comprising 10% of consumed biomass each.

Figure 10. Lucia Palacio analyzing feces to study jaguar, puma and ocelot diet. As part of her graduate thesis at the University of Mar del Plata, she developed a digital guide of mammal hairs of Misiones and analyzed 60 feces of wild cats.

We will continue with the analysis of feces during the next year. We are waiting the results of the feces identification process of 400 samples that will be incorporated into the data set. The identification will be developed by the Global Genetic Program of the American Museum of Natural History of New York. A higher number of samples will allow us studying the diets of jaguars, pumas and ocelots under different conservation regimes to understand the interaction of poaching (prey depletion) and intra-guild competition in jaguar conservation.

5- To evaluate the effect of fragmentation on jaguar persistence and population structure.

To maintain our volunteer's network active collecting jaguar and puma data along the Upper Parana Atlantic Forest eco-region, we trained two members of our team to lead the coordination of this network. Esteban Pizzio and Ricardo Melzew are park rangers that work in provincial and national parks respectively, and they have been collaborating with our project through many years. They are well-known by the volunteers and their relationship with different institutions (provincial and national institutions) makes them particularly important in maintaining the contact and the motivation of the volunteers. We elaborated and distributed our seventh dissemination bulletin, and we published and distributed through the nodes of the volunteer network a Track Identification Guide (De Angelo *et al*. 2008). These two materials, not only maintain volunteers informed about our work, but also they are an important tool for motivation and training.

Figure 11. Carlos De Angelo with volunteers of the Yaguareté Project Network collecting felids tracks in Paraguay.

In addition, we were working hardly in data analysis. Through a network of volunteers, in the past few years we have collected a lot of information of big felids presence along the ecoregion. We were analyzing these data and we elaborated maps of pumas and jaguar presence for this region (Figure 12). On the one hand, this work implied laboratory work for DNA identification of fecal samples with a new DNA-identification method that we developed together with a Brazilian research team (see Haag *et al*. 2009). Genetic material obtained from fecal samples were used by partners from Brazil to demonstrate that non-invasive DNA sampling can be used to study the genetics and ecology of melanism in the jaguar, by directly genotyping the molecular polymorphism underlying this coloration trait (see Haag *et al*. in press). This allowed us to confirm that all the jaguar samples collected in the Argentina come from non-melanistic animals, while in the northern Brazilian region (Alto Paraná – Paranapanema) there are a high proportion of melanistic animals (Haag *et al*. 2009b) that is coincident with the information obtained in camera traps surveys.

Furthermore, we were working on tracks identification and in the positioning of presence data by using GIS. Jaguar presence was confirmed in a large area of the Green Corridor in Misiones, and in the largest forest remnants of Brazil and Paraguay. Pumas showed a wider distribution, being recorded throughout Misiones province and including areas of Brazil and Paraguay where jaguars were not detected (Figure 12).

Jaguars and pumas are the largest felids of the American continent. They are similar in size and behavior, but pumas show larger distribution range and appear to be more resilient to human impacts. We used presence-only data collected through a monitoring program (Figure 12) to compare the response of both species to landscape characteristics in a highly modified environment, the Upper Parana Atlantic Forest, where both species had continuous distribution in the past.

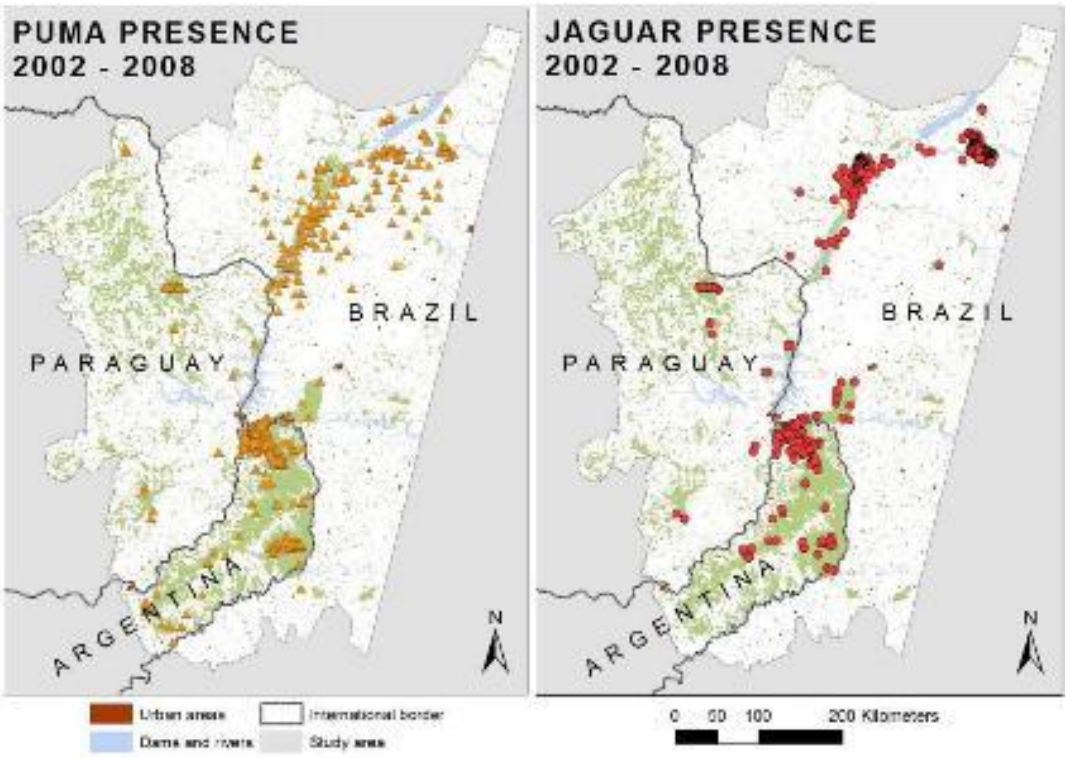

Figure 12. Location of data of puma (left) and jaguar (right) presence (between July 2003 and July 2008) in our study area. Locations in the northern region of Brazil were provided by Dr. Laury Cullen, Fernando Lima, Kaue Abreu and Denis Sana.

Using Ecological Niche Factor Analysis (ENFA), we characterized species-specific habitat requirements; built habitat suitability maps and examined interspecific differences in response to landscape fragmentation. Both species showed high dependence on native forest and habitat protection, and avoided highly modified environments and areas more accessible to humans. However, jaguars showed higher differences between their optimal habitat and the available landscape (higher "marginality") and lower tolerance to deviations from their optimal habitat than pumas that resulted in a larger area suitable for pumas (Figure 13). All jaguar suitable areas were also suitable for pumas; however 54% of puma suitable habitat, characterized by higher fragmentation and less protection, was unsuitable for jaguars.

Our results support the hypothesis of higher puma adaptability to human-altered environments. It has been suggested that this adaptability is related to puma's ability to survive on smaller and more diverse prey species than jaguars, but their differences in life history patterns and relationship with humans are probably also influencing their differential response. This difference may explain why pumas are now the only large cat in vast portions of a previously shared range in the Americas (De Angelo 2009).

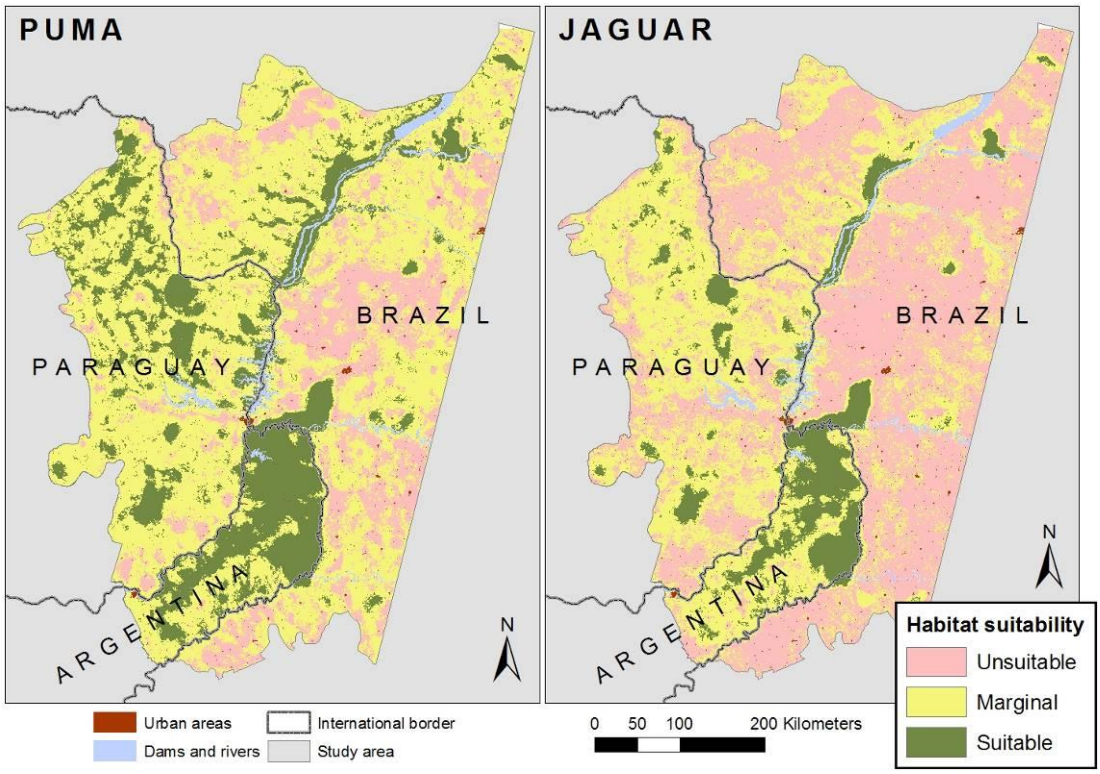

Figure 13. Habitat suitability for pumas (left) and jaguars (right) in the Upper Parana Atlantic Forest eco-region, estimated using ecological niche factor analysis (De Angelo, 2009).

At present, we are implementing a more detailed analysis for jaguars using generalized lineal models. Our preliminary results showed that jaguar persistence is determined not only by present conditions of this fragmented forest, but also by the fragmentation history of the landscape. Characteristics of surrounding land use and human pressure were also important to determinate jaguar presence in the forest remnants of the UPAF. A bidimensional model of habitat suitability is allowing us to determine the probable spatial structure of jaguar population and to detect priority areas to implement different management actions to preserve both this species and the UPAF (see De Angelo 2009).

6- Other conservation actions

Helping the authorities to punish jaguar poaching

In January of 2009 the Argentinean Federal Police and Park Rangers of Misiones Province capture a poacher with a jaguar coat in the 2000 ha area (near of Puerto Iguazú city) and called us to evaluate if the coat was of a recently killed animal (Figure 14). In general, when poachers are captured with jaguar coat in the region, they said that the coat is old and that they hunted the jaguar when hunting was not banned.

Due to our long time effort on research with camera traps in the Northern part of Misiones, we have a complete record of spot coat pattern of jaguars that live in the area. We compared the spot pattern of the coat with our studied animals and we identified the coat as belonging to a juvenile jaguar that was photographed in our 2006 survey at Iguazú National Park (Figure 14). The authorities denounce the poacher in the justice and used this evidence to confirm that the jaguar was poached recently. At present the judicial process is under way.

Figure 14. Left: Provincial Park Rangers and Federal Police agents with the coat of a jaguar poached. Write: The poached jaguar photographed by a camera trap in the Iguazú National Park during 2006 survey. Our camera traps record we demonstrate that the jaguar was recently poached.

Jaguar Conservation Plan for the region

During 2008 we participated in the elaboration of the Jaguar Conservation Plan for this jaguar population. This plan was elaborated in a participative process that includes National and Provincial authorities, NGOs and scientist. We provide most of the information related with the present status of jaguars in the Green Corridor (distribution, density, population size), and its main threats (evaluated by the PHVA that we developed). A preliminary version of this plan is being evaluated by the NPA and MEM authorities and, if approved, it will be officially supported.

Participation of Forest Landscape Planning Process

During 2008 was approved the National Law (26.331) that includes a nationwide one-year moratorium on clearing of native forests to avoid a rush of deforestation while forest management regulations are put in place. Regulations are related with the development of a participative Provincial Forest Landscape Planning, and also established environmental impact studies and public hearings. Provinces that have all the regulations ready will begin to receive funds to pay land owners a fund for forest conservation.

As a result of the Landscape Planning Process will be developed a map of the Province with areas of different categories (replacement of forest allowed, only selective logging allowed, no extractive activities allowed). As a result of our work in jaguar landscape analysis, we have developed a map of priority areas for jaguar conservation in the Misiones Province that could serve as input for this process. Recently the Misiones Government and NGOs invited us to participate in the process and show interest of use the jaguar requirements information as one of the main guides to the elaboration of the plan.

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PROBLEMS AND CONSTRAINTS:

One of the problems that we faced during this period was our difficulty to send the fecal samples to the USA, where they were going to be analyzed by the Global Felid Genetics Program (WCS- American Museum of Natural History's Center). The package we sent was returned by the USA customs without explanations, despite having all the Argentinean permits to export the feces (and USA did not require special permits for this material). We requested information in the USA custom but they don´t know what was the problem and why the package was returned. We sent the feces again to US with other researchers and we hope to have the feces identification for the next months.

We also had problems to receive on time the first two GPS collars and the receptor. The equipment arrived to Argentina in February 2008 but was retained by the Customs Office for six months and this delayed our plans to start capturing jaguars by mid 2008. We had access to the collars in September but at this time the veterinary team was not available and we decided to retard the captures until February 2009. Also, we plan to capture at least five jaguars during 2009 but we have captured only one. The problems were related with the low effort (only two months) due to that we have few funds to cover a more extensive work and to a relative low capture rate. For the next year we are planning to have funds to cover at least 6 months of capture work with higher number of traps and the use of other capture techniques.

GOALS/ACTIVITIES FOR THE NEXT YEAR

For the next year we will develop a new camera trap survey in the northern part of the Green Corridor to have information on population trends and population dynamics on jaguars and ocelots. I will travel to USA to develop these population models in collaboration with Dr. James Nichols. Also we will continue our attempts to capture jaguars to fit them with GPS collars and we will collect biomedical samples to assess their health status. We will monitor these animals and download their locations. We will build a GIS with the jaguar locations and start to analyze their movement patterns and habitat use. We will continue with the collection of domestic carnivore samples and health analysis. We are starting collaboration with Dr. Karen De Matteo, who is using two dogs trained to find jaguar, pumas and bush dog feces to assess habitat use by these species using this technique and we will continue our work of the analyses of the feces to analyze the diet of wild cats. We also will continue with the data collection by the network of volunteers.

We will proceed with the analysis of the data we have already gathered and we will be working in the dissemination of the result by different means. Another task for next year will be to help with the effective implementation of the Jaguar Conservation Plan and Misiones Forest Landscape Planning.

CONSERVATION ACCOMPLISHMENTS & EVALUATION

Despite some drawbacks (the delay of jaguar captures), the project was very successful at generating basic population information that was required to assess the status of jaguars and that was incorporated into the PVA and the Conservation Plan.

We finished some important analysis at landscape scale work, and we completed a new camera-trap survey. Also, we started with the diet study, we captured and fixed our first jaguar and we move forward with the health analysis of jaguars and domestic carnivores.

Likewise, an important part of the success of this project consists in the dissemination of the results to the public and the implementation, in collaboration with local partners (ONGs and public institutions), of effective actions to promote jaguar conservation in the Green Corridor. During this period we published several papers, chapters in books and two guides. We presented our results at national scientific conferences (see list of publications and papers presented at scientific meetings) thus making available new knowledge. We also have frequent contact with the media and our project has been featured in national and local TVs, radios and newspapers.

An important achievement was the completion of a first draft of the Jaguar Conservation Plan. The elaboration of this plan was a participative process and we hope that will promote the conservation of this jaguar population.

LIST OF PUBLICATIONS DURING LAST YEAR:

Peer review journals

2009. Paviolo, A., Di Blanco, Y. E., De Angelo, C. D. and Di Bitetti, M. S. Protection affects puma abundance and activity patterns in the Atlantic Forest. Journal of Mammalogy 90(4): 926-934.

2009. Haag, T., A. S. Santos, F. Valdez, D. Sana, L. Silveira, L. Cullen Jr, C. De Angelo, R. G. Morato, P. G. Crawshaw Jr., F. M. Salzano and E. Eizirik. Molecular tracking of jaguar melanism using faecal DNA. Conservation Genetics. In press.

2009. Di Bitetti M. S., Y. E. Di Blanco, J. A. Pereira, A. Paviolo and I. Jiménez Pérez. Time partitioning favors the coexistence of sympatric crab-eating foxes (*Cerdocyon thous*) and pampas foxes (*Lycalopex gymnocercus*). Journal of Mammalogy 90(2):479–490.

2009. Haag, T.; Santos, A.S.; De Angelo, C.; Srbek-Araujo, A.C.; Sana, D.; Morato, R.G.; Salzano, F.M. and E. Eizirik. Development and testing of an optimized method for DNA-based identification of jaguar (*Panthera onca*) and puma (*Puma concolor*) faecal samples for use in ecological and genetic studies. Genetica DOI 10.1007/s10709-008-9347-6.

2008. Paviolo, A., C. D. De Angelo, Y. E. Di Blanco and M. S. Di Bitetti. Jaguar population decline in the Upper Paraná Atlantic Forest of Argentina and Brazil. Oryx, 42(4): 554-551.

2008. Di Bitetti, M. S., C. De Angelo, A. Paviolo and Y. Di Blanco. Local and continental correlates of the abundance of a neotropical cat, the ocelot (*Leopardus pardalis*). Journal of Tropical Ecology 24:1-12.

2008. Di Bitetti, M. S., A. Paviolo, C. Ferrari, C. De Angelo and Y. Di Blanco. Differential responses to hunting in two sympatric species of brocket deer (*Mazama americana* and *Mazama nana*). Biotropica 40: 636-645.

2008. Kelly, M. J., A. J. Noss, M. S. Di Bitetti, L. Maffei, R. Arispe, A. Paviolo, C. D. De Angelo and Y. E. Di Blanco. Estimating puma densities from camera

trapping across three study sites: Bolivia, Argentina, Belize. Journal of Mammalogy. 89(2): 408–418.

2008. Izquierdo, A., De Angelo, C. and M. Aide. Thirty years of human demography and land-use change in the Atlantic Forest of Misiones, Argentina: a test of the forest transition model. Ecology & Society 13(2): 3. [online] http://www.ecologyandsociety.org/vol13/iss2/art3/

Thesis

2009 De Angelo, C. D. El paisaje del Bosque Atlántico del Alto Paraná y sus efectos sobre la distribución y estructura poblacional del jaguar (*Panthera onca*) y el puma (*Puma concolor*). PhD Thesis, University of Buenos Aires, Argentina.

Books

2009. Palacio, L. *Guía de pelos de los mamíferos de Misiones*. Centro de Investigaciones del Bosque Atlántico. 54 pp. Only in digital format.

2008. De Angelo, C., A. Paviolo, Y. Di Blanco & M. S. Di Bitetti. *Guía de Huellas de los Mamíferos del Bosque Atlántico del Alto Paraná*. Editorial Subtropical, Tucumán, Argentina.

2008. Taber A., et al. *Análisis de la Distribución y el Estado de Conservación del Tapir (Tapirus terrestris) y el Pecarí Labiado (Tayassu pecari) en Latinoamérica y una Llamada de Acción*. Grupo de Especialistas en los Suiformes (PPHSG) y Grupo de Especialistas de Tapires (TSG), Comisión para la Supervivencia de Especies (SSC), Unión Mundial para la Conservación de la Naturaleza (IUCN), Wildlife Conservation Society y Wildlife Trust

Chapters book

In press. Paviolo, A., C. De Angelo, Y. Di Blanco, I. Agostini, E. Pizzio, R. Melzew, C. Ferrari, L. Palacio, and M. S. Di Bitetti. Efecto de la caza furtiva y el nivel de protección en la abundancia de los grandes mamíferos del Bosque Atlántico de Misiones. In Contribuciones para la conservación y manejo del Parque Nacional Iguazú (B. Carpinetti and M. Garciarena, eds.). Administración de Parques Nacionales, Buenos Aires, Argentina.

In press. Di Bitetti, M. S., Quiroga V., De Angelo C. D., Altrichter, M., Paviolo, A., Cuyckens, E., Boaglio, G., Earnhardt, J. and E. Lonsdorf. El yaguareté (*Pantera onca*) en la Argentina: Situación poblacional, amenazas y acciones para su conservación. In Las especies amenazadas de Argentina. (G. Porini y D. Ramadori, eds) Subsecretaría de Fauna de la Nación. Buenos Aires, Argentina.

In press. Chalukian, S., de Bustos, S., Lizárraga, L. Paviolo, A., Varela, D. and V. Quse. El tapir (*Tapirus terrestris*) en Argentina: estado actual y perspectivas de conservación. In Las especies amenazadas de Argentina. (G. Porini y D. Ramadori, eds) Subsecretaría de Fauna de la Nación. Buenos Aires, Argentina.

Other publications

2009. Paviolo, A. El primer yaguareté monitoreado. Vida Silvestre. 107: 18-21.

2008. Di Bitetti M. S. Depredadores tope y cascadas tróficas en ambientes terrestres. Ciencia Hoy 18 (108), 32-41.

2008. De Angelo, C., A. Paviolo, D. Rode & M. S. Di Bitetti. Uniendo esfuerzos para monitorear al yaguareté en la Selva Paranaense. Boletín del Proyecto Yaguareté Nº 7, Junio 2008.

Works presented at scientific meetings

2009. De Angelo, C., Paviolo, A. and M. Di Bitetti. Tres historias detrás de un mismo paisaje: los cambios en los usos de la tierra del Bosque Atlántico del Alto Paraná en Argentina, Brasil y Paraguay. II Jornadas Argentinas de Ecología de Paisajes. Córdoba, Argentina. Oral presentation.

2008. Paviolo, A. J., De Angelo C. D., Di Bitetti M. S., Palacio, L., Cruz, P. Pizzio, E. and Di Blanco, Y. Estudio de la dinámica poblacional del yaguareté (*Panthera onca*) en Misiones mediante cámaras trampa, resultados de seis años de estudio. XXIII Reunión Argentina de Ecología. San Luis. Argentina. Oral presentation.

2008. Paviolo A. J., Di Blanco Y. E., De Angelo C. D. and Di Bitetti M. S. Abundancia y patrón de actividad del puma (*Puma concolor*) en áreas con diferente nivel de protección XXII Jornadas Argentinas de Mastozoología. Villa Giardino (Cba.), Argentina. Oral presentation.

2008. De Angelo, C., Paviolo, A. & M. Di Bitetti. Monitoreo participativo de la distribución del puma y el yaguareté en el Bosque Atlántico del Alto Paraná. XXII Jornadas Argentinas de Mastozoología. Villa Giardino (Cba.), Argentina. Oral presentation.

2008**.** De Angelo, C., Paviolo, A. & M. Di Bitetti. Modelos multivariados y desarrollo de claves para identificar huellas de puma, yaguareté y grandes cánidos. XXII Jornadas Argentinas de Mastozoología. Villa Giardino (Cba.), Argentina. Oral presentation.