

THE CARNIVORE ASSEMBLAGE OF LA PAYUNIA RESERVE,
PATAGONIA, ARGENTINA: DIETARY NICHE, PREY
AVAILABILITY, AND SELECTION

By

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ABSTRACT

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The Carnivore Assemblage of La Payunia Reserve, Patagonia, Argentina: Dietary Niche, Prey Availability, and Selection

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I studied the dietary niches of pumas (*Puma concolor*), culpeo foxes (*Pseudalopex culpaeus*), grey foxes (*Pseudalopex griseus*), Geoffroy's cats (*Oncifelis geoffroyi*), and pampas cats (*Oncifelis colocolo*) between November 2005 and October 2006, and investigated prey density and availability in the northwestern region of La Payunia Reserve, province of Mendoza, Argentina. The cat species proved to be primarily carnivorous, consuming in most abundance plains and/or mountain viscachas (*Lagostomus maximus* and *Lagidium viscacia*, respectively), and guanacos (*Lama guanicoe*) in the case of pumas. Both foxes had more generalized diets, consuming the same species as the cats, as well as a higher percentage of insects and vegetation. Other native large-bodied prey species such as choiques and maras (*Pterocnemia pennata* and *Dolichotis patagonum*, respectively) are likely ecologically extinct as prey for native carnivores, as they exist in low numbers within the reserve, probably due to a number of factors including hunting and competition from introduced species.

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I always knew it wasn't going to be easy finding myself in a new country with new faces and a new language, and it wasn't. But at some point in the year and four months that I was in Argentina, the initial tears, apprehension, and loneliness evolved into laughter, friendships, and an unforgettable learning and growing experience, for which I have many people to thank: Steve and my committee members for all their support and advice; Andres Novaro and Susan Walker for inviting me to Argentina and putting trust in me in the first place – they are true examples of dedication to the wildlife and conservation biology field; Lara, Bibi, and Gotardo Heidel who provided me a much-needed home away from home; Aníbal, Eduardo, Leo, Martín, Dany, Jorgito, Guillermo, Sylvana, Fabian, and the rest of the park guards of Llanquanelo, Payunia, and Caverna, for their help and friendship in the field; the Direction of Renewable Natural Resources of Mendoza for permitting my work in Payunia to happen; Rocio, Natalia, Lore, Emiliano, and Nito for help at various points and lessons in scat analysis, Distance, and transect layout, as well as Laura and Virginia for help in the lab – I don't think I would have finished on time if it weren't for those two; CEAN for allowing me use of the facilities and Paila for logistical help. A special thanks goes to Maco. Those initial awkward exchanges in separate languages soon turned to long conversations during countless field hours. I knew I could count on her to continue my project when I had to be away.

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PREFACE

I arrived for my first time in Argentina in September of 2005. I immediately took an overnight bus from the capitol city of Buenos Aires to the small town of Junín de los Andes in the Patagonian province of Neuquén, situated at the base of the Andes cordillera. There lived and worked the two biologists from Wildlife Conservation Society who had invited me to come work with them. Upon initial invitation, Andres and Sue had described to me their “Tehuelche (a native people to Argentina) landscape” approach to restoring and maintaining connectivity between core protected areas and surrounding low-impact human-use areas. They also described the three major locations where they tend to focus most of their time and energy: the high-altitude puna plateaus of San Guillermo National Park in the San Juan province to the northwest, volcanic Auca Mahuida Provincial Reserve in Neuquén, and La Payunia Provincial Reserve just north of Auca Mahuida but in southern Mendoza province (Fig. 1). On my third full day in Argentina, I found myself driving to this last reserve, which would become my home, life, and research site for the next year and three months.

Our purpose in driving to Payunia was to participate in a first-time effort to capture and shear the native guanacos (*Lama guanicoe*) for their wool, a community project directed by the Direction of Natural Resources of Mendoza. While the local cooperative of livestock owners had the guanacos captured, we hoped to fit some of them with radio collars, in order to monitor the effects of the shearing and learn more about the seasonal movements of the animals, as well as their use and selection of habitat, factors important to their overall conservation.

Guanacos are endemic to South America and once numbered in the tens of millions, compared to about 500,000 today (Conway, 2005). Historically, guanacos impacted plant distribution, abundance, and composition, served as a major prey for pumas (*Puma concolor*), and played a vital role in the lives of Tehuelches and Pehuenches, who migrated alongside the guanacos between winter and summer feeding grounds and depended on them for subsistence (Walker *et al.*, 2004). European colonization beginning in the sixteenth century subsequently led to the extermination of these native peoples through disease and the Campaña del Desierto in 1879, during which any remaining Indians not killed by sickness were executed (Perry, 1972).

Along with the Europeans came horses and firearms, both of which resulted in great increases in hunting and indiscriminate persecution of native wildlife. The original habitat and composition of native plant and animal communities were further decimated and severely altered through the introduction of other exotic species including domestic sheep, cattle, and goats (Conway, 2005). These species had not evolved with the Patagonian landscape as did the guanacos. Whereas guanacos have broad, soft feet, the sharp hooves of livestock destroy native vegetation and present competition for Argentina's tremendously overgrazed pasture (Baldi *et al.*, 2004).

The province of Chubut alone currently has about four million sheep, requiring between ten and eleven million pounds of forage each day (Conway, 2005). Overgrazing has resulted in severe desertification of about thirty percent of the Patagonian steppe. Approximately four percent of the region's shrub and steppe ecosystems are under strict

protection (Walker *et al.*, 2004); the rest of the land is managed by private ranchers.

Today Argentina is fragmented by trails left behind by oil exploration, fences, and seasonal movements of large livestock herds, all of which sever migration patterns and access to resources for native species.

Migration has been described as a seasonal movement between discrete areas not used at other times of the year (Berger, 2004). The definition of long-distance migration is more subjective, as what may seem a “long” distance to travel for some species, but not for others, varies by species size and life-history characteristics. Either way, the spectacular ecological phenomenon of long-distance migration of land mammals, documented in species such as saiga antelope of the Mongolian steppe and bison of North America, is increasingly at risk of extinction. Long-distance migration has important ecological implications: it defines the ecological adaptations of a species and the seasonal consumption of resources; defines the limits of ecosystems; and suggests the need for changes in hunting controls and management (Novaro & Walker, 2005). In fact, long-distance migration is a widely practiced husbandry strategy in Argentina; many livestock owners we interviewed move their animals (sometimes as far as 200 kilometers) so as to be able to maintain large herds in such a harsh environment (Appendix B).

Guanacos once made long seasonal treks, but current densities of many populations are so low that they no longer perform this role to take advantage of seasonal changes in resource availability, and many have become restricted to high-elevation summer feeding grounds due to livestock competition and hunting at lower elevations. Preliminary

research by Wildlife Conservation Society staff indicated that guanaco populations in Payunia may still be large enough, and the amount of threats low enough, that the animals may make annual movements into and out of the reserve. We hoped to find out if this was true or not with the radio collars we put on some of the guanacos caught at the shearing.

It was my everyday job, with help from another research assistant, to follow the sheared guanacos using radio telemetry in order to investigate not only to what extent the guanacos of Payunia might still migrate, but demographic characters of the population as well, including the impact of predation by pumas. According to 17 of the 20 interviews we conducted with local livestock owners, pumas are present in Payunia and their numbers have increased in the last two decades (Appendix B). Taking advantage of the hours spent tracking the guanacos, I began to collect carnivore scats whenever I came across them.

There are five main predators in Payunia: pumas, culpeo foxes (*Pseudalopex culpaeus*), grey foxes (*P. griseus*), pampas cats (*Oncifelis colocolo*) and Geoffroy's cats (*O. geoffroyi*). The puma is the largest of the five (26-55kg; Redford & Eisenberg, 1992) and has one of the largest distributions of all carnivores, ranging from northern Canada south to southern Chile and Argentina. It inhabits everything from moist lowland tropical forests to montane regions 5,800m in altitude. In Patagonia, they have been known to prey primarily on mammals, especially guanacos, introduced European hares (*Lepus europaeus*), and pudus (*Pudu pudu*) (Yañez *et al.*, 1986; Rau *et al.*, 1991).

Culpeo foxes (4-13kg; Redford & Eisenberg, 1992) range from Colombia down throughout Chile and Argentina along the Andes to Patagonia, where they range across the width of the country. Largely nocturnal, culpeo foxes may be found in many kinds of habitats to altitudes of 4500m, but usually seek out areas with abundant vegetation for cover. In Argentina's Neuquén province, the main prey of culpeos in terms of biomass consumed is the European hare, followed by sheep and carrion (Novaro, Funes & Walker, 2000).

Culpeos have been relatively well-studied in Argentina and Chile, along with grey foxes (2.5-5.5kg; Redford & Eisenberg, 1992). The grey fox is both diurnal and nocturnal and occurs in a broad range of habitats from grasslands to forests, although in Argentina, it typically inhabits arid and semiarid temperate portions of Patagonia and the Andes. Being a generalist omnivore, the diet may contain plant material, insects, birds, rodents, and even a high amount of fruit (Solar, Videla & Roig, 1997).

The biology of many South American cats, including the Geoffroy's cat (2-6kg; Redford & Eisenberg, 1992), has been poorly studied and remains relatively unknown (Branch, 1995). The Geoffroy's cat ranges from sea level to 3300m in southern Bolivia, across southern Brazil, in open woodlands, savannas, and marshes in Uruguay, to the southern tip of Patagonia in Chile and Argentina. Primarily nocturnal, vertebrate prey is 100% of their diet, with European hares accounting for as much as 57% (Johnson & Franklin, 1991).

Pampas cats (3kg; Redford & Eisenberg, 1992) are distributed south from Peru and west from Paraguay into Chile. Occasionally it may be found above 5000m in the Andes but also prefers lowland swampy, grassy areas (Romo, 1995).

Carnivores such as pumas, grizzly bears (*Ursus arctos horribilis*), and wolves (*Canis lupus*) have long been persecuted as nuisances and threats to livestock (Mech, 1996). In some areas, this persecution has led to local extinctions. Some populations have been listed as vulnerable and managed as endangered species. Carnivores as a trophic group have generally been found to be widespread and locally rare (to a large extent, this is the case of Payunia's species). This distribution and population density, in addition to habitat and diet specialization, is the reason why some of these species are designated rare or vulnerable (Arita, Robinson, & Redford, 1990). Carnivores of Payunia generally appear to occur at low densities and could be in a vulnerable state, but no specific studies have been conducted to determine their status. Food habits are considered one of the most important aspects of a species' behaviors (Romo, 1995). There is often debate about the effects carnivores have on their prey (or their prey on them), and it is essential to explore this subject further. The following manuscript details the methods I employed in investigating this topic and the results and conclusions I came to.

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1. INTRODUCTION

A predator faces many ecological constraints while seeking to maximize quality and quantity of its diet: prey abundance, spatial distribution and size of prey, hunting cover, presence of offspring, and/or competition from other predators. Gause's Law (1934; the competitive exclusion principle) states that in order for two competing species to coexist in a stable environment, the two species must differ in their respective ecological niche; without differentiation, one species will eliminate or exclude the other through competition. This idea was furthered by limiting similarity theories (MacArthur & Levins, 1967) and character displacement (Brown & Wilson, 1956; Bulmer, 1974) which predicted that there is a limit to the similarity and number of competing, coexisting species in a given locale, and that interspecific competition should lead to reduction in the niche overlap of competing species. Schoener (1974) suggested that microhabitat, diet, and activity time are the three most important niche axes, but that differentiation usually occurs along the first two: in order for two species with high habitat overlap to coexist, they must differ in diet, and vice-versa (niche-complementarity hypothesis; see also Pianka, 1973).

In Chile, Fuentes and Jaksic (1979) hypothesized that niche-complementarity of diet and habitat influenced the distributions and body sizes of culpeo and grey foxes (*Pseudalopex culpaeus* and *P. griseus*, respectively). Where the foxes were sympatric in southern Chile, they differed in body size, and where the foxes were allopatric in central Chile, they were of similar sizes because altitudinal habitat partitioning allowed for relaxed competition for prey of similar sizes. In the south, the altitude of the Andes range

decreases, and both foxes are forced to use lowlands. Jiménez *et al.* (1996) re-examined the niche components of Fuentes and Jaksic's work, along with temporal activity, at a site in central Chile, where the foxes should have been allopatric. They found that the foxes were actually sympatric and able to coexist through partitioning habitat at a finer scale (culpeos excluded grey foxes from high-quality/abundant prey habitat patches), overlapping moderately in dietary preferences, and completely overlapping in activity time.

Estimating consumption of a particular prey through diet analysis can be a useful, non-invasive technique to study carnivores and interspecific interactions, particularly when other types of observations are logistically difficult. Many field experiments that compare predators' diets to prey availability focus only on one or two predators, or have been conducted in boreal or northern temperate areas (Sih *et al.*, 1985). Few carnivore food habits studies have occurred in neotropical sites or looked at entire carnivore assemblages (Jaksic *et al.*, 1992; but see Palacios, 2006). Novaro *et al.* (2000), however, analyzed the food habits of a carnivore assemblage and determined that native species such as guanacos and rheas are ecologically extinct as prey and sources of carrion at a neotropical site in the Neuquén province of Argentina.

A carnivore guild food habits study has not been conducted for the northwestern region of La Payunia Reserve, Mendoza province. Such a project would be useful in better understanding the area's predator and prey species and in development of appropriate management strategies. The project would increase understanding of human-wildlife

conflicts, and serve as part of a landscape level project to restore and maintain suitable habitat and connectivity for the purpose of conserving wildlife populations in Argentine Patagonia.

2. OBJECTIVES

I sought to describe the carnivore assemblage of northwestern La Payunia Reserve, including trophic niches, mechanisms governing coexistence such as dietary niche, overlap and separation, and the role that various prey species play in the diet during the period of November 2005 through October 2006. Specifically, I:

1) estimated the densities of native prey species including guanacos, choiques, maras (*Dolichotis patagonum*), pichis (*Zaedyus pichiy*), plains vizcachas (*Lagostomus maximus*), and martinetas (*Eudromia elegans*);

2) estimated the densities of introduced prey species including European hares (*Lepus europaeus*), cattle (*Bos taurus*), sheep (*Ovis aries*), goats (*Capra hircus*), and horses (*Equus caballus*);

3) collected and analyzed scats from pumas (*Puma concolor*), grey foxes (*Pseudalopex griseus*), culpeo foxes (*Pseudalopex culpaeus*), and the smaller cats (*Oncifelis colocolo* and *Oncifelis geoffroyi*).

4) gathered local knowledge about livestock densities and seasonal movements, the presence of carnivores, guanacos, choiques, and mountain viscachas, and the prevalence of illegal hunting by conducting twenty semi-structured interviews with residents of the area surrounding the study site.

3. METHODS

3.1 Study Area

The study area was located in the northwestern section of La Payunia Reserve (36°10'S, 68°50'W, elevation from 1300 to 2000m), a protected natural area in northern Patagonia, Province of Mendoza, Argentina (Fig. 1). La Payunia consists of 442,996 hectares (192,996 of which are government-owned) and is home to a high density of ancient volcanoes and what is probably one of the largest populations of guanacos left in the world. This reserve, along with that of Auca Mahuida, in the Neuquén province to the south, forms a major landscape that helps conserve one of Patagonia's richest ecosystems (Walker *et al.*, 2004).

Annual precipitation averages 255mm, occurring mostly during the summer months, and mean seasonal temperatures range from 6°C in winter to 20°C in summer (Puig, Videla & Cona, 1997). Moderate vegetation cover (58%) is shrubby interspersed by grasses; dominant species include: *Neosparton aphyllum*, *Chuquiraga erinacea*, *Larrea divaricata*, *Cassia aphila*, *Panicum urvilleanum*, *Poa spp.*, and *Stipa spp* (Puig *et al.*, 1997).

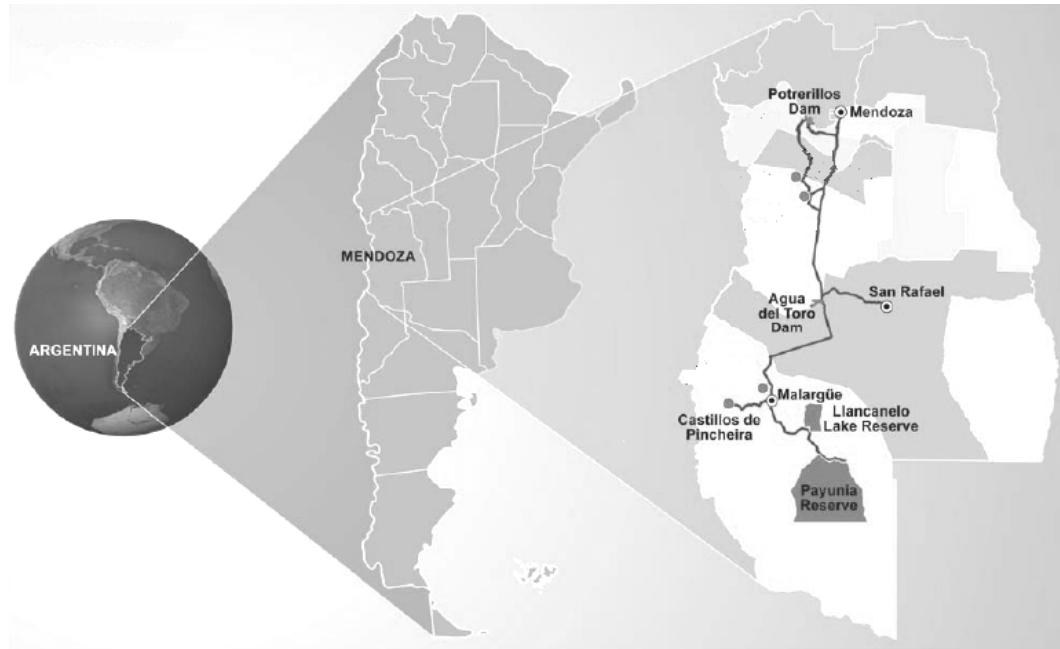


Fig. 1. Location of study site (Payunia Reserve) in southern Mendoza province, Argentina.

3.2 Food Habits

The project was constrained by and conducted at the same time as a radio-telemetry project on guanacos. Consequently, I collected 101 puma scats, 45 culpeo scats, 98 grey fox scats, and 88 small cat scats were collected opportunistically while hiking to telemetry sites that consisted of rocky hills and volcanoes. These were areas that according to locals (Appendix B) and the literature, are utilized by carnivores. Location and elevation were recorded with a GPS, and date, who collected the scat, probable species of origin, and whether the scat was estimated as old, semi-fresh, or fresh were noted. Scats from pumas are easily identified correctly, as they are quite large, and scats from Geoffroy's and pampas cats can be distinguished from fox scats as the latter are noticeably more twisted (Johnson & Franklin, 1991). I grouped the scats from Geoffroy's and pampas cats together, as it is difficult to distinguish the two. Scats from foxes are also highly variable and hard to identify to species; methods of identification by

pH or thin-layer-chromatography are unreliable (Green & Flinders, 1981; Jiménez, 1993). I used the maximum diameter indicated by Jimenez (1993) to classify fox scats as coming from either culpeo or grey foxes: scats with maximum diameters $\leq 15\text{mm}$ were said to be from grey foxes, and scats with maximum diameters $\geq 15\text{mm}$ were said to be from culpeos.

All scats were air-dried and their contents analyzed following the methods of Reynolds & Aebischer (1991). Specimens were broken down in water and macroscopic fragments were separated from microscopic ones using a sieve with a mesh size of 1mm. For the purpose of this study, the microscopic fraction was not examined. The macroscopic fraction was dried and mammalian prey was identified by comparing hair and teeth to voucher specimens from the region and with the use of keys (Chehebar & Martin, 1989; Pearson, 1995). This appears to be the first study to examine carnivore diets that could potentially contain both plains and mountain viscachas (*Lagidium viscacia*). Without further investigation, I found the hairs of the two species to be indistinguishable from one another and could only rely on the presence of teeth and/or claws to identify scat remains to species level. If no teeth or hair were present, I classified the remains as “undetermined Chinchillidae”. Results are presented as percent occurrence (number of times an item occurred as percentage of the total number of prey items in all feces) and the percent of scats in which each food item was found. For purposes of comparisons with other studies, I computed four basic diet metrics: dietary niche overlap, dietary separation, dietary niche breadth, and mean weight of vertebrate prey.

3.2.1 Dietary Niche Overlap

Using Gotelli & Entsminger's EcoSim 7.72 (2006), I calculated dietary niche overlap between all pairs of species with Pianka's (1973) index, $\alpha = \sum p_i q_i / (\sum p_i^2 \sum q_i^2)^{1/2}$, where p_i is the proportion of taxon i in the diet of the first species, and q_i is the proportion of taxon i in the diet of the second species. This index ranges from 0 (no overlap) to 1 (complete overlap). 1000 simulations were used to determine if the probability of observed overlaps was greater or less than those expected by chance.

3.2.2 Dietary Separation

I studied dietary separation among the carnivore species by plotting the major axes of dietary variation identified with correspondence analysis. Those food items that constituted $\geq 5\%$ of the diet of one or more of the predators were included in the analysis (Ray & Sunquist, 2001; Walker *et al.*, accepted 2007).

3.2.3 Dietary Niche Breadth

Dietary niche breadth is described by Levins' (1968) formula, standardized by Colwell & Futuyma (1971), $B_{sta} = (B_{obs} - B_{min}) / (B_{max} - B_{min})$ where $B_{obs} = 1 / \sum p_i^2$, p_i is the proportion of taxon i in the diet, B_{min} is the minimum niche breadth possible (=1), and B_{max} is the maximum possible (=n, the number of prey taxa actually taken by a given species of predator). B_{sta} ranges between 0 and 1. Niche breadth was calculated using the total number of individuals in each of the families Muridae and Chinchillidae (because of the inability to determine some individual prey items in scats to species level), but at species level for all other prey taxa.

3.2.4 Mean Weight of Vertebrate Prey

Size of prey has been shown to influence a predator's choice to hunt a particular species; in the absence of other factors, the most profitable prey is the largest available prey that can safely be killed (Sunquist & Sunquist 1989). To further compare diet partitioning among the carnivores of La Payunia, I used the mean weight of vertebrate prey (MWVP). MWVP was found as the arithmetic means of the body masses (Table 1) of all the prey individuals found in the scats. Confidence intervals were estimated with log transformations of the data that are back-transformed. As opposed to the geometric means sometimes used in the literature and which tend to underestimate, arithmetic means provide more realistic estimates of MWVP (Fowler, Cohen & Jarvis, 1998; Walker *et al.*, accepted 2007). The presence of guanacos in scats was included in this analysis for pumas, but excluded in the analyses for the other carnivores, on the assumption that these species only scavenge on guanacos. Livestock were also excluded as it was assumed to be scavenged, although larger carnivores may sometimes prey on newborn livestock or guanacos.

3.3 Prey Biomass

I assumed that prey biomass, estimated as the product between prey density and mean body mass, was an acceptable estimator of prey availability (Jaksic *et al.*, 1992; Novaro *et al.*, 2000). Body masses were obtained from the literature (Table 1; Redford and Eisenberg 1992; Novaro *et al.* 2000) and prey densities were measured using the line transect sampling methods described by Buckland *et al.* (2001). Date, observers, climate, habitat, starting and ending times, species, total number of adults and/or juveniles,

distance from observers, and angle from line transect were noted. In addition, transects were performed at night using a spotlight to estimate densities of nocturnal species (plains viscacha and European hare).

During the beginning of the study, in the summer season (December through February), transects covered every stretch of road and trail driven. Buckland *et al.* (2001) recommend random placement of line transects within the study area. If this is not logistically possible, as it was not in my study, a systematic grid of lines with random starting position is considered sufficient. Realizing that my study design used in the summer season (during which I sampled every stretch of road and trail driven) was not the most desirable, the design was adjusted at the beginning of March to a more systematic layout. I established a total of thirty-four transects over the entire study area, each transect five kilometers long. Between each transect were three kilometers of un-sampled road or trail. The transects were sampled approximately once every two weeks by one observer standing in the back of a truck driving at a speed of about twenty kilometers per hour. This design was followed for the rest of the study, and data was analyzed using the program Distance (Thomas *et al.*, 2005).

Line transect methods are not suitable for estimating the densities of mountain viscachas or small rodents, and as budgetary and logistical constraints did not allow for it, the densities of small rodents were not estimated in this study but taken from the literature (Table 1). Density estimates of mountain viscachas do not exist because being rock and cave-dwelling creatures, it is complicated to obtain information about their populations;

one must consider the number, size, and distribution of rock outcrops, as well as the number of animals in each outcrop (Walker, pers. comm.). I therefore used the same density estimate for mountain viscachas as that for plains viscachas.

The amount of food available to predators is not necessarily represented by prey density (Sunquist & Sunquist, 1989). The assumed ability of each carnivore species to capture and kill prey determined the availability of each prey item (Novaro *et al.*, 2000). Sheep and goats, hares, small mammals, young choiques, martinetas, pichis, and viscachas were assumed to be available to culpeos. Hares, small mammals, martinetas, pichis, and viscachas were assumed to be available to grey foxes and the small cats. Guanacos, young cattle and horses, burros, and all previously mentioned prey were assumed to be available to pumas.

Table 1. Population density (ind/km²), as determined through line transects, and body mass (kg) of prey species of La Payunia Reserve, Mendoza, Argentina between November 2005 and October 2006

Prey	Density(ind/km ²) ^a		Body Mass ^b
	Summer	Winter	
Muridae			
<i>Phyllotis</i>	540.00		0.06
<i>Reithrodon</i>	986.67		0.08
<i>Eligmodontia</i>	350.00		0.02
Chinchillidae			
<i>Lagostomus maximus</i>		24.71	5.19
<i>Lagidium viscacia</i>			1.54
<i>Ctenomys</i>	665.00		0.35
<i>Microcavia australis</i>	2440.00		0.29
<i>Lama guanicoe</i>	8.08		120-80-30
<i>Zaedyus pichiy</i>	9.25		1.02
<i>Lepus europaeus</i>	3.04		3.1
Livestock			
Cattle	9.58		475-190-80
Horses and burros	1.35		
Goats and sheep	10.58		47-25-3
Birds			
<i>Pterocnemia pennata</i>		0.92	15-6-1
<i>Eudromia elegans</i>			0.6

^a Densities for Muridae, *Ctenomys*, and *Microcavia* were taken from the literature (Redford & Eisenberg, 1992; Rosi *et al.*, 2005)

^b Masses for adult, yearling, and juvenile guanacos, livestock, and choiques were obtained from the literature (Redford & Eisenberg, 1992; Novaro *et al.*, 2000). For all other species, one mean estimate was used

3.4 Statistical Analysis of Prey Selection

To predict if predators utilized each prey type in proportion to its occurrence within the study area, I used a goodness-of-fit χ^2 test to compare frequencies of occurrence in the diets to relative densities of each prey (Jaksic *et al.*, 1992; Fowler *et al.*, 1998; Novaro *et al.*, 2000). When differences were significant ($p < 0.05$), I tested for selection or

rejection of individual prey with 95% Bonferroni confidence intervals for each prey frequency (Neu, Byers & Peek, 1974; Byers, Steinhorst & Krausman, 1984).

3.5 Interviews

To gather important local knowledge about the area's predators and abundance of prey, I interviewed all residents of the area immediately surrounding the study site (Appendix B). Semi-structured interviews were typically conducted in the residents' homes, usually with the male heads-of-the-households, and with the assistance of my Spanish-speaking co-worker. Questions were pre-determined and given in a casual manner, and answers were recorded afterwards, as participants were generally leery of papers and note-taking.

4. RESULTS

4.1 Food Habits

While guanacos were the most frequently consumed prey of pumas (33.1%), insects were the most frequent prey in the diet of culpeos (22.9%; Table 2). Chinchillidae represented 24.1% of numbers of prey for grey foxes, followed by Muridae (15.6%; Table 2). This was the opposite for Geoffroy's and pampas cats, as Muridae appeared most frequently (27%), followed by Chinchillidae (23.3%; Table 2).

Table 2. Food habits of pumas, culpeo and grey foxes, and Geoffroy's and pampas cats as determined by scat analysis in La Payunia Reserve, Mendoza, Argentina, between November 2005 and October 2006

	<i>Puma concolor</i>			<i>Pseudalopex culpaeus</i>			<i>Pseudalopex griseus</i>			<i>Oncifelis spp.</i>		
	n	%food items	%scats	n	%food items	%scats	n	%food items	%scats	n	%food items	%scats
Muridae												
<i>Phyllotis</i>	1	0.8	1.0	0	0.0	0.0	3	2.1	3.1	21	15.3	23.9
<i>Reithrodon</i>	0	0.0	0.0	0	0.0	0.0	2	1.4	2.0	1	0.7	1.1
<i>Eligmodontia</i>	0	0.0	0.0	2	2.9	4.4	9	6.4	8.2	3	2.2	3.4
Undetermined	0	0.0	0.0	4	5.7	8.9	8	5.7	8.2	12	8.8	11.4
Chinchillidae												
<i>Lagostomus maximus</i>	24	19.4	23.8	2	2.9	4.4	9	6.4	9.2	1	0.7	1.1
<i>Lagidium viscacia</i>	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	8	5.8	9.1
Undetermined	26	21.0	25.7	6	8.6	13.3	25	17.7	25.5	23	16.8	26.1
<i>Ctenomys</i>	0	0.0	0.0	11	15.7	24.4	21	14.9	21.4	26	19.0	20.5
<i>Microcavia australis</i>	0	0.0	0.0	3	4.3	6.7	5	3.5	5.1	13	9.5	14.8
<i>Lama guanicoe</i>	41	33.1	40.6	10	14.3	22.2	18	12.8	18.4	4	2.9	4.5
<i>Zaedyus pichiy</i>	8	6.5	6.9	3	4.3	6.7	2	1.4	2.0	2	1.5	2.3
<i>Lepus europaeus</i>	9	7.3	8.9	3	4.3	6.7	9	6.4	9.2	14	10.2	15.9
Livestock	6	4.8	5.9	5	7.1	11.1	4	2.8	4.1	0	0.0	0.0
Unidentified mammal	1	0.8	1.0	1	1.4	2.2	0	0.0	0.0	0	0.0	0.0
Birds	3	2.4	3.0	1	1.4	2.2	1	0.7	1.0	3	2.2	3.4
Reptiles	0	0.0	0.0	0	0.0	0.0	1	0.7	1.0	1	0.7	1.1
Vegetation	2	1.6	2.0	3	4.3	6.7	3	2.1	3.1	2	1.5	2.3
Insects	3	2.4	3.0	16	22.9	35.6	21	14.9	21.4	3	2.2	3.4
Total Food Items	124			70			141			137		
Total Scat Samples	101			45			98			88		

4.1.1 Dietary Niche Overlap

The diets of grey foxes and *Oncifelis spp.* had the highest overlap (0.92; Table 3), followed by the diets of culpeo and grey foxes (0.91; Table 3). The simulated mean overlap was 0.44 (variance = 0.004), with the observed overlap greater than expected by chance ($p = 0.001$).

Table 3. Dietary niche overlap of culpeo and grey foxes, Geoffroy's and pampas cats, and pumas in La Payunia Reserve, Mendoza, Argentina (November 2005 - October 2006)

Species	<i>P. concolor</i>	<i>P. culpaeus</i>	<i>P. griseus</i>	<i>Oncifelis spp.</i>
<i>P. concolor</i>	X	0.44	0.46	0.65
<i>P. culpaeus</i>		X	0.91	0.78
<i>P. griseus</i>			X	0.92
<i>Oncifelis spp.</i>				X

4.1.2 Dietary Separation

Differentiation existed in the diet of Payunia's carnivores (Fig. 2). Pumas, Geoffroy's cats and pampas cats all consumed more viscachas and European hares. Pumas also consumed more guanacos and pichis, while the smaller cats consumed more small rodents. Culpeo foxes tended to specialize towards insects, while grey foxes had a more general diet, consuming small rodents, insects, and viscachas.

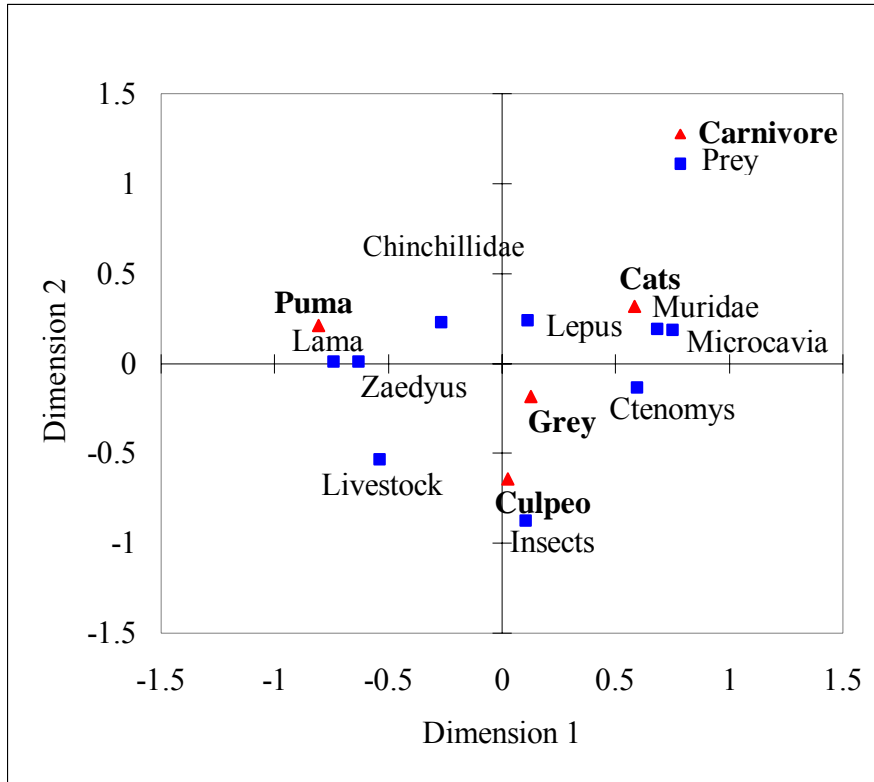


Fig. 2. Dimensions 1 and 2 of the correspondence analysis for La Payunia Reserve, Mendoza, Argentina, comparing frequency of occurrence of prey items by carnivore species. Dimension 1 accounts for 69.71% of the total variation (97.88%); Dimension 2 accounts for 28.17%.

4.1.2 Dietary Niche Breadth

Standardized niche breadth for the entire study period was widest for culpeo foxes ($B_{sta} = 0.645$), followed by grey foxes and the small cats ($B_{sta} = 0.515$ and $B_{sta} = 0.440$, respectively). Niche breadth was narrowest for pumas ($B_{sta} = 0.306$).

4.1.3 Mean Weight of Vertebrate Prey

As expected, mean weight of mammalian prey was greater for pumas, because of their larger size and preference for guanacos as a prey item. Grey foxes on average consumed the next largest prey, followed by culpeo foxes and the small cats, respectively (Table 4).

Table 4. Mean weight of mammalian prey (kg) and 95% confidence intervals (in parentheses) for pumas, culpeo and grey foxes, and pampas and Geoffroy's cats in La Payunia Reserve, Mendoza, Argentina (November 2005-October 2006)

Species	MWVP (95% CI)
<i>P. concolor</i>	31.12(22.86-42.36)
<i>P. culpaeus</i>	1.41(0.82-2.43)
<i>P. griseus</i>	1.84(1.25-2.69)
<i>Oncifelis spp.</i>	1.25(0.93-1.68)

4.2 Prey Biomass

Unlike some areas of Argentina, native prey still comprise the majority of the total biomass of herbivores and omnivores in Payunia. The biomass of native prey was 72, 99, and 76% of the total biomass of potential prey available to pumas, grey foxes and small cats, and culpeos, respectively (Table 5). Although native prey made up the majority of the biomass available, this was due largely to the numbers of guanacos and small rodents present in the reserve; choiques, once an abundant and widespread native herbivore, made up less than 1% of the biomass available to each of the carnivore species. Maras, another native herbivore that has experienced drastic population reductions (Walker *et al.*, 2004), were almost non-existent within the reserve, to the point where I could not obtain a sufficient number of observations needed to estimate density with acceptable precision (Buckland *et al.*, 2001).

Table 5. Relative percent biomasses of prey available to culpeos, grey foxes, Geoffroy's and pampas cats, and pumas in La Payunia Reserve, Mendoza, Argentina (November 2005- October 2006)

Prey	<i>P. concolor</i>	<i>P. griseus/Oncifelis spp.</i>	<i>P. culpaeus</i>
Muridae	3.90	9.51	7.27
Chinchillidae	5.48	13.36	10.22
<i>Ctenomys</i>	7.66	18.70	14.31
<i>Microcavia australis</i>	23.30	56.86	43.50
<i>Lama guanicoe</i>	31.65	0.00	0.00
<i>Zaedyus pichiy</i>	0.31	0.76	0.58
<i>Lepus europaeus</i>	0.31	0.76	0.58
Livestock	27.17	0.00	23.41
Birds	0.23	0.04	0.13
Total kg/km ²	3037.08	1244.37	1626.78

4.3 Selection of Prey

The frequencies of prey in the diets of pumas ($\chi^2 = 13320.42$; $d.f. = 8$; $p < 0.01$), culpeos ($\chi^2 = 1111.43$; $d.f. = 7$; $p < 0.01$), grey foxes ($\chi^2 = 2725.87$; $d.f. = 6$; $p < 0.01$), and Geoffroy's and pampas cats ($\chi^2 = 2518.27$; $d.f. = 6$; $p < 0.01$) differed significantly from the relative densities of prey available. All species consumed viscachas more than expected according to their densities. Pumas consumed guanacos and pichis more than expected, and pumas, grey foxes, and the small cats consumed European hares more than expected. All species of carnivores consumed *Microcavia* less than expected; pumas consumed *Ctenomys* less than expected, while culpeo foxes consumed *Ctenomys* more than expected. Muridae were consumed less than expected by pumas and the small cats (Table 6).

Table 6. Food selectivity by pumas, culpeo and grey foxes, and Geoffroy's and pampas cats in La Payunia Reserve, Mendoza, Argentina, based on relative occurrence and density of prey. Ranges given are 95% Bonferroni confidence intervals (BCI) for relative occurrence of prey in diets (p_i)^a

Prey	<i>P. concolor</i>	<i>P. culpaeus</i>	<i>P. griseus</i>	<i>Oncifelis spp.</i>
Muridae	-0.015<pi<0.032L	-0.005<pi<0.305	0.117<pi<0.352	0.183<pi<0.400L
Chinchillidae	0.298<pi<0.550M	0.027<pi<0.373M	0.228<pi<0.495M	0.148<pi<0.356M
<i>Ctenomys</i>	0.000<pi<0.000L	0.082<pi<0.468M	0.108<pi<0.339	0.108<pi<0.301
<i>Microcavia australis</i>	0.000<pi<0.000L	-0.039<pi<0.189L	-0.009<pi<0.115L	0.030<pi<0.175L
<i>Lama guanicoe</i>	0.226<pi<0.469M			
<i>Zaedyus pichiy</i>	0.004<pi<0.132M	-0.039<pi<0.189	-0.019<pi<0.061	-0.014<pi<0.045
<i>Lepus europaeus</i>	0.009<pi<0.144M	-0.039<pi<0.189	0.014<pi<0.177M	0.035<pi<0.185M
Livestock	-0.005<pi<0.107	-0.018<pi<0.268		
Birds	-0.015<pi<0.066	-0.043<pi<0.093	-0.018<pi<0.039	-0.013<pi<0.060

^a Prey items are consumed significantly more (M) or less (L) than expected according to their availability if expected proportions based on prey densities are smaller than the lower limit or larger than the upper limit of each BCI, respectively ($p < 0.05$).

4.4 Interviews

The majority of the local residents we interviewed indicated that pumas are present in the area and that their numbers are increasing. Most also said that hunting/poaching occurs in the area but that the amount is decreasing. Interviewees indicated the presence of guanacos, choiques, small cats, mountain viscachas, and culpeo and grey foxes (Figure 3, but see Appendix B for interview questions and individual responses).

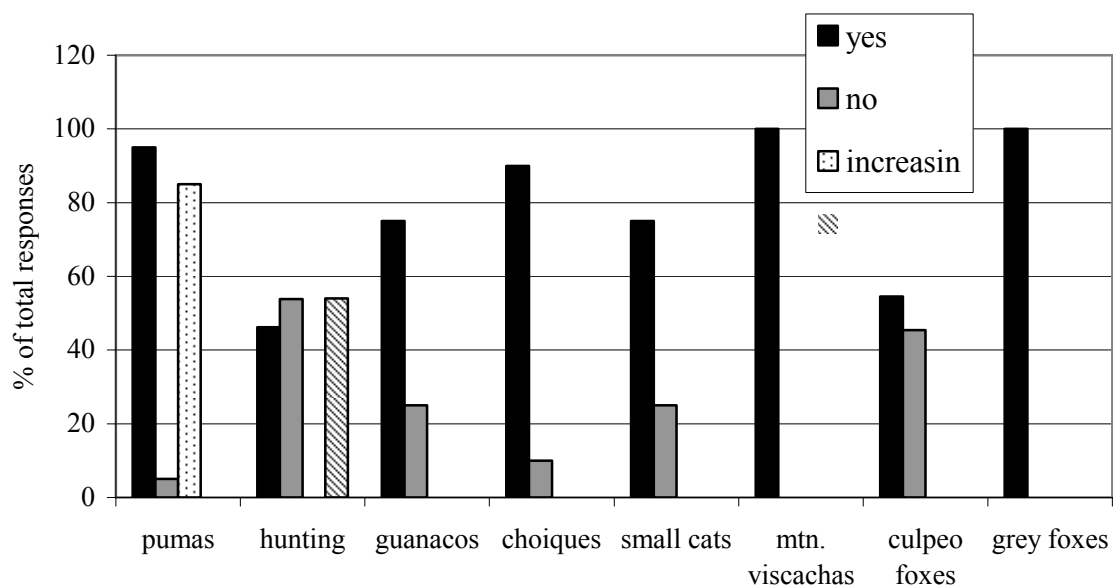


Fig. 3. Responses from twenty semi-structured interviews conducted with nearby residents of La Payunia Reserve, Mendoza, Argentina, indicating whether respondents notice the presence or absence of certain species and hunting, and whether respondents believe puma populations and hunting prevalence are increasing or decreasing.

5. DISCUSSION

Many studies have investigated theories behind optimal foraging, the idea that predators should select for the most profitable prey, which would seem to be the largest available prey that can safely be killed (Sunquist & Sunquist, 1989). This is complicated by the fact that search time, encounter rates, risk of injury to predator, and energetic costs of capture must be taken into account. For example, a smaller, more abundant prey might become more rewarding to a predator if too much energy is spent searching for a larger prey that exists in low numbers.

Plains viscachas are large, nocturnal rodents that live in social groups of 10-30 animals and have been shown to be a relatively reliable, abundant, and spatially predictable prey due to their aggregated burrow systems (Branch, Pessino & Villareal, 1996). Although they are of relatively small size compared to larger herbivorous prey, this disadvantage to predators may be offset by lesser search and handling times and/or risk of injury. Little is known of mountain viscachas, but they too are colonial, and potentially present a predictable clumped resource for predators (pers. obs.).

All carnivore species in this study consumed viscachas significantly more than expected based on density estimates. In Lihue Calel National Park, Argentina, Branch *et al.* (1996) observed a high percentage of viscachas in puma diets subsequently decrease after the population of viscachas crashed, which in addition to low dietary breadth and low frequency of large prey in periods of high viscacha abundance, led them to hypothesize that pumas selectively forage on viscachas. Something similar may be occurring in

Payunia, where pumas have a low breadth of diet in comparison to other South American sites (Taber *et al.*, 1997) and viscachas are abundant and easily caught. Both species of foxes and both species of smaller cats also appear to be optimally foraging on the relatively large (in comparison to the body sizes of these predators) viscachas, consuming significantly more than expected based on their population density.

The diets of Felidae tend to be more specific than those of other Carnivora, generally consisting of mammalian prey of sizes commensurate with their own body size, with little or no fish, vegetation, or invertebrates (Kruuk, 1986). The results of this study support this statement, and suggest that separation occurs in the dietary niches of the carnivores of Payunia. The diets of all three Felidae species contained lower numbers of vegetation and insects than those of the foxes.

Although pumas have been shown to take smaller introduced prey such as European hares (Yañez *et al.*, 1986; Rau *et al.*, 1991) and even smaller native prey such as viscachas (Branch, 1995; Branch *et al.*, 1996; this study), the relatively intact population of guanacos in Payunia has allowed continued predation and selection by pumas on this large native, and historically important herbivore. This is in contrast to other Patagonian sites where guanacos no longer provide this ecological role (Novaro *et al.*, 2000). Maras and choiques, the next largest available native prey species, were not selected for. No evidence of maras was found in any of the carnivores' diets, and although prey items identified as birds were not classified to species, birds represented no more than 2.4% of numbers of prey for any of the carnivores, and were consumed as expected based on

density. These results are most likely due to the low abundances of maras and choiques (Walker *et al.*, unpubl. data) and these species may be considered ecologically extinct as prey and sources of carrion in the area (Novaro *et al.*, 2000). There may be low densities of these animals for several reasons: native herbivores may experience intense competition for habitat and diet resources due to high niche overlap with introduced species (Grigera & Rapoport, 1983; Baldi *et al.*, 2004), native prey species are often hunted for subsistence (Walker *et al.*, 2004), and due to the introduction of additional prey species, densities of predators may be greater than before. A higher density of predators can cause a decreasing or low prey population to survive only at a very low density (Bergerud, 1983).

In general, foxes tend to be omnivorous and opportunistic, adjusting their diets in response to changes in local and seasonal prey availability (Romo, 1995). As could be expected, the dietary preferences of foxes in this study generalized more than the other carnivores, and had the widest dietary preferences. Culpeos appeared to prefer *Ctenomys*, insects and carrion or young of livestock and guanacos more so than grey foxes. Grey foxes tended to prey more on viscachas and European hares. However, to see if these two foxes are exhibiting the niche-complementarity hypothesis that they do in other parts of South America, it would be necessary to examine the temporal and/or spatial components of their niches in relation to diet.

A few other observations regarding the dietary preferences of Payunia's carnivores are worth noting: all species consumed significantly less *Microcavia* than expected based on

prey density, and pumas, grey foxes, and the smaller cats all consumed European hares significantly more than expected based on density. One reason the results indicate lack of consumption of the former might be that actual densities of *Microcavia* in Payunia are not as great as indicated by the literature, which was based on a study done in the province of Buenos Aires, well to the east of Payunia (Reford & Eisenberg, 1992). The high consumption of European hares could indicate that carnivores find them an easy prey, or that their numbers in Payunia are high. The latter suggests that European hares could present competition to native species.

Further examination of dietary preferences for viscachas could provide a more detailed description of dietary separation among Payunia's carnivore species. Of the viscachas that I was able to identify to species during scat analysis, pumas and foxes appeared to consume only plains viscacha, while the smaller cats consumed eight mountain viscachas and only one plains viscacha. Could it be that the smaller cats overlap in habitat use with either the foxes or pumas, therefore causing the species to differ in diet and exhibit the niche-complementarity hypothesis? To explore this, it would be necessary to distinguish between the scats of Geoffroy's cats and pampas cats, and more definitively distinguish between the scats of culpeo and grey foxes. The scats from small cats in this study may have all or mostly been from one species or the other. Thus, care should be taken when drawing conclusions about the dietary preferences of these two species. In addition, it would be useful to estimate the total and seasonal minimum number of scat samples needed for this study, following the methods of Hanson & Graybill (1956) or Ray & Sunquist (2001). Since many of the scats were collected from the same, repeatedly-

visited telemetry sites, the results of this study may indicate dietary preferences of just a few individuals, rather than those of the region's carnivores as a whole. In future research, it might be useful to identify scats to species and/or individual level through genetic analysis of mitochondrial DNA isolated from intestinal cells found in deposited scats (Palacios, 2006).

Finally, although livestock did not make up a large percentage of the diets of Payunia's carnivores, local complaints about predation on livestock cannot be ignored. Livestock frequently range within the reserve boundaries, and tend to concentrate around the perimeter (pers. obs.). Most of the scats collected in this study were found in this area. It is difficult to say whether the scats that did contain livestock remains were from carnivores that actually left the reserve to prey on livestock or from carnivores feeding on the animals found just within the boundary. Further research and collection of carnivore scats in areas well outside of the reserve, and several areas well within the reserve, and not influenced by the reserve boundary and each with multiple transects, are needed to compare and document the actual amount of predation on livestock taking place.

If scats found well within the reserve contain livestock remains, it will be obvious that carnivores are selecting for livestock, as no livestock is found deep within the reserve. And if scats found well outside the reserve contain many native prey remains, it will be obvious that carnivores are seeking out native prey, as native prey densities are low outside the reserve (pers. obs.). If carnivores are not selective, prey types should be

consumed in proportion to their respective availabilities at a given locale, regardless of whether or not the boundary is nearby.

Either way, although the ecological roles of most of Payunia's carnivores and their prey appear to still be relatively intact, they are in a vulnerable state, and immediate conservation action needs to be taken to prevent the introduction of additional exotic species, stop the decline of native herbivores, and restore Patagonia's landscape to what it once was. To do this, some key issues need to be addressed.

First of all, although interviewees indicate that hunting is decreasing (Appendix B), carcasses and events witnessed by ourselves and park guards indicate that illegal hunting is still common in the reserve. Currently, park guards do not have the resources to control hunting. They are often short on staff, vehicles, and/or fuel. In addition, since they are unarmed, park guards often need to call for assistance from the police or the national guard, which can be difficult to coordinate and often happens too late, after the hunter is already gone. If park administration can not supply sufficient funding or supplies to control hunting, effective conservation will require the acquisition of outside resources, such as from donors or non-governmental organizations.

Conservation of Payunia's carnivores and their prey also requires involvement of local livestock owners. Area residents spend time in the field and are important sources of local knowledge. They also have a vested interest in working with researchers and/or

park guards to understand predator-prey interactions, as their livelihoods may be threatened by lack of predator management.

Livestock-guarding dogs have been shown to be successful in protecting livestock (Marker, Dickman & Macdonald, 2005). Currently, Wildlife Conservation Society is developing a program with locals in the Payunia area to implement guard dogs in protection of their livestock from predation. Livestock-guarding dogs are generally recognized for their attentiveness and trustworthiness, are raised with the livestock herds, and when threatened, will place themselves between the threat and the herd, barking loudly to deter any predator. This non-lethal method of predator control could have direct economic benefits for livestock owners in terms of reduced losses, as well as facilitate the coexistence of humans and carnivores.

While the interviews in this study were an important start to developing involvement and partnerships among researchers and livestock owners, these sorts of open dialogues need to be repeated over time. These continued conversations may prove useful in discovering shifts and seasonal variability in predator/prey numbers and interactions. Giving area residents a participatory role, as field assistants or as informants to study locations, for example, may also establish a sense of importance, understanding, and/or ownership in the area and its wildlife, thereby increasing the desire for conservation of these resources. In addition, increased public education could serve to inform residents of the detrimental effects that introducing more exotic species could have on the surrounding vegetation and populations of native herbivores. Only by collaborating with the private sector can we

hope to promote and consolidate protected areas in order to conserve, restore, and maintain suitable habitat and reduce threats to wildlife.

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7. APPENDICES

Appendix A. Afterword

My time in Argentina was an amazing experience for which I would not trade a thing. I feel that given the resources available to me, I conducted a significant scientific, exploratory investigation, but if I could do it over again, there are some changes I would make to increase rigor and precision.

It is always recommended to conduct a pilot study or at least to lay out your methods before beginning. This not only applies to how you are going to collect the data, but also to how you are going to analyze it. The whole experience was a learning project and something I had never done before, and not wanting to waste valuable time, I was reading articles and background information even after I had already started and as I went along, trying to ask the right questions and get advice when I wasn't in the reserve, which wasn't very often.

The line transects did not get set up in their final design until mid-March; I also did not start counting guanacos until this time – we thought initially that I did not need to do so because I could use pre-existing data. While I had been counting animals since November and was able to still use some of the data to fit the new design, it would have been better to have implemented the transect design at the beginning to ensure equal sampling among seasons and to obtain an adequate number of observations each season to estimate density with more precision. Instead, I was unable to estimate density for a

couple species and had to lump all observations across the year to come up with a total density rather than for each season.

The study might also have been more systematic if I had used transects to collect scats rather than opportunistically. While I still collected a fair number of scats, most of them were collected as I was hiking up rocky hills/volcanoes to search for guanacos with radio-telemetry or as we found carcasses while driving or walking along. Again, determining minimum sample size and more definitively identifying scats to species level would have been helpful.

Appendix B. Interviews

Questions:

- a) Name
- b) Ranch name and location
- c) Site of summer livestock feeding grounds and dates of arrival and departure
- d) Site of winter grounds and dates of arrival and departure
- e) Numbers and types of livestock
- f) Are pumas present in your area? If so, have their numbers increased, decreased, or stayed the same? Since when did you start noticing this change in numbers?
- g) Is there hunting/poaching in your area? If so, has the amount increased, decreased, or stayed the same? Since when did you start noticing a change in the amount?
- h) Have you noticed the presence of guanacos? If so, where?
- i) Have you noticed the presence of choiques? If so, where?
- j) Have you noticed the presence of small cats, small cat latrines, or skins of small cats? If so, where?
- k) Have you noticed the presence of mountain viscachas? If so, where?
- l) Have you noticed the presence of culpeo foxes? If so, where?
- m) Have you noticed the presence of grey foxes? If so, where?
- n) Other comments

Answers:

1.
 - a) Sosa Domingo
 - b) Matansilla; 36°48'23.6" 68°51'10.4" 1403m
 - c) No separate summer and winter grounds
 - d) [See above]
 - e) 1300 goats; several cows; had sheep before but pumas killed them
 - f) Yes, pumas have increased since 1985
 - h) Not on this ranch but on Chachauen Hill
 - j) No
 - l) No
 - m) Yes, many

n) Ranch is 37,000ha. Not fenced. Many problems with puma all over in the Chachauen area and in that area I see many guanacos.

2.

- a) Gregorio Moya
- b) Los Toscales; 36°33'51,5" 69°2'38,9" 1387m
- c) No separate summer and winter grounds
- d) [See above]
- e) 1200 goats; few cows; had sheep before but pumas killed them; 28 horses
- f) Pumas number have been increasing for about eighteen years
- g) No
- h) Yes, it's been three years since I saw so many in the area. They arrived in May.
- i) Yes, not many
- j) Yes, 'gato overo', but no latrines or skins
- l) No
- m) Yes, usually when the goats are being born

3.

- a) Juan Oliva
- b) El Molina; 35.92613 69.09983 1337m
- c) No separate summer and winter grounds
- d) [See above]
- e) Have goats, cows, sheep, and horses
- f) The numbers of pumas are increasing but I don't know since when
- h) Yes, makes me mad because they eat the pasture
- i) No
- j) Yes, pampas and Geoffroy's cats
- l) No, but it's been 18 years and they used to cause a lot of damage to the livestock

4.

- a) Moyano Isidoro
- c) Casa de Piedra, Chacayco; depart in April
- d) Agua Botada; arrive in April
- e) 1500 goats; 120 cows; 80 horses
- f) Pumas have been increasing for about 10 years
- g) No
- h) No
- i) Yes, in Agua Botada
- j) Yes, Geoffroy's cats in Chacayco and Agua Botada
- k) Yes, in Chacayco and Agua Botada
- l) Yes

5.

- a) Humberto Zagal
- b) El Durazno; 35.94904 69.41187 1922m
- c) Laguna Verde; arrive in Nov.-Dec.; depart at the end of March
- d) Palauco; arrive at the end of March; depart in Nov.-Dec.
- e) 400-500 goats; 200 cows; 10 horses
- f) Yes, in Laguna Verde; increasing for 15 years
- g) No, decreased in the last 2-3 years
- h) Yes, in Palauco
- i) Yes, in Palauco but not in Laguna Verde
- j) Yes, pampas cats in Palauco and in Laguna Verde, but not latrines or skins
- l) Yes, there are a few in Laguna Verde because there is puma there; there are a few in Palauco

6.

- a) Nolasco Barreda
- b) Ciénaga de Borbaran, Tierra de Reyes (30 kilometers from Payunia Ranger Station)
- c) No separate summer and winter grounds
- d) [See above]
- e) 250 goats; 30-40 cows; 40-50 horses
- f) Few pumas
- g) Yes, hunters come from San Rafael, but the amount has decreased
- h) Yes, in December I see more
- j) Yes, pampas cats
- k) Yes, many
- l) No
- m) Yes

7.

- a) Rolando Mansilla
- b) Coihueco Sur
- c) We take only the goats and horses to Puerta Barranca; arrive in December and depart in April
- d) We have the cows and sheep in Coihueco all year long; arrive in April and depart in December
- e) 1000 goats; 100 cows; 60 sheep; 30 horses
- f) Yes, in Coihueco; increasing for about ten years
- g) No, decreasing
- i) Yes, in Coihueco
- j) Yes, pampas and Geoffroy's cats and latrines in Santa Maria volcano
- k) Yes, in Santa Maria
- l) Yes, in Barranca, Coihueco, and Palauco
- n) There was more wildlife when YPF was not here in Fortunoso. The cats eat mountain viscachas.

8.

- a) Luca Cara
- c) El Salitre; take the goats and the horses and sometimes the cows
- d) Chacayco
- e) 500 goats; 50 cows; no sheep; 40 horses
- f) Yes, in Chacayco; they have been increasing for 20 years
- g) No, because there is no road to get in
- h) No
- i) Yes, in Chacayco, there is a big number actually
- j) Yes, pampas cats in El Salitre and Chacayco and Geoffroy's cats in El Salitre; latrines too
- l) Yes, in El Salitre and Chacayco
- n) Before, we used to see guanacos in Cañada Seca

9.

- a) José Carrozco
- b) Cajón del Pehuenche
- c) Pehuenche; arrive in September and depart in April
- d) Malhal del Medio; arrive in April and depart in September
- e) 3000 goats; 900 cows; before we had several sheep but when the oil company came we lost them all; 50 horses
- f) No because we are near the oil activity; haven't noticed them since the oil company came
- g) No
- h) No
- i) Yes, a few in Malhal del Medio
- j) No cats, latrines, or skins
- k) Yes, in the mountain range of Malhal del Medio; before, we used to see more
- l) No
- n) Before, we used to see more guanacos; now, only in the mountain range of Colhi Malhal, Camileo Hill, and Rincón Agua de las Sierras Cordón del Mar

10.

- a) Dicerio Vallejo
- c) Polcuro Potimalal; arrive in September and depart in April
- d) Arroyo Llenqueco; arrive in April and depart in September
- e) 500 goats
- f) Yes, increasing for about 10 years
- g) No, the amount has decreased in the past 10 years
- h) No, but there are some signs of them
- i) Yes, in Arroyo Llenqueco
- j) No
- k) Yes, in mountain range of Potimalal
- l) Yes
- n) Before, we used to see more guanacos; now, only in the mountain range of Colhi Malhal, Camileo Hill, and Rincón Agua de las Sierras Cordón del Mar

11.

- a) Forquera
- b) Forquera
- c) No separate summer and winter grounds
- d) [See above]
- e) 500 goats, some cows and some horses
- f) Yes, the numbers have increased in the past 5 years
- h) Yes
- i) Yes, many
- j) Yes, Geoffroy's cats in Payún Matrú
- n) The guanacos in winter pass through to the southeast; the choiques when it snows come down from Payún Matrú

12.

- a) Daniel Mendoza
- b) Mendoza; 36.18443 69.45555 1848m
- c) Palauco mountain range or in the area, but don't move much
- d) Palauco
- e) 700-800 goats; some cows and some horses
- f) Yes, the numbers have been increasing always
- h) Yes, Palauco, near the house
- j) Yes, pampas and a few Geoffroy's cats
- k) Yes, many
- l) Yes, they do a lot of damage to the goats
- m) Yes, but less quantity [than culpeos]
- n) Sometimes you can see Chacal fox (longer and lighter hair). The guanacos in winter go to Zaino and Nevado, to the southeast. We have water on the ranch all year and good pasture, for that we don't move the animals much.

13.

- a) Ubaldino Diaz
- b) Rincón Amarillo; 36.09539 69.35810 1938m
- c) We take the goats to Cañada de la Gata, Palauco; arrive in October
- d) Rincón Colorado, 5km from the ranch; arrive at the end of March and depart in October
- e) 800 goats; 160 cows; 90 sheep; 50 horses
- f) Yes, the numbers have been increasing for 20 years
- g) The amount has gone down
- h) Yes, a few in the area of Cañada de la Gata
- i) Yes, a few

n) Ranch is rented. The guanacos in March come down from the area of Cañada de la Gata some kilometers until Palauco.

14.

- a) Pabez Nicolas; Owner is Zambrano
- b) La Niebla; 36.02896 68.96150 1465m
- c) No separate summer and winter grounds
- d) [See above]
- e) 700 goats; 1000 cows
- f) Yes, but there isn't a problem [with them]
- h) Yes, many
- n) There are more problems because of the quantity of guanacos than because of puma

15.

- a) Maya
- b) La Agüita
- f) Yes, it's been years that the numbers are increasing
- n) There used to be less pumas because they were hunted

16.

- a) Oscar Zagal
- e) 500 goats
- f) Yes, increased in the last 5-6 years
- g) Stayed the same

17.

- a) Epifario Forquera
- b) Cerro Colorado
- e) 80 goats; 20 cows; no sheep; 5 horses
- f) Yes, many in the mountain ranges; increased
- g) Decreased
- n) The owner of the ranch is Rostaño. It is 1000ha.

18.

- a) Martín Zagal
- b) Los Pirquitos; 35.96035 69.42188
- c) Valle Noble; only the goats; arrive in Nov.-Dec. and depart in March
- d) near Loma Atravesada; arrive at the end of March
- e) 1000 goats; 150 cows; 70-80 sheep
- f) Yes, increased in past 14 years
- g) Decreased
- n) Killed a pair of pumas because they did a lot of damage

19.

- a) Bety Zagal
- b) Kiñe, La Agüita
- f) Yes, increased in past 20 years

20.

- a) Silverio Antonio Forquera and Mirta Lara (wife of Silverio)
- b) Cajón Chico; 35.97445 69.42552 2054m
- e) 200 goats; 40 cows; 20 horses
- f) Yes, increased
- g) Decreased
- n) Owner of the ranch is Rostaño