FINAL REPORT TO THE RUFFORD FOUNDATION

"The effect of overgrazing and deforestation on a population of gray brocket deer (*Mazama gouazoubira*) in the arid area of the Chaco Region of Córdoba, Argentina."

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MANAGEMENT PROBLEM

The loss of biological diversity is closely related to economic progress, which is currently reaching dramatic proportions (Sánchez, 1999). The loss of good quality and extensive natural habitats is considered to be one of the principal causes of extinction or loss of biodiversity (overexploitation of species, chemical contamination of local and global habitats, and introduction of exotic species) (Ehrlich and Ehrlich, 1981; Martino *et al*., 1996). The loss of habitat could be associated to many factors, but today's deforestation is currently one of the most important (Bucher and Huszar, 1999).

The loss of forested area is presently reaching alarming proportions. Between 1960 and 1990, the world's forest coverage was 13%, with an average calculated loss that is equivalent to that of 16 million hectares a year (Bertonatti and Corcuera, 2000). Argentina is not a stranger to this worldwide reality; there were 160 million hectares of forest (26.5%) and mountains (73.5%) in Colonial times which represented 61.4% of the continental national territory. According to the "First Forest Census" in 1914, there were 105,888.400 hectares. According to the First National Inventory of Native Forests, there are currently still 33 million hectares remaining which have a high rate of transformation of approximately 250,000 hectares annually. These are found mainly in the Dry Chaco, the Wet Chaco and the piedmont forest of the Yungas. The process of conversion of natural ecosystems to cultivated land is a reality driven and stimulated by many socioeconomic, political, technological (direct and transgenic cultivation) and even climatic variables (Montenegro *et al*., 2004; Brown *et al*., 2006). Forest exploitation for the production of coal from wood and the use of fire for the production of pastures are considered to be two of the main activities that threaten the integrity of the Chaco forests.

In Córdoba, deforestation and the expansion of agriculture have affected considerable proportions of the original autochthonous vegetation of the province, including the Eastern *espinal* and the Northern and Western Chaco forests (Luti *et al*., 1979; Martino *et al*., 1996). Córdoba is considered the third province with the greatest loss of total forest (Bucher and Gavier, 2004; Montenegro *et al*., 2004). This process, described in detail by Morello and Saravia Toledo (1958), Bucher and Schofield (1981) and Bucher and Huszar (1999), may have a negative impact on biodiversity and the potential productivity of the natural vegetation. The intense entropic disturbances in the region have specifically affected the physical and biological parameters of the soil and the biota in general (Adamoli *et al*., 1990; Abril and Bucher, 1999; Bonino and Araujo, 2005; Abril *et al*., 2005). The fragmentation and

degradation of its forests has negatively affected the distribution of populations and the structure of the communities of different vertebrates such as mammals, birds and reptiles (Lopez de Casenave *et al*., 1998; Altritcher and Boaglio, 2004; Politti (2003) Leynaud and Bucher 2005). Nonetheless, the response of other groups of vertebrates to the loss and degradation of de Chaco forest has yet to be analyzed.

There are limited studies in the continent that have evaluated the effect of this process of environmental degradation on the gray brocket deer (*Mazama goazoubira*). The gray brocket deer is a typical inhabitant of border and forested areas where it is usually seen by itself or in couples. Its ecological behaviour is that of a generalist since it is found in a variety of habitats, preferably in different types of forests with a good amount of tree cover (Parera 2002).

There is indirect evidence that indicates that this species is decreasing in numerous localities throughout the entire country (Chebez and Jonhson 1984, Parera 1993; Richard *et al*. 1995). The loss of forest mass could negatively affect the population density of the grey brocket deer, as well as the indiscriminate hunting of cervids in different parts of the country (Richard, 1999) and the use of them by different rural communities (Richard *et al*., 1996; Giraudo and Abramson, 1998; Barbarán, 2000; Bolkovic, 1999).

Although the gray brocket deer has a wide distribution, there is still limited knowledge of its natural history, which is restricted to *M. americana* y *M. gouazoubira* (Stalling, 1986; Branan, 1985; Yanovski and Mercolli, 1994; Richard *et al*., 1995; Cartes, 1999; Juliá and Richard, 1996; Black, 2000; Richard and Juliá, 2001). Only recently, in Argentina, there have been certain advances based on studies that inform about some aspects of its biology and conservation (Chébez and Johnson, 1985; Richard *et al*., 1995; Juliá and Richard, 1999; Richard and Juliá, 2001). There is, nonetheless, a great deal of information that is still needed in order to study the different aspects of the natural history that affect this species, including its population state and dynamic, feeding, use of habitat and present real status, among others equally important. This lack of information makes it hard, if not impossible, to implement consistent politics of management and/or conservation.

Studies on the use of habitat are fundamental in order to evaluate the adaptive characteristics of a species. Eventually, the use of the species by humans can also be evaluated. Nonetheless, this type of information is fragmentary, incomplete and punctual for *M. gouazoubira*, with isolated references and anecdotic information on the entire distribution range of the species (Schaller, 1983; Redford and Eisemberg, 1992). In Argentina, we only find a few bibliographical references for the North-eastern Region (NOA) (Richard *et al*.,

1995; Juliá and Richard, 2000) and for other punctual areas of the country. It is important to highlight studies by Yanovski and Mercolli (1994) and Cartes (1999) on use and habitat preferences of the gray brocket deer.

PREVIOUS STUDIES

The pellet count technique was validated in the Chancaní Reserve and the population density of *Mazama goauzoubira* was calculated in an area of the Arid Chaco Reserve during the previous grant received by this research team (Density estimates of grey brocket deer *Mazama gouazoubira*: validation of censuring techniques in Chancaní Reserve, Córdoba, Argentina). The average population density of the gray brocket deer in the Chancaní Reserve was 5.26 individuals/km$_2$ (0.96 – 8.97 individuals/km$_2$, according to the different areas of vegetation present). The parameters used for the equation to estimate density for this species in the area were also adjusted (maximum persistence time of the feces on the ground and rate of daily defecation).

In this manner, a reference population size was established for an area of the reserve that was in a good conservation state and where the intervention of man is nonexistent. The purpose of this estimated value is for comparative measures, in order to evaluate presence of changes in surrounding areas where traditional management of the fields take place. These management techniques include the removal of trees and the introduction of cattle, which negatively affect the establishment and use of habitat by the gray brocket beer.

GENERAL OBJECTIVE

To evaluate the state of the populations of gray brocket deer in areas with an intense history of environmental degradation by comparing them to reference data obtained from populations of a protected area with more than 25 years of closure (Chancaní Forest Reserve) in the Eastern part of Córdoba Province.

SPECIFIC OBJECTIVES

1. To estimate the population density of the gray brocket deer in areas with different degrees of forest and cattle farming use and to establish comparisons with data from protected areas (without impact) (data from previous study).
2. To identify the habitat characteristics that influence the abundance of the gray brocket deer populations.

3. To evaluate the role of the Chancaní Reserve in the protection of the species in this area by comparing the density observed in areas surrounding the protected area with the one registered in the Reserve.
4. To reveal information on the aspects of the natural history which demonstrate to be key aspects in the conservation of the species, such as use of habitat and diet.

METHODS

Population density estimates in degraded areas and the relationship with a well conserved reference area (Chancaní Reserve)

Population density estimation of the grey brocket deer in degraded sites was based on group pellet counts in temporary plots. Sixty-five 600-m2 plots were distributed randomly throughout the degraded areas, surrounding Chancani Reserve (Fig. 1).

Plot assignation was determined using a 150m2 cell grid on top of an aerial image of the region. The number of plots fixed was determined through an estimate of the minimum number of samples (Sutherland 1996), calculated with values obtained by an initial sampling. The plots were marked and their satellite position was established using a GPS. Two investigators walked each plot identifying and recording the number of pellets observed at each point.

The density estimate of the grey brockets was determined using the following equation:

$$\text{Density} \quad \frac{\#\textit{pellets per area}}{\#\textit{daily defecations x max persistence in days}}$$

Assuming that pellet abundance is proportional to the number of individuals present in an area and the daily defecation rate, this equation divides the number of pellets/area by the daily defecation rate to obtain an estimate of use (days x animal)/area. The population density (animals/area) is obtained by dividing the resulting value by the days the pellets persist on the ground (Ojasti & Dallmeier 2000).

We also analyzed pellets abundance difference between degraded area with reserve area data using the Poisson regression model (a generalized linear model with log link function; Dobson 1990).

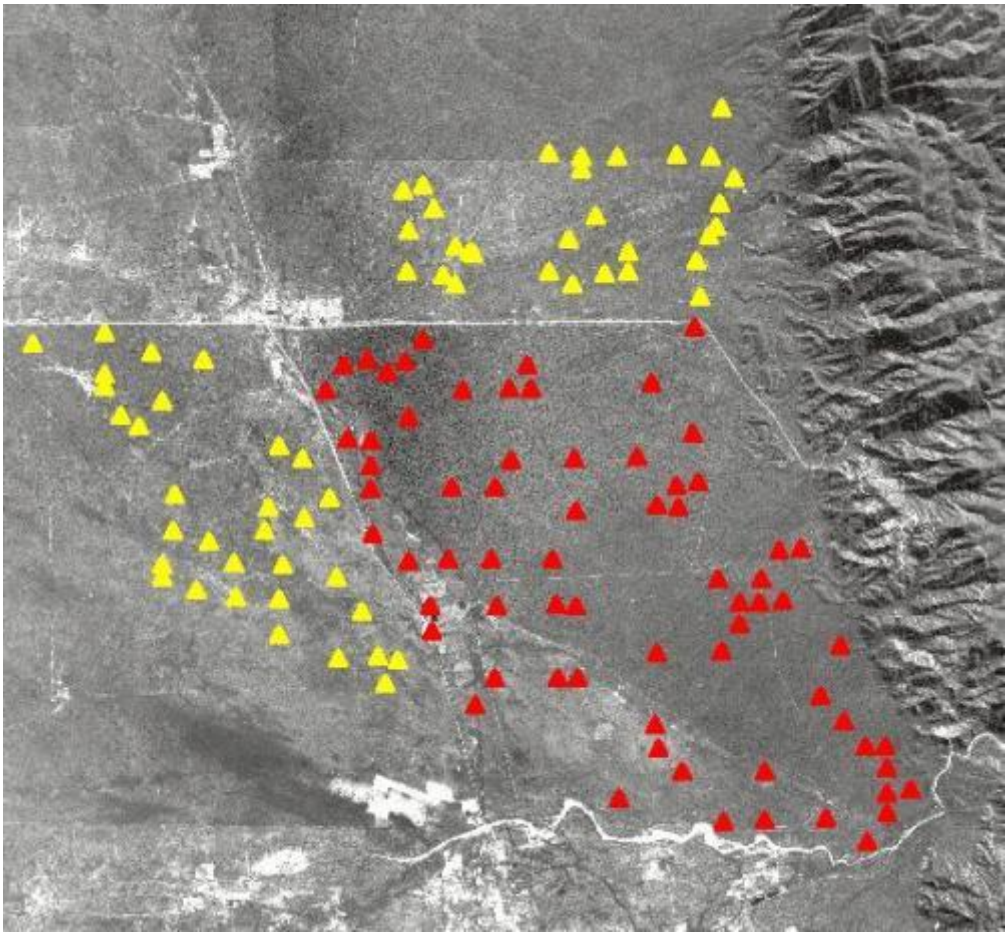

Fig 1. Map of Chancaní Reserve and surrounding areas. Sample points in red are inside the reserve (in 2006); sample points in yellow are in surrounding areas. The orange line indicated the Reserve limits.

Habitat Use

We used a combination of descriptive statistics and explanatory models to relate habitat conditions. Habitat variables were measured in 65 plots in the degraded area, and 58 plots in Chancaní Reserve. These variables included: tree and shrub diversity and density, canopy and ground cover, as well as the altitude of each plot (m. above sea level). These habitat variables were measured in a dry season (October – November).

We used multiple logistic regressions to predict species presence or absence as a function of the habitat variables measured. For this analysis, the dependent variable was presence or absence gray brocket deer feces at each plot in each habitat type (degraded site versus Chancaní Reserve). In each of these models, we employed stepwise selection (P to enter set to 0.1 and P for retention set at 0.05). The relative effectiveness of each of these models was evaluated using Akaike's information criterion (AIC). For each significant

variable in the final logistic regression models, we calculated confidence intervals on the odds-ratios.

We designed our study to identify ecological factors that affect the abundance of the *M. gouazoubira* population.

Diet

We determined plant components of gray brocket deer's diet by micro-histological analysis (Holechek 1982, Mátrai and Kabai 1989) of composite fecal samples. Fresh fecal samples were collected in the study area between August and November 2007.Composite samples of feces are widely used to estimate diet of many herbivorous. In our study, the composite fecal samples consisted of 10-25 pellets from each fresh fecal group, which were homogenized by sodium bicarbonate for 1-2 weeks. Then, dispersed epidermis fragments were dispersed into 1 drop of glycerin and the fragments were observed under a microscope at 400X magnification by systematic scanning (Fig. 2).

Behaviour

We installed a 15 trip cameras, set up around the Chancaní Reserve, in identified defecation sites of different individuals. The resulting photographs were analyzed for sex and age differences, as well as daily activity patterns (Fig.3).

Fig.2. Group member analyzing and identifying diet components in pellets gathered in the study area.

Fig.3. Trip cameras installed throughout the study area.

RESULTS

300 pellet groups pertaining to gray brocket deer were found in 65 plots sampled in the degraded area surrounding the Reserve, with an average of 3.86 pellet groups/plot. Comparatively, during the same season in 2007, 280 pellet groups were found in 56 plots inside the Reserve, with an average of 6.36 pellet groups/plot (Fig 4).

Gray brocket deer population in the dry season in the degraded area was an average of 3.86 individuals/km2. Meanwhile, the data obtained the previous year inside the reserve gives an estimate of 6.36 individuals/km2 (Fig. 4).

The terms used in the equation for this calculation, with respect to the points developed before, were:

- Maximum persistence days of the pellets on the ground: 200.
- Number of daily defecation per individual: 13 (recommended number, Neff 1968).

Conventional statistical methods for comparison of averages (one-way ANOVA) were not appropriate in this particular analysis for the found values of pellet groups, in degraded areas versus protected areas. Due to the nature and high variability of the data, it was convenient to analyze the data with more robust statistical methods such as the General Lineal Models (GLM). This way, and assuming a Poisson-type distribution for the variable "presence/absence of pellet groups", the differences observed in general terms between both

situations (degraded versus protected) resulted statistically significant, with a higher proportion of pellet groups found within the limits of the Reserve.

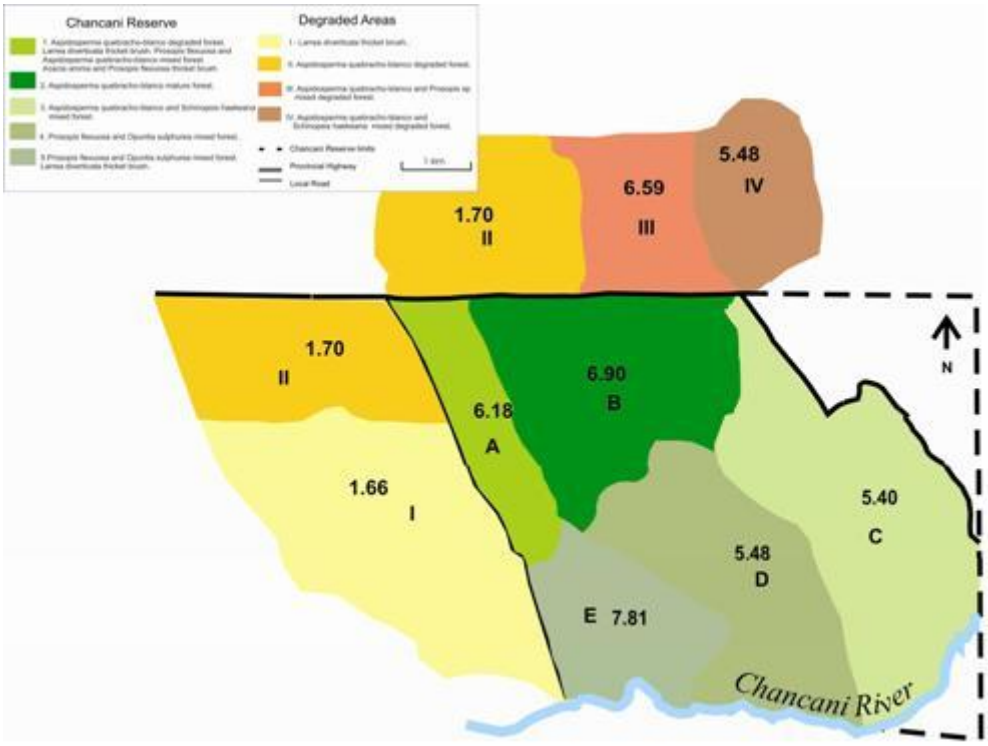

Fig. 4. Gray brocket deer densities across the different vegetation zones, in both the Reserve (from 2007) and surrounding areas.

Habitat Use

Vegetation characteristics in degraded areas differ significantly in some of the variables measured with respect to protected areas (within the Reserve). In general terms, the values for canopy and ground cover were significantly reduced in degraded areas. Shrub density was significantly higher in degraded areas while tree density was lower (Fig.5).

When analyzing the variation in brocket density throughout the study area, it is evident that there is a strong environmental component that conditions the presence or absence of the species in the different zones (Fig. 4).

A logistic regression was used to identify those habitat variables that best discriminated between use and random habitat site types through stepwise elimination of the least significant variable. We obtained 14 significant logistic regression models, and the most important habitat variables (based on number of retentions in the different models generated) were mean “bush density” (8 retentions); followed by “ground cover” (7) and tree density (5).

Mazama presence were inversely correlated with bush density, but positively related to tree canopy.

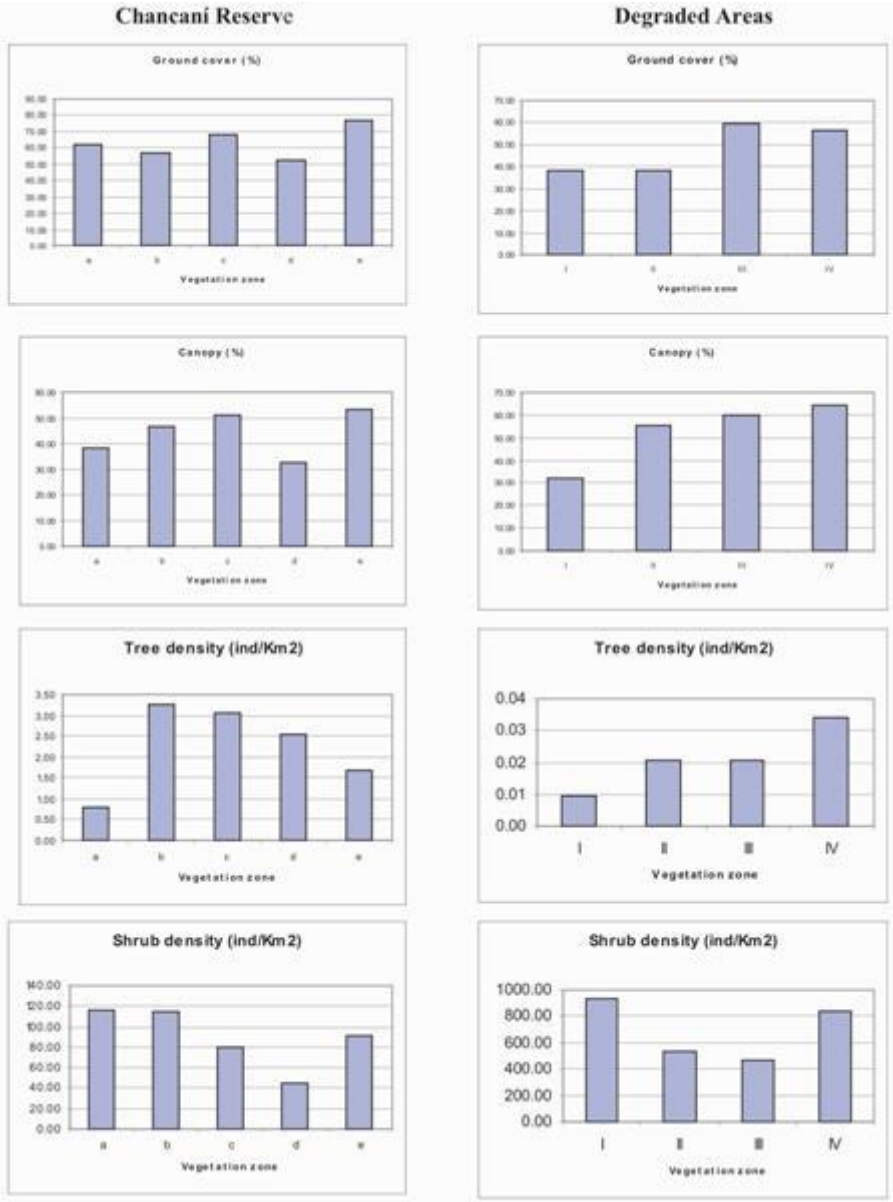

Fig. 5. Average variations of habitat variables in both the Reserve and surrounding areas.

Diet

Preliminary results indicate that the gray brocket deer's diet is based mainly on the consumption of dicotyledon plants: *Schinus fasciculatus*, *Ximenia americana*, *Condalia microphylla* and cactus as principal items, followed by *Maytenus spinosa*, *Castella coccinea*, *Trichomona usillo* and *Capparis atamisquea*. *Malvastrum* and *Poligonum* were the most common of the herbaceous group. Grass sp. were not identified at the species level since the

total volume was small in comparison. The brockets consume leaves in the same proportion as seeds and fruits.

Behaviour

A total of 102 photographic observations were obtained during the project period. The largest percentage (40%) of these was obtained in the morning hours, while 34% were obtained during the afternoon and 26% during night hours. The proportion between males and females were equivalent (45% females, 37% males, and 18% undetermined). Activity or daily patters of the animals were not significantly different, even when considering each sex separately ($X^2 = 4.42$; $p = 0.34$).

The photographs showed that the defecation sites are utilized repeatedly by more than one individual and more than once a day by the same individual (Figs. 7 and 8).

GENERAL CONCLUSIONS

Density values obtained (1.6-5.48 individuals/km2) allow us to conclude that there is a negative effect on gray brocket populations linked to the loss of forest mass, but above all, to factors like fire and overgrazing, which favour the regeneration of dense shrub cover. This way, recuperated areas, even in sectors outside the Reserve, hold almost identical densities of gray brockets to those within the Reserve.

The data obtained allows us to also have a more detailed appreciation for the information obtained in 2006, by the same work group, regarding use and habitat selection of the brockets. The species selects parts of the forest with better tree coverage, but fundamentally open areas that are free of a dense shrub structure such as mature forests, o areas recovering after a big disturbance.

The diet includes an ample assortment of shrub plats, preferably dicotyledonean plants. Gray brockets' diet includes a small proportion of grass (monocotyledon).

The use of trip cameras is of notable value for ecological studies, in particular for gray brocket deer, allowing us to hold evidence to behavioural aspects that cannot be registered in a different manner, such as use of defecation sites or variations in daily activity patters. This information results necessary in order to perform long term studies of the populations, in an effort to define behaviour patterns extremely important in monitoring programs and conservation.

Fig. 7. Individual gray brocket deer registered by the trip camera.

Fig 8. Gray brocket deer fawn.

ACTIVITIES PERFORMED

- Master's thesis entitled "Efectos de la degradación ambiental sobre las poblaciones de Corzuela parda en el Chaco árido de Córdoba". Celina Abrahmn. Programa de Maestría en Manejo de Vida Silvestre. Universidad Nacional de Córdoba.
- Undergraduate thesis entitled "Dieta y uso de hábitat e la corzuela parda en el Chaco árido de Córdoba". María Pilar Serbent. Facultad de Ciencias Exactas Físicas y Naturales Universidad Nacional de Córdoba.

- Presentation of preliminary results at the XX Jornadas de Mastozoologia. August 2007. Abstract accepted and poster presented entitled “El uso de las cámaras trampa como técnica para relevar información sobre la Corzuela parda”.

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