FACTORS UNDERLYING THE INTERACTIONS BETWEEN PEOPLE AND WILDLIFE IN THE ARGENTINE CHACO

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DEDICATION

To the people of the Chaco.

To my parents and siblings.

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ABSTRACT

I assessed major factors influencing the interactions between the mestizo community and wildlife of the *Impenetrable*, in the Argentine Chaco, and the ways in which these interactions are influenced by the larger economic and political context. I used a mixed qualitative and quantitative methods approach, between 2001 and 2005. I found that wildlife represented an important food source, especially for the poorer rural households. The importance of wild meat varied across the community and region, in relation to the socioeconomic characteristics of households, village size, forest condition, season, species biology, and cultural preferences. Some species used by local people, primarily white-lipped and Chacoan peccaries, and jaguar, were in decline and their range had been reduced by habitat destruction and overhunting, especially in the humid sub-region. These species persisted in areas of low human density, low hunting pressure and scarce development. Harvest of peccaries for food was unsustainable. Characteristics of the resource and of the community explained the lack of incentives for community-based management of peccaries. The resource was too large in relation to the local technology and the community's institutional capacities were scarcely developed. Changes in property right regimes also influenced people-wildlife interactions and were related with species mobility. Acquisition of land title by peasants did not reduce overexploitation of highly mobile resources such as peccaries, which continued to be hunted as open access resources. The national economic collapse of 2001 had a strong influence in the region. Hunting by villagers increased as a result of growing unemployment, whereas peasants

reduced their hunting and turned to forest exploitation. Acquisition of land title by non-locals and intensification of ranching and forest exploitation subsequently increased, thereby affecting the livelihoods of local peasants by reducing grazing areas and affecting wildlife by reducing habitat. This study shows how people-wildlife interactions are complex and dynamic, and indicates that conservation measures are unlikely to succeed without considering the biological, cultural, socio-economic, and political factors involved. External factors require especial consideration. In this case, a national change in economic policy produced a local change in land use that is jeopardizing the peasants culture and the region's biodiversity.

INTRODUCTION

The science of conservation biology recognizes the need to further understand the complexity and diversity of interrelationships between societies and their environment. Overexploitation of wildlife not only affects the ecosystem but may also negatively affect local people when they depend on this resource as part of their livelihood. Thus, the fate of wildlife is of interest not only for conservationists but also for governments, aid agencies, conservation organizations, professionals of many disciplines and local people.

The sustainable coexistence of rural communities and the natural resources they use has been the focus of much research. Many of these efforts have emphasized the perspective of one discipline and have frame the problem as one of overexploitation of wildlife by local people who hunt for subsistence or to defend their livestock or crops (Olfield and Alcorn 1991, Robinson 1993, Bissonette and Krausman 1995, Freese 1997, Robinson and Bennet 2000a, Mainka and Trivedi 2002, Silvius et al. 2005). However, the problem is generally more complex and dynamic, and may go beyond local people's actions. Other local factors, as well as the larger economic and political forces that, in turn, shape these factors themselves, have to be considered to understand what influences people-wildlife interactions. Thus, the success of conservation of natural resources depends on basing management on the integration of the biological, political, cultural and socioeconomic perspectives involved in the problem (Sponsel et al. 1996, Stevens 1997, Silvius et al. 2005).

In the Argentine Chaco, poor local people strive to make a living in a harsh environment, using and depending on natural resources for fodder, wood and food. Populations of the largest game species, the peccaries (Artiodactyla: Tayassuidae), and the largest predator, the jaguar (*Panthera onca*), have been declining over the last decades (Barbarán 1999, Perovic 2002). This is not only a local trend; these species are in decline in most of their range of distribution in Latin America. Causes of decline are varied, but overhunting and habitat destruction have been identified as the main threats (Sowls 1997, Medellin et al. 2002). Depletion of these species has wider repercussions on ecosystem health and diversity (Robinson and Bennet 2000b). Given the importance of these species in the ecosystem, their tight connection with local people either as part of their diet or as a threat to their livestock, and the need to integrate development with conservation, an understanding of the problem and the factors affecting it becomes indispensable. By providing an integral understanding of the problem I aim to create the basis on which locally appropriate approaches to solve human-wildlife conflicts can be founded. Whether wildlife species are being affected by deforestation or by hunting, whether people are hunting for food, for cash income, or to eliminate a species that they consider undesirable, and whether local people have the capacity to organize and regulate use of resources, requires completely different approaches to solve problems of wildlife depletion.

Definitions

Throughout this dissertation, I use the term *hunting* to include capture or killing of wild animals for elimination, consumption, traditional medicine, or trade. Following the

definition of Ortiz von Halle (2002) and Stearman (2000), I consider s*ubsistence hunting* as small-scale hunting practiced by poor settlers. It includes hunting for sale, which is a means to obtain income for meeting basic needs. The difference with *commercial hunting* is that in the latter the main objective is profit through sale of the meat or other derivatives. Because subsistence hunting is not regulated except for a few species, I do not differentiate between legal and illegal subsistence hunting. *Sport hunting* is practiced with recreation as the main objective, and it, too, can be legal or illegal. Although sport hunting in Argentina is regulated and hunters have to obtain a license, many practice hunting without following the legal procedures. I consider *wild meat* as the meat derived from any type of hunting of any type of wild animal.

The local setting

The Chaco, a word derived from Indigenous language and meaning plains full of animals, is a dry, vast plain of about 1.3 million square kilometers extending over part of Paraguay, Argentina and Bolivia. The Chaco is one of the most degraded ecoregions in South America (Bucher 1983) and has received scarce attention from conservationists. In the 19th century, the large expansion of wilderness in the Chaco inhabited by Indigenous people was considered an embarrassment to the civilized bourgeoisie society, and an obstacle for the expansion of livestock frontier and wood extraction (Rosenzvaig 1996). The almost complete extermination of indigenous populations and colonization of the region by non-native people have changed the patterns of traditional utilization of natural resources. Today, I see the results of these unsustainable uses of land and natural

resources in the form of progressively increasing poverty in the region and steady degradation of the natural system (Saravia-Toledo 1984, Bucher et al. 1998, Bucher and Huszar 1999, Torrealba et al. 2003, Zak et al. 2004). The original landscape of the Chaco was mostly a savanna with patches of forest intermingled with grasslands (Bucher 1983). Increasing human density and unsustainable uses of natural resources, such as overgrazing, excessive timber harvesting and charcoal production and overhunting are transforming the region into a dense and unproductive shrubland (Morello and Saravia-Toledo 1959, Bucher et al. 1998). These processes of alteration and degradation of the forest and the depletion of wildlife in the Argentine Chaco are accelerating (Bucher and Huszar 1999). The degradation of the ecosystem by livestock has been studied by several researchers (Morello and Saravia-Toledo 1959a,b, Bucher et al. 1998, others), but the depletion of wildlife, its causes and effects, is almost unknown. Some wild species such as *Lama guanicoe* and *Rhea americana* have locally gone extinct during the last century, probably due to habitat alteration and overhunting (Saravia-Toledo 1984).

The Chaco is divided in three sub-regions based on an east-west rainfall gradient: eastern or humid, central or transition, and western or semi-arid Chaco (Bucher 1983, Morello and Adamoli 1968). Economic characteristics of residents, human density, natural resources use and land uses are related to this classification. The humid Chaco has the highest human density and the largest development of agriculture. The landscape is a heterogeneous mosaic of swamps, reedbeds and gallery forests. The dominant vegetation is savanna with patches of subtropical semi-deciduous tall forest, with an upper layer of emergent trees 25 to 30 m high. Its flora is the richest of all Chaco formations. *Schinopsis*

balansae, *Astronium balansae* and *Aspidosperma quebracho-blanco* are the dominant tree species. Annual rainfall reaches 1200 mm and the dry season lasts two months. Other important types of vegetation are gallery forests, low forests, palm forests and savannas. There are three reserves within the study area in this sub-region: Pilcomayo (47,000 ha) and Chaco (15,000 ha) National Parks and Pampa del Indio (8,600 ha) Provincial Reserve. The transitional or central Chaco has annual rainfall between 700 and 900 mm. The dominant vegetation is a xenophile subtropical forest. Other types of vegetation found in this region are lowland and fire-maintained grasslands. The semi-arid Chaco has the lowest human density and it is the least developed sub-region. This is the driest and most markedly seasonal region, with rainfall between 450-700 mm of which 80% occurs between October and April. Average annual temperature is 21.9^{o} C with minimums below zero and maximums around 50^{o} C. The vegetation is a medium-tall xerophilous forest with a canopy layer of about 12 m high surpassed by a few species of taller trees reaching 16 m to 18 m (Bucher 1983). The dominant species of trees are *Schinopsis quebracho-colorado*, *Aspidosperma quebracho-blanco* and *Bulnesia sarmientoi*. The shrub layer is dominated by species of *Acacia*, *Mimosa*, *Prosopis*, and *Celtis*. Cacti *Opuntia* and *Cereus*, grasses and bromeliads are abundant in the understory. This is one of the most heavily wooded areas of the semi-arid regions of the world (Bucher 1983). There are five protected areas: Formosa (9,000 ha) and Copo (114,000 ha) National Parks, Copo National Reserve (70,000 ha), and Loro Hablador (23,750 ha) and Fuerte Esperanza (28,200 ha) Provincial Reserves. In the Chaco province, there is a large area to the west of Fuerte Esperanza of about 150,000 ha of state land that the government reserves from selling. Although this

area is called Wichi indigenous reserve, it does not have the legal status of a reserve and there are no indigenous people living on this land. There are some mestizo people settled in the reserve but they cannot acquire the land's title.

The transitional and humid sub-regions were colonized by small and medium-scale farmers at the beginning of the 20th century. The original vegetation was first replaced by cotton and later by soybean and pastures for cattle ranching (Bucher 1983, Torrealba et al. 2003). Intensive timber extraction occurred during the 1950's (Bucher 1983). Since approximately 1990, small farms have been replaced by large properties dedicated to intensive cattle ranching and agriculture. Today, these two sub-regions are the most developed and have the largest percentage covered by agriculture. The semi-arid Chaco was colonized by small-scale farmers about two decades later than the other sub-regions (Torrealba et al. 2003). This is one of the poorest, least developed regions of the country. Most inhabitants of this sub-region are rural peasants who occupied the land and practice small-scale livestock ranching.

The *Impenetrable*, which is found in the semi-arid region, has been considered as the last refuge for wildlife in the Chaco (Rosenzvaig 1996). However, this same region has been under intense pressure from governmental programs promoting colonization and development during recent decades (Saravia-Toledo 1984). Many roads and some aqueducts have been built and new villages established to promote colonization (Saravia-Toledo 1984). Despite these attempts at colonization and development, this region is still the largest extension of continuous forest and one of the poorest regions of the country. Today it is inhabited by peasants who live in small settlements spread throughout the

forest and in a few villages. Peasants have an economy of subsistence based mainly on goat and cattle breeding, and small-scale forest exploitation for charcoal, fuel wood and fence posts (Bucher *et al.* 1998). Wildlife in the *Impenetrable* has been an important resource for peasants since the colonization of this region (Barbarán 1999). Commercial hunting of peccaries and other wild species provided one of the main economic revenues to local people until export of peccary hides was prohibited by the Argentinean CITES authority in 1998 (Barbarán 1999).

The Chaco is of interest from an ecological perspective because it has high levels of biodiversity and endemism, especially in the mammals group (Mares 1992). This is the only region in which the three species of peccaries of the family Tayassuidae coexist: the collared peccary (*Tayassu tajacu*), the white-lipped peccary (*Tayassu pecari*), and the Chacoan peccary (*Catagonus wagneri*) (Sowls 1997). The largest predator of Latin America, the jaguar, also inhabits this region. Forest exploitation is increasing and the agricultural frontier is advancing even into the driest and most marginal areas (Torrealba et al. 2003, Zak et al. 2004). The area occupied by agriculture is predicted to quadruple in the next six years with the expansion of soybean plantations and pastures for grazing (Torrealba et al. 2003). Increasing human population, habitat fragmentation and overhunting make it unlikely that large and susceptible species like jaguars and peccaries will persist. If the Chaco forest is to continue providing meat for local people while maintaining ecosystem integrity, it is essential to develop measures of conservation that will not negatively affect local people's livelihoods.

Jaguars

The jaguar (*Panthera onca*) is the largest feline of the Americas and it is among the most threatened species, surviving in only a fraction of its former range (Swank and Teer 1989). Remaining jaguar populations are restricted to patches of wild land (Rabinowitz 1995). In Argentina, this species was once widely distributed, from the north of the country to the Patagonia (Guggisberg 1975, Brown 1983). Currently, its range has been reduced by about 85% (Perovic 2002). This species is considered in danger of extinction and it is classified in appendix I of CITES (Parera 2002). The Argentine Chaco has been highlighted as one of the priority sites for research on jaguars (Medellin et al. 2001, Sanderson et al. 2002). The main causes of jaguar population declines are habitat loss and hunting due to livestock-predator conflicts (Swank and Teer 1989, Rabinowitz 1995). It is difficult to discern between these two factors because they generally occur together and often synergistically (Peres 2001).

Whether hunting causes local extirpation can also be addressed by understanding how local people perceive and react to the presence of this species. Local people around the world generally hold negative attitudes towards large carnivores that prey upon livestock (Kellert et al. 1996, Mishra 1997, Ericsson and Heberlein 2003). This is the case of jaguars throughout its range of distribution where they are persecuted and killed by local people defending their livestock (Jorgenson and Redford, 1993; Nowell and Jackson, 1996; Johnson et al., 2000; Sanderson et al. 2002). Attitudes towards wildlife are shaped by basic values, knowledge, perception of individual species and past and present interactions with animals (Kellert 1996). Understanding people's perceptions is

indispensable for planning conservation strategies because it influences their attitudes towards such efforts (Kellert 1996). Attitudes of local people are in many cases the main factor upon which the survival outside protected areas of species that require large territories depends (Madden 2004). For this reason, it is essential to understand local people's perceptions towards jaguar presence in the Argentine Chaco.

Peccaries

There are three species of extant peccaries (Artiodactyla: Tayassuidae). The collared peccary (*Tayassu tajacu*) ranges from the southwestern U.S. to northern Argentina and the white-lipped peccary (*Tayassu pecari*) from southern Mexico to northern Argentina. The Chacoan peccary (*Catagonus wagneri*) is endemic to the Chaco of Southeastern Bolivia, Northwestern Argentina, and Western Paraguay (Sowls 1997, Taber 1991). Throughout their distribution, peccaries are hunted for meat and sport, and the leather is used for a variety of products. Peccaries are among the most preferred game mammals and constitute an important source of protein and income for many rural and indigenous groups (Redford and Robinson 1987, Robinson and Redford 1991, Bodmer et al. 1993, Sowls 1997, Robinson and Bennett 2000). Peccaries have both relatively large body sizes for terrestrial Neotropical species and a relatively fast reproductive rate (Gottdenker and Bodmer 1998).

Sustainability of peccary hunting has been evaluated in many parts of Central and South America. The hunting of collared peccary for commercialization of hides in the Peruvian Amazon has been shown to be sustainable when it is practiced under a controlled system, either community-based or co-management with community and government

involvement (Bodmer 1994, Peres 1996, Bodmer et al. 1997, Sowls 1997). In other areas of South America, however, where hunting is not controlled either by the government or the local communities, or where the habitat is highly degraded and fragmented, hunting of peccaries is not sustainable (Peres 1996, 2000, Cullen et al. 2001). Especially susceptible to overhunting are the white-lipped and Chacoan peccaries (Peres 1996, 2000, Taber 1991, Taber et al. 1993). In Argentina, the Chacoan peccary is classified as in danger of extinction, the white-lipped peccary as vulnerable, and the collared peccary as non-threatened (Parera 2002). The Chacoan peccaries are suffering high mortality and low recruitment which has contributed to a decline in their population since the 1970s. This trend is probably due to overhunting, habitat destruction and disease (Taber 1991). The white-lipped peccary is susceptible to overhunting and habitat loss because it requires large territories (Sowls 1997).

Despite the ecological significance of these coexisting species and their importance to local people, the Chaco is the least studied site within the distribution of peccaries (Oliver 1991, Sowls 1997). Little is known about Chacoan peccary in the wild (Taber 1991, Taber et al. 1993, 1994, Mayer and Brandt 1982), and even less about effects of hunting on this species. In the Argentine Chaco, the conservation status of the three species of peccaries is unknown. Scattered studies report a precarious situation and very low densities of Chacoan peccary populations, suggesting that this species is in danger of local extirpation (Taber et al. 1993, Sowls 1997, Barbarán 1999). The meat is consumed in rural areas and peccary pelts have been exported in the past. In 1987 Argentina placed a ban on the export of peccary pelts, giving export permits only for those pelts that were stock piled (Barbarán

1999). Currently, most peasants inhabiting the Chaco practice subsistence hunting of peccaries without regulations and without discriminating among the three species (Barbarán 1999). Inhabitants from villages and cities also hunt peccaries for food and for recreation (Barbarán 1999).

PRESENT STUDY

The methods, results, and conclusions of this study are presented in the papers appended to this dissertation. The following is a summary of the most important findings in this document.

Interrelationships between rural communities and their environment are complex and diverse. To more fully understand these interrelationships, I must focus upon the factors that influence them and the larger economic and political forces that, in turn, shape the factors themselves. Finding sustainable solutions for the coexistence of rural communities and wildlife requires an interdisciplinary approach.

For many rural people, wildlife contributes importantly to their livelihood as a source of food or cash. Thus, when wildlife is overhunted, I are doubly concerned for the conservation of biodiversity and for the local people's livelihoods. Mestizo peasants (non-indigenous), often inhabiting the poorest regions, are the largest users of wildlife in Latin America. Little is known, however, about their use of wildlife. My objective was to understand the interactions between local mestizo peasants and wildlife in the Argentine semi-arid Chaco by assessing the biological, socio-economic, cultural and political factors shaping these interactions. In the Argentine Chaco, mestizo communities live in the forest and their livelihoods are mainly based on the use of natural resources. Natural resources, including wildlife, have been overexploited by these communities and outsiders. Some of the wildlife species used by local people such as the peccaries (Artiodactyla:

Tayassuidae), and the region's largest predator, the jaguar (*Panthera onca*), have been declining over the last decades.

I found that wildlife was used by rural and village dwellers for many purposes, but the consumption of meat was the most prominent. Other uses of wildlife such as commercialization of animals or derivatives were limited. In the rural areas, the peoples' diet centered on meat as it was a primary component of every meal. With nearly a third of the meat consumption derived from wild game, the remainder was gathered from their own domestic stock. Consumption of domestic and wild meat followed opposite seasonal patterns. Consumption of beef increased and consumption of wild meat decreased during the cold months. Although all rural families owned cattle, they considered them as a live reserve to be used during emergencies and therefore refrained when possible from consuming them. Beside the direct use of wildlife as food, wildlife represented an important economic value because its replacement cost in terms of purchased domestic meat could reach two months salary for a family.

In the *Impenetrable*, the least developed region within the semi-arid Chaco, people consumed at least 26 wild species of which armadillos (Dasypodidae) and Chacoan cavies (*Pediolagus salinicola*) were consumed most. Mammals provided 90% of the wild meat consumed. Wild meat was a part of the diets of all rural peoples interviewed and 70% of village households interviewed. Wild species were not consumed equally throughout the year. Armadillos and peccaries were harvested with more frequency during the cold months whereas other species, such as tegu lizards, were exclusively harvested during the

hot months. Recreational hunters from more distant cities also harvested wild game and generally killed larger numbers partially due to their better equipment.

Although wildlife was used mainly as a source of meat, hunting could not be fully explained simply as a need for food. Many factors, including cultural and socio-economics, affected the peoples' dependence on wild meat. Cultural preferences for meat taste, for example, influenced seasonality of hunting of some species. Hunting also played an important role as one of the few recreational activities in the rural area. Local people often hunted even if they had enough meat in their homes.

The importance of hunting was not the same across the community and region. There was large variation among households on the amount of wildlife consumed. In the rural area, wild meat was consumed more when household size was large, families were poor, forest was in better condition and the settlement was young. For the poorer and larger households, wildlife provided up to 50% of their meat consumption. In the villages, consumption of wild meat was higher when the village was small and the household was poor.

Of all the species used by local people in one way or another, peccaries and jaguars had the most evident decline during the last decades. I found that jaguars range in the Chaco has been reduced by about 60% in the last 20 years. Most of this reduction occurred in the humid and transitional Chaco, probably due to the development of agriculture. Signs of jaguar presence were found more frequently in the semi-arid Chaco, although its range is been reduced with the advance of settlements. In the *Impenetrable* where there are still extensive forested lands, jaguars had not been recorded within the last 10 years in

settlements > 35 y old, with the exception of sites near protected areas. Although jaguars were hunted in the past because their skins had high economic value, the current main motivation for hunting was to eliminate a potential threat for livestock. Few cases of livestock predation, however, were reported.

The distribution of peccaries has also been largely reduced, especially in the humid sub-region. Current peccary distribution and relative abundance was explained by settlement density, forest condition, and number of roads. Of the three species of peccary, the collared peccary was the most common and widely distributed. Several points indicated that harvest of Chacoan and white-lipped peccaries were unsustainable in the rural area. These species remained in areas of low human density, high forest cover and scarce development. All three species exist at low densities, and they were more abundant inside a protected area than in hunted sites. Peccaries were harvested more often during the winter, and the largest proportions of harvested peccaries were young animals. Harvest characteristics also indicated over-harvest around the villages. Hunters from the larger villages had to invest more effort and travel longer distances to find peccaries. The results of two sustainability models also indicated that harvests of Chacoan and white-lipped peccaries were not biologically sustainable. Hunters are taking a large proportion of the production of peccary populations. However, harvest of collared peccary could be managed within sustainable levels. However, results indicated that the socio-political conditions were not propitious for the community-based management (CBM) of peccaries. Characteristics of both the community and of the resource in question affected the ability of people to manage wildlife sustainably, and did not seem appropriate for community-

based management of peccaries. Given the level of technology that locals used, the resource for them was unpredictable and its spatial extent too large. Furthermore, the community's institutional capacities were scarcely developed. I identified several factors contributing to this situation: a) There was little communication among settlements and between settlements and villages, b) there were few community activities and few people participating in these, c) past attempts to form cooperatives had failed, d) the existing organized groups in the rural area included a small proportion of the people and e) organizational and leadership experience were poorly almost inexistent. As a consequence of these conditions, local people may not have the institutions and traditions necessary to design mechanisms to manage a resource, such as collared peccary, in a sustainable way.

Changes in property right regimes promoted by the government also influenced the interactions between people and wildlife. Although privatization as a conservation tool has been implemented in many parts of the world assuming that owners will sustainably use their resources, the results in the *Impenetrable* were varied. Traditionally, the land was used by locals for free ranging livestock grazing and there were no boundaries or restrictions for hunting and cutting trees. During the last decade, local peasants started to acquire the title to small portions of land. Since this process of privatization began, there has been a change in the way that people manage some resources but not others. I found that these changes in management were related with the degree of mobility of the resource. For non-mobile and important resources such as trees and nesting parrots, peasants started to actively control and limit access of neighbors and outsiders. For resources of low mobility, such as armadillos, people also started to regulate and negotiate

access. People's perceptions have also changed because they were now claiming ownership over these resources if found within their farm's boundaries. These changes in behavior indicated that the previous open-access situation of these resources, which is known to be incompatible with sustainability, had been reduced. However, for highly mobile resources such as peccaries, whose presence in people's properties is transitory, the situation of open access had not been modified. People's perceptions that these animals do not belong to anybody remained.

All these previously described interactions were not static but highly dynamic, influenced by external factors. I analyzed the effects of the devaluation of the national currency produced by the national economy changes of 2001. I found that as a consequence of the increased unemployment in the villages and increased prices for basic products, people turned to hunting and illegal logging to get food and cash. In the rural area, however, with the increased value of forest products, peasants reduced their hunting and turned instead to forest exploitation. The proportion of rural households gaining their main revenue from forest exploitation increased by 25% in the two years following the economic changes that favored exportation.

Also as a consequence of this national economic change, the value of land and forest products for export increased. For this reason, non-local people started to buy land in the Chaco, implementing a land management system different from the local traditional system. New ranchers fenced their land and replaced forest with pasture for cattle. This resulted in less grazing area for the livestock of local people. Large-scale forest exploitation by non-locals also increased. This is probably going to affect wildlife in

different ways, reducing habitat and increasing hunting pressure by loggers who illegally obtain their meat through hunting.

Overall, this study shows the complexity and dynamism of interactions between rural peoples and wildlife, and how the influences of these interactions are highly modified by external factors beyond an individual's need for food. In some cases, these interactions resulted in the overexploitation of species such as Chacoan and white-lipped peccaries and the jaguar. Overexploitation of these species was related to poverty, cultural preferences and customs, the institutional capacities of the communities, dimensions of private properties, biological characteristics of the species, and changing environmental conditions. Even in remote and under-developed regions like the *Impenetrable*, changes at the national level, which reflect international policies, can influence the patterns of use of wildlife by local people.

Today, however, the largest threat to the future of wildlife in the Chaco is not overhunting by local peasants. Although hunting of some species by local peasants is currently unsustainable, their practices are less destructive than the alternative economic policies that are being implemented by the national government. These new policies produce inequalities in land distribution, which is likely to increase poverty of small peasants, and promote large-scale forest exploitation by external players, which adversely affects the entire ecosystem. Thus, under current management forecasts, both the wild species and the culture of the local peasants are in jeopardy.

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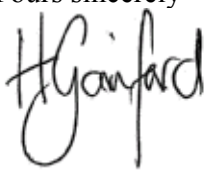

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APPENDIX A

DISTRIBUTION AND RELATIVE ABUNDANCE OF PECCARIES IN THE ARGENTINE CHACO: ASSOCIATIONS WITH HUMAN FACTORS

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Abstract

In the Argentine Chaco, the three species of peccaries (Artiodactyla) are likely affected by habitat destruction and hunting, yet basic information on peccary distribution and status in this region is poorly known. This study identifies human factors associated with relative abundance and distribution of each species. Estimation of relative abundance was based on interviews with local hunters, and variables potentially related to distribution and relative abundance of peccaries were estimated for 153 circular sample sites of 10 km diameter in the Argentine Chaco. Peccaries were found in sites of high forest cover, low human density, far from towns and with low density of roads. After accounting for forest cover and other variables, number of settlements was identified as the main variable negatively associated with relative abundance of the three species, which may be a result of local hunting. Density of roads was also negatively associated with presence of Chacoan peccaries. Collared peccary seems to be the least susceptible to human perturbations. It was the most widely distributed and found in a wider range of conditions than the other species. Chacoan peccary was relatively rare. Because colonization and development programs are increasing in the region, areas still uninhabited should be protected, construction of roads controlled, and hunting managed.

Keywords: Chaco; subsistence hunting; peccaries; Tayassuidae.

Introduction

Understanding the ecological and anthropogenic factors that underlie present distribution and abundance of large mammals is a key factor by which to focus conservation efforts. Species with large area requirements generally inhabit a mosaic landscape, with different levels of human pressures. Such is the case for peccaries, ungulates with relatively large home ranges. There are three species of peccaries: the collared (*Tayassu tajacu*) occurs from Southern United States to Northern Argentina, the white-lipped peccary (*Tayassu pecari*), is found from Southern Mexico to Northern Argentina, and the Chacoan peccary (*Catagonus wagneri*) is endemic to the Chaco region of Northern Argentina, Western Paraguay and Eastern Bolivia (Sowls, 1997). Although the three species are ecologically similar, they have different susceptibilities to human impacts (Peres, 2000, 1996; Fragoso, 1999; Sowls, 1997). With accelerated process of alteration and degradation of the Chaco's natural resources (Bucher et al., 1998), I need to assess whether these species can persist in altered landscapes and what features of human modified landscapes are the most important in determining distribution and status of peccaries.

The Argentine Chaco is one of the poorest regions of Argentina (Bolkovic, 1999). Peasants live in small settlements spread throughout the forest, in a subsistence economy based on cattle and goat ranching, charcoal and fuel wood production, and hunting (Bucher and Huszar, 1999). They harvest several species of wildlife to complement their diet and peccaries are their favorite wild meat (Bolkovic, 1999). Commercial hunting of peccaries and other wild species was an important activity in the Argentine Chaco until

the federal government prohibited exportation of peccary hides in 1987 (Barbarán, 1999). Currently, peccaries are under the pressure of conversion of natural habitat to agriculture and subsistence hunting by local peasants and inhabitants of local villages (Bolkovic, 1999), and sport hunting by urbanities from cities. Although sport hunting is officially regulated, there is almost no in situ control.

A considerable problem confronting peccary conservation is lack of information (Taber and Oliver, 1993), as no current information exists about the status of peccaries in the Argentine Chaco. The most recent information on the population status of Chacoan peccary in Argentina suggests that populations are at very low densities (Taber, 1993). The status of this species is especially worrisome because most of its populations in Paraguay are in danger of extinction and its numbers are declining (Taber, 1993). The Chacoan peccary is currently classified as endangered by the IUCN/SSC specialist group (Hilton-Taylor, 2000). Conservation status of white-lipped peccaries varies in different areas of its range of distribution. The IUCN/SSC group recognized in 1993 that there is insufficient information about this species in the Chaco (March, 1993), and no newer information has been provided.

Because the Argentinean government expressed interest in the conservation status of peccaries in the Chaco region, I conducted this research within the Argentine Chaco to obtain basic information important for conservation of peccaries. Our objectives were a) to assess the population status and distribution of the three species of peccaries, and b) to explore the associations between peccary status and human factors such as land use, road density, human density, and proximity to urban centers.

Methods

Study area and data collection

The Gran Chaco is a vast plain extending across northern Argentina, eastern Bolivia, western Paraguay and part of southeastern Brazil. Originally the Chaco was parkland or savanna with patches of hardwood intermingled with grasslands (Bucher, 1983), but has been altered after an intense period of overgrazing, excessive timber harvesting, and charcoal production that have transformed large parts of the Chaco into a dense shrubland (Bucher and Huszar, 1999; Morello and Hortt, 1985; Morello and Saravia-Toledo, 1959). There are still some extensive uninhabited areas in the semi-arid sub-region, due mainly to the scarcity of drinkable water and irregular precipitation.

The study area, an approximate rectangle of 400 x 200 km, was chosen so as to partially cover each of the main sub-regions of the Chaco (humid, transition and semi-arid; Bucher, 1983; Morello and Adamoli, 1968). The study area encompasses the central and western part of El Chaco province and the northeastern portion of Santiago del Estero Province (Fig. 1). The area is mostly rural with people living in small settlements (average < 7 households) spread widely (> 5 km) throughout the forest, and several towns with more than 20 households (Fig. 1). There are five protected areas within this territory: Copo National Park (114,250,000 ha) in Santiago del Estero Province, and Fuerte Esperanza Provincial Park (28,220 ha), Pampa del Indio Provincial Park (8,633 ha), Loro Hablador Provincial Reserve (17,500 ha) and Chaco National Park (15,000 ha) in El Chaco Province.

The three sub-regions of the Chaco are classified based on an east-west rainfall gradient: eastern or humid, central or transition, and western or semi-arid Chaco (Bucher, 1983; Morello and Adamoli, 1968). Following this gradient, economic characteristics of residents, human density and land use also change. The humid sub-region is the most productive, with rainfall between 900-1200 mm and a dry season of about two months. This is the most altered portion of the Chaco where agriculture has expanded over the last decade (Bucher and Huszar, 1999). This region has the highest human density and the landscape is a heterogeneous mosaic of semideciduous tall forest, wetlands, gallery forests and agriculture. The transitional sub-region is an ecotone between the eastern and western type, where the dry season lasts four to five months. Cotton and other crops are increasingly replacing the original vegetation. The semi-arid sub-region is the driest and most markedly seasonal region, with rainfall between 450-700 mm and a dry season that lasts from four to six consecutive months. The vegetation is a medium-tall xerophilous forest with many cacti and terrestrial bromeliads (Bucher, 1983). Today, the western Chaco has the lowest human density and is one of the most heavily wooded areas within the semi-arid regions of the world (Bucher, 1983).

To assess peccary population status, I used an index of relative abundance based on frequency of sightings and/or of hunting of peccaries by local rural hunters. This index of abundance was the only practical alternative because of the scarcity of peccaries, the nocturnal or crepuscular habits of collared (Taber et al., 1994) and white-lipped peccaries (Mayer and Wetzel, 1987) and the large study area. I considered information provided by local hunters as a good indication of peccary's status given that hunters spent much time

in the forest, are born in the region or have lived there for long periods of time, peccaries are a favorite game species, and hunters do not miss the opportunity to hunt them when they are available (Pers. obs.). In general, local people demonstrated good knowledge about peccary's natural history and easily recognized and differentiated the three species as well as their tracks. Hunters' perceptions on peccary population trends have coincided with research results on peccary status in the Bolivian Chaco (Noss, 1997).

During May-August 2001 and May-July 2002 I conducted semi-structured interviews (Bernard, 1995) with local rural hunters who have been living in the region for at least 10 years. I interviewed 270 rural hunters, but only the information provided by 153 of them was included in the analysis for reasons later explained. Interviews were conducted in Spanish (local language) and lasted as long as necessary to obtain the desired information. I obtained a Global Position System location for each hunter that provided reliable information on peccary abundance in his immediate surroundings. Reliability of information was considered according to consistency between different informants, quality of provided information such as accurate descriptions of morphology and life history of the three species of peccaries, and presence of peccary skins, feet and skulls in their houses. I were able to confirm number of peccaries harvested within the last months by observing skulls and feet of peccaries that hunters saved, following a local costume. Often, interviewees showed us signs of peccaries in the surrounding forest such as tracks, bedding sites, and fallen logs where peccaries hid when chased by dogs. As other mean to confirm reliability of the provided information by each hunter I interviewed some of their neighbors to whom I asked about the hunter activities. In those sites where none of the

three species of peccaries is currently present, key informants were small-game hunters who showed knowledge about peccaries and were able to recognize and distinguish them in pictures.

Frequency of sightings and/or harvesting of peccaries reported by hunters were used as indicators to create three categories of relative abundance (0, 1 and 2). Category 0: peccaries had not been observed for the last 5 years; category 1: peccaries had been observed and/or hunted less frequently than once every three months, and category 2: peccaries had been observed and/or hunted at least once within the previous three months. I present the three categories only to describe the relative abundance of peccaries in the study area. However, to avoid the potential subjectivity associated with reports of peccary abundance as either category 1 or 2, for the other analysis I pooled these two categories and used only presence and absence.

Local hunters live in settlements spread into the forest and normally walk the forest at least twice a week with dogs in search of small game. Less frequently, but with more intensity, they walk the forest in search of larger game species such as brocket deer (*Mazama gouazoubira*) and peccaries. Therefore, for most informants, the opportunity to sight peccaries would be at least eight days per month. Because hunters use dogs to locate peccaries and dogs do not discriminate among species while searching (Pers. obs.; Noss, personal communication), there was likely no bias toward observing one species more frequently than other species.

The index of relative abundance I used may not be comparable across species because it did not incorporate typical differences in group sizes among species. White-lipped and

Chacoan peccaries, for example, could be classified in the same category if the frequency of hunting was similar, although white-lipped may be more abundant than Chacoan peccary because its groups are much larger (Sowls, 1997). I used the index with spatial comparative purposes within each species, assuming homogeneity of detection throughout the study area.

Hunters were also asked about the size of groups they had observed most recently. I report range of group sizes mentioned by the majority of the hunters (≥ 60%). Additionally, I interviewed 30 elder hunters born in the region or who have lived there for more than 50 years to gather information about their perception on peccary abundance trends, and changes of hunting success and herd sizes during the last decades.

Within the hunting ranges of each of our 153 interviewees, I estimated, using satellite imagery, several human-related variables of the landscape. I created a geospatial database using ARC/VIEW 3.2 and ARC/INFO 8.2 where each GPS point location was buffered to a radius of 5 km to create circles representing the hunting range. Thus, the interviewed hunter's home lies in the center of the circle. The radius of the circle was chosen as the average distance within which the people in this region normally hunt (Bolkovic, 1999). Because some circles overlapped, I randomly eliminated 100 of them until I had 156 circles distributed almost evenly over the study area with no overlap. Three points corresponding to people living inside protected areas were also eliminated. Circles were separated from each other by at least 5 km. For each circle I estimated several variables related to land use, roads density, distance to urbanization and human density. Using hardcopy print satellite image (scale 1:250,000) I annotated land use within each circle.

Land use polygons from annotated satellite images were digitized using workstation ARC/INFO. I classified the land use and estimated percent cover of eight categories, which were then grouped into four: forest (includes riparian and dry forest), open area (includes agriculture and bare soil), wetlands (includes lagoons) and grasslands. I also estimated the total length of roads (including dirt roads) within each circle, the distance of each circle center to the nearest town (I considered as towns those settlements with more than 20 households; Fig.1), and the number of settlements inside each circle. Settlements are visible because the bare soil around them is clearly distinguishable in the satellite images from the forest or other land uses.

Statistical analysis

The sample unit is the circle for which I have an associated category of abundance (presence or absence) for each species and a value for each one of the variables considered (land use, road density, number of settlements, and distance to nearest town). To assess the average condition of human-related variables of the landscape under which each species was present, I estimated the mean of each variable for all the circles where peccaries were present. I report 10% and 90% quantiles as indicative of the width of the range of conditions under which the species were present. To assess whether conditions under which each species was present differed among species, I used one-way ANOVA. Variables were log transformed to meet assumption of parametric test when necessary.

To test for associations between human factors (explanatory variables: land use, road density, number of settlements, and distance to nearest town) and relative abundance of

peccaries (response variable) I used a nominal logistic regression for each of the three species of peccaries separately (Hosmer and Lemeshow, 1989). I tested for correlation among explanatory variables. Because percentage of forest cover and percentage of open area were highly correlated ($r \geq 0.60$) I used only forest cover. For each species, I fitted a model with all variables and then excluded variables by eliminating those with $p > 0.1$. For Chacoan peccaries I excluded 32 points corresponding to humid Chaco, considering that this region may not be within the rainfall and temperature tolerance range of the species (Sowls, 1997). I assessed the need to include interaction terms in the models, but as no interaction contributed significantly none was included in the final model.

Results

Relative abundance of peccaries, distribution, and herd size

Collared peccaries were classified as present in almost two times as many sites as than the other two species. Collared peccaries were present in 109 of 153 sites (71.2%), white-lipped peccaries in 54 (35.3%) and Chacoan peccaries in 55 of 121 sites (45.5%). Collared peccaries were classified in category 2 in 31 (20.3%) sites, white-lipped in 16 sites (10.4%), and Chacoan peccaries in 3 (2.5%; Table 1). The distribution of the three species overlapped in the center and western regions of the study area (Fig. 1). Collared peccaries were most widely distributed and were present in all three sub-regions (semi-arid, transition and humid Chaco). White-lipped peccaries were also distributed throughout most of the study area, and were found mainly in the semi-arid (45%) and transition (45%)

sub-regions. Chacoan peccary distribution was limited to the semi-arid (80%) and the transition Chaco (20%).

Hunters typically mentioned a range to describe peccary's group size. Of those hunters that provided information on groups sizes, most (≥ 60%) mentioned ranges within 15-30 individuals for groups of white-lipped (n = 43 hunters), 5-10 for collared (n = 16 hunters) and 2-3 for Chacoan peccary (n = 31 hunters).

Associations between presence and absence of peccaries with human factors

The three species of peccaries were present in sites with different amounts of forest, settlements, and open area (Table 2). Forest cover in the sites where Chacoan peccaries were present was greater than for other species (Table 2). Average number of settlements and average percentage of open area where white-lipped peccaries were present were lower than for other species. All three species were present in sites with similar average road length, percentage of wetland and percentage of grassland cover. Sites where white-lipped and Chacoan peccaries were present tended to be further from towns than those where collared peccaries were present (Table 2). Collared peccaries were present under a wider range of forest cover, distance to towns, number of settlements, and open area than the other two species (Table 2). Percentage of forest cover was associated with presence of Chacoan and collared peccaries (Table 3). After accounting for the effects of forest cover, numbers of settlements had the strongest effect on the presence of the three species (Table 3).

Local perceptions on peccaries populations trend

All elder hunters interviewed (n = 30) who have lived in the region all their lives or for more than 50 years agreed that peccaries are observed less frequently today than in the past. They mentioned that peccaries have not disappeared but that they have moved away. All interviewees of the humid Chaco (n = 13) mentioned that collared and white-lipped peccaries were observed more frequently in the past. They also agreed that Chacoan peccaries were never observed in this region, and have never heard of the existence of that species in the region. In the transition and semi-arid Chaco, interviewees mentioned different trends for different species. Most interviewees (87%) agreed that white-lipped and Chacoan peccary are less common now than in the past. Some (52%) mentioned that it was common to see large groups (over 50 individuals) of white-lipped peccaries and it was common to hunt several individuals at a time. Those who reported hunting before 1990 (n = 12) mentioned having harvested white-lipped peccaries considerably more frequently (almost every other day) than they can now (less than two per month). Several interviewees of the semi-arid Chaco (45%) mentioned that in the past Chacoan were more common that collared peccaries, whereas today the situation has reversed and collared peccaries are even more abundant than in the past. Hunters of the semi-arid Chaco also mentioned that groups of Chacoan peccaries are smaller than in the past when it was common to observe groups of 4-8 individuals.

Discussion

Number of settlements and forest cover were associated most strongly with the presence of peccaries in the study area, with number of settlements having the strongest effect for the three species. Although the same factors were associated with the presence of the three species, they seem to have different susceptibility to human disturbances; collared peccaries are still widely distributed while white-lipped and Chacoan peccaries are less common and apparently declining.

The effect of number of settlements on peccaries is probably due mainly to hunting, although habitat disturbance through cattle ranching can not be discarded. The effect of cattle on wildlife in the Chaco is unknown, although a negative association between cattle presence and abundance of peccaries has been suggested (Noss and Cuellar, 1999). Local people mentioned that natural sources of water in the forest dry out much quicker because of cows drinking and trampling (Altrichter, unpublished), which may decrease water availability for peccaries. Diseases transmitted by domestic livestock have also been mentioned as a possible cause for population declines of peccaries in Paraguay (Taber, 1991) and in Amazonia (Fragoso, 1997). However, hunters interviewed neither reported sudden declines in peccary populations nor disease-induced mortalities both of which might be expected with disease outbreak (Fragoso, 1997). More likely, intense commercial hunting for hides prior to 1987 depleted local populations (Barbarán, 1999) to a point from which white-lipped and Chacoan peccary populations could not recuperate given continued subsistence hunting.

It is difficult to separate overhunting from habitat destruction as the cause for population decline of peccaries (Peres, 2001). Our findings suggest that forest cover alone is not enough to predict presence of peccaries suggesting that continuous forest is insufficient for the persistence of peccaries under hunting pressure. In the humid and the eastern transition Chaco, where most of the forest has been cleared for agriculture, peccaries have disappeared or are limited to forest fragments and protected areas. However, in the semi-arid Chaco, still mostly forested, peccaries have also declined and were rare or absent if there were more than 10 settlements in a circular area of 78.5 km^2, (or an approximate human density of 1.2/km^2).

The collared peccary was more common, widely distributed and present under a wider range of conditions than the other two species. Locals mentioned that in some sites they are even more abundant than in the past. These findings suggest a higher tolerance for human disturbance especially with regards to human density and reduction of forest cover. Although presence of collared peccary was also negatively correlated with number of settlements, they were mentioned as present in areas with twice as much human density than the other two species. Collared peccaries were mentioned as present in places with the lowest forest cover, around 70%. Previous studies have shown that collared peccaries are less vulnerable than white-lipped peccaries to habitat fragmentation and hunting pressure, and usually maintain healthy populations even in highly degraded areas (Cullen et al., 2000; Peres, 1996).

The Chacoan peccary was the rarest and seems to be the most vulnerable to human disturbances; it was mentioned as absent in many sites where it was previously common,

and had a more restricted distribution than the other species. Chacoan peccaries were not present where forest cover was smaller than 87% and number of settlements was larger than six, indicating a strong correlation with human disturbances. Current group sizes reported by hunters (none mentioned groups of more than 3 individuals) are smaller than herd sizes reported by others also in sites under hunting pressure (Sowls, 1997: average = 4.3; Taber et al., 1993: average = 4.5; Mayer and Brandt, 1982: average = 3.7). If group size represents population status, these numbers indicate a low density of Chacoan peccary in the study area.

It is possible that in the past the Chacoan peccary was more abundant in the Chaco region, which is optimum habitat for this species and marginal habitat for the other two species, but it has remained in low densities under human pressure (Taber, 1993). Chacoan peccaries are thought to be able to exist in degraded dry Chaco brush and survive in altered, but not cleared, environments so long as they are not overharvested (Taber 1993).

Presence of Chacoan peccaries was also significantly associated with roads density. Roads provide access to forested areas to hunters from towns and cities and make easier to local hunters to find peccaries. Chacoan peccaries frequently use roads and do not flee when encountered by hunters, which makes them particularly susceptible to overhunting (Taber, 1993). The absence of Chacoan peccary in the humid sub-region could be more related to environmental conditions than to human disturbances. The Chacoan peccary is the most specialized of the three species; it has cranial and dental characteristics suggesting adaptation to dry environments, and although its climatic tolerances are not

well known, it apparently requires low rainfall and high temperature (Sowls, 1997). In the humid sub-region of the Chaco, where rainfall can reach 1200 mm and temperature can drop below zero (Bucher, 1983), climatic conditions may be unfavorable for this species.

White-lipped peccary seems to be still common in a few sites of the semi-arid Chaco but was rare in most of the transition and humid Chaco; it had not been observed during the last five years in 65% of the sites, although hunters of those sites mentioned the existence of this species in the past. Group sizes reported by hunters in the study area were small compared to group sizes typically reported for this species, which can be over 100 (Fragoso, 1998; Sowls, 1997; Peres, 1996; Mayer and Wetzel, 1987; Kiltie and Terborgh, 1983). There is little information of white-lipped peccary group sizes in the Chaco. Sowls (1997) reports herd sizes of white-lipped peccary for the Paraguayan Chaco of 40-60 individuals, and groups observed in the Bolivian Chaco range between 30 and 100 (Cuéllar, personal communication), sizes that are two to three times as big the group sizes reported by hunters in the study area.

The range of conditions where white-lipped peccary was present was narrower than for collared peccary. Sites were white-lipped peccaries were mentioned as present had more than 80% forest cover and less than four settlements, indicating its susceptibility to human disturbances. Similar effect has been observed in Amazonia, where white-lipped peccaries were rare or absent in accessible areas within the hunting range of human settlements (Peres, 1996).

White-lipped are more susceptible than collared peccaries to overharvesting (Cullen et al., 2000; Peres, 1996). Peres (2001, 2000, 1996) asserts that overharvest may be the main

cause of white-lipped peccaries disappearances across Amazonia. There might be several reasons why white-lipped peccaries are particularly susceptible to overhunting. This species forms large groups allowing hunters, acting together or alone with dogs, to kill many individuals at once (Altrichter and Almeida, 2002; Sowls, 1997; Peres, 1996). Another reason may be a lower productivity than collared peccaries (Gottdenker and Bodmer, 1998) although no such information exists from the Chaco.

Competition between peccary species could also affect species density, however, the interaction between the three species remains little known. It has been suggested that white-lipped peccaries may out-compete the other two species for the resources they share because of its larger herd size and more aggressive behavior, although they have lower ability to survive during drought periods (Taber et al., 1994). While the apparent replacement of Chacoan peccaries by collared peccaries reported by hunters in some areas could be related to interspecific competition, currently, no information exists to support this.

In conclusion, all three species of peccary were limited to areas with low human density and high forest cover. The Chacoan peccary was additionally limited to areas with low road density. Human density probably affects peccary presence mainly through hunting pressure. Collared peccaries were more widely distributed and more common, suggesting they have higher tolerance than the other two species to human disturbances as reported by other authors (Bodmer et al., 1997, Sowls, 1997, Peres, 1996).

Different conservation strategies have to be promoted for the different sub-regions of the Chaco. Most emphasis should be put into the semi-arid Chaco region, which is still

mostly covered by forest, have extensive areas uninhabited by humans, and the three species of peccaries are present. However, the expansion of settlements in this region continues and agriculture is promoted under current governmental plans for development. Management of hunting, regulations of land development, expansion and better protection of protected areas, and environmental education should be priority actions for conservation of peccaries in the Argentine Chaco. Forest management plans for the region should be revised as to include wildlife conservation and minimize fragmentation and habitat perturbation. Of special concern is the Chacoan peccary, apparently the most scarce and susceptible to human presence. The largest protected area of dry Chaco, Copo National Park, is probably not large enough to ensure the long-term protection of peccaries in the Argentine Chaco, especially because of the lack of effective protection. Areas that are largely uninhabited, where peccaries are still apparently abundant, should be incorporated into the system of protected areas and the construction of roads in these areas should be minimized. These areas could provide a source of animals for the areas where subsistence hunting is practiced. Subsistence hunters should be encouraged to focus on collared peccaries, in order to release pressure over Chacoan and white-lipped peccaries.

In the humid and transition Chaco, major emphasis should be put in the control of poaching in protected areas and the enforcement of hunting regulations. Sport hunting should be evaluated, since current quotas and hunting season are not based on biological information. More studies on hunting patterns, importance of peccaries for the local people, and magnitude and effect of subsistence and sport hunting should be carried out.

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Table 1

Relative abundance of three species of peccaries. Values represent number of sampled circles where peccaries were classified under each category of relative abundance.

Species	Category		
	0 (not observed for the last 5 years)	1 (observed and/or hunted less than once every three months)	2 (observed and/or hunted at least once within the previous three months)
Collared	44	78	31
White-lipped	99	38	16
Chacoan	66	52	3

Table 2

Average (SE) conditions under which the three species of peccaries were present. Interquantile distance IQD (10- 90%) is shown to indicate the range of conditions under which the species were present.

Conditions		Species			ANOVA
		Collared	White-lipped	Chacoan	
		N = 109	*N* = 54	*N* = 55	*d.f.* = 2,214
Forest	Mean	88.6 (1.4)	91.4 (1.1)	94.4 (0.7)	F = 4.8,
(Percentage)					*p* = 0.01
	IQD	71.2 - 98.2	78.4 - 99.2	87.1- 98.7	
Distance to town	Mean	35.7 (1.8)	39.6 (2.7)	43.2 (2.6)	F = 2.7,
(km)					*p* = 0.06
	IQD	12.5 - 71.1	16.2 - 71.2	20 - 71	
Settlements	Mean	4.5 (0.4)	2.2 (0.2)	2.9 (0.3)	*F* = 7.5,
(Number)					*p* < 0.01
	IQD	0 - 10	0 - 4	0 - 6	
Open area	Mean	6.3 (1.1)	3.5 (0.8)	3.6 (0.4)	*F* = 3.1,
(Percentage)					*p* = 0.04
	IQD	0 - 12.7	0 - 7.5	0 - 6.6	

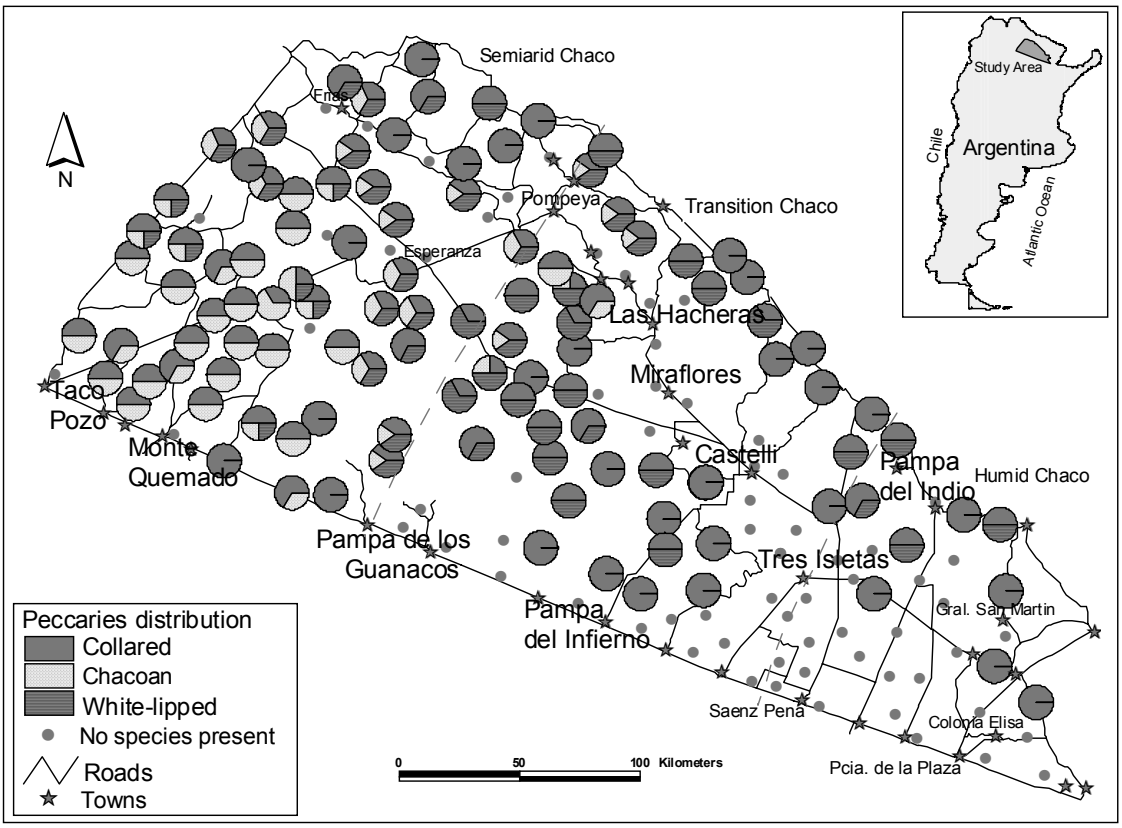
Road length (km)	Mean	27.6 (1.2)	23.5 (1.6)	26.9 (1.6)	$F = 2.2$, $p = 0.11$
	IQD	12 - 50.2	11.8 - 36.2	14 - 45.1	
Wetland (%)	Mean	1.8 (0.6)	1.9 (0.9)	0.6 (0.1)	$F = 1.9$, $p = 0.15$
	IQD	0 - 4.2	0 - 4.3	0 – 0.5	
Grassland (%)	Mean	2.7 (0.5)	3.5 (0.8)	2.2 (0.8)	$F = 0.8$, $p = 0.35$
	IQD	0 - 9.7	0 - 12.8	0 - 8.1	

Table 3

Parameter estimates of a logistic nominal regression of presence-absence of the three species of peccaries vs. number of settlements and percentage of forest cover.

Species	Term	Coefficient	SE	X^2	p
Collared	Intercept	7.75	3.47	4.99	0.02
	Number of settlements	-0.08	0.03	5.74	< 0.01
	Forest cover (ln)	-2.12	0.76	7.7	< 0.01
White-lipped	Intercept	-1.22	0.37	10.9	< 0.01
	Number of settlements	-0.48	0.11	18.7	< 0.01
	Forest cover (ln)	-1.22	1.38	0.78	0.35
Chacoan	Intercept	41.5	14.9	7.71	< 0.01
	Number of settlements	-0.21	0.07	8.23	< 0.01
	Forest cover (ln)	-9.01	3.26	7.75	< 0.01
	Roads length	-0.04	0.02	3.56	0.05

Figure 1. Distribution of peccaries in the study area. Pie graphs are samples of 10 km diameter and indicate presence of all three peccary species based on interviews with local hunters Partitions of the pie graph only indicates presence, not abundance. Circles are not in scale with the map.



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APPENDIX B

THE STATUS OF JAGUARS (*PANTHERA ONCA*) IN THE ARGENTINE CHACO

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Abstract

With this study I contribute to the knowledge of jaguar (*Panthera onca*) distribution and status in the Argentine Chaco, one of the least known areas within its range, and to the understanding of human-jaguar conflicts. I believe the current distribution of this species in the Chaco encompasses part of the center and west of Formosa, west of Chaco, east of Salta and the northeastern corner of Santiago del Estero. Jaguar range has been reduced in relationship with colonization in the semi-arid Chaco, where there has been little deforestation. Jaguars have not been observed within the last 15 years in areas where colonization occurred more than 35 years ago, probably reflecting hunting pressure. Livestock predation is currently low compared to levels of predation suffered by local peasants during their first years of settlement in the forest. This may therefore indicate low densities of jaguar as the livestock management system has not changed. Locals, however, continue hunting jaguars with the intention to exterminate them, because of the perceived threat they represent for livestock and people. Proposed solutions to resolve human-jaguar conflicts in other sites do not seem feasible for this region. A combination of short-term measures such as increasing control of poaching in protected areas and enforcing jaguar hunting laws, and long-term measures such creating more protected areas, education and reduction of livestock mortality, may be the most efficient strategies to preserve the jaguar population of the Chaco.

Keywords: Argentine, Chaco, conservation, jaguar, *Panthera onca*, perceptions, poaching, predation.

Introduction

Conflicts between humans and wildlife are more acute when coexistence produces negative consequences for humans. Such is the case of large felines such as jaguars (*Panthera onca*) preying upon domestic animals and threatening human life. This conflict occurs throughout the range of distribution of jaguars producing their persecution and killing (Rabinowitz, 1986; Quigley & Crawshaw, 1992; Hoogesteijn *et al*., 1993; Jorgenson & Redford, 1993; Johnson *et al.,* 1996; Nowell & Jackson, 1996; Perovic 2002a). The jaguar is among the most threatened species in Latin America, surviving in only a fraction of its former range in patches of wild land (Swank & Teer, 1989; Rabinowitz, 1995). In Argentina, this species was once widely distributed, from the north of the country to the Patagonia (Guggisberg, 1975; Brown, 1983), but its range has been reduced during the last decades by about 85% (Perovic & Herran, 1998; Perovic, 2002a). Current distribution of jaguars in Argentina, however, is not well known. Some studies have addressed the distribution, ecology and conservation status of jaguar in the northeast tropical forest of Misiones (Schiaffino *et al*., 2002) and in the northwest tropical Yungas (Perovic & Herran, 1998; Perovic, 2002a), but no such information exists for the Chaco region (Perovic, 2002a). So little known is this region that contradictory information is presented by different authors. Some authors consider the distribution of jaguars as either occurring in the Chaco and the Yungas as one connected area separated from the Paranaense forest of Misiones (Arra, 1974), or as three separated areas (Olrog & Lucero, 1981). Others mention the entire Northeast-northwest region of the country as the area of distribution of jaguars (Roig, 1991) whereas others do not include the Argentine Chaco

(Swank & Teer, 1989; Redford & Eisenberg, 1992; Johnson *et al*., 2000) as a site where jaguars occur. Data from the Bolivian Chaco (Maffei *et al.,* 2004) suggest that jaguars are widespread in forest types similar to those found in the Argentine Chaco. Because of this lack of information, the Argentine Chaco was highlighted as one of the priority sites for research (Medellin *et al*., 2002; Sanderson *et al*., 2002). Responding to this need, I assessed the status and distribution of jaguars in the Argentine Chaco.

The current main causes of jaguar population declines throughout its range are habitat loss and hunting due to livestock-predator conflicts (Swank & Teer, 1989; Rabinowitz, 1995). It is difficult to discern between these two factors because they generally occur together and often act synergistically (Peres, 2001). It is important to assess these factors independently, however, because the presence of good habitat may not always guarantee a species' persistence if hunting is causing population declines. The humid and transitional sub-regions of the Argentine Chaco have been extensively converted to agriculture (Roig, 1991; Torrealba *et al*., 2003). The semi-arid sub-region, however, has been degraded by overgazing and small-scale logging, but not by large-scale deforestation (Bucher & Huszar, 1999). For this reason, reduction of jaguar range in this sub-region could be attributed more to hunting than to habitat destruction. To test this hypothesis, I collected information about presence of jaguars and time of human colonization. I predicted that if hunting is responsible for the reduction of jaguar distribution, the species would have disappeared at a time related to the establishment of human settlements, while it would still be present in areas uninhabited by humans or that have been recently colonized.

Whether hunting explains local extirpation of jaguars can also be addressed in part by understanding how local people perceive and react to the presence of this species. For carnivores that conflict with humans, the real conservation challenge lies in understanding human behavior and attitudes toward them because the thoughts and actions of humans are what ultimately determine the course and resolution of conflicts (Marker & Dickman, 2004; Manfredo & Dayer, 2004). Local people around the world generally hold negative attitudes towards large carnivores that prey upon livestock (Kellert, 1996, Kellert *et al*., 1996; Mishra, 1997; Ericsson & Heberlein, 2003). For species such as the jaguar that have large home ranges, their survivorship outside protected areas mainly depends on the attitudes of the local people cohabiting with them (Crawshaw, 1995; Sillero & Laurenson, 2001; Perovic, 2002a). For these reasons, I assessed local people's perceptions and reactions towards jaguar presence.

Study area

I surveyed the northern part of the Argentine Chaco region, encompassing El Chaco, Formosa, Santiago del Estero and Salta provinces (Fig. 1), for a total of approximately 240 000 km^2. The study area covers three sub-regions of the Chaco, differentiated by an east-west rainfall gradient: eastern or humid, central or transitional, and western or semi-arid Chaco (Morello & Adamoli, 1968; Bucher, 1983). The humid Chaco is a mosaic of swamps, reedbeds and gallery forests. The dominant vegetation is savanna with patches of subtropical semi-deciduous tall forest. Annual rainfall reaches 1200 mm and the dry season lasts two months. There are three protected areas within my study area in this sub-

region: Pilcomayo (47 000 ha), Chaco (15 000 ha), and Pampa del Indio (8 600 ha). The transitional Chaco has annual rainfalls between 700 and 900 mm. The vegetation is a xerophyllos subtropical forest, intermingled with lowland and fire-maintained grasslands. The semi-arid sub-region is the driest and most markedly seasonal region, with rainfall between 450 and 700 mm of which 80% occurs between October and April. The vegetation is a medium-tall xerophilous forest. There are five protected areas: Formosa (9,000 ha), Copo National Park (114,000 ha), Copo Reserve (70,000 ha), Loro Hablador (23,7500 ha) and Fuerte Esperanza (28,200 ha). In the Chaco province, there is a large area to the west of Fuerte Esperanza of about 150 000 ha of state land that the government refrains from selling. Although this area is called Wichi indigenous reserve, it does not have the legal status of a reserve and there are no indigenous people living on this land. There are some mestizo settlements in the reserve but they cannot acquire the land's title.

The transitional and humid sub-regions were colonized by small and medium-scale farmers at the beginnings of the 20th century. The original vegetation was first replaced by cotton and later by soybean and pastures for cattle ranching (Bucher, 1983; Torrealba *et al*., 2003). Intensive timber extraction occurred during the 1950's (Bucher, 1983). Since 1990, small farms have been replaced by large properties dedicated to intensive cattle ranching and agriculture. Today, these two sub-regions are the most developed and have the largest percentage covered by agriculture. The semi-arid Chaco was colonized by small-scale farmers about two decades later than the other sub-regions (Torrealba *et al*., 2003). This is the least developed region with the lowest human density. Most

inhabitants are peasants who live in small settlements spread throughout the forest. Peasants live a subsistence lifestyle based on livestock breeding, and small-scale forest exploitation.

Methods

I surveyed the northern part of the Argentine Chaco for a total of 18 months between 2000 and 2003. I collected information on jaguar presence through my own observations of tracks, feces and livestock preyed upon by jaguars and through interviews with local people, other researchers, park rangers and government personnel. I interviewed 400 local people from the rural areas, most of whom (95%) were mestizo. Interviews were conducted in Spanish (my native language). I used semi-structured interviews (Bernard 1995) consisting of questions that addressed: a) interviewee level of knowledge on the topic (time living in the area, time spent in the forest, hunting activities, identification of different felid species and their tracks) b) Information on direct sightings of jaguars, sightings of tracks, domestic animals killed by jaguars, jaguars hunted or captured alive, and last year jaguars were present, c) identification of location of last sign of jaguar presence in a map of the local area, and d) Identification of other people who could provide information on jaguar presence. When there was more than one indication of jaguar presence for a single site and year I used only one, assuming that it could be the same animal observed by different people. As part of other research the three authors have spent time living in different rural communities (from 1999 to 2003), which allowed me to develop rapport with local people and increased my ability to assesses the

reliability of local people's reports. Information was considered reliable when there was consistency among different informants, and interviewees demonstrated ability to differentiate between tracks of jaguars and pumas (*Puma concolor*). Local people are familiar with pumas' tracks because they often suffer repeated attacks on their goats by these felines. Predation on cattle by pumas is rare. Thus, when locals find carcasses of cattle that have been attacked by a large predator they are confident that it has been a jaguar. I confirmed 25% of local people's reports by observing animal parts (skulls, skins or feet) that people are accustom to saving after killing wild animals and/or by photographs. Dubious data were not included, and scats were only included as data when observed by the authors. Besides reports of local hunters, the Governmental wildlife agencies of El Chaco and Formosa provinces provided information on confiscation of jaguar hides, jaguars captured alive and on killings of jaguars. I recorded a GPS location where I had reliable information on jaguar presence and I plotted these points onto a map. Because of the varied sources and types of information I gathered, I refer to my data as "signs of jaguar presence." These included my own observations, reports from hunters, sightings or indirect signs such as tracks, and reports from local wildlife agencies.

I addressed local people's perceptions and reactions to jaguars in the west side of Chaco province using ethnographic methods. I repeatedly visited and spent time living with 38 local families during three years as part of other research addressing use of wildlife. I also obtained information on relative levels of livestock mortality and its causes by interviewing local ranchers and veterinarians and through direct observation. I did not quantify livestock mortality because most local people did not know the number

of livestock they own. To ascertain whether the local disappearance of jaguars was related to human colonization, I performed a regression analysis using the age of the settlements as the explanatory variable and the time of the last sign of jaguar presence as the response variable. For this analysis, I only used information from sites in the semi-arid Chaco, covering about 3 million ha, where there has been little conversion of forest into agriculture land.

Results

Jaguar's range

I recorded 107 signs of jaguar presence between approximately 1920 and 2003. Of these, 53 (52%) were signs of jaguar presence within the six years previous to the finalization of this study (Table 1), 66% of which consisted of tracks or killed cattle, 28% involved jaguars killed by local hunters and the rest were direct sightings. Between 2001 and 2003, 25% were reports of jaguars killed by locals. Signs of jaguar presence within the last six years were reported mainly in the semi-arid and the transitional sub-regions (96%). The two recent reports of jaguar presence in the humid sub-region, located north of Pampa del Indio Reserve (Fig. 1), were from two large private ranches (30,000 and 10,000 ha) where there has been little deforestation and hunting is forbidden.

Assuming that jaguars may still exist where signs of their presence have been reported within the last six years, I identified the current jaguar distribution as an area encompassing the center and western portions of Formosa province, the western portion of Chaco province except by the west-southern corner, and an area along the eastern

boundary of Salta province (Fig. 1). Using GIS analysis I estimated that the total area of current distribution of jaguars in the Chaco is roughly 67,000 km^2. Considering the points where jaguars were observed between 6 and 20 years ago, I estimated that jaguar range has been reduced by 90,000 km^2. Based on direct observation of agricultural and urban development, I suspect that the Chaco population is isolated from the other two jaguar populations of Argentina: the Yungas of Salta and Jujuy and the forest of Misiones (Fig. 1). Besides a private ranch (around 100,000 ha in total) in Salta next to the limit with the Chaco province, the rest of the Chaco forest of Salta has been logged intensively and fragmented, probably impeding the connection between the Yungas and the Chaco jaguar populations. The same is true in the humid Chaco sub-region, where there is larger development of agriculture. Within the current area of distribution, there is probably reduced connectivity between Chaco and Formosa provinces. Separating both provinces is the Bermejo River, along which there is high human density and agricultural development. The jaguar population is probably not isolated from the Paraguayan Chaco. The river that separates both countries has low development and the presence of lagoons, swamps and reedbeds makes human access to this region difficult. The frequency of signs of jaguars reported by locals and observed by us were higher in the central-northern part of Formosa and in an area encompassing Copo and Loro Hablador Reserve.

The jaguars' range in the semi-arid Chaco seems to have been reduced by colonization. There was a positive and linear relationship between age of settlements and years since last sighting (Fig 2; $y = -1.3 + 0.73x$; $t = 8.2$, $P < 0.001$). The average age for settlements where signs of jaguar presence were reported for the last six years was 15.1

years. Except in the area neighboring Copo, there have not been sightings of jaguars within the last 10 years in settlements > 35 y old. Because colonization of the semi-arid region has not been associated with extensive deforestation, I presume that reduction of jaguars' range results from hunting.

Livestock predation and locals' perceptions and reactions to jaguars

Local people mentioned that they lost many cattle by jaguar predation and that they killed dozens of jaguars during the first years they settled the region. Currently, however, cases of predation by jaguars are rare. During the study I learned of six reliable cases of jaguars preying on cattle. Of these, only one was a case of repeated attacks. In contrast, most interviewees (72%) reported predation of goats by pumas at least once a year, often loosing many goats in each predation event.

Although I were not able to quantify livestock mortality, I estimated that in the semi-arid Chaco more than 80% of deaths reported during the study period were at least partially attributable to the style of livestock management. Livestock management in this region is an extensive husbandry. Cattle range freely in the forest during most of the year and goats roam freely during the day and return to the settlements every evening, spending the night in corrals. There is little veterinary health care and there are no breeding strategies. I found that the most common causes of mortality were starvation, thirst, diseases, and parasites, produced by the lack of food and water in the forest during the dry season. Three of the 38 families with whom I worked lost over 50% of their livestock in one season because of disease or starvation.

Interviewed peasants mentioned that jaguars are dangerous and injurious. Interviewees expressed a desire to eliminate jaguars because they represent a danger for people when they are hunting, logging or working with their livestock in the forest. About 73% of rural interviewees had never seen jaguars or signs of their presence. Besides one case of a human attacked by a jaguar in 1995 known by several people, most interviewees (95%) had never heard of jaguar attacks on humans, although most of them expressed fear of jaguars.

The action of persecuting and killing jaguars does not follow predation but is a continuous process. Jaguars are persecuted as soon as their tracks have been observed in the forest. In contrast, pumas are generally persecuted only after they have attacked goats. Killing jaguars is simple because they tend to climb trees when chased by dogs, and they can be easily shot from the ground. Some locals mentioned that they had killed jaguars that had climbed trees with a machete or knife tied at the end of a long stick. Although the extermination of jaguars seems to be the main motivation to hunt this species, some people also sell jaguar hides to local traders. During my field study I learned of two cases where locals sold jaguars' skins. However, I did not find evidence of locals making a living out of jaguar skin commercialization, as was common in the past, according to interviewees.

Discussion

My findings suggest that the distribution of jaguars in the Chaco is separated from the Paranaense forest of Misiones and from the Yungas, as indicated by Olrog & Lucero

(1981), and furthermore I suggest that the jaguars' range in the Chaco has been reduced within the last 10 years. I believe that the jaguar population in the Chaco is currently mostly isolated, by agriculture and high human densities, from the other two existing populations in the Yungas and in the Paranaense forest of Misiones. Roig (1991) mentions that, within the Chaco region, jaguars are more abundant in the eastern part of Formosa and the northern part of Salta. My findings, however, suggest that jaguars have disappeared from the eastern part of Formosa but they are more common in the center-northern part of Formosa. This area has a low density of settlements and a variety of environments, with wetlands intermingled with forest and savannas. Periodic inundations impede further development and agriculture. I also found that jaguars were observed more frequently in Copo National Park and surroundings areas. Using Maffei *et al.* (2004) minimum estimates of 2-5 jaguars per 100 km^2 for an unhunted site in the Bolivian Chaco, I estimated that Copo National Park could harbor between 23 and 60 jaguars. However, not all of the park may be suitable habitat for jaguars, because there are settlements inside and there is hunting along the boundaries.

Several causes may have contributed to the reduction in jaguars' range in the Chaco. Hunting for fur trade was an important mortality factor until the market for skins declined sharply (at the end of the 80's) and Argentina joined CITES. At present, the trade of skins does not seem to be the main motivation to hunt jaguars. The most important factor that has affected jaguar persistence in the humid and transitional sub-regions has probably been habitat loss. These regions have suffered extensive deforestation and large areas have been converted to cultivation (Roig, 1991; Torrealba *et al*., 2003). High mortality of

large carnivores with the advance of humans into wild areas and the conversion of landscape into a mosaic of natural and anthropogenic patches is a phenomenon recorded worldwide (Woodroffe & Ginsberg, 2000). In the semi-arid Chaco, where there has not been massive deforestation, hunting by locals motivated by a desire to exterminate the jaguars from the region seems to be the main threat. Although many studies have shown that high human density has adverse effects on large mammals (Woodroffe, 2000; Parks & Harcourt, 2002), in the semi-arid Chaco I found that low human density has affected the persistence of jaguars. The existence of small isolated settlements over more than 35 years has led to local extirpations of jaguars, suggesting that human presence can make it inhospitable for this species even when enough forest cover remains, as is the case for other large carnivores (Woodroffe & Ginsberg, 2000). Jaguars apparently can survive in areas with slight disturbance if there is enough vegetation cover and prey (Aranda, 1996), but not if there is high hunting pressure (Swank & Teer, 1989). It is difficult to evaluate hunting pressure in the semi-arid Chaco, but the low number of reports of jaguar signs in settlements that are 10 or more years old suggest high hunting pressure. The proportion of animals killed (28%) from the total number of reports of jaguars in 2002 and 2003 also suggests that there was high removal of individuals. This percentage is higher than the 18.4% determined by Perovic & Herran (1998) over a period of ten years in the Yungas.

The impact of human hunting outside protected areas or at the borders can cause extinction of carnivores (Woodroffe & Ginsberg, 1998, 2000; Harcourt *et al*., 2001). Few protected areas exist in the Argentine Chaco, and their effectiveness to protect jaguars is questionable. The two reserves that protect humid forest in the El Chaco province are

small and isolated in a matrix of agriculture, and no sightings of jaguars have been reported from these areas in more than 15 years. The largest protected area in the Semi-arid Chaco, Copo (1840 km^2), supports an undocumented number of jaguars. Although home range and movements of jaguars in the Chaco environment are unknown, the 5486 km^2 estimated minimum area to harbor a viable jaguar population of 500 individuals (Redford and Robinson, 1991) suggests that Copo alone will not be enough to protect jaguar populations. Furthermore, the effective size of this park is smaller than its total area because of the presence of people living inside and hunting along the borders. The areas outside the national park are becoming more and more populated and forest exploitation for charcoal production is increasing (Caziani *et al.*, 2003). This will probably increase edge effects creating sink areas outside the park where jaguar populations will have higher mortality than production (Woodroffe & Ginsberg, 1998). Given the small size of the park relative to jaguars' home range, it is unlikely that a core area inside the park can act as source to replenish these sink borders (Woodroffe & Ginsberg, 2000).

Another potential threat to jaguar persistence in the semi-arid Chaco is prey depletion. Some studies have shown a large overlap between the diet of jaguars and of humans (Hoogesteijn *et al*., 1993, Jorgenson & Redford, 1993, Leite & Galvao, 2002, Conforti & Azevedo, 2003). This may be the case in the Agentine Chaco where local people hunt over 15 species of mammals for food (Altrichter, Appendix C), including all the potential prey for jaguars such as brocket deer (*Mazama* spp), armadillos (*Dasypodidae)* and peccaries (*Tayassuidae*) (Jorgenson & Redford, 1993; Crawshaw

1995; Nuñez *et al*., 2002). Peccaries range in this region has been reduced and populations are declining (Altrichter & Boaglio, 2004).

Jaguar-livestock conflicts in Latin America are common, and there is higher predation when jaguars and livestock are in close contact (Rabinowitz, 1986) and when cattle are left untended (Rabinowitz, 1986; Weber & Rabinowitz, 1996; Polisar *et al*., 2003). In the Chaco, I were surprised to find such small number of reports of predation of livestock where the ranges of jaguars and livestock overlapped completely. This same type of cattle husbandry has, however, generated numerous conflicts during the time of colonization of the semi-arid Chaco when jaguars killed many domestic animals. I presume that the low predation reported is probably an indication of low jaguar abundance, since livestock management has not changed. Furthermore, similar livestock management is currently generating high numbers of conflicts with jaguar predation in the other two areas that support jaguar populations in Argentina (Perovic, 2002a; Schiaffino *et al.,* 2002) and through its range of distribution in Latin America (Rabinowitz, 1986; Quigley & Crawshaw, 1992; Crawshaw & Quigley, 2002; Hoogesteijn *et al.,* 1993). Mortality of livestock generated by the rudimentary management and by the harsh climatic conditions in the semi-arid Chaco seems to be much higher than from jaguar predation. However, even if the level of damage inflicted by predators is low it perpetuates negative attitudes towards carnivores.

The negative attitude of people towards jaguars is a widespread phenomenon associated with carnivores in general, reflecting a history of predation and competition (Kellert, 1985; Oli *et al*., 1994; Woodroffe, 2001; Conforti & Azevedo, 2003). Humans

see carnivores as adversaries to be avoided or killed (Oli *et al*., 1994; Johnson *et al*. 2000; Conforti & Azevedo, 2003; Marker & Dickman, 2004). In my study, I found that fear of jaguars was a more important factor driving people to kill jaguars than the actual damage to livestock. This perception of jaguars as a threat to human life exists throughout the jaguars' range (Sillero & Laurenson, 2001). Unprovoked attacks by jaguars on humans are, however, quite rare (Almeida, 1990; Sillero & Laurenson, 2001; Conforti & Azevedo, 2003; Crawshaw, 2004). Instead, there are many reports of pumas attacking humans throughout their distribution (Kellert *et al*., 1996), but people did not express as much fear of the possibility of being attacked by this species as by jaguars. This difference in concern between jaguars and pumas has also been reported in Brazil (Conforti & Azevedo, 2003).

Proposed strategies to resolve human-jaguar conflicts can be grouped as reduction of livestock-jaguar conflicts, change of human attitudes, and protection. Restricting cattle movement by fencing, or impeding jaguars abilities to approach cattle with electric fences have had varied results (Scognamillo *et al.,* 2002; Schiaffino *et al*., 2002). These cattle management measures do not seem applicable in the Chaco for a variety of reasons. Local people are resistant to the idea of fencing, not only because it is costly to establish and maintain, but because their properties are not large enough to maintain the cattle they own. Furthermore, in areas of the semi-arid Chaco where almost 90% of the land is covered by forest and settlements are spread out throughout the forest, fencing will not make any difference because settlements and livestock are inside jaguars' potential range.

Reimbursement for livestock depredated by carnivores has been used in different countries and it has reduced hunting (Mishra, 1997; Perovic, 2002a, 2002b), but has not always been an effective conservation measure. It is an impractical solution for such an extensive region as the Chaco, and presents other types of problems such as the difficulty of confirming predation and finding carcasses. Removing problem animals can be a solution when the jaguars preying on livestock are old or injured individuals (Rabinowitz, 1986; Quigley & Crawshaw, 1992). However, when jaguars are killing domestic animals because of the reduction of their habitat and their natural prey, or as result of the type of livestock management, removal of individuals will not solve the ultimate causes of the problem.

Changing attitudes towards jaguars may be even more difficult. Some authors have found that as knowledge about predators increases, attitudes generally become more positive (Ericsson & Heberlein, 2003), suggesting that increasing awareness of jaguars' role in the ecosystem may decrease negative attitudes of local people towards them (Conforti & Azevedo, 2003). Others have suggested that people can develop a positive attitude towards a species when they learn to appreciate it as a symbol of wilderness (Mech, 1970). This is unlikely to happen in the Chaco where the concept of wilderness is *per se* negative. Mestizo peasants talk about the natural forest as "dirty" and about agricultural fields as "clean." It is the removal of wildness that motivates people in this situation, not its preservation. Jaguars are in fact the symbol of wildness and it is through their extermination that people feel they gain control over nature. This link between large predators and uncivilized wildness has been the cause of persecution with the aim of

extermination of many carnivores in the U.S (Kellert, 1985). Even in the U.S, a country with widespread environmental education, environmental advocacy groups, and regulations to protect endangered species, predators of livestock still bear the stigma of vermin and are killed for this reason (Kellert, 1985).

Another solution that has been proposed for changing attitudes is to involve local people with activities that bring benefit from the conservation of jaguars such as ecotourism (Conforti & Azevedo, 2003). Some authors have found that people are willing to lose domestic animals and preserve jaguars when they receive benefits from tourism and see its connection to the presence of jaguars (Miller, 2002). However, there are few examples where ecotourism or sport hunting have resulted in carnivore conservation (Rabinowitz, 1995; Sillero & Laurenson, 2001; Miller, 2002), and it is not seem a viable option for the Chaco given the poor development of infrastructure, the harsh climatic conditions, and the dense vegetation that impedes visibility of fauna.

Jaguars' future in the Argentine Chaco

Prospects for long-term persistence of jaguars in the Argentine Chaco are unfavorable, although the same is not true for the Bolivian Chaco where there is a large protected area and there is low human density (Maffei *et al*., 2004). My study indicates that jaguars' range has been reduced since the colonization of the Chaco, populations have declined, and current density is low. Jaguars have been almost completely extirpated from the humid Chaco, and remaining populations in the semi-arid Chaco are associated with areas of low human density, low levels of deforestation and protected areas. The situation in this region however, started to change rapidly during my field study. Forest

exploitation is increasing and the agricultural frontier is advancing even into the driest and most marginal areas (Torrealba *et al*., 2003; Zak *et al*., 2004). The area occupied by agriculture is predicted to increase by about four times in the next six years with the expansion of soybean plantations and pastures for intensive grazing (Torrealba *et al*., 2003). Forest encroachment will further expose the remaining populations to hunting and reduce jaguars' habitat. I believe that a combination of long-term and short-term measures may increase jaguar persistence in this region. Short-term solutions have to include reduction of human-produced mortality through enforcement of hunting regulations and increasing protection in existing reserves. Long-term solutions should include education at schools geared towards fostering a coexistence with jaguars. The most important measure that should be contemplated promptly is the creation of protected areas. Given the destruction of habitat that is currently occurring in the Chaco (Zak *et al*., 2004), it is imperative to promote land- use planning that incorporates a network of private, small state reserves, corridors, national parks and buffer areas. Copo, the largest protected area in the Chaco, is not yet isolated. According to recent reports of jaguar presence, it is possible to identify a potential corridor between Copo in the south and Paraguay in the north, going through Loro Hablador and Fuerte Esperanza Provincial Reserves, the Indigenous Reserve and Formosa National Reserve. This corridor could connect the Argentine Chaco population with both the Paraguayan (Neris *et al*., 2002) and the Bolivian Chaco (Maffei *et al*., 2004) which have jaguar populations in relatively good conservation status. The semi-arid Chaco, which encompasses these mentioned protected areas, has low human population and abundant state land. Reports of regular

sightings of jaguars in the area between Copo and the Loro Hablador Reserve suggest that animals move between these two protected areas. The recently annexed land in the south side of the Loro Hablador Reserve is a step forward in connecting these reserves. The remaining land between reserves could be kept as state land or under some regime of protection that does not necessarily imply the exclusion of other uses, such as livestock grazing or small-scale selective logging, which could be compatible with jaguar conservation (Perovic, 2002b).

Protection of large wide-ranging species, however, cannot stop at reserve borders (Woodroffe, 2001). The existence of protected areas alone will not guarantee the persistence of jaguars if poaching continues. I believe that stronger control inside and outside protected areas will probably reduce poaching because locals are not trying to profit from illegal hunting and they fear legal consequences. Although local peasants were generally unaware of hunting regulations, they knew that killing jaguars was "very prohibited," and that the penalty for doing so could be substantial. During my field work, a local peasant killed a jaguar and attempted to sell the skin but was intercepted by the Fauna Service. The news of this hunter being caught spread rapidly through the region. This indicates that with only a few cases of police presence in the area, people will be less eager to kill jaguars, so long as the pelt market remains unimportant and/or prices remain low. Hunting control and protected areas seem to be, at least in the short term, necessary measures to implement if we want to preserve such species as jaguars that need extensive and undisturbed areas and whose extermination motivates local people to hunt them.

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Table 1. Percentage of the records of jaguar presence

Period of time	Percentage of total records (n = 107)
2001-2003	34
1998-2000	18
1993-1997	16
1983-1992	12
1920-1982	20

Figure 1. Signs of jaguar presence since 1920 in the Argentine Chaco.

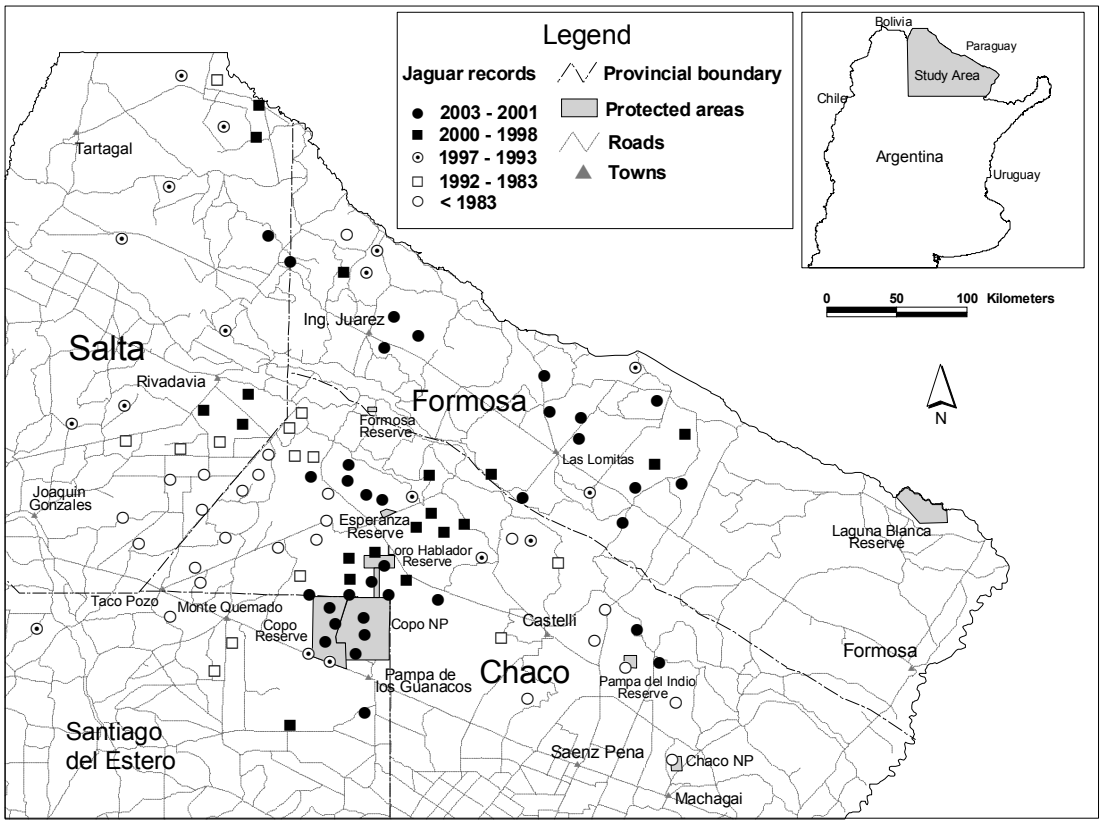

Figure 2. Relationship between age of settlement and years since last sighting of jaguars.

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APPENDIX C

WILDLIFE IN THE LIFE OF LOCAL PEOPLE OF THE SEMI-ARID ARGENTINE CHACO

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Abstract

The semi-arid Argentine Chaco ecosystem is inhabited by mestizo people who live on an economy of subsistence based on the use of natural resources and livestock ranching. Responding to an interest of the Argentinean Government to solve the increasing problem of wildlife depletion in this region, I investigated patterns of wildlife usage and the nutritional and economic importance of such uses for local people. Through interviews and participant observation, I found that wildlife is used primarily as food, providing about a third of the total meat consumed by local peasants. Local people use at least 26 species of wildlife although they concentrate on few species. Small species, Chacoan cavies and armadillos, are the most consumed, representing 48% of the total wild meat. Consumption of wild meat follows seasonal patterns determined by species behavior, hunting methods and preferences for meat quality. The consumptive value of wild meat is high in comparison with wages but lower in comparison with forest exploitation. Illegal commercialization of wildlife is practiced mainly by a small proportion of villagers and by outsiders and it affects endangered species. Patterns of use of wildlife by local people differ from other Latin American groups in terms of the diversity of species hunted and the role that hunting plays in local people' livelihoods. Results from this study suggest that hunting patterns are strongly influenced by cultural preferences. The first steps towards conservation of this increasingly threatened region should involve decreasing hunting by local people of the more vulnerable species and controlling all illegal commercial hunting.

Key words: Argentina, armadillos, Chaco, conservation, hunting, peccaries, Pediolagus, Tayassu, wild meat.

Introduction

Wildlife is an important resource for many people in Latin America who use it for various purposes, although food and cash income are the most common uses (Prescott Allen and Prescott Allen 1982; Ojasti 1996; Fang et al. 1999; Robinson and Bennet 2000a; Wildlife Conservation Society 2004, Silvius et al. 2005). Many studies have shown that hunting has a strong impact on wildlife populations, often driving species to local extinction (Robinson and Bennet 2000b, Bennet and Robinson 2000). Thus, when there is a tight and conflictive relationship between local people and wildlife, the challenge is to find a compromise between local people's needs and wildlife conservation. The role of wildlife in the life of local people, however, is highly variable, reflecting socio-economic, environmental and cultural differences.

Large biological and cultural differences in the nature and intensity of hunting have been found between mestizo and indigenous people in Latin America (Vickers 1984; Redford and Robinson 1987; Ojasti 1996). The importance of wildlife for mestizo people (non-indigenous) is less well known (Smith 1976; Vickers 1984; Redford and Robinson 1987; Bodmer 1995; Ojasti 1996), even when they are the main users of wildlife in Latin America (Ojasti 1996; Ortiz von Halle 2002). The fact that large numbers of mestizo peasants inhabit the poorest regions of Latin America and their

hunting impacts wildlife populations (Bodmer et al. 1997; Ortiz von Halle 2002) makes it imperative to better understand the role of wildlife in their livelihoods.

Most studies on the use of wildlife by local people in Latin America have focused on humid tropical regions, but less attention has been paid to semi-arid ecosystems (Ojasti 1996, Robinson and Bennet 2000a, Silvius et al. 2005). A Latin American semi-arid system of great interest is the Chaco, one of the most endangered ecosystems of the world (Bucher et al. 1998; Bucher and Huszar 1999; Zak et al. 2004) that harbors high levels of biodiversity and endemism (Mares 1992). The Chaco is a vast plain of about 1.3 million square kilometers extending over part of Paraguay, Argentina and Bolivia.

The semi-arid region of the Argentinean Chaco called the "*Impenetrable*" is the least developed and poorest region of the country, inhabited by a population of mestizos who live spread throughout the forest in small settlements and in several villages. Peasants and villagers use wildlife for different purposes (Bolkovic 1999; Barbarán and Saravia-Toledo 2000; Barbarán 2001) and are apparently overharvesting some species (Barbarán 2001; Altrichter and Boaglio 2004). These uncontrolled uses of wildlife, together with human population increase and the advance of agriculture, threaten the future sustainability of wildlife harvests (Bucher and Huszar 1999). As in many forested places in developing countries with growing human populations, the challenge in the Chaco is to implement wildlife conservation strategies that will not negatively affect the livelihoods of the local people. However, the necessary basic information on the economic and dietary importance of subsistence hunting for local people is lacking. This study contributes to the general understanding of the role of wildlife in the livelihoods of non-

indigenous people in a semi-arid ecosystem, by addressing the following objectives: (1) to determine the species hunted; (2) to identify the uses of wildlife; (3) to estimate the extent to which rural and village people depend on wild meat as a source of food and cash; (4) to determine temporal patterns of wildlife use; (5) to determine how the consumption of wild meat is related to the consumption of domestic meat.

Study Area

The Gran Chaco is a vast plain extending across northern Argentina, eastern Bolivia, western Paraguay and part of southeastern Brazil. Originally the Chaco was parkland or savanna with patches of hardwood intermingled with grasslands (Bucher 1982). In recent decades, intense overgrazing, excessive timber harvesting, and charcoal production have transformed large parts of the Chaco landscape into a dense thorny shrubland (Morello and Saravia-Toledo 1959; Morello and Hortt 1985; Bucher and Huszar 1999). The Chaco is divided in three sub-regions based on an east-west rainfall gradient: eastern or humid, central or transition, and western or semi-arid Chaco (Bucher 1983; Morello and Adamoli 1968). The study area covers 1.2 million hectares of the semi-arid subregion locally called "*Impenetrable*" (24^{o} 30' to 25^{o} 30' SL and 62^{o} 50' to 61^{o} 40' WL; Fig. 1). This sub-region is the driest and most markedly seasonal, with rainfall between 450-700 mm, most of which (80%) falls between October and April. Average annual temperature is 21.9^{o} C with minimums below zero and maximums around 50^{o} C. The vegetation is a medium-tall xerophilous forest with a canopy layer of about 12 m tall surpassed by a few species of taller trees reaching 16 m to 18 m (Bucher 1982). The dominant species of

trees are *Schinopsis quebracho-colorado*, *Aspidosperma quebracho-blanco* and *Bulnesia sarmientoi*. The shrub layer is dominated by species of *Acacia*, *Mimosa*, *Prosopis*, and *Celtis*. Cacti *Opuntia* and *Cereus*, grasses and bromeliads are abundant in the understory.

The study area is mostly rural with people living in about 200 small settlements spread throughout the forest, separated from each other by about 5 km. Most of these settlements consist of one household but some have up to seven. There are also several villages located along a paved inter-provincial road (Fig. 1), ranging between 20 and 1300 households. Rural peasants have a subsistence economy based on small-scale livestock ranching and forest exploitation for charcoal and fence posts. Most villagers are former peasants who moved into town. They have diverse sources of income, and many of them have farms.

Methods

Dietary importance of wildlife

I collected information on meat consumption among both rural peasants and villagers. However, different levels of detail were gathered from both populations. Rural peasants' diet in terms of meat consumption was recorded over a one-year period. Villagers were interviewed only once and were asked to mention the wild species they had consumed over the past year and to estimate a monthly average frequency of consumption. Scientific names of wildlife are in table 1.

Rural population: I randomly selected a sample of 58 rural households from different settlements (18% of the total number of settlements and 11% of the total number of households in the study area). Settlements are visible in satellite images because of the bare soil around houses, which allowed the selection of a random sample. I visited the selected families seven times from June 2001 to July 2003. The duration of my visits increased over the study period, with the final visits lasting two or three days. To estimate the importance of wildlife as a source of food, I relied on interviews and people's records of their consumption of meat. From June 2002 to July 2003, a member of each household recorded every day the domestic and wild meat consumed in the house, regardless of the amount.

I used several means to assess the reliability of the information recorded by the people. My unexpected visits to families helped me to corroborate what they had recorded with what they were eating that day and previous days. My assistant and I talked with different members of the family at the same time but separately as a further validation of the accuracy of responses. Local teachers assisted the research by collecting information on the wild meat that their students consumed during one month. By knowing the family origin of the students, I was able to compare the children's information with that provided by their families. I was also able to cross check information with neighbors who could tell when somebody had hunted large prey such as peccaries (*Tayassuidae*). I eliminated those cases where the information was dubious or inconsistent. At the end of the study, 38 families (from the original sample of 58) had kept consistent records of their consumption of meat during a complete year.

From the information collected by the 38 families I determined the species consumed in the region, frequency of consumption, seasonal patterns of consumption, proportions of wild and domestic meat consumed, and proportion of households that consume each type of wild meat. The variable "consumption of meat" was measured as days per month that each type of meat is consumed per household, and cannot be directly translated into number of animals consumed. I obtained monthly averages of consumption for each type of meat among all the families who provided information. For example, Chacoan cavy (*Pediolagus salinicola*) was consumed on average 2.7 days per month per household (Table 1). For seasonal comparisons of wild meat consumption I considered two seasons as recognized by local people according to temperature, which correspond roughly to wet and dry season: hotter months (September-April) and colder months (May-August).

To learn about hunting patterns I participated in hunting events and conducted in-depth interviews with 15 hunters. Some of these hunters were part of the random sample and others were specifically selected because local people mentioned them as having more knowledge about hunting and wildlife. Four of these hunters participated in the research process by keeping a journal where they recorded date and site of hunting, distances traveled, and species, sex and reproductive stage of animals killed.

Villages: I randomly selected 157 households from 7 villages (3.2% to 30% of the total number of households per village). The selection of household was based on our previously drawn maps. To survey the villages I used structured interviews covering similar topics assessed in the rural area. A field assistant stayed for several days in each

village (in family houses) from May to August 2003 and interviewed one adult member (52% women, 48% men) of each selected household. Data on estimated frequency of consumption of wild meat provided by interviewees were compared with our own observations while staying with families in villages. In addition to the random sample of households, I interviewed 20 key informants from different villages to obtain more detailed information on hunting. Key informants were regular hunters, native or long-term residents of the region.

Economic importance of wildlife

I estimated the economic importance of wildlife as: a) a source of cash, b) its consumptive value and c) its economic value.

Source of cash: I obtained information on legal and illegal commercialization of wildlife, prices, and modalities of trade through non-structured interviews with local people, hunters, government officials and park rangers. I estimated the proportion of households obtaining cash from wildlife commercialization and the relative importance of this income, but it was not possible to estimate the actual income.

Consumptive value: I determined the cost of replacing the amount of wild meat consumed with purchased meat (Bodmer et al. 1994). To find out the amount of wild meat consumed I relied on counting skulls and armadillo shells that people collected, on interviews, and on people's own records. I used average adult weights reported in the literature (Mares et al. 1989) for each species and considered 60% of weight as edible

(Martin 1985). I extrapolated the average amount of wild meat consumed per family during the year of study to the entire rural region (roughly 360 families).

Economic value: I estimated the economic value that hunting represents for local people by comparing the value of meat acquired through harvesting with alternative ways of obtaining the money necessary to buy the same amount of meat. The options available for rural people to obtain cash are wage labor and logging in their properties for fence posts. For this analysis, I only used hunting of peccaries.

Results

Access to domestic meat

All rural households owned cattle, goats, and chickens. Many households also had pigs, sheep and other farm birds. Local people did not know exactly the number of cows and goats they own, but it was possible to estimate that there was a large variation among households; while some do not have more than 10, others have around 500. Cows are kept for sale while other domestic animals are mainly used for household consumption. None of the interviewed rural households purchased meat; they consumed either their own animals or wild animals. Most villagers acquired domestic meat by purchasing it in local markets and some of them used their own animals. Thirty four percent of village households owned farms and about 70% had livestock.

Use of wildlife as food

Sixteen species of wild mammals, eight birds, two reptiles, and an unknown number of fish species were consumed by local inhabitants. However, only six species were consumed by more than 50% of households (Table 1). Rural peasants and villagers expressed similar preferences for wild meat: The general consensus was that the three-banded armadillo is the tastiest of all the wild meat. Other species mentioned as favorites were the Chacoan cavy, brocket deer, and collared and white-lipped peccaries.

Rural: Consumption of meat in the rural area was high. On average, households consumed meat 27 days per month (SD = 3.2, n = 38), of which 72.5% (SD = 11.7) of days represented domestic and the rest wild meat. The amount of meat consumed per day was not weighed but I observed that it varied from a few grams to about 500 g/adult. Often, meat was the only food served as the meal. Consumption of both types of meat varied throughout the year and the two were negatively associated (Spearman correlation, ρ = -0.53, $p < 0.01$). Consumption of domestic meat was higher during the colder months, while consumption of wild meat followed the opposite pattern. In the colder months, beef was the domestic meat most consumed, while goat was the most consumed in the hotter months (Fig. 2).

Almost all interviewees (97%) expressed a preference for including wild meat in their diet, but none of them relied entirely upon wild animals, although in some cases (8%) wildlife constituted about 50% of their meat consumption. Wild meat (adding all species) was consumed on average 7.7 days per month per household (SD = 1.7). In terms of total

number of days that meat was consumed, wild species comprised a similar proportion (27.5%) to beef (29.7%) and goat (27.8%), and more than chicken (13.2%) or pork (1.8%). Mammals provided the main source of wild meat in terms of frequency of consumption (83%; Table 1). The most frequently consumed species was the Chacoan cavy (about 33 days/year/family), which constituted the largest proportion (around 40%; Table 1) of the total amount of wild meat consumed. The second most frequently consumed mammal was the three-banded armadillo (Table 1). In terms of biomass, mammals constituted 92% of the total amount of wild meat consumed. Chacoan cavy provided 35% and peccaries 25% of the amount of wild meat consumed per family per year (Table 2). Adding peccaries and brocket deer, ungulates provided similar amount of meat than Chacoan cavies (40%). There was a large variation among households in the amount of meat consumed (Table 2). While some households did not harvest cavies, others killed up to 130 during the year of study, representing about 252 kg of edible meat. The 38 households participating in the study killed about 3,250 wild animals during the year of study, obtaining an average of 167 kg of edible meat per family (Table 2).

Consumption of different species varied through the year (Fig. 3). Chacoan cavies were consumed more frequently than other species all year except during the coldest months (May-July), when armadillos were consumed more frequently. Armadillos and peccaries were consumed more frequently during the colder months than during the rest of the year (*t*-test, $t = -2.45$, df = 10, $p < 0.001$; $t = -2.92$, df = 10, $p < 0.05$ respectively). Hunters neglected armadillos and peccaries during the hotter period because, according to them, these animals have low fat content in those months. Tegu lizards were consumed

almost exclusively during the summer, when they became active ($t = 2.82$, $df = 10$, $p < 0.05$). Chacoan cavies, brocket deer and birds were consumed with similar frequency during the year ($t = 0.63$, df = 10, $p = 0.5$; $t = 1.5$, df = 10, $p = 0.1$; $t = 1.14$, df = 10, $p = 0.27$ respectively).

Villages: Consumption of meat in villages was also high. Most households consumed meat almost every day, and most of this meat was purchased. Only a few (2%) households obtained their meat mainly from hunting. Most households (94%) had consumed wild meat at least once during the year of the study (2003). The species consumed were the same as those in the rural area, with the exception of fish and rhea (Table 1). Fish were taken from an artificial canal that crosses the region along the paved road where villages are located. The proportion of households consuming each species was smaller than in the rural area (Table 1). Only brocket deer and armadillos were consumed by more than 50% of households (Table 1). Armadillos, vizcachas, and Chacoan cavies were the most consumed according to interviewees' estimated frequency (between 8 and 12 times per year/household), followed by tegu lizard, chachalaca and brocket deer (between 5 and 7 times per year/household). All species were consumed more frequently in the rural area except vizcachas (10 per year in the villages in comparison with 2 per year in the rural area).

Hunting methods

Most rural peasants (95%) hunted, either actively seeking game or as a secondary activity while working in the forest or in agricultural fields. Hunting was practiced mainly by

males. Women and children often harvested Chacoan cavies and armadillos, and children also hunted doves using slingshots. Hunting methods differed between rural and village hunters in some aspects. Rural hunters generally hunted alone or with members of their family, and the harvested meat was consumed by the hunter's household. They went hunting by walking, biking or riding horses, and only during the day. Hunting range was generally within 5 km from the settlement. They never spent more than one day hunting. The most commonly used technique to hunt employed dogs. Firearms were used for some species but others such as armadillos, tegu lizards, and collared peccaries were often killed with axes, clubs or machetes. Village hunters, in contrast, commonly hunted in groups, used vehicles for transportation and often spent more than one day in the forest. These hunters commonly hunted at night, using spotlights. Distances traveled by village hunters varied between 5 km and 100 km from town. Harvested meat was shared among hunters and among relatives and friends. The techniques used by rural and village hunters were similar with the exception that village hunters used almost exclusively firearms.

Other uses of wildlife

Local people mentioned few uses of wild species for medicinal purposes or handcrafts. The fat of tegu lizard is the most commonly used medicine for multiple purposes such as cuts, snake bites, and colds. The fat of pumas and boas (*Boa constrictor*) was also mentioned as a curative for contusions and muscular pain. Some people mentioned that the fat of the peccaries is used for cough, and their feces or the content of their intestines is used to cure the wounds that the same peccaries inflict on dogs. The hides of hunted

animals were generally wasted, with some exceptions when people used them to make shoes, hats, and parts for saddles.

Local people also used some wild species as pets, or for adornment and luck. About 60% of the interviewed households had blue-fronted Amazon parrots (*Amazonia aestiva)* as pets. Other less common pets were peccaries, tamandua anteaters (*Tamandua tetradactyla*), armadillos, and some species of birds. Almost all interviewees had some animal part as an ornament in their houses. Skins of felines and of tamandua anteaters were the most common adornment found hanging on the walls. Shells of large armadillos were also used as adornments, generally painted with the colors of the favorite soccer team. It was common to find parts of animals hanging on trees or on the roofs, such as skulls, feet and shells, which people saved under the belief that they bring good luck for future hunting. The use of animal parts for making handcrafts was uncommon and implied no more than five species. Fourteen percent of interviewees occasionally used some animal parts such as the skin of anteaters, brocket deer and peccaries to make huts, shoes, belts and saddles.

Economic importance of wildlife

Source of cash: Wildlife does not currently provide an important source of cash. Skins of tegu lizard and live parrot chicks are the only wildlife products that can be legally commercialized as part of a National Office of Fauna project. For the families involved with the project, this represents an important source of income but it is limited to a month or two per year.

Illegal commercialization of wildlife was common but not very meaningful for the majority of the population. I identified two types of commercialization of wildlife. One is a small-scale trade of meat, pelts and live animals, providing modest and occasional cash income to some rural households (< 10%) who have a vehicle for transportation or live close to towns. Additionally, in some cases, people sell parrots to illegal buyers who visit the rural area or exchange them for merchandise. Some rural people also occasionally sell belts and hats that they make from the skins of giant anteaters (*Myrmecophaga tridactyla*) and peccaries. The other type of commercialization of wildlife I identified provides higher cash income to a small percentage of village households (< 5%) who are dedicated to this activity. This is the trade of live animals such as giant armadillos (*Periodontes maximus*), peccaries and jaguars (*Panthera onca*) for illegal hunting farms or zoos. These people are also involved with the illegal sale of hides and occasionally guide foreign sport hunters to hunt endangered species such as Chacoan peccaries. Additionally, some villagers harvest large numbers of armadillos (up to 200 per weekend) to sell in nearby cities.

Sport hunting by foreign visitors in this region is rare and does not provide important economic benefits for local people. More common is recreational hunting practiced by people without hunting licenses from nearby cities. These hunters generally visit the same local family year after year and stay with them for a few days. Visiting hunters do not directly compensate the owners of the land where they hunt or the local people who act as guides. However, they may provide local people with goods, food and alcoholic beverages.

Consumptive value: The consumption value of meat was high in comparison with minimum daily wages. If the amount of wild meat consumed were to be replaced by buying meat it would represent a consumption value of US$ 223 per family per year, equivalent to two months of minimum wages. For the entire region, considering only the rural area, the amount of meat consumed was estimated to be around 59,700 kg per year, representing US$ 79,600 (at the 2003 conversion rate of dollar-Argentinean peso 1:3). This estimate considers only the consumption of meat by rural inhabitants. The value would certainly be higher considering the amount of meat consumed by non-local loggers, villagers and sport hunters from cities. For example, it was estimated that village hunters from the seven villages killed about a fourth of the numbers of peccaries killed by rural hunters in the same area. If this were representative of hunting of all species, villagers would be harvesting an additional 14,000 kg of wild meat, adding US$ 18,600 more to the consumptive value of wildlife in the study area.

Economic value: Hunting peccaries was an economically advantageous strategy in 2001 when considering the average daily wage and the price of meat in local markets. Hunting a collared peccary takes less than one day and provides approximately 15 kg of edible meat, representing US$ 10. To replace this meat with purchased meat, the hunter would have to work for three days to earn US$ 10 (average daily wage $ 3). When compared with logging, hunting was similarly advantageous in economic terms. One experienced man cutting fence posts could earn in one day the price equivalent to 15 kg of meat.

With the national economic changes in 2001 (devaluation of the Argentinean currency), hunting became more advantageous than in previous years in comparison with

prices of domestic meat but less in comparison with prices of wood. In 2003, the cost of 15 kg of meat was twice as much as before the devaluation. Prices of food increased proportionally more than wages, such that a man had to work four days instead of three to buy 15 kg of meat. Prices of fence posts also increased such that a man cutting wood in one day could earn the equivalent to 25 kg of meat. These values, however, would vary among households depending on the number of young males who could work making posts and on the time they need to dedicate to other activities such as agriculture and livestock ranching.

Discussion

Patterns of use of wildlife by peasants and villagers in the *Impenetrable* differed from other human groups studied in Latin America in terms of the diversity of species hunted and the role of hunting in local people's livelihoods. Wildlife in the *Impenetrable* is mainly used for food, and its economic importance is not due to cash generation but to the consumptive value of wild meat.

Small species, cavies and armadillos, constitute the main source of wild meat in the *Impenetrable* in terms of frequency and biomass. This result differs from others and in the Neotropics where large mammals are the most important game species (Hill and Hawkes 1983; Vickers 1984; Alvard 1993; Bodmer 1995; Stearman and Redford 1995; Peres 2000). This result also differs from the Bolivian Chaco where Izoceño Communities, although they harvest a larger number of armadillos than of other species, most of the meat is obtained from brocket deer and collared peccary (Cuéllar 2000). The

fact that hunters in the *Impenetrable* are concentrating on small species may reflect depletion of large prey near settlements. Previous studies in this region have shown that white-lipped and Chacoan peccaries have diminished or disappeared in association with settlement age (Barbarán and Saravia-Toledo 2000; Altrichter and Boaglio 2004). Depletion of large species near human habitations is a commonly observed phenomenon in Latin America (Smith 1976; Hill and PadI 2000; Lopes and Ferrari 2000; Peres 2001). Preference for small species may also result from the fact that local people are not depending on wild meat sales. However, when sale of hides was one of the main sources of income for local people (before 1990), harvest composition was probably very different. Concentration of harvest in large species in other regions has been explained as a way to maximize economic gains from wild meat sales (Bodmer 1995).

Illegal commercialization of wild meat in the *Impenetrable* is scarce and irrelevant as a source of income for the majority of the population. This differs from many other sites in Latin America where commercialization of wild meat generates important economic revenues for rural communities (Bodmer et al. 1988; Redford 1993; Bodmer et al. 1994; Bodmer 1995; Loibooki et al. 2002; Ortiz von Halle 2002). Although trade of wild meat is not important, its consumptive value is significant in comparison with local wages. If the average amount of wild meat consumed in rural households were replaced by purchasing meat, this would represent two months worth of minimum salary. When compared with economic value of cutting wood, the consumptive value of hunting decreases. A tendency to dedicate more time to forest exploitation and less to hunting has

been observed in the rural area, probably responding to this increased value of cutting wood.

The species consumed in the *Impenetrable* and the proportion of each in the diet of local people differs from other Latin American mestizo communities and from indigenous communities in other regions of the Chaco. Whereas in several mestizo communities in Latin America it was found that mammals composed 60% and birds 30% of their diet (Redford and Robinson 1987), in the *Impenetrable* mammals alone constitute 92% of the consumed biomass and birds only 3.1%. Ojasti (1996) found that tortoises, peccaries and birds were numerically the major hunted groups (around 18% each group) in mestizo communities in Latin America. This result contrast with the *Impenetrable* where Chacoan cavies alone constitute 42% of the total number of animals harvested, indicating that peasants concentrate on a few species. Although concentration on few species seems to be characteristic of mestizo hunters (Vickers 1984; Redford and Robinson 1987), the range of species commonly used in the *Impenetrable* is smaller than reported for other mestizo communities in Latin America (Ojasti 1996).

The range of species consumed and the seasonal patterns of hunting respond to preferences for quality of meat, cultural practices of hunting and behavior of the species. Hunters in the Paraguayan Chaco consider the meat of Chacoan peccaries to be the tastiest of all Chacoan fauna (Sowls 1984; Brooks 1996), whereas in the *Impenetrable* this species was not among the most preferred. Several species that are relatively abundant in the region and are appreciated as a source of meat in other parts of Latin America, such as anteaters, parrots, and carnivores (Cuéllar 2000, Thomsen and

Brautigam 2001; Ortiz von Halle 2002) are not consumed in the *Impenetrable* because the meat is considered to taste bad. Species such as pumas that are killed because they are regarded as pests are rarely consumed, whereas they form part of the diet of other mestizo communities (Ojasti 1996; Bennet and Robinson 2000) and indigenous people of the Bolivian Chaco (Cuéllar 2000). The nocturnal Brazilian rabbit is consumed by Latin American mestizo communities (Ojasti 1996) but not in the *Impenetrable*, even when it is abundant, because local people prefer not to hunt at night. In a study using track tramps in this region I found that number of tracks of this species were three times more abundant than the tracks of Chacoan cavy (Altrichter unpublished). Some species such as peccaries, although available all year, are mainly consumed during the time of the year when their meat has higher fat content. Seasonal changes of hunting activity and species consumed observed in other regions responds generally to climatic conditions such as seasonal floods (Behrens 1981; Bodmer 1990), or because hunters are occupied in planting crops (Smith 1976) or in seasonal jobs (Cuéllar 2000). Seasonal patterns of hunting based on preferences for content of fat do not seem to be common (Souza-Mazurek et al. 2000), although it has been observed in Indigenous people of the Bolivian Chaco (Noss and Cuéllar 2001). Although it is difficult to discern between preference for meat quality and availability of armadillos it was occasionally observed that hunters encountering them in the forest during the hotter months choose to not kill them. Seasonality of hunting in the *Impenetrable* is also affected by species behavior. Species that are nocturnal during the hot months are not hunted during that season, while others that are only active during the summer, such as tegu lizards, are consumed exclusively on

that period. Generalist species that are associated with human habitation, such as vizcachas, are consumed more frequently in villages than in rural areas where they are less abundant. Some species, such as white-lipped peccaries, are hunted more often during the dry season when they frequent areas close to settlements searching for crops or water. The effects of seasonal hunting in terms of sustainability should be studied. For example, hunting season coincides with the breeding season of peccaries in this region (Yahnke et al. 1997; Noss et al. 2003) and tegus (Fitzgerald et al. 1991), but the effects of this overlap on the populations are poorly understood (Fitzgerald et al. 1991).

The use of wild animals for pets, medicine and adornment does not seem to have important implications for conservation in this region, but the illegal trade of species should be further studied. Medicinal and ornamental uses of wildlife in the *Impenetrable*, unlike other Latin American regions (Redford and Robinson 1991; Thomsen and Brautigam, 1991), do not motivate hunting. Domestic medicinal uses are limited, contrasting with Indigenous people of the Bolivian Chaco (Cuéllar 2000), and there is no market for medicinal products derived from wildlife. Local people in the *Impenetrable* use basically only blue-fronted Amazon parrots as pets, in contrast with indigenous people across Latin America who use large numbers of species (Redford and Robinson 1991). However, the illegal trade of wild animals occurring in the *Impenetrable* is probably impacting wild populations because it affects some of the most vulnerable species such as jaguars, Chacoan peccary and giant armadillo.

Rural hunters in the *Impenetrable* use hunting methods similar to other mestizo hunters (Ojasti 1996), with some differences. Hunting only during the day, alone and

almost always with dogs, is not common among mestizo peasants (Smith 1976; Ojasti 1996; Altrichter 2000). This practice probably results from the spread out spatial disposition of settlements that precludes working collaboratively. Villagers however, generally hunt in groups, sharing the costs and the harvest. Access to technological improvements has allowed villagers to modify their hunting methods, as it has been observed in many other Latin American cases (Stearman 2000; Ortiz von Halle 2002). Incorporation of other elements such as spotlights and vehicles has improved their hunting effectiveness. Village hunters harvest larger number of peccaries (per hunter) than rural hunters (Altrichter Appendix E). It is possible that with the increased economic gains from forest exploitation, rural hunters will also incorporate the technology used by village hunters, which may influence game selection as it has been observed in other Latin America mestizo communities (Vickers 1984).

Whether wild meat is a significant source of food for local people in the *Impenetrable* does not have a simple answer. On the one hand, wild meat seems important because it constitutes one third of the total amount of meat consumed, and provides fresh food during the hotter months when it is difficult to store meat. Wild meat also represents a considerable consumptive value, especially for rural peasants without a regular source of income. On the other hand, rural peasants have ready access to domestic meat and total consumption of meat is high (almost 90% of the meals have meat) in comparison with other mestizo in Latin America (Ojasti 1996) and indigenous communities in the Bolivian Chaco (Cuéllar 2000). The total amount of meat consumed was roughly constant throughout the year, indicating that people want to maintain a certain level of meat

consumption and they reach this level by modifying the types of meat they consume. Other indications that local people do not depend on wild meat can be deduced from hunters' behavior.

Hunters behave in ways that suggest selective rather than opportunistic hunting, in contrast to the findings of Redford and Robinson (1987) who say that mestizo hunters will take whatever game they encounter, within their range of acceptable species. Ortiz von Halle (2002) also asserts that prejudices against non-preferred species disappear when the favorite species are exhausted and people hunt whatever they must to meet their needs. In the *Impenetrable* however, hunters harvest species according to preferences for taste, meat quality, accessibility and availability of preys, and concentrate on a few species disregarding others that are abundant and consumed in other regions. Overall, these findings suggest that peasants could decrease, but probably not eliminate, their consumption of wild meat and their nutritional condition would not be adversely affected by a shortage of protein. However, other aspects, such as the cultural importance of hunting for local people need to be addressed. Decreasing hunting of some vulnerable species, such as peccaries, may not be acceptable by local people, as it has been observed in rural communities in the Bolivian Chaco (Noss and Cuéllar 2001). Other measures that do not directly involve a change of behavior of local people should be considered. For example, controlling illegal commercial hunting and hunting by outsiders seems to be a type of measure more supported by local people (Noss and Cuéllar 2001). The fact that hunting in the rural areas of the *Impenetrable* remains common despite the existence of

alternative sources of meat calls for more research about the cultural factors related to the hunting activity itself, and the cultural value associated with the possession of livestock.

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Table 1. Wild species consumed in the *Impenetrable*, July 2002-June 2003.

English name	Scientific name	Consumption per rural family (Mean days/year and SD)	Proportion by species (%)	Proportion of households that consume wild meat (%)	
				Rural	Village
Mammals					
Chacoan cavy	*Pediolagus salinicola*	32.9 (0.52)	36.5	95	37.4
Three-banded armadillo	*Tolypeutes matacos*	16.5 (1.07)	18.4	100	
Brocket deer	*Mazama gouazoubira*	8.6 (0.32)	9.6	75	68.2
Collared peccary	*Tayassu tajacu*	6.2 (0.33)	6.9	57.5	40
Six-banded armadillo	*Euphractus sexcinctus*	3.0 (0.15)	3.3	57.5	

Chacoan peccary	*Catagonus wagneri*	2.6 (0.17)	2.9	27.5	16.1
White-lipped peccary	*Tayassu pecari*	1.7 (0.1)	1.9	17.5	22.0
Plains vizcacha	*Lagostomus maximus*	1.7 (0.09)	1.9	27.5	22.0
Larger hairy armadillo	*Chaetophractus villosus*	0.6 (0.07)	<1	38.9	
Nine-banded armadillo	*Dasypus novemcinctus*	0.3 (0.03)	<1	8.3	
Naked-tailed armadillo	*Cabassous chacoensis*	0.2 (0.01)	<1	13.9	
Mountain lion	*Puma concolor*	0.4 (0.04)	<1	5	2.5
Geoffroy's cat	*Oncifelis geoffroyi*	0.1 (0.01)	<1	<3	0
Brazilian rabbit	*Sylvilagus brasiliensis*	0.1 (0.02)	<1	<3	0

Small hairy armadillo	*Chaetophractus vellerosus*	0.06 (0.01)	<1	8.3	
All armadillos *				100	84
TOTAL		74.8	82.4		
Birds					
Chaco chachalaca	*Ortalis canicollis*	5.6 (0.17)	6.2	62.5	30.7
White-tipped dove	*Leptotila verreauxi*	3.2 (0.14)	3.6	40	
Brushland tinamou	*Nothoprocta cinerensis*	1.4 (0.11)	1.6	17.5	
Black-legged seriema	*Chunga burmeisteri*	1.1 (0.05)	1.2	19.4	14.6
Quebracho crested-tinamou	*Eudronia formosa*	0.3 (0.05)	<1	7.5	
Ringed teal	*Calloneta leucophrys*	0.3 (0.03)	<1	7.5	

Tataupa tinamou	*Crypturellus tataupa*	0.03 (0.01)	<1	<3	
Rhea americana	*Rhea americana*			0	4.4
Small birds*				77.9	5.5
TOTAL		11.8	13.1		
Reptiles					
Tortoise	*Geochelone* sp.	0.03 (0.01)	<1	<3	0
Tegu lizard	*Tupinambis rufescens*	3.4 (0.39)	3.7	47.5	28.4
TOTAL		3.4	3.8		
Fish				0	7.6

* Different species of armadillos and of small birds were not distinguished by people in the villages.

Table 2. Average, standard deviation and range of the amount of wild meat (total weight*0.6) consumed per household in the rural area and proportion of each species in the total amount of wild meat consumed from July 2002 to June 2003.

	Edible amount of meat/household/year (Kg)			
Species	Mean	SD	Range	Proportion of total (%)
Chacoan cavy	59.2	61.1	0-232	35.4
Peccaries	42.6	71.1	0-252	25.5
Brocket deer	25.1	24.5	0-101	15.0
Armadillos	21.6	17.0	2-67	12.9
Birds	6.5	10.9	0-41	3.9
Vizcacha	5.2	10.8	0-48	3.1
Reptiles	4.9	6.7	0-23	2.9
Others	2.1	8.7	0-50	1.3
TOTAL	167.2			100

Figure 1. Study area. Location of settlements participating in the study.

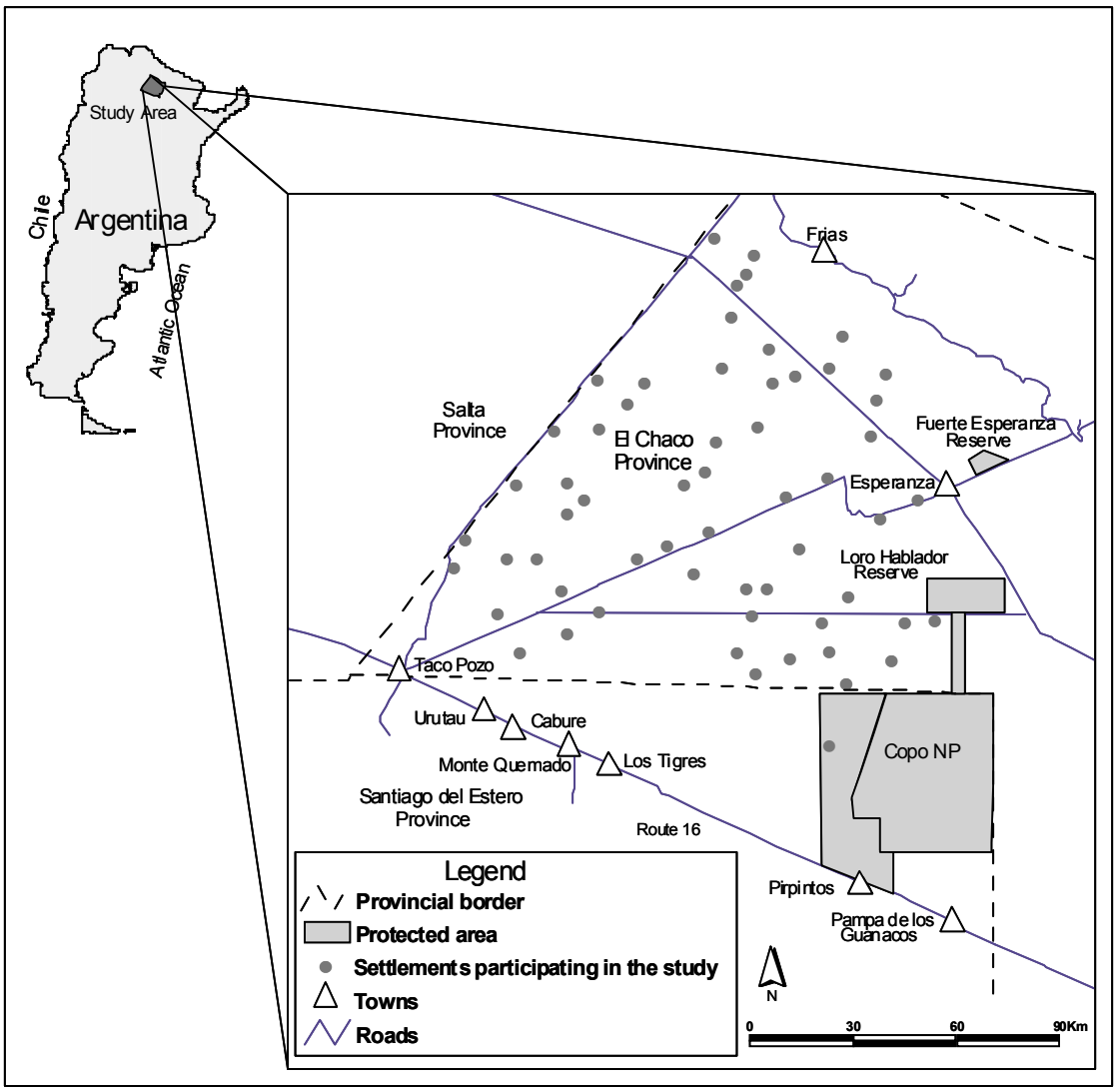


Figure 2. Seasonal consumption of domestic meat (mean (± SE) number of days/month/household).

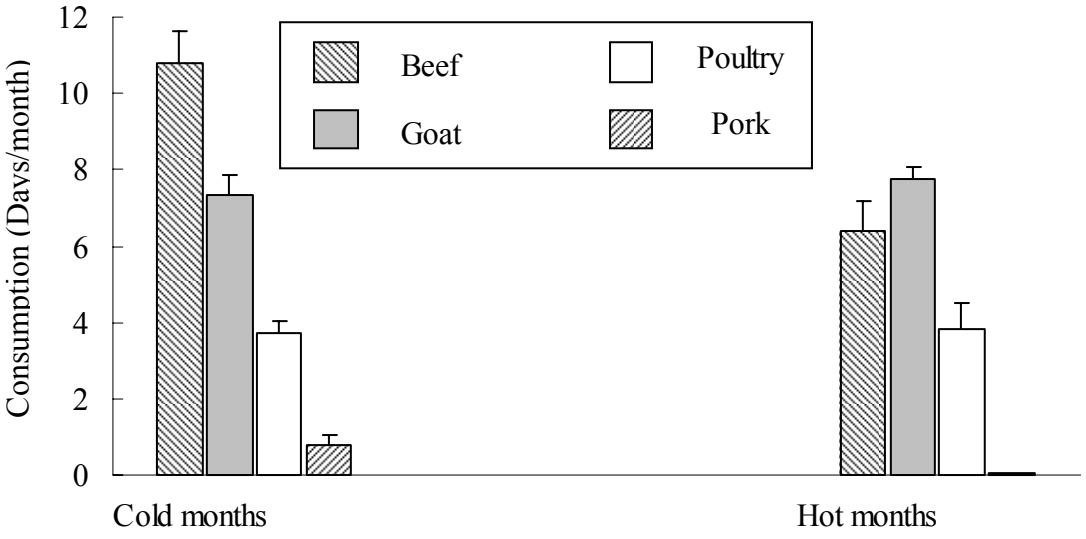
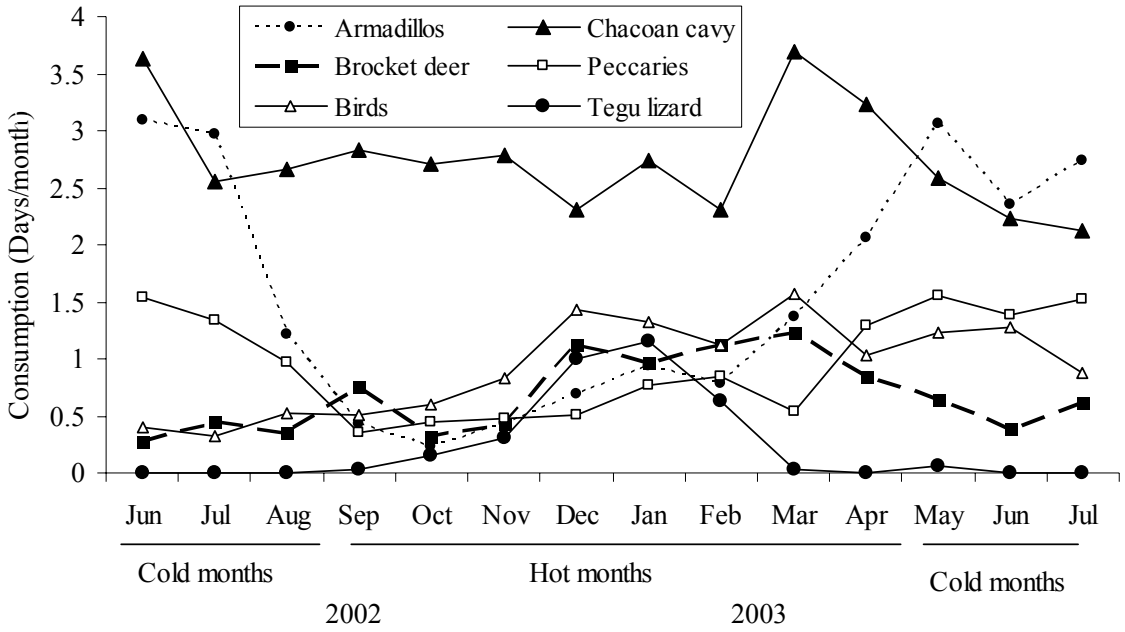


Figure 3. Consumption of wildlife species throughout the year (mean number of days/month/household).



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APPENDIX D

FACTORS UNDERLYING USE OF WILDLIFE IN THE SEMI-ARID ARGENTINE CHACO

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Abstract

Wildlife is an important resource for many local communities. Communities have been typically conceived as static, distinct, small, homogeneous and cohesive groups of individuals with similar interests. The purpose of this study was to illustrate, through a case study in the Argentine Chaco, how the heterogeneity of this rural mestizo community and the larger system in which it is embedded influence the ways that people interact with wildlife. I focused on the use of wildlife at the household level to explain how it is affected by: a) socio-economic intra-community differences, b) regional variations in colonization patterns and forest degradation, c) changes in national and international wildlife policies, and d) economic changes produced by the Argentine economic crisis of 2001-2002. The study area encompasses several villages and a large rural area. This study was based mainly on interviews. I found that hunting in this region is practiced by local peasants, village dwellers, non-local hunters, and logging workers. Wildlife was an important source of cash in the past, but currently it is mainly used for food even though people have access to domestic meat. The importance of wildlife as food varied within the community and regionally. Larger and poorer households, and households located in the most recently colonized region, consumed more wild meat. In the villages, consumption of wild meat was negatively associated with village sizes and economic status. The importance of wildlife also was affected by national economic changes that resulted in devaluation of the national currency and increase in unemployment. This negatively affected village people who started to hunt more frequently to obtain food and cash. Rural peasants decreased hunting because they started

to dedicate more time to forest exploitation. This study shows how the importance of wildlife is variable for different members of a heterogeneous community and is subject to change. Recognizing this complexity is an important step towards development of appropriate conservation strategies.

Keywords: Argentina, Chaco, community, hunting, subsistence hunting, wildlife.

Introduction

Wildlife is an important resource for the subsistence of many people in Latin America, and its use often produces conflicts between conservation and human needs (Robinson & Redford 1991, Olfield & Alcorn 1991, Robinson 1993, Alvard *et al.* 1997, Robinson & Bennet 2000, Mainka & Trivedi 2002, among others). Viable solutions to this conflict require an accurate understanding of the role of wildlife for local people. Although interactions between local people and wildlife have been the subject of many studies, most studies treat the use of wildlife as an inherent property of the community, and the community as a homogeneous group of individuals with similar interests (see Robinson & Bennet 2000, Silvius *et al.* 2005). Although this may be the case when considering indigenous communities, mestizo peasants in Latin America are often settlers entering new territories, and are generally embedded in a market economy. Even though mestizo peasants are the largest users of wildlife in Latin America (Ojasti 1996, Ortiz Von Halle 2002), few studies have addressed the importance and characteristics of subsistence

hunting for them (Smith 1976; Vickers 1984; Redford & Robinson 1987; Bodmer 1995; Ojasti 1996, Vickers 1984, Redford & Robinson 1987, Bodmer 1995).

Understanding what characterizes communities and their use of wildlife is indispensable given that putting communities at the center of resource management and conservation has been advocated during the last decades as one of the most viable approaches to solve problems of overexploitation of wildlife (Western & Wright 1994). The mechanism of community-based conservation programs (CBC) is to vest planning and management of the resource into the local community which captures the benefits of its use, expecting that if wildlife is valuable to locals they will have more incentives to protect it (Western & Wright 1994, Barrett *et al.* 2001). However, results of CBC schemes have not always been as expected. Studies trying to explain causes of poor performance of CBC found that these projects are typically based on incorrect or insufficiently tested social and ecological assumptions (Barret & Arcese 1995, Hackel 1999, Leach *et al.* 1999, Barrett *et al.* 2001). One of the social assumptions found to be common among CBC advocates is a simplistic conceptualization of the local community.

The local community typically has been conceptualized as a distinct, small, homogeneous and cohesive group of individuals with similar interests (Agrawal & Gibson 1999, 2001). This notion leads to the assumption that all community members perceive the same values from biodiversity use. Communities also have been commonly conceptualized as static and isolated (Agrawal & Gibson 1999, 2001, Berkes 2004). Recent critics from the social sciences have demonstrated that communities are not static but constantly changing (Leach *et al.* 1999, Berkes 2004), therefore, changing their

interactions with wildlife. Critics also have highlighted social differences that divide and crosscut community boundaries (Leach *et al.* 1999, Li 2001). These social differences can affect the value that wildlife represents for different members of the community, and as a consequence, the way it is used. For example, some studies have found that consumption of wild meat is negatively associated with economic status (Stearman & Redford 1995, Eves & Ruggiero 2000).

From these examinations of communities, it has been proposed that it is more useful to think about communities as "multidimensional, cross-scale, social-political units or networks changing through time" (Carlsson 2000 *cited in* Berkes 2004). In this paper, I contribute to the advancement of this line of thought by showing the level of heterogeneity that characterizes a mestizo community and the dynamism of its interaction with wildlife through the analysis of a case study in the *Impenetrable*. In this northern Argentine region there are multiple actors who interact with wildlife in different ways. I identify the community of users of wildlife as a source of food and the factors that affect this usage. I focus on the use of wildlife at the household level to explain how it is affected by: a) intra-community differences in socio-economic terms, b) regional variations in colonization patterns and forest degradation, c) differences in size of villages, d) changes in national and international policies that affect the market for wild animal skins, and e) economic changes produced by the Argentine economic crisis of 2001-2002.

The semi-arid region of the Argentinean Chaco called the "*Impenetrable*" has undergone important environmental changes since colonization of this area by mestizo

peasants at the beginning of the 18th century (Morello and Hortt 1985; Bucher and Huszar 1999). The semi-arid Chaco is inhabited by poor rural and village mestizos who practice subsistence hunting. Some species, such as the white-lipped peccary *(Tayassu pecari)* and the endemic Chacoan peccary *(Catagonus wagneri)* have declined because of overhunting (Barbarán and Saravia-Toledo 2000, Altrichter and Boaglio 2004). The increasing human population and the rapid advance of agriculture in the Chaco make it unlikely that uncontrolled harvest of wildlife will be sustainable (Bucher & Huszar 1999), which makes it essential to develop measures of conservation that will not negatively affect the livelihoods of the local people. Although the proportion of wild meat consumed by rural peasants is considerable, locals do not depend exclusively on wildlife for their protein intake, and other factors than the need for food influence patterns of hunting (Altrichter Appendix C). In this region wildlife is not important as a source of cash but is has high consumptive value, and this value is affected by the relative economic importance of the main activities of the region; livestock rising, logging and wage labor (Altrichter Appendix C). In this paper I analyze how the importance of wildlife has changed through time, and how its current importance is influenced by different socio-economic, environmental and regional factors.

Study Area

The Gran Chaco is a vast plain extending across northern Argentina, eastern Bolivia, western Paraguay and part of southeastern Brazil. Intense overgrazing, excessive timber harvesting, and charcoal production have transformed large parts of the Chaco landscape

into a dense thorny shrub land (Morello and Saravia-Toledo 1959, Morello and Hortt 1985, Bucher and Huszar 1999). The Chaco is divided in three sub-regions based on an east-west rainfall gradient: eastern or humid, central or transition, and western or semi-arid Chaco (Bucher 1983; Morello and Adamoli 1968). The study area covers 1.2 million hectares of the semi-arid subregion locally called "*Impenetrable*" (24^{o} 30' to 25^{o} 30' SL and 62^{o} 50' to 61^{o} 40' WL; Figure 1). This sub-region is the driest and most markedly seasonal, with rainfall between 450-700 mm, most of which (80%) falls between October and April. Average annual temperature is 21.9 ^{o}C with minimums below zero and maximums around 50 ^{o}C. The vegetation is a medium-tall xerophilous forest (Bucher 1983).

The semi-arid Chaco is the largest extension of continuous forest and the poorest, least developed region of the country. The scarcity of water during the long dry season and high temperatures during the summer make the *Impenetrable* an inhospitable place, reasons for which it was one of the latest regions to be colonized. The largest migration into the *Impenetrable* was between 1920 and 1960 with the expansion of railroads and logging exploitation by British companies (Saravia-Toledo1985, Bucher 1995). The land in the Chaco was state property but access to the land and natural resources was unregulated and open to everyone who wanted to settle in this region. Mestizo peasants from neighbor provinces of Santiago del Estero in the south and Salta in the west (Figure 1) successively migrated into this land creating extended family settlements focusing on cattle ranching. The provincial government also promoted colonization, constructing villages and wells distributed throughout the forest. Since the colonization of this region,

rural peasants have lived on a small-scale economy based on livestock ranching and exploitation of natural resources. Construction of many roads for oil prospecting increased communication between the rural area and the villages. However, the region remains scarcely developed. There is no electricity, tap water or telecommunication. Health services are minimal and education only covers elementary school. In the study area there are no rivers or other sources of natural water other than temporal ponds formed during the rainy season. Rural peasants either build wells to get water from underground reservoirs, or collect water from the rain and save if for the rest of the year. Underground water often has high contents of salts or arsenic. This area is mostly rural with people living in about 210 small settlements spread throughout the forest, separated from each other by about 5 km. At the south it is crossed by an inter-provincial paved road (Route 16), along which there are several villages that range in size from 20 to 1300 families (Figure 1). The northern limit of the study area starts 20 km south of the Bermejito River. Between the southern and northern limits there are about 150 km of forest (Figure 1). From south to north the density and size of settlements decrease.

Methods

In this study I combined quantitative data on the use of wildlife as a source of food by rural peasants and villagers in the *Impenetrable* with qualitative data on aspects of people-wildlife interactions. Rural families were visited several times over a period of three years, while village households were visited once. Three types of samples of households were used for different purposes: 1) A randomly selected sample of 157

households from seven villages, covering from 3.2% to 30% of total number of households in each village, 2) A purposive sample of 15 rural and 20 village hunters specifically selected because of their knowledge and their willingness to participate in the study, and 3) A randomly selected sample of 57 rural households out of 210 settlements. Socioeconomic information was gathered from this later sample, while information on consumption of wild meat was obtained from a sub-sample of 38 households, representing 11% of total number of households in the area. The original sample of 57 households was reduced to 38 because of logistic constraints, such as difficulty to access some settlements, and other reasons beyond my control such as people moving out of the area. Additionally, I interviewed three groups of urban sport hunters who were staying in different settlements, the president of one sport hunting club, and locals who receive sport hunters in their settlements. I also interviewed logging workers from two camps and visited recently abandoned logging camps where it was possible to count carcasses of consumed animals. Information about hunting in the past and the effects of the national economic changes on locals and their hunting activities was based in oral testimonies of local people.

Rural: I visited the selected families seven times from June 2001 to July 2003 and spent from several hours to days with each family. Consumption of wildlife was estimated using interviews and based on people's records of their consumption of meat. From June 2002 to July 2003, a member of each household recorded the domestic and wild meat consumed in the house every day. I recorded socio-economic information such as

household size, sources of income and economic situation. Although all households have several sources of income, I identified the main source for each household as originating from livestock, forest exploitation (charcoal and fence posts), or jobs (salaried or wage labor). I created two categories of economic situations using several indicators because of the difficulty of estimating annual incomes. I classified households as poorer or richer (relative to the region, not comparable with other places) based on land tenure, size of farm, number of domestic animals owned, economic activities, main income, household goods, expenses (i.e., number of children going to school in town) and possessions of capital such as vehicles and water pumps. Additionally, I divided the study area into two regions. This differentiation was based on personal observation of the status of the forest, on observation of satellite images and on the history of colonization as recounted by elders who were the original settlers. By mapping age of settlements with GPS I was able to differentiate a southwest region that was the first to be colonized (from 30 to 80 years ago), and a northwest region that has been recently colonized (less than 30 years ago). In this second region, some settlements were established during my field work. The southwest region is closer to the paved road and to towns, and has higher density of settlements. I also classified the forest within a circle of 10 km diameter around each settlement (people normally hunt within this distance from their homes, Altrichter Appendix E) as highly degraded and less degraded, according to forest exploitation activities of the site. All forest has some degree of degradation because of overgrazing (Bucher and Huszar 1999), but in some areas there has been intense degradation resulting from charcoal production. The classification of the condition of the forest was based on a

qualitative assessment from satellite images and then corroborated in the field (for further details see Altrichter Appendix A).

Villages: I classified villages by size according to the number of households, information that was obtained from hospital records. Four villages were classified as small (less than 300 households), two as medium (740 and 850 households) and one as large (1300 households). An assistant spent two to three weeks in each of the seven villages and visited each randomly selected household once. Information was collected through structured interviews with an adult member of each family. Interviewees were asked to mention the wild species they had consumed in the last year and to estimate a monthly average frequency of consumption. The same socio-economic information that was collected in the rural area was gathered in the villages. The classification of poorer versus richer families was mainly based on ownership of the house, ownership and size of farm, existence of a regular salary, and possession of capital such as vehicles. The existence of a salary, either as a public employee or as employee in the private sector mainly marked the difference between richer and poorer households. Most of those families receiving income from a salary, or that had their own enterprise, were owners of their houses and had land.

Analysis

Different levels of information on importance of wildlife as a source of food exist for both types of populations. For rural peasants “consumption of wild meat” was measured

as number of days per month that households consumed wild meat, whereas for villagers I recorded whether they had consumed wildlife during the year previous to the study (for further details see Altrichter Appendix C). To explore factors that underlie use of wildlife for food at the household level, I analyzed the relationship between consumption of wild meat and different potential explanatory variables. I performed different analyses for village and rural households because of the different quality of data gathered for each population in terms of consumption of wild meat. For the rural households I obtained monthly averages of consumption of wild meat per family and the proportion of families consuming each species. I performed a multiple regression analysis with consumption of wild meat per household (log transformed) as the response variable and the following explanatory variables: frequency of consumption of domestic meat, household size, number of males in the house between 15 and 60 years old (potential hunters), economic situation, main income, age of settlements (southeast or northwest region) and forest condition. For the villages I performed a logistic regression with consumption of wild meat measured as "consumed" and "not consumed" as the response variable and the following explanatory variables: economic situation, ownership of farm, ownership of domestic animals (cows and goats), household size, village size, and main income. Then I repeated the same analysis but differentiated between two levels of wild meat consumption: regular, defined as consumption of wild meat at least twice a month, and occasional, defined as consumption less frequently than twice a month. I tested for correlation among explanatory variables and used only one of them when variables were highly correlated ($r \geq 0.60$). I fitted a model with all variables and then excluded

variables by eliminating those with $p > 0.1$. Complementary analysis focused on the most commonly consumed species in the rural area and in the villages. I analyzed the variation in consumption of individual species between poorer and richer households and between regions.

Results

Socioeconomic situation of rural peasants

People in the rural area live in small settlements spread out in the forest with an average distance of 5 km between settlements. Settlements have between one and seven households, with a mode of one and a mean of 1.8 (SD = 1.1, n = 58). The mean household size in the rural area was 5.8 (SD = 2.4, n = 58), with a low representation (36%) of young males (from 18 to 30). Most rural households (80%) own land ranging from 250 ha to 3500 ha, with a mode of 250 ha and a mean of 1029 ha (SD = 934.5, n = 58). A typical ranch has a house built with mud and wood, corrals for cattle and goats, and a small deforested area (from 1 to 20 ha) with crops, mainly corn and squash, that are used for domestic consumption. The rest of the ranch has forest in different levels of deterioration and exploitation. All rural households owned cattle and goats although the amount varied among them. All households had abundant farm birds, and many also had pigs, sheep, horses and mules.

Livelihoods of rural peasants are based on a combination of a variety of activities, wage-labor and use of natural resources. The economic situation of households cannot be easily deduced from the observation of their houses and living style because they have a very homogeneous standard of living. Fifty-two percent of the interviewed households

were classified as of lower economic situation and 48% as of higher economic situation. The difference in wealth between the richest and poorest households is mainly associated with the existence of a regular salary, ownership of land, land holding size, and the number of livestock owned. The richest households do not necessarily have a regularly higher income because they maintain the custom of saving cattle as capital and selling them only in cases of necessity. The difference is that by having a larger number of animals, they are better prepared to cope with uncertainties, such as droughts, diseases, and emergencies. More recently, the possibility of exploiting the forest provides richer households with a source of cash without the need to reduce their cattle stock.

Income is generated from diverse sources and it is difficult to know which activity provides the main income, as this is highly variable according to the needs of the family, the weather, the prices of the products, the market and changes in legislation. However, it was possible to discern that small-scale commercialization of cattle is the primary means of gaining revenue for a majority of rural households, followed by small-scale exploitation of the forest (Table 1). Some families receive salaries for jobs such as local health clinic workers or tenants of somebody else's land, and some receive wages for occasional jobs such as fencing, opening roads, or working for somebody else's charcoal production enterprise. Some families receive money from their children working in cities or from governmental aid. Commercialization of other local products provides additional sources of income (Table 1).

All rural households manage livestock similarly, which is an extensive husbandry style without fences delimiting properties, and with minimal veterinary health care and

no breeding strategies. Goats are used for household consumption, and a few families (less than 10%) sell young goats. Locals typically did not know the number of animals they own, but it was possible to observe that there was a large variation among households (some had less than 20 cows and others had around 500). People normally save their cattle as capital and only sell cows in cases of emergencies or when they have to acquire products of basic needs or products related with their livelihoods (e.g., vaccination for livestock, chainsaws). However, the scale of commercialization varies among households. The richest households may sell up to 30 cows per year and poorer households may sell less than five and only in emergencies.

Exploitation of the forest varies from sale of fuel wood, which produces little income, to production of charcoal and logging for fence posts, which produces higher revenues. Forest exploitation is regulated by the government under forest management plans and it is available for households that have the title to their land or are in the process of adjudication of the title. Charcoal production and logging for posts is generally a family enterprise, although some families who do not have enough young males have to hire people. Without having started the process of land acquisition, peasants cannot legally exploit the forest for commercial purposes. Exploitation of the forest provides the main income for a larger proportion of richer (42%) than poorer households (22.7%). Most of the poorer households receive their main income from livestock, fuel wood sale and occasional jobs.

Socioeconomic situation of villagers

The combined mean household size in all villages was 5.4 (SD = 2.5, n = 157). Sources of income in towns were more diverse than in rural areas. Most households receive their main source of income from a variety of jobs in the private and the public sectors (46%) and from wage labor (36%). Other households (18%) receive their main income from government aid or retirement. Several families were receiving monthly aid from a governmental emergency plan created to temporarily solve problems of unemployment produced by the economic crisis of 2001. About 34% of village households own land, ranging from 1 ha to 1800 ha (mean = 223 ha, SD = 374, n = 50). Half of them own less than 20 ha of land. Most of the households (70%) who own land have cows and/or goats, mainly for domestic consumption. Most of these people owning land in the rural area either live part of the time in town and part in their farm, or have some family members living in the farm.

Hunting in the past

Local people mentioned that hunting was much more important for them in the past than today. It was important during colonization when hunting provided their main or even only source of food. It would take several months before the new settlers were able to bring their domestic animals or start a new stock, and they were isolated in the forest without easy access to villages where they could purchase merchandise. Hunting also was very important for locals as it provided their main source of income before 1990 when the commercialization of hides was a significant commercial activity for the country.

Most local households (82% of interviews) were dedicated to this activity. People remember those times as an easy life with abundant resources. For example, locals recall that trading one skin of a wild cat (*Felis geoffroyi*) would provide enough money to purchase food for one week. Most animals were harvested for their skin, while their meat was discarded or used to feed dogs. Interviewees mentioned that they spent most of their time hunting, and less time was invested in livestock ranching or logging, because commercialization of hides was economically much more advantageous. People were hunting and trapping animals every day and accumulating the hides in their houses, waiting for buyers from towns who visited the rural region, often exchanging pelts for merchandise. At those times, people were hunting any species whose skin had value, and there were no restrictions about hunting areas or quantities of harvests. People from the villages and non-residents coming from nearby towns and cities were also hunting in the region with the purpose of selling hides. These hunters used to camp in the forest and spend many days trapping and hunting large quantities of animals. Since export of hides was prohibited at different times by the Argentinean CITES (International Convention in Trade of Endangered Species) authority during the decade of the 1990s, commercial hunting decreased and almost disappeared. Today, there is some illegal commercial hunting for pets, zoos and game ranching, but less than 10% of rural households occasionally obtain an extra income from this activity. Hunting large amounts of some species like armadillos for commercialization of their meat in town seems to be more common among villagers.

Hunting today

Currently, hunting is practiced in the rural area by local peasants, people from the villages, workers of logging companies, and non-local sport hunters. Sport hunting is allowed for those who obtain a license from the state government. State laws regulate the species that can be hunted, numbers and seasons. Thus, most hunting in this region practiced by locals is illegal. Most non-local hunters are from nearby towns and cities but some also come from cities as far as 250 km, from the neighbor provinces of Salta and Santiago del Estero. Relative to locals, these hunters tend to be wealthier and hunt mainly for recreational purposes. Some of them have hunting licenses and belong to hunting clubs; however, they expressed that they rarely follow regulations on species bans or quotas.

Rural peasants and people from the villages hunt wildlife mainly for food. Local people consumed at least 26 species, of which 63% were mammals. In the rural area, six species were consumed by more than 50% of households and three species consumed by more than 75%. These three species were Chacoan cavy *(Pediolagus salinicola),* three-banded armadillo *(Tolypeustes matacos)* and brocket deer *(Mazama gouazoubira).* In the villages, only armadillos were consumed by more than 75% of households. The other two species most commonly consumed in the villages were brocket deer and collared peccary (*Tayassu tajacu).* All rural and 94% of village households consumed wild meat at least once during the year of study. The proportion of households consuming each species in the villages was smaller than in the rural area. For example, one of the preferred species

for consumption, the armadillos, were consumed by 100% of rural households and by 84% of village households.

In the rural area, all the interviewed households practiced some hunting. Some people practiced hunting actively seeking wildlife on a regular basis and others did it as a secondary activity while working in their agriculture fields or with the cattle. Hunting was almost exclusively practiced by males. Women and children often harvested small species, such as Chacoan cavies, armadillos and doves. While spending time living with local families, I observed that hunting was not always related to need for meat in the house. On several occasions, young men went out to hunt even when there was a sufficient amount of meat in the house. This happened especially during Sundays when locals do not work. Meat obtained from hunting in the rural area was consumed in the household of the hunter or shared within the settlement, but rarely among settlements. Contrasting with the rural area, meat sharing among families and friends was common in the villages. The proportion of people consuming wild meat in the villages was larger than the proportion of people hunting; only 45% who had consumed wild meat had acquired it through hunting, and the rest received it as gifts from friends or relatives who hunt.

Although peasants are the main users of wildlife in terms of frequency and quantity, proportionally they harvest a smaller number of individuals per hunter/event. For example, whereas less than 3% of the rural hunters had killed more than three peccaries in one hunting event, 10% of village hunters mentioned that they commonly kill 5 to 10 at once if they are hunting alone, and more if they are hunting in a group. Although most

of the hunting practiced by village dwellers is for their own consumption, there is also illegal commercial hunting. Local peasants expressed concern about hunters from villages harvesting large numbers of animals, especially armadillos, which are then sold in the villages or nearby cities. Non-local recreational hunters also hunted a larger number of individuals per event. However, because of the illegality of this activity, it was not possible to obtain quantitative data about their hunting activity. These hunters can kill a larger number of animals than peasants because they spend several days camping in the forest for the sole purpose of hunting, have better guns and vehicles than locals and generally go hunting in groups. One of these groups of hunters killed 23 armadillos in two days, in comparison with local peasants who during the study period never killed more than 7 in a day. Logging workers also seem to hunt proportionally more than local peasants. Based on few interviews it was estimated that, for example, a logging worker's family consumes twice as many peccaries per month as a local peasant family. Visiting recently abandoned logging camps, it was possible to observe large numbers of carcasses of wild animals. Logging companies hire workers from the villages who are expected to supply their meat by themselves. These workers are among the poorest people of the villages, generally unemployed and without property. They are hired temporarily by logging companies or by local charcoal enterprises, and live in the forest in rudimentary camps with their family.

Correlates of consumption of wild meat

Rural: Consumption of wild meat in the rural area varied among households. Whereas 40% of households consumed wild meat less than 5 days per month, 35% consumed wild meat more than 10 days per month. Number of species consumed also varied among households. Few households (20%) consumed more than 10 different species, and the rest consumed between 2 and 10 species. The most important factor associated with variation in frequency of consumption of wild meat among households was the frequency of consumption of domestic meat. Households that consumed wild meat more frequently consumed less domestic meat (t ratio = -3.33, $P < 0.01$). After accounting for the effect of the amount of domestic meat in the diet, other factors significantly associated with consumption of wild meat were forest condition around each settlement, household size and economic status of the household (Table 2). Households surrounded by forests in relatively good condition tended to consume more wild meat than those with forest in worse condition. These are settlements located in the north-eastern region, where colonization has been more recent and the forest has not been intensively degraded. Settlements where the forest was classified as highly degraded were older (mean = 45 years) than those where the forest was in better condition (mean = 28 years). Larger households tended to consume wild meat more frequently than smaller households. Household size was associated with number of 15-60 year old males in the family (Spearman correlation, $r = 0.5$, $P < 0.05$). Poorer households consumed almost 60% more wild meat than the richer households (Table 2). Total consumption of meat was similar between poorer (mean = 28.1 days/month, SE = 1.1) and richer households (mean = 27.3,

SE = 1.4), but poorer households tended to acquire a larger proportion (30%) of meat thorough hunting than richer households did (18%, $X^2 = 3.9$, $P = 0.04$). Poorer and richer households used most species in similar proportions except for peccaries (Fig. 2). Poorer households consumed twice as many peccaries as richer households, although this difference was not statistically significant ($t = 1.94$, $df = 37$, $P = 0.07$). Comparing consumption of Chacoan cavy, armadillos and brocket deer between the two regions I found that Chacoan cavies were consumed at higher frequency in the north-east region (mean = 3.5 days/months, SD = 3.3) than in the south-west region (mean = 1.9 days/month, SD = 2.1; $t = 2.2$, $df = 35$, $P = 0.03$). The other species were consumed in similar proportions.

Villages: Consumption of wild meat in villages was associated only with the size of the village. There was a significant difference between small and medium size towns (Multiple nominal logistic regression, $X^2 = 5.3$, $P = 0.02$), but not between medium and large size towns ($X^2 = 0.01$, $P = 0.9$). The proportion of households of smaller villages that had consumed wild meat (90%) was larger than of medium size villages (79.6%) and the large village (65.2%). Economic status, economic activity, ownership of farm and livestock, and household size were not related to consumption of wild meat. However, when analyzing consumption of wild meat as "regularly consumed" and "occasionally consumed", economic situation became a significant predictor of wild meat use (Multiple nominal logistic regression, $X^2 = 4.7$, $P = 0.03$). Comparing the three most frequently consumed species among villages of different sizes, I found that households in the

smaller villages consumed them with larger frequency: brocket deer was consumed 10 times more, and armadillos and collared peccaries four times more than in the largest village. Methods for hunting also varied among villages according to its size. Hunters from the larger villages more often went hunting using vehicles for transportation, whereas hunters from smaller villages went hunting by foot or bicycle. This can be observed by comparing distances traveled by hunters. Average distance traveled by hunters from the large village was 39 km (SD = 29, n = 16), in contrast with 27 km (SD = 32, n = 21) and 7 km (SD = 6, n = 27) traveled by hunters from the medium and small villages respectively.

Effects of national economic changes on hunting

The Argentine economic recession that resulted in the crisis at the end of 2001 and beginning of 2002 affected the livelihoods of villagers. Besides the effects of the banking restrictions imposed in December 2001 and the decreased funds for public services, unemployment and inflation grew and state pensions and public sector workers' salaries were not paid for several months. The crisis negatively affected villagers more than the rural peasants. A majority of villagers interviewed (65%) said that their economic situation worsened as a consequence of increased prices of basic food products, or because their pensions were taken away or reduced and because many of them lost their jobs. Interviewees reported that during the crisis they increased their hunting as well as other uses of the forest such as collection of fuel wood and honey. Hunting increased not only for consumption but also to obtain cash. Villagers who were not previously involved

with illegal trade of wildlife admitted to having turned to this activity to obtain cash. Some of them also illegally logged forests on private or state land to obtain cash. Rural people, who typically do not depend on jobs or state pensions, nor have savings in banks, were mainly affected by the increased prices of food and other goods. On the other hand, the increased value of forest products such as fence posts and charcoal, resulting from the 70% devaluation of the national currency and the new exchange-rate regime, was favorable. Forest products increased in value because the devaluation of the national currency boosted exports. The benefits of these changes however, favored more the richer households that have access to forest exploitation. Richer households that received significant cash incomes from forest exploitation and livestock trade started to fence and plant a non-native grass that will allow them to intensify livestock production. During 2003, some of the richer households acquired vehicles (16%), freezers (10%) or engines to pump water (5%), demonstrating an unusual cash flow.

Proportionally, the price of wood increased more than that of cattle. During 2002 and 2003 there was a remarkable increase in the transit of trucks transporting wood or charcoal out of the rural region. Households that had the title to their land and had the means to exploit the forest started to invest more time in this activity. The proportion of families receiving their main revenue from forest exploitation increased almost twofold from 2001 to 2003 (Table2). This shift of the main economic activity from livestock to forest exploitation affected hunting indirectly. Several interviewees (20 %) who started to exploit the forest during the study period recognized that they were hunting less than when they were only occupied with livestock because they had less time available.

Estimates of harvest rates of peccaries showed a 20% decrease in the rural area in 2003 in comparison with the same period in the previous year.

Discussion

Advocates of community-based conservation approaches often assume a typical vision of community that tends to neglect how social differences and the embeddedness of the community within a larger context affect human-wildlife interactions. Rural communities have been assumed to be a homogeneous group of individuals sharing similar interests (Agrawal & Gibson 1999, 2001, Leach *et al.* 1999). At first glance, the rural area of the *Impenetrable* seems to be a highly homogeneous community because it possesses common characteristics in terms of lifestyles, ethnicity, religion, and language, which according to the general assumptions of community-based approaches, would lead to better management of natural resources (Agrawal & Gibson 1999, Leach *et al.* 1999). Thus, the unsustainable use of wildlife and forest in the *Impenetrable* needs explanation. This study provided some insights to better understand mestizo community-wildlife systems by using a wider and larger perspective, identifying the different actors involved with the use of wildlife, and the factors that underlie those usages.

In the context of this study, consumption of wild meat is not equally important for all wildlife users, and has not been equally important through time. Subsistence hunting in the *Impenetrable* results from a complex and dynamic interconnection of many factors, and that the community of users of wildlife involves more than local people living in the forest in direct contact with wildlife. In the rural area, differences in household size,

access to domestic meat, and economic situation affected the quantity of wild meat consumed. At the regional level, the patterns of colonization and exploitation of the forest in the rural area and the size of villages influenced the consumption of wild meat. Despite the apparent isolation of this region, the importance of wildlife for local people and the way they use it has not been static. It has changed since the colonization of the region, mostly affected by international policies, national economic changes, and changes in prices of natural resources.

The size of the household may affect hunting in two ways. Large households may hunt more simply because there are more people to feed or because there are more potential hunters. In small households all males may be too occupied working with livestock or forest exploitation to be able to invest time in hunting. Large family size allows the household to have a diverse livelihood system that may include hunting. Household demographic changes related with sources of jobs in cities then may affect hunting. Because of emigration of youth to urban areas during the last decade, households tended to have a low representation of youth who practice most of the hunting activity. However, with the economic changes of 2001 that favored the production sector, the demography of rural households started to shift again, with youth staying in the rural areas or moving from villages back to the rural areas.

The relationship between alternative sources of meat and hunting is complex. In the *Impenetrable* people have easily available domestic meat and yet they prefer to include wild meat in their diet, similarly to what has been observed in some regions of Africa and Asia (Bakarr *et al.* 2002, Barnett 2002, Bennet & Rao 2002, Ly 2002). Some authors

have asserted that, differing from Africa and Asia, people in Latin America prefer domestic over wild meat and readily make a switch to domestic meat when it becomes available (Bennet & Robinson 2000, Bennet & Rao 2002,), and that hunting is not important for peasants who have access to alternative sources of meat (Ojasti 1996, Loibooki *et al.* 2002). Consumption of wild meat in Latin America has been interpreted as an expression of underdevelopment and marginalization that can be resolved by promoting breeding of domestic animals and increasing access to domestic meat (Ojasti 1996, Apaza *et al.* 2002, Loibooki *et al.* 2002, Fa *et al.* 2003). In the *Impenetrable*, however, the use of wildlife as food may reflect a cultural appraisal of cattle that cannot be overlooked while analyzing the role of hunting. Peasants do not have capital in the form of belongings, besides the land they live on. Therefore, livestock serve as a living reserve and cultural asset, similar to some regions in Africa (Bakarr *et al.* 2002, Barnett 2002, Ly 2002) and Latin America (Dourojeanni 1985), especially for the poorer households. Poorer households refrain from using their livestock for consumption if they can obtain meat from hunting, which remains an option in this region. However, the fact that peasants often hunt even though they have enough meat in their house reflects an appreciation for wild meat and for hunting.

The relationship between household economic status and consumption of wild meat is not straightforward. Barret and Arcese (1995) assert that there is a general expectation of increased demand for wild meat where standards of living are improved. Some studies have found results supporting this prediction in Africa (Eves & Ruggiero 2000) and in Latin America (Wilkie & Godoy 2001). However, other studies have found an opposite

pattern, where increases in household wealth shift preferences from wild to domestic meat (Stearman & Redford 1995) or decrease the number of species consumed (Layton *et al.* 1991). Results of this study concur with the second scenario. In the rural *Impenetrable*, although the total amount of meat consumed is similar among households, there is a difference in the proportion of domestic and wild meat; poorer households tend to consume more wild and less domestic meat than richer households. Since rural households do not purchase but consume their own domestic animals, this difference may result in poorer households refraining from using their livestock for consumption and complementing their desired level of meat consumption through hunting. Poorer households can spend more time hunting because they are less involved with forest exploitation, which is an activity that demands more time than raising livestock.

The relationship between household wealth and consumption of wild meat in the villages is different from the rural area. Economic status becomes important to distinguish households that consume wild meat on a regular basis from those who do it occasionally. The fact that there is a smaller proportion of village households actively hunting than households consuming wild meat indicates that many consume wild meat because they occasionally obtain it as gift. For people without a regular source of income, hunting is an important means to acquire food, especially during times of economic crisis.

At a regional level, the exploitation of the forest in the rural area affects the intensity of current harvests. Higher consumption of wild species in settlements with better forest conditions probably reflects higher abundance of wildlife. Previous studies have

demonstrated that after intense forest exploitation for charcoal production, in addition to overgrazing, the forest becomes a dense unproductive thorny shrubland (Morello & Saravia-Toledo 1959). These changes in vegetation structure and composition may affect habitat suitability for the native fauna. However, it is difficult to discern the effects of habitat alteration from the effects of past hunting pressure, given the fact that there is a coincidence between forest degradation and settlement age. Different species also may have different susceptibilities to habitat degradation and hunting pressure, as has been found in the Amazonian forest where white-lipped peccaries are extirpated close to older settlements while collared peccaries persist (Peres 2001). Similarly to the rural area, the lower consumption of wild meat in the larger villages probably results from depletion of wildlife. The fact that hunters from larger villages must travel long distances to find game species supports this hypothesis. Wildlife depletion near villages is a common phenomenon in other parts of Latin America (Alvard 1993, Alvard *et al*. 1997, Hill & PadI 2000, Robinson & Bennet 2000). Again, this can be a result of hunting pressure, habitat degradation near larger villages, or of both factors acting synergistically as it has been observed in Amazonia (Peres 2001).

Use of wildlife in the *Impenetrable* was also influenced by changes at the national economy level in 2001-2002 in two opposite ways. Increased unemployment and higher prices for basic need products pushed villagers to turn to wildlife and other forest products as a source of food and cash. This is similar to what has been observed in some regions of Africa (Fimbel *et al.* 2000, Hart 2000) and in other regions of the Chaco during past hyperinflationary times (Barbarán & Saravia-Toledo 2000). Livelihoods of

rural peasants are based on a combination of strategies of wage labor and use of natural resources. Which activity provides the main source of income is variable and responds to pressures and incentives. Thus, the role of hunting as one of these many strategies of livelihoods decreased for the better-off peasants when they started to invest more time logging than hunting.

The increased monetary value of forest products due to the new exchange-rate regime added to the governmental adjudication of permits to exploit the forest will probably lead the rural community to become more engaged with market economy. How the involvement of rural communities in the larger economy affects hunting is variable. In other regions of Latin America, hunting pressure has been reduced when rural people started to participate more in the market economy (Jorgenson 1995), while in other cases the access to market allowed people to purchase better equipment to increase efficiency of hunting (Souza-Mazurek *et al.* 2000). In the *Impenetrable*, the involvement with the larger economy through trade of timber is not evenly distributed across the community because forest exploitation is less an option for poorer than richer households. Richer households are investing their revenues in ways that will allow them to intensify livestock production, which will probably deepen the gap between economic classes and poorer households will continue using wildlife as a source of food. With the economic changes of Argentina in the last years and the increased value of agriculture and forest products for export, habitat fragmentation started to accelerate. The combined effects of habitat degradation and fragmentation with hunting can be devastating for wildlife populations (Cullen *et al.* 2000).

The factors identified in this study as influencing hunting do not represent the whole multidimensionality and dynamism of human-wildlife interaction in this region. Other cultural aspects beside the use of wildlife as food affect human-wildlife interactions. Although hunting did not form part of rituals and did not seem to be strongly related with social integrity or personal status as it is in many Latin American indigenous groups (Hill & PadI 2000, Stearman 2000, Ortiz von Halle 2002), hunting seemed to play a role as a recreational activity among peasants. Some characteristics of the way locals hunt, such as actively searching their prey instead of using traps, and hunting even when meat was plentiful in the house, showed that they were not only trying to maximize harvest but that they were enjoying the activity.

Conclusions

The dynamism of people-wildlife interaction in the *Impenetrable* was influenced by social differences and the embededdness of the communities within a larger system. The community of users of wildlife in the *Impenetrable* is not territorially circumscribed, has no boundaries, and is changing. Multiple actors with multiple interests overlap: villagers harvest wildlife for consumption, recreation, and small scale commercialization; the poorest local peasants with largest families harvest wildlife to supply about a third of their meat consumption; richer peasant households also harvest for consumption but do not depend on wildlife for meat intake; hunters coming from long distances away are better equipped than locals and harvest wildlife for recreational purposes; and logging workers are expected to acquire their own meat from the forest they are logging. These

uses have not been constant but have being changing during the last decades because of fluctuations in the international market for skins and international restrictions in wildlife trade, such as CITES, and more recently, because of the national economic crisis. The use of the wildlife and the degree of dependence on this resource is also highly variable. Variations in the relative importance of wildlife products, forest exploitation and livestock as sources of income indicate that there is not a long-term need for a specific resource, but needs are rather responding to momentary pressures and incentives. This indicates that the local human-wildlife system is not isolated and static but dynamic and inserted in a larger system. Considering this complexity when designing conservation strategies involving mestizo communities in Latin America is an indispensable step towards sustainability.

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Table 1. Proportion of rural households receiving their main income from livestock, forest and jobs in 2001 and in 2003 (n = 57).

Main income	Percentage of households	
	2001	2003
Livestock sale	62.3	48.1
Forest exploitation	19.4	37.3
Jobs	15.1	10.5
Other	3.2	4.1

Table 2. Factors associated with consumption of wild meat in the rural area (Multiple regression).

Variable	Condition	Consumption of wild meat (days/month)	
		Average	SE
Forest condition	Less degraded	7.68	0.88
t Ratio = 2.75, $p < 0.01$	More degraded	4.83	1.01
Households size	≥ 6 people	7.60	1.21
t Ratio = 4.97 $p < 0.01$	< 6 people	5.62	0.91
Economic status	Poorer	8.01	1.09
t Ratio = 2.38 $p = 0.02$	Richer	5.10	0.71

Figure 1. Study area. Location of settlements participating in the study.

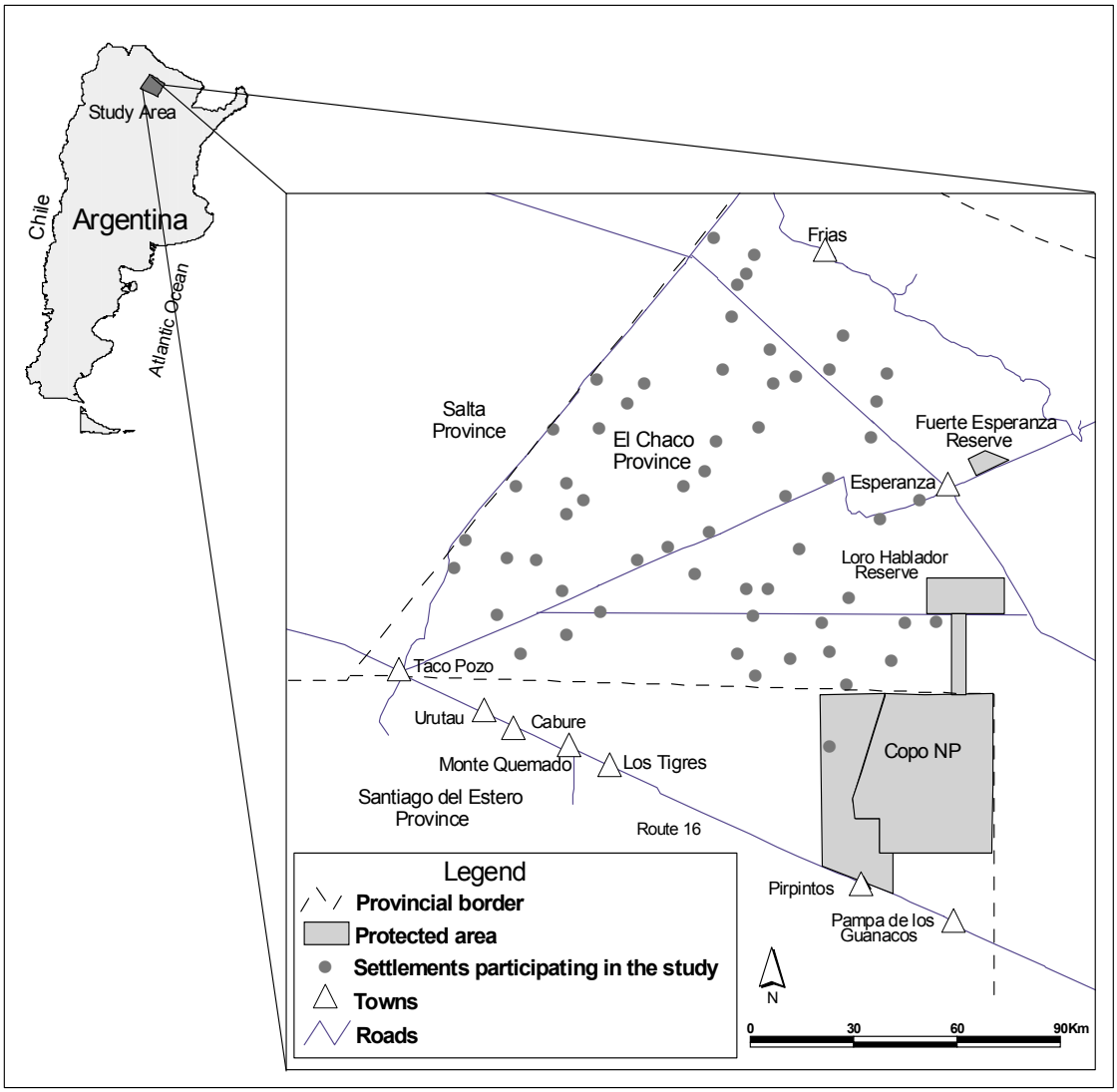
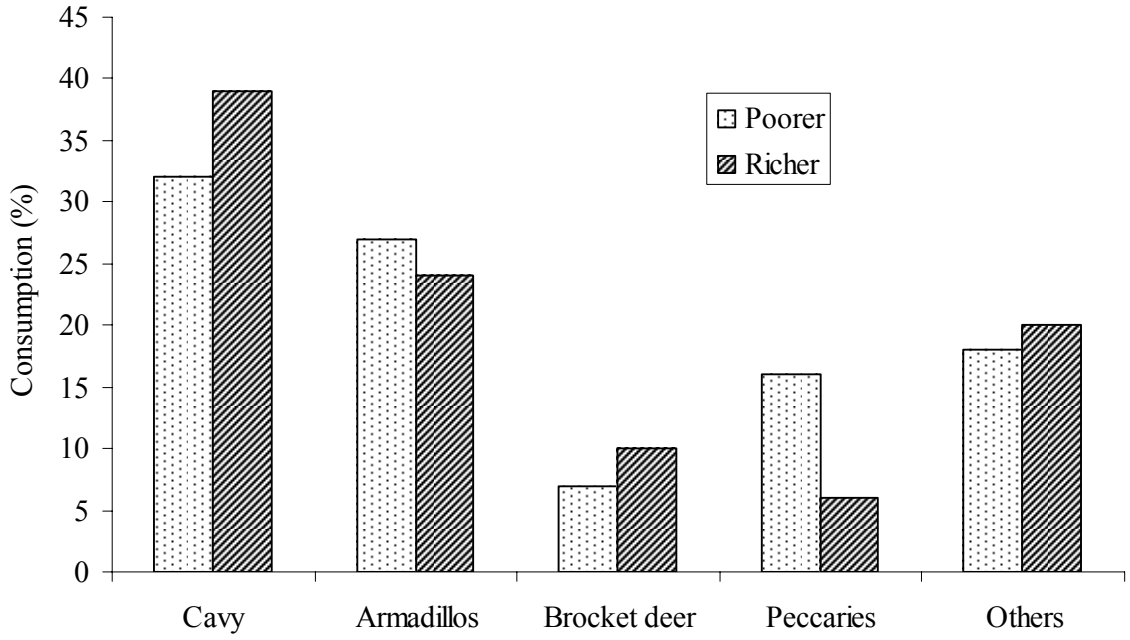


Figure 2. Proportion of the most commonly consumed species within the total harvest consumed by poorer and richer rural peasants.



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APPENDIX E

THE SUSTAINABILITY OF SUBSISTENCE HUNTING OF PECCARIES IN THE ARGENTINE CHACO

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Abstract

Subsistence hunting by poor rural and indigenous people in Latin America differentially affects the three species of peccaries (Artiodactyla: Tayassuidae). The sustainability of subsistence hunting of peccaries in the Argentinean Semi-arid Chaco, where the three species coexist, was unknown. My objectives were to determine the importance of peccaries for the local people, describe the current patterns of hunting, the factors that affect hunting sustainability, and to estimate the impact of hunting on the three species of peccary. I found that many rural (70%) and village people (40%) consumed peccaries. White-lipped and Chacoan peccaries were more susceptible to overharvesting than collared peccary. Current rates of hunting of white-lipped and Chacoan peccaries are likely not sustainable because: a) Density of both species was between two and three times higher inside a protected area than outside; b) Populations have declined near larger villages and in older settlements; c) Herds sizes were small compared to other regions; d) Large numbers of juveniles less than one year old were harvested; e) Hunting did not discriminate based on sex or reproductive status; and f) The unified harvest model indicated unsustainable harvest because more than 40% of the reproductive production was taken and populations densities were less than 60% of carrying capacities. In contrast, harvest of collared peccary seems sustainable at the current rates of hunting by rural peasants. Other threats such as forest exploitation are accelerating, however, and are likely to reduce sustainability.

Keywords: Argentina; Chaco; Peccaries; Sustainability; Tayassuidae.

Introduction

Peccaries (Artiodactyla: Tayassuidae) are among the most preferred game mammals for rural and indigenous people through Latin America who use them as a source of food and cash income (Bodmer et al., 1994; Sowls, 1997; Robinson and Bennett, 2000a). Reconciling the needs of poor local people and the conservation of these ungulates is an issue of concern in Latin America (Alvard et al., 1997; Bodmer et al., 1997; Aquino et al., 1999; Robinson and Bodmer, 1999; Bodmer and Puertas, 2000; Robinson and Bennett, 2000a; among others). This concern developed because in most cases peccaries represent the largest amount of meat harvested for subsistence thereby providing an important source of protein (Smith, 1976; Sowls, 1997). However, overharvesting is depleting some peccary populations and producing local extirpations (Cullen et al., 2000; Peres, 2000). Studying hunters' impacts and species susceptibility to overharvesting contributes to our understanding of factors associated with sustainability of subsistence hunting (Alvard, 2000). Although the three species of peccaries have similar body sizes, ranging from an average of 21 kg for morito to 34 kg for quimilero (Sowls 1997), they are differentially affected by hunting (Bodmer, 1995). However, there is no research assessing sustainability of subsistence hunting where the three species of peccaries coexist. The Chaco is the only region where the three species coexist and the least studied site within the distribution of peccaries (Taber, 1991; Sowls, 1997). The morito (collared peccary, *Tayassu tajacu*) and the majan (white-lipped peccary, *T. pecari*) have extensive geographical ranges that encompass much of the Neotropics, whereas the quimilero (Chacoan peccary, *Catagonus wagneri*) is endemic to the Chaco region (Sowls, 1997).

In the Argentine Chaco the three species of peccaries persist in the driest region, the *Impenetrable*, where human density is lowest, development is scarce, colonization is relatively recent, and large areas of continuous forest remain (Altrichter and Boaglio, 2004). In this region, subsistence hunting by rural peasants and villagers is common (Bolkovic, 1999; Barbarán, 2000; Altrichter and Boaglio, 2004) and habitat degradation is accelerating (Bucher and Huszar, 1999), making it unlikely that unrestrained harvesting of peccaries will be sustainable. Depletion of peccaries will not only affect forest composition and structure (Cullen et al., 2001) but also the livelihoods of local people, especially the poorest peasants (Altrichter, Appendix D).

The purpose of this study was to assess sustainability of hunting of peccaries in the *Impenetrable* to better understand the effects of subsistence hunting on populations and the differential susceptibility of peccaries to harvesting. A secondary objective was to evaluate possibilities of expanding subsistence into commercial hunting of peccaries for hides, as proposed by the Fauna and Flora Service of the Argentinean government. In this research I addressed the following questions: a) What is the importance of peccaries for rural and village people? b) What are the current patterns of hunting? c) What are the factors that affect hunting sustainability? and d) What is the impact of hunting on peccary populations?

Methods

Study area

The Gran Chaco is a vast plain extending across northern Argentina, eastern Bolivia, western Paraguay and part of southeastern Brazil. The three sub-regions of the Chaco are classified based on an east-west rainfall gradient: eastern or humid, transition, and western or semi-arid Chaco (Morello and Adamoli, 1968; Bucher, 1983). The study area covers 1.2 million hectares of the semi-arid region called *Impenetrable*, located in the western part of the Chaco Province (Fig. 1; 24°30′ to 25°30′ S and 62°50′ to 61°40′ W). This is the driest and most markedly seasonal region, with rainfall between 450-700 mm of which 80% occurs between October and April. Average annual temperature is 21.9° C with minimums below zero and maximums around 50° C. The vegetation is a medium-tall xerophilous forest with a canopy layer of about 12 m high surpassed by a few species of taller trees reaching 16 m to 18 m (Bucher, 1983). The dominant species of trees are *Schinopsis quebracho-colorado*, *Aspidosperma quebracho-blanco* and *Bulnesia sarmientoi*. The shrub layer is dominated by species of *Acacia*, *Mimosa*, *Prosopis*, and *Celtis*. Cacti *Opuntia* and *Cereus*, grasses and bromeliads are abundant in the understory. The study area is mostly rural with people living in about 200 settlements of one to seven households (mode =1) spread throughout the forest and separated by about 5 km. Colonization of this region by peasants from other parts of the province and from other provinces started about 80 years ago and continues. Rural peasants live a subsistence lifestyle based on livestock ranching and small-scale forest exploitation for charcoal and fence posts. There are also seven villages located along a paved inter-provincial route

(Fig. 1). I classified four of the villages as small (between 20 and 300 households), two as medium (739 and 850 households) and one as large (1300 households). There are two protected areas within the study area (Fig. 1): Copo National Park and Reserve (169,250 ha) and Loro Hablador Provincial Reserve (17,500 ha).

Importance of peccaries in the diet of local people

Consumption of peccaries was measured in terms of proportion of households that consumed peccaries, frequency of consumption and order of importance in terms of amount of meat consumed. Amount of edible meat consumed was estimated as 60% of the average adult weight of peccaries (Martin 1985). To estimate consumption of peccaries I relied on interviews with a randomly selected sample of 58 rural and 157 village households. Information was collected in different ways for both populations. Consumption of peccaries by rural households was recorded from June 2002 to July 2003, with repeated visits and by examining people's own records (Altrichter, Appendix E). Village households were visited only once and were asked to estimate the number of times they had consumed peccary meat during the twelve months before the study.

Hunting pressure and patterns of hunting

To determine patterns of hunting I used interviews and participant observation. I spent time (from hours to days) with the randomly selected rural families on several occasions during the study and I participated in hunting events. In addition to this sample, I

conducted in-depth interviews with other 18 peccary hunters. I estimated that in total I interviewed approximately 40% of the rural peccary hunters.

I used different methods to estimate numbers of peccaries killed in the rural area and the villages. In the rural area, a member of each of the 58 selected households was in charge of recording the number of peccaries killed in the settlement and of saving skulls from January 2002 to July 2003. Based on this information I determined the proportion of settlements in which there was at least one hunter of peccaries who had killed at least one individual during the year of study, species hunted, and number of animals killed. I then extrapolated this harvest rate to the entire study area to estimate the total number of peccaries harvested. In the villages, peccary hunters were identified from interviews with the random sample of households and additional informal interviews with villagers, policemen, and a park ranger. After identifying peccary hunters, a field assistant conducted in-depth interviews with 15 of them. Village hunters provided their own estimate of the number of peccaries they harvested per year.

I addressed seasonality of hunting according to the seasons recognized by local people. I compared number of peccaries hunted during the hot months (September to April) and the cold months (May to August) using the Mann-Whitney U-test. I assessed whether harvest of each species of peccaries was associated with time of colonization of the rural area using contingency tables. The response variable was the percentage of settlements that harvested peccaries (at least 1 individual during the study period) and the explanatory variable was age of settlement classified as new ($\leq$ 36 y) or old ($>$ 36 y). Age of settlements varied between 1 and 80 years (mean = 36.1). I tested whether percentages

of urban households that consumed peccaries during the year before the study were associated with village size using the Chi-square test. Additionally, I compared distances traveled to hunt peccaries among villages of different size using the ANOVA test.

Biological information

Herd sizes: I recorded herd sizes observed by local hunters, researchers, park personnel and myself. Hunters noted herd sizes they observed during the study period. Because only on rare occasions was it possible to count an entire herd, herd sizes were reported as a range. In these cases I recorded the median of the range as the likely size of the herd.

Reproduction, age structure and sex ratio: Hunters collected mandibles and fetuses and recorded the sex of the peccaries they harvested. Fetuses were stored in plastic containers with a 10% formaldehyde solution. In most cases, however, hunters were not able to save fetuses, but they recorded date, site, and size and number of fetuses. A picture with different stages of fetus development helped them to estimate fetus' ages. I estimated age of harvested individuals based on dental wear according to Maffei's (2000) key for age identification. I also aged peccaries killed in the previous two years analyzing the mandibles that hunters traditionally save. Because there is no key for age determination for quimilero I created five categories based on dental wear (Table 1). I compared proportion of harvested females versus males using the Chi-square test.

Density estimate

I used two methods to estimate peccary abundance: 1) Between June 2001 and August 2003 I drove about 9000 km of dirt roads throughout the rural area. Most traveling was done during the dry season when, according to hunters, animals are more active. 2) Based on satellite images I selected three sites whose limits were possible to identify using roads and other landmarks as references such as oil prospecting trails). Two sites of 18 km^2 and 16 km^2 were located in a hunted region and the third site of 12 km^2 was located inside Copo National Park (Fig. 1). Hunted sites were 65 km apart from each other and the three sites had similar histories of forest exploitation and similar livestock pressure. The site inside the National Park was located close to two resident families who own cattle and do not hunt peccaries. In each site I established a grid of transects of varied lengths crossing the entire site. With the help of local hunters and field assistants I walked the transects every day for ten days and then I walked randomly through the forest for several days more until I had confidence that I had identified the minimum number and size of peccary herds living in or using this site, based on tracks and/or sightings. I stopped surveying the area at the point when I were not obtaining any new or different information. Different herds were identified by number of individuals and proportion of juveniles/adults. The same method was repeated for two years at the same sites, with a total of approximately 400 km walked at each site. I estimated density for each site as number of individuals/area and I report the average of the two years' estimates. Although there may be inaccuracies on the estimates of density, I can confidently compare relative abundance between hunted and non-hunted sites. For the

following analysis of sustainability, I also used density estimates from other Chaco region.

Sustainability of current harvest rates

To assess sustainability of current harvest rates I used two approaches: 1) reports from hunters on population trends and changes in hunting yield through time, and 2) the unified harvest model that combines the stock recruitment and the harvest models (Robinson and Bodmer, 1999; Bodmer, 2003). The harvest model compares productivity with harvest rates. Productivity is estimated as $P = (0.5D)\ x\ (Y * g)$ where Y is the number of young per females, g is the number of gestations per year and D is population density. It has been estimated that 40% of the production of peccaries can be harvested sustainably (Robinson and Redford, 1991; Robinson and Bodmer, 1999). Given the small sample sizes of my own estimates of density and reproduction, I also used information generated from other studies in the Chaco region or from the most complete published work when data from the Chaco were not available. Density and reproductive parameters estimated for the *Impenetrable* were lower than in other regions. Thus, for each species I present a range between what would be the minimum production if estimates of density and reproductive parameters from this study were accurate, and a maximum if these parameters were closer to what has been estimated in other studies. The stock recruitment model compares the density of a harvested population with carrying capacity (K) and maximum sustainable yield (MSY). Carrying capacity is defined as the density of the species in sites without hunting with similar characteristics to the hunted site. Maximum

sustainable yield for peccaries has been defined as 60% of K (Robinson and Redford, 1991). Thus, density of a hunted site (D) is compared with density of an unhunted site (K) as D/K. If D/K is above 60% of K the harvest is considered safe, whereas if D/K is below 60% of K it is considered risky (Bodmer, 2003).

To estimate harvest rates (individuals taken/km^2) I considered the number of peccaries harvested in a year only by rural hunters. To determine production and harvest rate per unit of area I used an estimate of area occupied by each species based on a previous study on peccaries distribution, where presence of each species was mapped (Altrichter and Boaglio, 2004). I estimated that moritos inhabit 90% of the study area, quimileros 80% and majanes 42% (Altrichter and Boaglio, 2004).

Results

Importance of peccaries in diet

Rural: Most rural households (70%) consumed peccaries during the study period. Average frequency of consumption of peccaries was 10.5 days/year/household (SD = 3.4), ranging from 0 to 56 days/year, and constituted 12% of the total number of days that wild meat was consumed. During a year rural households consumed an average (60% of weight) of 23 kg of morito (SD = 48), 11 kg of quimilero (SD = 25) and 9 kg of majan meat (SD = 34), ranging from 0 kg to 252 kg. This represents an average of 7.4 kg of peccary meat/capita, based on an estimate of household size of 5.8 (SD = 2.4).

Village: Forty percent of village households consumed peccary meat at least once during the year before the study. Only 24% of these families mentioned that they acquired the

meat by hunting. The rest (60%) said that they acquired it as a gift from friends or relatives or by buying (16%). There was large variation in frequency of peccary meat consumption reported by village households. Some mentioned that they had eaten peccary only once during the year previous to the study, whereas others reported that they had consumed peccary about twice a week.

Hunting pressure and patterns of hunting

A larger percentage of settlements harvested moritos (51%) than quimilero (32%) and majan (19%). Fourteen percent of settlements harvested individuals of the three species during the year of study, 45% harvested morito and quimilero, 14% harvested morito and majan and 15% harvested quimilero and majan. These hunters harvested an average of 3.8 moritos/year (SD = 2.9), 3.1 majanes/year (SD = 2.1) and 2.4 quimileros/year (SD = 1.9). Based on the percentages of hunters and the average number of animals killed per hunter, I estimated that between January and December 2002 rural hunters killed at least 404 moritos, 158 quimileros and 123 majanes. The three species were harvested throughout the year but with a marked peak during the colder months, between May and August (Mann-Whitney U-test; morito: $z = -2.5$, $P = 0.01$, $n = 27$; majan: $z = -2.4$, $P = 0.01$, $n = 11$; quimilero: $z = 2.3$, $P = 0.02$, $n = 18$). More moritos were harvested in almost every month (Fig. 2). Harvest of peccaries in the rural area decreased 20% in the year 2003 compared to the same period in the previous year (Fig. 2).

In the villages, 17% of interviewees mentioned that they regularly harvest moritos, whereas less than 11% mentioned that they had hunted majanes or quimileros. According

to village hunters' reports, it was estimated that they harvest an average of 4.3 (SD = 3.7) moritos, 3.7 (SD = 2.8) quimileros and 3.6 (SD = 3.2) majanes per year. If the proportion of hunters within the sample of interviewees represents the proportion of hunters in the villages, then there would be an annual harvest of approximately 2300 moritos, 870 quimileros and 840 majanes. The area where villagers hunt is difficult to estimate because distances traveled by hunters and the locations they go to hunt are highly variable.

Percentage of settlements that harvested majanes was negatively associated with settlement age. Most (90%) settlements that harvested majanes were ≤ 36 y old (X^2_1 = 8.1, P = 0.01). Percentage of settlements that harvested morito and quimilero was not associated with settlement age. Percentage of village households that consumed peccaries was negatively associated with village size (X^2_2 = 5.99, P = 0.05). In the large village 21% of households had consumed peccaries in the twelve months previous to the study whereas in the medium and small villages 40% and 44% of households had consumed peccaries respectively.

Hunting ranges in the rural area form rings around each settlement because hunters do not find peccaries at a distance closer than 1.5 km from the settlement and they rarely go further than 5 km. The average distances traveled were 3.8 km (SD = 1.9) to hunt morito, 4.1 km (SD = 2.1) to hunt quimilero and 4.2 km (SD = 1.8) to hunt majan. Village hunters traveled longer distances than rural hunters (range 3-113 km) and the distances increased with size of village (small villages: mean = 4.6 km, SD = 1.9, medium villages:

mean = 29 km, SD = 32.4, large village: mean = 62 km, SD = 14.1; ANOVA, $F_{2, 26}$ = 15.4, $P < 0.001$).

All hunters in the rural area used similar methods to hunt peccaries. To hunt moritos it is not necessary to have firearms, but it is for the other two species. Dogs play an important role in hunting of the three species, making it efficient. Most hunting events with dogs (93%) were successful. Hunting of moritos was always done with dogs, while the other species where occasionally killed with firearms when encountered in the forest or on roads. Another technique used to hunt majanes involves waiting for them in sites that the hunters assumed the animals would visit, such as agriculture fields and water sources. Village hunters used similar methods of hunting with some differences: they used firearms almost exclusively, used vehicles for transportation and went on hunting expeditions in groups, staying overnight in the forest. They often brought ice chests to their hunting expeditions anticipating killing a large number of individuals that could be kept fresh.

Herd sizes, reproduction, age structure and sex ratio

Herd sizes of morito ranged between 3 and 12 with an average of 5.4 (SD = 2.4, *n* = 46), of majan between 7 and 50 with a mean of 23.5 (SD = 14.2, *n* = 18), and of quimilero between 1 and 5 with a mean of 3.0 (SD = 1.1, *n* = 28). Reports of hunters and the pregnant females I examined indicated that the three species reproduce year round with peak reproduction between September and November. Of the examined females harvested in one year, 22% of morito (*n* = 40), 20% of quimilero (*n* = 20) and 21% of

majan (n = 14) were pregnant. Litter size of pregnant harvested females of the three species ranged from 1 to 3 with a mode of 2. Hunters mentioned that the most frequent litter size found was 2 and that they rarely find 3 or more.

Larger proportions of young than adult individuals were killed for all three species. Seventy percent of harvested morito examined (n = 128) were ≤ 2 y old and 40% of majan (n = 39) were ≤ 1 y old (Fig. 3). The percentages of quimilero harvested (n = 50) were similar for the first four categories of age (between 20% and 28%). However, when adding data on ages of 68 mandibles hunted in the previous two years, the first two categories of age constituted 64%. Hunters took more males than females of majan (62.2%, X^2_1= 5.95, P = 0.014). Males and females of the other two species were taken in similar numbers.

Abundance

Road counting did not provide enough data to estimate abundance. Only one group of majanes was observed after driving 9000 km of dirt road. Density estimates for the three species obtained by surveying an area of known size were higher inside the protected area than outside. In the hunted sites, density of moritos was two times larger than density of majanes and three times larger than density of quimileros. Inside the protected area however, majanes had the highest density (Table 2).

Sustainability of current harvest rates

The unified harvest model suggests that the morito is harvested within sustainable rates because less than 40% of the production is taken, and harvested population density is above MSY (Table 3). Using estimates of density and reproduction from the literature, the model indicates that the proportion of the production of quimileros taken (around 18%) is sustainable. However, using my own estimates of density the model indicates overharvest because over 70% of the production is taken and harvested population density is lower than MSY (Table 3). The model indicates that harvest of majan is unsustainable because the proportion of the production taken is close to or above 40%, and the harvested population density is almost half MSY (Table 3).

Discussion

Peccaries are used in the *Impenetrable* for consumption, although not in as large proportions as in tropical areas and other regions of the Gran Chaco (Broad, 1984; Redford and Robinson, 1987; Bodmer et al., 1993; Sowls, 1997; Mena et al., 2000). The pattern of use of peccaries and its impact on peccary populations is a result of a combination of biological aspects of the species, their ecological context, and cultural factors influencing hunters' behavior. To discern the effects of hunting from other human influences and from ecological conditions is difficult, but several indicators point to hunting as the most important factor currently affecting peccary populations in the *Impenetrable*. Although overhunting seems to be the major current threat, habitat loss

will probably be more important for peccary's persistence in the long term (Altrichter and Boaglio 2004).

Peccaries in the *Impenetrable* are not abundant. I did not observe any peccaries using road counting whereas the same method has been used in the Paraguayan Chaco resulting in many sightings. In 1975, Sowls (1984) observed 18 herds of quimileros in 19 days traveling along dirt roads in the Paraguayan Chaco. Mayer and Brandt (1982) traveled about 1000 km and observed 217 quimileros. In 1988, Taber observed quimileros seven times along a 1.5 km road in 4 months and a year later only four times traveling over much of the Paraguayan dry Chaco (Taber et al., 1993). He concluded that the decreased number of observations using similar methods indicated that populations had declined sharply (Taber, 1991). Another clue indicating that hunting may have reduced peccary populations is the higher density of peccaries found inside the protected area. Comparisons between hunted and unhunted sites have been used in many studies assessing hunting effects (Hill and Padwe, 2000; Peres, 2000; Cullen et al., 2000, among others). This comparison alone however is not conclusive because it does not eliminate the possibility of differential densities due to environmental variables. However, it can be assumed that for species with large geographical ranges and broad ecological tolerances, differences in density caused by hunting would override differences in habitat (Cullen et al., 2000).

Trends on hunting yield and peccary populations also indicate overharvest. Majanes have disappeared from 68% of their original distribution in the *Impenetrable* (Altrichter and Boaglio, 2004). Furthermore, comparing hunting yield with settlement age indicates

that majanes have declined or disappeared in the areas that were colonized first, suggesting that this species cannot withstand long-term hunting pressure and habitat disturbance. The same pattern has been observed in the Amazonian forest where this species is extirpated close to older settlements (Peres, 2001). Although peccary populations have not been monitored, I have the information provided by local hunters who assert that quimilero and majan populations have been steadily declining through time and have disappeared in many sites where they used to be common. Lower consumption of peccaries found in larger villages and the long distances village hunters have to travel to harvest peccaries may indicate depletion. Peccary population depletions near villages have been recorded in many tropical sites (Alvard et al., 1997; Hill and Padwe, 2000; Robinson and Bennett, 2000b), but the *Impenetrable* presents an additional factor of hunting pressure. Because of the dispersed pattern of settlements, hunting territories of settlements overlap, and villagers' hunting territories overlap with rural hunters. Village hunters have increased their efficiency by using better equipment, which allows them to harvest larger numbers of individuals per hunting event. Foot transportation limits the distances that rural hunters can travel, but village hunters with access to motorized vehicles can travel long distances. Therefore, most territory is subject to hunting, which probably precludes the source-sink dynamic that allows overharvested populations to be replenished with immigrants from non hunted areas (Novaro et al., 2000). A similar conclusion was reached by Souza-Mazurek et al. (2000) studying the Waimiri-Atroari Indians in a central Amazonian reserve where hunters with modern

transportation exploited distant sites that would otherwise act as sources if hunters moved only by foot.

Comparisons of herd size can also be indicative of population status (Leopold, 1959). Herd sizes in the *Impenetrable* are smaller than in other regions of the Chaco that are not heavily hunted. Reports of herd sizes of majanes in the Paraguayan and the Bolivian Chaco vary between 14 and 95 (Mayer and Brandt, 1982; Taber et al., 1994; Sowls, 1997; Noss, pers. comm.), whereas in the study area herds larger than 50 had not been observed in many years. Reports of herd sizes of quimilero in the Paraguayan Chaco vary between 1 and 9 (Mayer and Brandt, 1982; Sowls, 1997), with an average of 4.5 (Taber et al., 1994), whereas in the study area the most commonly reported herd size was 3, rarely exceeding 5. Herds of moritos of up to 17 and 20 have been observed in the Bolivian (Miserendino, 2002) and the Paraguayan (Taber et al., 1994) Chaco respectively, whereas in the study area herds of more than 10 individuals were rare. The smaller herd sizes in the Argentine Chaco could be a result of local habitat conditions. However, the fact that hunters remember seeing larger herds in the past, mentioning up to 100 majanes and up to 9 quimileros, indicates reduction of herds sizes as an effect of hunting.

Age structure of harvested peccaries has been used to infer the effects of hunting on population structure**,** assuming that hunters select individuals randomly with respect to age (Bodmer et al., 1994; Bodmer, 1995; Leeuwenberg and Robinson, 2000). Interpreting age distribution of hunted animals, however, is always problematic (McCullough, 1987). This is especially true in cases like in the *Impenetrable* where the hunting method for moritos influences which individuals are killed because dogs capture the most

susceptible. An indication of this bias can be observed by comparing age of the harvested moritos with published studies. In the *Impenetrable*, 70% of moritos killed were ≤ 2 year old contrasting with Mexico (8%; Jorgenson, 2000), Ecuador (10%; Mena et al., 2000) and the Bolivian Chaco (36%; Noss, 1999; Noss et al., 2003) where juveniles were the least represented age category. However, because most of those studies are based on skulls collected by hunters, it is possible that youngest classes were underrepresented in the collection. For example, Bodmer (1995) omitted 0-1 year range animals from his analysis because hunters did not evenly sample this age.

Age of harvested majanes and quimileros may be representative of population age distributions (Bodmer, 1995). Any bias that might exist would be skewed towards adults assuming that hunters would prefer to harvest larger animals. According to Robinson and Redford (1994), decreased survivorship of adults due to hunting is reflected in a population structure where juveniles make up a higher proportion. These authors compared an infrequently hunted population of peccaries with 35% juveniles and a heavily hunted population with 60% juveniles. The high proportion of harvested juveniles (≤ 3 years old) majanes in the *Impenetrable* (49% as compared to 23% of harvested majanes in the Bolivian Chaco; Noss et al. 2003) may indicate high hunting pressures, although my sample size may be too small to make inferences (Caughley, 1977). Interpretation of the age structure of quimileros is difficult because there are no references for unhunted populations. However, age structure of harvested quimileros showed similar patterns to majanes. Juveniles comprised 50% of the sample from the year of study, and 64% considering animals hunted in the previous two years. These

proportions are similar with two harvested populations of the Paraguayan Chaco where individuals ≤ 3 years old comprised 67% in one case (n = 15; Taber et al., 1993) and 58% in another (n = 48; Sowls 1997).

Hunting in the *Impenetrable* was also biased towards males, especially of majanes. A similar pattern was found in the Bolivian Chaco where males of morito and majanes were taken in larger proportion than females (Noss et al., 2003). In contrast, other studies found that males and females of majanes were taken in similar proportions (Gottdenker and Bodmer, 1998; Jorgenson, 2000) or skewed towards females (Souza-Mazurek et al., 2000). The larger proportion of males harvested in the *Impenetrable* is probably also a result of the hunting method. According to hunters, majan males tend to stay and confront the dogs, which may make them more susceptible to being shot.

Results of the unified harvest model support the supposition that hunting of quimilero and majan is unsustainable because harvest rates exceed population production at this given time, and population densities are below the predicted MSY of 60% of K (Bodmer, 2003). In this model I used only the estimated harvest rate of rural hunters. Harvest rates would certainly be higher if I could incorporate number of animals killed by villagers and non-local hunters. Visiting sport hunters use better equipment and kill large numbers of individuals per event. Lumbermen also hunt proportionally more than local peasants, as has been observed in other regions (Bodmer et al., 1988), because they have to procure all their meat through hunting.

The unified harvest model requires reliable information on population density and productivity. My own estimates, although similar to what has been found in other Chaco

regions under hunting pressure, were calculated with small sample sizes, and the use of estimates from other studies is problematic because of the large variability of density and reproductive parameters. Variability in these parameters would affect sustainability model outcomes. This is evident when observing the great differences found between the proportion of quimileros taken using my own estimates (73%) and using density and reproductive information from the literature (18%). The only available estimate of density for this species in the Chaco region (Taber et al., 1993) is 3.5 times larger than my own estimates, creating these different model outcomes. Thus, the results of the sustainability model are weak and can not be considered as the only evidence of overharvesting.

Density is the largest contributor to the model. When estimates of this parameter are inaccurate, there may be large errors in the final outcome (Robinson and Redford, 1991). Density estimates of peccaries vary enormously in the literature, from less than 1 individual/km^2 to as high as 9.2 individuals/km^2 for quimileros (Mayer and Brandt, 1982) and more than 10 individuals/km^2 for moritos (Wright et al., 1994; Kudrenecky et al., 1999) and majanes (Robinson and Redford, 1991; Bodmer et al., 1997). These variations may result from environmental differences (Emmons, 1984), from inaccuracies of the methods used (Robinson and Redford, 1991) or from different hunting pressure and habitat disturbance (Peres, 1996).

The method used to estimate densities in this study is not conventional. Almost all studies estimating peccary density in the tropics have used line transects (see for example studies published in Robinson and Bennett, 2000a). In the Chaco researchers have found

it very difficult to estimate peccary densities (Ayala and Noss, 1999). Researchers in the Bolivian Chaco concluded after trying different methods that relative abundance indexes and information provided by hunters are the most efficient and accurate indicators of peccaries status (Ayala and Noss, 1999; Noss, 1999). The method I used was relatively easy and used the expertise of local hunters who are able to recognize and identify tracks in difficult terrain. However, these results should be interpreted with caution. In addition to this method, I estimated density by mapping hunting territories of two hunters who provided information on the number and sizes of herds of quimileros living within that territory. These two estimates were very close (0.13 and 0.15 individuals/km^2) to my average estimate (0.16 individuals/km^2) using the other method. Surveying an area of known size is less trustworthy for majanes because this species has very large home ranges and nomadic behavior (Sowls, 1997), and herds often split temporarily into smaller units (Keuroghlian et al., 2004). Thus, majanes may inhabit an area but never be encountered during sampling time, as happened inside Copo National Park the second year of study.

Reproductive productivity also varies in relation to environmental conditions across sites, and it is apparently lower in the Chaco than in tropical regions. The observed peak of reproduction at the beginning of the rainy season coincides with the reproductive pattern observed for quimileros in the Paraguayan Chaco (Mayer and Brands, 1982; Taber et al., 1993; Yahnke et al., 1997), and for moritos in sites with a marked seasonality in rainfall (Henry, 1994; Hellgren et al., 1995; Noss et al., 2003). However, in tropical regions, majanes and moritos reproduce in an aseasonal pattern (Gottdenker and

Bodmer, 1998). Number of gestations per year also varies across sites. In the southern US moritos reproduce once per year (Hellgren et al., 1995) whereas in the Peruvian Amazon they reproduce from 1.4 to 1.8 times per year (Gottdenker and Bodmer, 1998). Captive quimileros reproduce 1.5 times per year (Yahnke et al., 1997) whereas free-ranging populations of the three species apparently reproduce once per year in the Paraguayan and the Bolivian Chaco (Taber et al., 1993; Noss et al., 2003). I could not determine number of gestations in the study area, but reproductive patterns are likely similar to the southern US and other Chaco regions, given similarities of climatic conditions with a marked seasonality in rainfall. Litter sizes of quimilero in Paraguay have been reported to vary between 1 and 4 with averages over 2 fetuses (Mayer and Brand, 1982; Brooks, 1992; Yahnke et al., 1997). However, these data come from small sample sizes or from captive animals, making it problematic to infer to wild populations (Noss, 1999). Taber et al. (1993) estimated litter size of 1.7 for a wild population and presumed that this small litter size resulted from low reproductive rate or high neonate mortality. This latest estimate (1.7, Taber et al., 1993) seems more accurate for the *Impenetrable*, coinciding with hunters who asserted that findings of 3 or 4 fetuses are exceptional. Proportions of pregnant females of morito and majan found in the study area are considerably lower than the proportions found in Peru (46% and 32% respectively, Gottdenker and Bodmer, 1998), but similar to proportions found in the Bolivian Chaco (15.9% and 11.0% respectively, Noss et al., 2003) and in Mexico (15%, Jorgenson, 2000) and Bolivia (25%, Townsend, 2000) for moritos.

Results of this study suggest that morito is the least susceptible of the three species and is able to withstand heavier hunting pressure, a pattern found in many other sites (Peres, 1996; Alvard et al., 1997; Gottdenker and Bodmer, 1998; Cullen et al., 2000; Altrichter and Almeida, 2002; among others). Moritos have higher productivity (Gottdenker and Bodmer, 1998), use a wider range of environments (Sowls, 1997) and can tolerate more degraded habitats (Peres, 1996) with higher human density (Altrichter and Boaglio, 2004). These characteristics make them less susceptible to overharvesting and therefore, moritos could be considered for management for commercialization of hides. However, hunting pressures on the other two species must be diminished if popultions are to be maintained. As noted by Sowls (1997), management of peccaries presents several difficulties. For instance, there is no season when peccaries can be harvested without killing pregnant or nursing females because although there is a peak period of births, the three species reproduce all year. Even worse is the situation in the Argentine Chaco because the peak of hunting coincides with the last months of pregnancy before the peak of births, which may have important effects on the population. The marked hunting season in the Chaco reflects the cultural preferences for the quality of meat and for climatic conditions (Altrichter, unpublished). Cultural preferences like this may make it difficult to implement regulations to protect females. Other researchers have found that although hunters are aware of reproductive periods of game species, they do not refrain from killing potentially pregnant females because of the effort it takes to catch the prey before they can identify its sex and reproductive status (Jorgenson, 2000; Noss and Cuellar, 2001).

Conclusion

Consistency of results from different indicators reinforces my conclusion that harvest of quimileros and majanes is not sustainable whereas harvest of moritos practiced by rural people is currently sustainable. The commercialization of skins of harvested moritos could be considered as a conservation strategy, providing extra source of income for rural peasants as proposed by the Argentinean Flora and Fauna Office. However, other factors besides biological sustainability should be considered when evaluating the possibility of opening the market for morito hides, such as control, monitoring, distribution of benefits, possibilities to decrease hunting by non-locals, potential for community management, and trends in land use changes. The future sustainability is uncertain if current trends showing increasing forest exploitation (Zak et al., 2004) and hunting by non-locals continue. With the economic changes of Argentina in the last years and the increased value of agriculture and forest products for export, habitat fragmentation has accelerated (Altrichter and Boaglio 2004). The combined effects of habitat degradation and fragmentation with hunting can be disastrous for peccary populations (Cullen et al., 2000; Peres, 2001). Hunting pressure from logging workers is expected to increase because more companies are exploiting the forest, hiring workers from towns who are expected to supply the meat by themselves (Altrichter, unpublished). Hunting by villagers also showed a tendency to increase with the economic problems of the country and high rates of unemployment (Altrichter, Appendix D.). For these reasons, populations and habitat will have to be monitored continuously. Because rural hunters who are not engaged in forest exploitation

activities maintain a similar hunting effort and hunt in a restricted area, changes of hunting yield can be used as indicators of population trends.

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Table 1. Age categories of quimilero based on dental wear.

Category	Dental wear class
1	Molars have not erupted.
2	All teeth erupted, first premolar worn.
3	First premolar with flat surface, first molar worn.
4	First molar with flat, concave surface, other teeth worn.
5	All teeth with flat or concave surface.

Table 2. Mean (SE) density estimates (individuals/km^2) of peccaries.

Species	Hunted sites	No hunted site (Copo NP)
Morito	0.62 (0.10)	0.91 (0.16)
Quimilero	0.17 (0.06)	0.44 (0.11)
Majan	0.33 (0.32)	1.04 (1.04)

Table 3. Production and harvest rates using biological data from literature and from this study.

Species	Density Ind/km^2	Litter size	Gestations per year	Pregnant females (%)	Production Ind/km^2	Harvest rate Ind/km^2	Production taken (%)	D/K (%)
Morito	0.8 [3]	1.93 [2]	1 [3]	46 [2]	0.355	0.04	11.3	
	0.62 [1]	1.93 [2]	1 [3]	22.5 [1]	0.135	0.04	29.7	68
Quimilero	0.43 [5]	1.7 [5]	1 [3]	30.5 [4]	0.111	0.02	17.9	
	0.16 [1]	1.7 [5]	1 [3]	20 [1]	0.027	0.02	73.5	38
Majan	0.34 [3]	1.67 [2]	1 [3]	32 [2]	0.091	0.03	33.0	
	0.33 [1]	1.67 [2]	1 [3]	21.4 [1]	0.059	0.03	50.9	32

References: [1] this study, [2] Gottdenker and Bodmer (1998), [3] Noss (1997), [4] Mayer and Brandt (1982), [5] Taber et al. (1993).

Figure 1. Study area. Location of settlements participating in the study, sites for estimating density and villages.

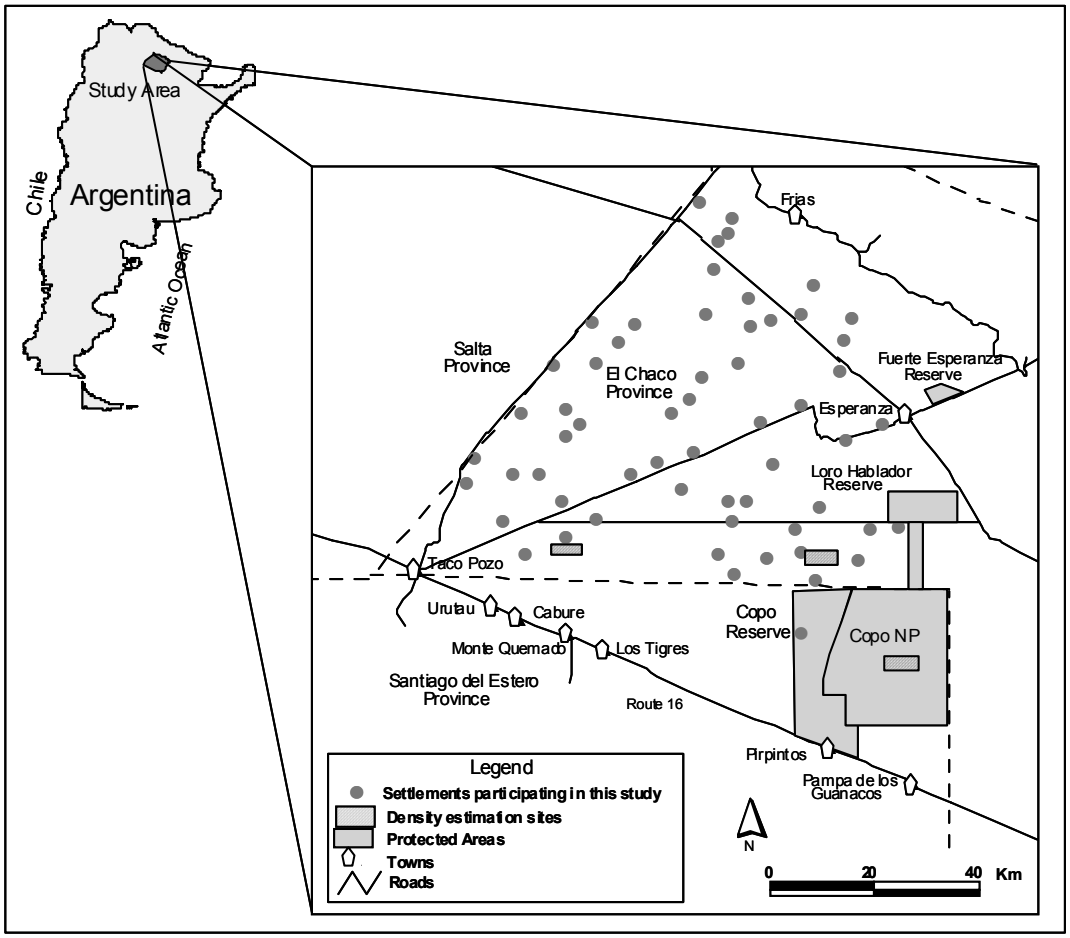


Figure 2. Number of peccaries harvested by 23 rural hunters from January 2002 to July 2003.

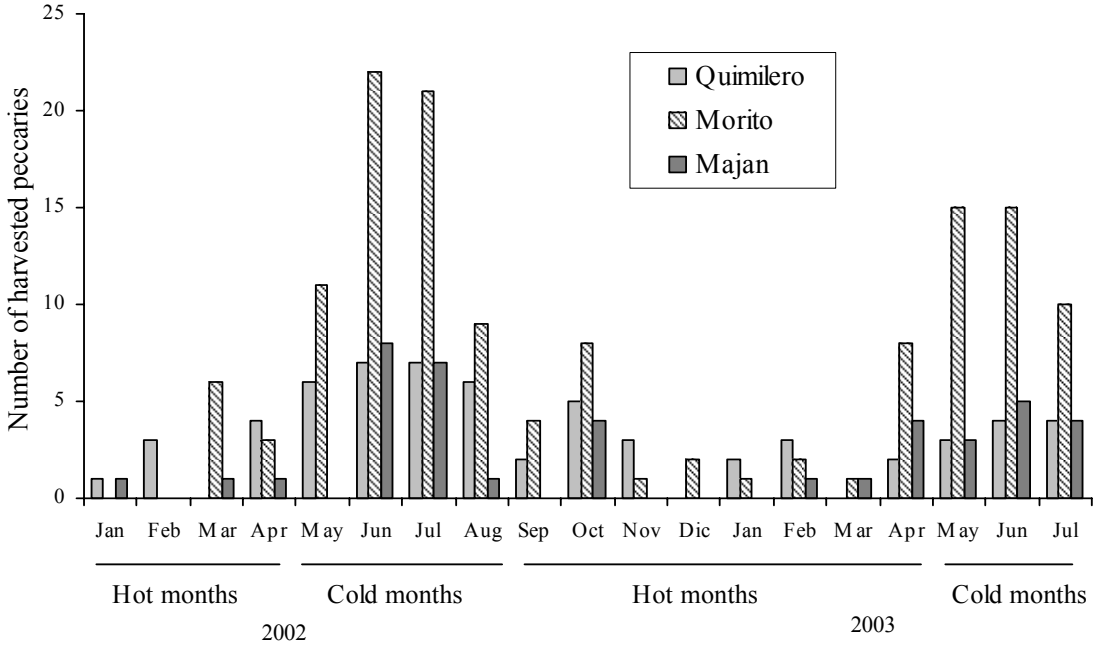
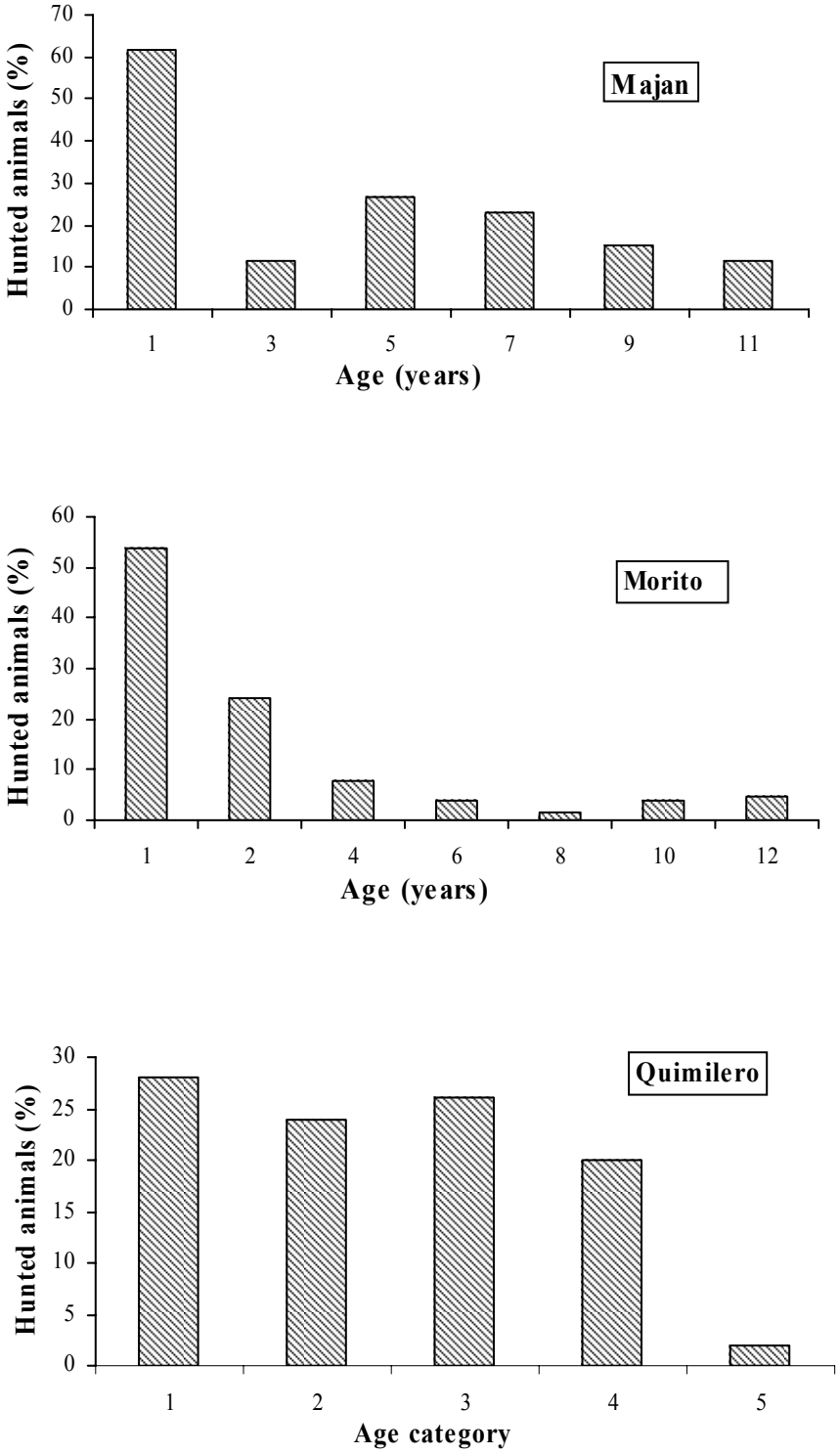


Figure 3. Age structure of harvested peccaries from January 2002 to December 2002.



APPENDIX F

LIMITATIONS TO COMMUNITY BASED MANAGEMENT OF PECCARIES IN THE RURAL AREA OF THE ARGENTINE CHACO

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Abstract

Community based management has been a viable solution in many cases of overexploitation of wildlife. Many communities have demonstrated that they have the capacity to design and maintain mechanisms for regulation of natural resources use. However, community based management of wildlife is not always possible. The social and political context of each community must be analyzed before trying to implement such types of management. In the Argentine Chaco, wildlife is an important food resource for local peasants, however, several species are declining because of overhunting. My objective was to analyze, using the framework of the common pool resource theory, the potential for implementing a project of community based management of peccaries in the *Impenetrable*, a region of the semi-arid Chaco. This project was proposed by the Argentine Federal Wildlife Agency. I found that some conditions of the resource and of the community are not conducive to community based management, at least in the short term: a) People can not easily recognize the boundaries and the condition of the resource and they do not acknowledge the existence of a problem of peccary depletion produced by overhunting, b) Locals do not differentiate between peccaries as a separate resource from other wildlife, c) Locals use a high discount rate and have not authority to control access, inclusion and management rules, and d) There is scarce communication, institutional development and organizational capacity. Some of these conditions could be changed with assistance. It seems particularly relevant to focus on institution building and education. Under current conditions, a situation of adaptive and flexible co-management seems more appropriate.

Key words: Chaco, Argentina, common pool resources, community-based management, open access, subsistence hunting, sustainability.

Introduction

Giving responsibility to communities for natural resource management, government decentralization, and community participation have been strongly advocated in the last two decades as a more appropriate approach to conservation than the typical top-down approaches (Western & Wright 1994, Leach et al. 1999). The main assumptions for the appropriateness of this community based management (CBM) approach are that local communities have higher stakes than the state on their natural resources, and locals have better knowledge of local resources and can manage them more efficiently based on local or traditional practices (Brosius et al. 1998). However, the implementation CBM as a viable solution for the problem of overexploitation of wildlife has had varied results (Barret and Arcese 1995, Twyman 1998, Hackel 1999, Kellert et al. 2000, Barret et al. 2001). While some CBM efforts have been quite successful, others have failed, with continuous overexploitation or failed recovery (Gibson and Marks 1995). In light of these diverse results of CBM efforts, it is not always clear whether local control of resources is the best strategy for sustainability. The response to this problem must be site-specific, depending on particular characteristics of resources and communities. A focus on institutions as mediators of the interactions between people and the environment has been lately advocated as a way to improve our understanding of CBM (Leach et al. 1999, Barret et al. 2001). For example, although locals generally have institutional arrangements regulating use of natural resources

(Berkes 2004), in other cases the scope of the resource or the problem is outside the ability of local institutions to deal with it successfully (Ostrom et al. 1999). To understand these diverse circumstances, the biological, social and political context of each case has to be analyzed.

If the biological conditions are such that a sustainable use is possible, the social and political sustainability has to be assessed. In other words, it is necessary to know whether the community has organizational or institutional systems to design and maintain mechanisms of regulation that can sustain the use of a resource within its ecological limits. One way to analyze the social and political potential for the implementation of a CBM is to examine the reasons why arrangements to avoid overexploitation have not evolved in the community in question. The theory of common pool resources (CPR) (Ostrom 1990, Ostrom & Schlager 1996) provides a framework that can be used for this type of analysis. CPR theory explains the conditions under which appropriators of a resource are likely to engage in devising and altering governing arrangements, and the conditions under which such arrangements are likely to succeed (Schlager 2002).

Difficult and costly exclusion and subtractability are the characteristics that define a common pool resource (Ostrom et al. 1999, Schlager 2002). Wildlife is a common pool resource because it is difficult to claim property rights over wild animals, making it difficult to establish a management regime where access and use can be controlled, and because harvest of individuals reduces the amount of available resource for others. These types of resources are typically subject to overexploitation, unless attributes of the resource and its appropriators are such that increase the likelihood of self-organization and motivate

successful and lasting communal institutional arrangements (Ostrom 2000). Attributes of the resource are related to the feasibility of its improvement, existence of indicators of resource condition, predictability and spatial extent. Attributes of appropriators are related to the degree of dependence on the resource, understanding about the resource, discount rate used by appropriators, trust and reciprocity among them, degree of autonomy and organizational experience and leadership (Schlager 2002). The examination of such attributes in a given case of overexploitation of a common pool resource can help to identify the reasons for unsustainability, and to estimate the potential for the implementation of community based management as a viable solution. According to Barret et al. (2001), these types of studies are necessary to further advance our understanding about the link between characteristic of communities and successful conservation. Based on this premise, I analyze the potential of a governmental proposal for community based management of peccaries (Ungulates) in the *Impenetrable*, a region of the semi-arid Argentine Chaco, through the assessment of the conditions of resources and the community of users that are believed to be associated with successful management (Ostrom 2000).

In the *Impenetrable*, peasants and wildlife coexist in an extended forested area. Peccaries are an important cultural and dietary resource for the local peasants (Bolkovic 1999, Altrichter Appendix E). However, peccary populations are declining because of overhunting (Altrichter and Boaglio 2004). The biological reasons for this unsustainable use were explained in another study by comparing reproduction rates with harvest rates (Altrichter Appendix E). This study also revealed that one of the three species of peccaries, the collared peccary (*Tayassu tajacu*), could be used sustainably if harvested only by local

peasants and current harvest rates do not increase. Given that peccaries are an important source of food and represent a high consumptive value (Altrichter Appendix E), their depletion is not only a concern for conservationists but also for local peasants, especially the poorest and most insecure who will be mostly affected (Altrichter Appendix D). The Argentine Federal Wildlife Agency has proposed the implementation of a community-based management of harvest and commercializing of peccaries hides as a solution to the problem of overexploitation of peccaries. Under this project, commercialization of hides of peccaries killed by subsistence hunters would be legalized, and the local community would be in charge of the management of this resource. The underlying assumption is that if peasants receive an important source of cash from this commercial activity, they will have an incentive for the sustainable use of this species, and will reduce hunting pressure on the other two more endangered species of peccaries. I do not analyze the logistics and the practical feasibility of this proposal but the potential for its implementation in terms of the characteristics of the resource and of users, within the framework of the common pool resource theory.

Impenetrable, the ecological and social setting

The Gran Chaco is a vast plain extending across northern Argentina, eastern Bolivia, western Paraguay and part of southeastern Brazil. In recent decades, intense overgrazing, excessive timber harvesting, and charcoal production have transformed large parts of the Chaco landscape into a dense thorny shrub land (Morello and Saravia-Toledo 1959, Morello

and Hortt 1985, Bucher and Huszar 1999). The Chaco is divided in three sub-regions based on an east-west rainfall gradient: eastern or humid, central or transition, and western or semi-arid Chaco (Morello and Adamoli 1968, Bucher 1983). The study area covers 1.2 million hectares of the semi-arid subregion locally called "*Impenetrable*" (24^{o} 30' to 25^{o} 30' SL and 62^{o} 50' to 61^{o} 40' WL; Fig. 1). This sub-region is the driest and most markedly seasonal, with rainfall between 450-700 mm, most of which (80%) falls between October and April. In the study area there are no rivers or other sources of natural water other than temporal ponds formed during the rainy season. Average annual temperature is 21.9 ^{o}C with minimums below zero and maximums around 50 ^{o}C. The vegetation is a medium-tall xerophilous forest (Bucher 1983).

The semi-arid Chaco is currently the largest extension of continuous forest and the poorest, least developed region of the country. Health services are minimal and education only covers elementary school. The lack of electricity and telecommunication, the scarcity of water during the long dry season, and the high temperatures during the summer make the *Impenetrable* an inhospitable place, which may explain why it was one of the last regions to be colonized. The region was largely unsettled until about 80 years ago when mestizo peasants started to colonize the area, coming from the neighboring provinces of Salta and Santiago del Estero. Today, human density is low, and most of the region is rural with people living in about 210 small settlements spread throughout the forest, separated from each other by about 5 km. Most of these settlements consist of one or two household but some have up to seven. Rural peasant livelihoods are based mainly on small-scale livestock ranching and forest exploitation for charcoal and fence posts. Besides cattle, all rural

households have other smaller domestic animals, mainly goats, chickens and ducks, for domestic consumption. There are also several small villages located along a paved inter-provincial road (Fig. 1), ranging between 20 and 1300 households. Most local peasants practice subsistence hunting of several species of wildlife that are used mainly as sources of food, and to a less degree, as sources of cash (Altrichter Appendix C). Hunters from towns and nearby cities visit the rural area frequently and harvest large numbers of individuals of diverse species for domestic consumption and trade. Hunting is also practiced by workers of logging companies. Logging and charcoal companies working under concessions granted by the provincial government exploit the forest in state lands. This is less common than in the past because most land is being privatized. Most rural households are in the process of acquiring title of small portions of land (mode 250 ha), and during the last two years, there have been an increased number of non-local residents buying large extensions of land (up to 30000 ha) in this region.

Methods

I conducted fieldwork between June 2000 and August 2003, using a mixed methods approach. On repeated occasions, I visited 58 local families that were chosen randomly from different settlements (23% of total number of families inhabiting the study area) and spent time with them, conducted informal and semi-structured interviews with adult members of these families, performed settlements mapping exercises, and participated in their daily activities and in hunting events. From this initial sample of local households, I identified and interviewed key informants, who were members or presidents of past and current communal

organizations, such as cooperatives, school and religious committees, and the only current organization that consists of goat-producers. I also participated in different types of gatherings, religious and school related celebrations, and meetings of the goat-producer association. Additionally, I interviewed local teachers, health workers, veterinarians, and personnel of the Forest and Colonization Institutes. For the analysis of peccary's use I identified the existence or absence, in the rural area of the *Impenetrable*, of each attribute of the resource and of its users identified by CPR theory (mainly taken from Schlager 2002). These findings are integrated with results from my research on wildlife use (Altrichter Appendix C) and sustainability of hunting of peccaries in the *Impenetrable* (Altrichter Appendix E) when appropriate.

Results

Most of the attributes of the resource and of users that have been identified by the theory of common pool resource as associated with an increased likelihood of successful management of natural resources, are absent or scarcely developed in the *Impenetrable*. Table 1 is a summary of the condition of these attributes in the *Impenetrable*, and suggested actions required to reach the desirable situation. Following is an analysis of each one of the attributes.

Attributes of the resource

a) Feasible improvement: The resource needs to be sufficiently scarce to motivate users to change their behavior with the objective of increasing sustainability, but sufficiently abundant that can be recuperated.

I found that populations of peccaries in the *Impenetrable* are declining and have disappeared in some sites (Altrichter and Boaglio 2004). However, although peccaries are in short supply, there is still a good potential to recuperate the populations. Thus, it would be worthwhile for local people to organize to recuperate this resource. In places that are close to towns (less than 10km) or where there is high density of settlements peccaries have been extirpated. Everywhere else there are peccaries and although they are not abundant, there are enough to enable hunters to harvest at least one per year (Altrichter Appendix A). However, the case of peccaries in this region is interesting because even though they are one of the preferred species for consumption (Atrichter Appendix E), for the local people the resource "wild meat" refers to all kind of game used for foods and collectively these wild food are relatively abundant. Thus, the decline of peccaries does not seem to motivate a change of behavior, since they can complement their consumption of wild meat with other species. In fact, in sites in the study area where peccaries have disappeared, it was observed that people continue consuming similar levels of wild meat compared with sites where peccaries are common. This is accomplished simply by modifying the frequency and diversity of species harvested (Altrichter Appendix D).

b) The condition of the resource can be assessed and predicted: There are indicators of the condition of the resource system that are viable and valid, and can be available at low costs.

When the resource has indicators of its status that are easily recognized, and the flow of the resource units is predictable, users can act to change their behavior of use. Although the diminishing numbers of peccaries and reduction of herd sizes observed in this region (Altrichter and Boaglio 2004) could be valid indicators of their status for ecologists, these are not used by local people in the *Impenetrable* as indicators. Furthermore, these trends are not necessarily indicators of the causes of population decrease. Peccaries can decrease locally for various reasons besides hunting, such as diseases (Fragoso 1997), habitat degradation (Peres 2000), and probably competition with domestic animals (Noss and Cuéllar 2000). In a previous study in this region, it was determined that local peccary depletion was associated with human density, indicating overhunting (Altrichter and Boaglio 2004). However, although peasants in the *Impenetrable* recognize that it is becoming more and more difficult to find peccaries than in the past, they do not relate this with the condition of the resource.

c) Spatial extent: The resource is relatively small and its boundaries can be known.

In systems of large-scale resources, users may not recognize problems of decline, and may not act to stop or revert this problem. Furthermore, the lack of defined and known boundaries reduces the capacity to control access to the resource. The size of the resource is

measured in relation to the technology of transportation and communication that exist among users and which makes it possible for them to know where the resource is located (Schlager 2002). The spatial extent of peccaries in the *Impenetrable* can be considered large because they inhabit a large area of continuous forest that covers more than 10 000 km^2, within which there are hundreds of human settlements. Moreover, peccaries can walk long distances every day and have large home ranges (Sowls 1997) that extend beyond the limits of rural families' properties (mode 250 ha). Such large home ranges make their presence in someone's property transitory, which complicates the recognition of their distribution. Thus, the boundaries of the resource cannot be known, and its spatial extent is large in comparison with the technology of transportation (by foot, horse, bicycle) and communication (oral communication, direct observation, use of dogs) that locals use, making it difficult for them to have an accurate knowledge of the boundaries of the resource.

Attributes of users

a) Salience: Users are dependent on the resource or the resource constitutes an important part of users' livelihoods.

Dependency on the resource motivates people to protect it. At present, peccaries in the *Impenetrable* are not an important resource as a source of cash, in contrast to some other regions of Latin America. If commercialization were to be allowed, and current harvest rates have to be maintained, this will represent an extra income that could be important for some households. However, it still will not comprise a major portion of people's livelihoods. In

terms of food, peccaries are an important part of people's diet, although they do not depend exclusively or largely on these species as a source of meat. Local people use over 20 wild species, and peccaries constitute about 25% of the wild meat consumed. Although meat is never a scarce component in local people's diet, it is worth noting, that the role of peccaries as a source of food is correlated with households socio-economic situation, being more important for the poorer and larger households (Altrichter Appendix D).

b) Common understanding: The community of users must have a shared understanding of the dynamics of the resource and of the effect that its use has on each other and on the resource.

A common understanding of the resource situation facilitates communication and can motivate the elaboration of strategies for management. Assuming that users have the capacity to cooperate, first they need to understand the problem of overusing the resource so that cooperation can emerge. In the *Impenetrable*, people are largely unaware of the larger political, economic and environmental forces that affect them, as it has been found in other rural communities (Western 1994). More specifically, local people do not recognize the effects of hunting on peccaries. Because they do not have a perception of resource depletion and, therefore, do not see how their behavior is affecting the resource, they may not have an incentive to change their behavior. This can be a result of the fact that locals are recent immigrants into this region (no more than 80 years). This short tenure may not have enabled them to attain the ecological knowledge that naturally develops over many generations.

Depletion of natural resources in areas recently colonized is a common phenomenon in Latin America, generally attributed to the lack of ecological knowledge of new settlers (Lopes and Ferrari 2000, Durand and Lazos 2004). Furthermore, people may not be able to develop an understanding of the dynamic of the resource because peccaries are highly mobile and their boundaries are not recognizable. Although locals acknowledge a decline in peccaries, they generally do not interpret this as a depletion of populations as a result of hunting. In fact, they clearly expressed that they do not believe that peccaries are less abundant today than in the past, but rather that peccaries "have moved to other regions because there is too much noise here". They stated that further north there are large extensions of forest uninhabited by humans, which they call "the desert", where all species of animals are abundant and reproduce prodigiously. Other researchers who have worked in the Chaco noticed this same belief (Bolkovic 1999). This perception may be a historic reminiscence of the times of colonization of this vast uninhabited region, when wildlife was plentiful, and colonization followed a pattern from south to north. This belief is also consistent with their general perception that animals, as well as the forest, are inexhaustible. A probable explanation of this perception may be the lack of communication between settlements and the scarce communal activities, which create few opportunities to share information over natural resources.

c) Low discount rate: Users use a low discount rate in relation to future benefits that can be obtained from the resource.

When the magnitude of the benefit that users can obtain by overexploiting a resource in the present time is low in comparison with what they can obtain in the future by conserving the resource, there is an incentive to protect the resource. Specifically related to peccaries, the unpredictable location of this resource and its unknown boundaries make their present use more valuable than potential future benefits. As noticed by other researchers working in this region, discount rate used by locals in relation to all natural resources has been typically high since the colonization of this area, given their concern with present income (Bucher et al. 1998). This has been promoted by insecurity related to land tenure, laws and interventions of government, as well as unpredictable fluctuations of natural resource prices and high inflation and interest rates. Currently, this situation is worsening because not all local families have title to their land, and their traditional livestock husbandry system is threatened by the arrival of non-locals who buy large extensions of land and fence their properties, decreasing grazing area for local families. These changes in land uses in the region are producing uncertainty among local peasants about the future feasibility of maintaining their lifestyle, which in turn provides no incentive to conserve resources.

d) Experience on organization and leadership: Users have minimal skills of organization and leadership.

Experience in communal organization and leadership allows users to engage in collective actions and to develop institutional arrangements to manage the resource. The rural community of the *Impenetrable* has limited experience in this respect. In terms of

administration purposes, there is not a local government or "Comuna" as there are in larger towns. Rural people depend on the governments of nearby towns, which can be as far as 100 km away. In terms of local uses of natural resources, there are no communal rules regulating grazing and hunting, although this is starting to change in relation to modifications on land tenure regimes (Altrichter Appendix G). Settlements are decentralized, without leadership and rarely engage in collective actions.

The currently organized groups that exist are related to schools and religious activities. Participation in these groups is reduced. Less than 35% of all interviewed people participated in any of these groups. None of these groups embrace all the rural community, but rather they work in sectors determined by the location of the schools and churches, and by the type of religion. Schools receive students from a radius of about 15 km around. Some of the students' parents are organized in groups that work to raise funds for the school, cook for the students, and provide food and fuel wood. Religious groups clustering catholic people are more common than evangelic groups. Catholic groups work raising funds to maintain local religious figures and churches and organizing celebrations. Similar to school groups, religious group are composed by people living in a radius of up to 15 km form the church.

During the last years there have been several attempts to create cooperatives but these have failed for different causes. Probably the main cause of failure has been the top-down style of these initiatives, which have been promoted and developed by the provincial government, with little participation of local people. Less than 10% of local people interviewed had participated in these cooperatives, and most who have participated have

done so for less than 2 years. Furthermore, some locals believe that these cooperatives created more conflict among members than existed before. The lack of participation in communal activities can be explained by the long distances between settlements that make communication difficult, and by the individualistic lifestyle of peasants. The life of peasants in this region focuses to the nuclear family, with scarce interaction with other settlements, and showing little sense of community. This cultural trait may be linked to the productive system. Each family needs to have enough uninhabited land around the settlement to maintain their livestock in an open range system, which created a pattern of dispersed locations of families rather than groupings in villages during the colonization of this region. Currently there is an organization of goat producers that includes about 30% of the settlements, which has been organized by the provincial government. Participation of peasants in this group is limited to attending meetings where they receive instructions from professionals and to following their directions related to goat production. Failures of previous attempts to form cooperatives, and the number of lasting conflicts that were produced by those attempts have reduced motivation of locals to self-organize in order to deal with issues that require collective actions and are acknowledged by them as of current interest, such as improving transportation and commercialization of their products.

e) Trust and reciprocity: users can trust one another to maintain devised regulations of use, and to relate with reciprocity.

Users of a common pool resource must be able to develop trust that the rules they design will be respected by all users. In the *Impenetrable*, the previously mentioned failures to organize have created distrust among local people. When asked about possibility of organizing to do work for the community they generally expressed that it would be unattainable because "I are very selfish people". Distrust is also generated by the spatial arrangement of settlements. Settlements are isolated in the forest and separated from each other by long distances, makings it difficult for community members to interact and communicate in a daily basis. Thus, the actions of a household can go unnoticed even by their closest neighbors. This reality makes it difficult for locals to control each other. Therefore, there is little or no peer pressure to conform to norms.

On the other hand, the lack of a long history in common and of perspectives of a common future has probably also limited the establishment of behavior norms and reciprocal trust. Although in some cases communal regulations have evolved in short periods of time (Berkes 1996) most frequently this happens over long periods of time (Hanna et al. 1996). For example, peasant populations living in arid zones of Africa similar to the *Impenetrable* have developed, over more than 2000 years, many ways to exploit the environment without producing ecological adverse consequences (Niamir-Fuller 2000). The society of the *Impenetrable*, however, is not more than 90 years old. The process of colonization and human settlement is recent and it is still occurring, and settlers have different origins; therefore, the history in common shared by this community is brief. Probably as a consequence of this short shared history and the isolation of settlements, households are largely disconnected. This is evidenced by spatially limited knowledge of

local peasants, who can rarely recognize more than the location of nearby neighboring settlements, and settlements located along their route to the nearest town. Most people had never gone to the capital of the province.

f) Autonomy: Users can determine access and harvesting rules and these rights are recognized by external authorities.

Communities that manage their resources must have the possibility of designing rules of management, access, and inclusion, and this right has to be recognized by the government. In the *Impenetrable*, all types of hunting, except for sport hunting, are currently illegal. For this reason, it would be difficult for the local community to design their own rules of use and have the support of the government, without a change in the provincial legislation. If the provincial government were to recognize the rights of local peasants to design rules, other type of obstacles, such as the large areas covered and lack of property demarcations, would make it difficult to stop non-locals from hunting in the region. However, locals are gaining rights to control access of outsiders through the individual titling program that is currently being implemented. The use of this right based on private property is being exerted by locals participating on a governmental project for harvest of parrots (*Amazona aestiva*) and tegu lizard (*Tupinambis rufescens*) skins. Although the management of this project is completely under governmental direction and control, locals participate in denying access to outsiders to harvest animals within their property boundaries.

Discussion

Although community-based management of commercialization of peccary hides has been successfully implemented in the Peruvian Amazon (Bodmer 1994, Bodmer et al. 1997), the situation in the Argentine Chaco does not seem appropriate for the implementation of a similar project. Strategies for conservation have to be designed in a way that they are appropriate for the local cultural, economic, geographic and ecologic context. According to this study, the implementation of a community-based management of peccaries in the *Impenetrable* is probably doomed to failure if some assumptions are not reassessed and some conditions are not changed. Peccaries are currently used as an open access resource, which is not compatible with sustainability (Berkes 1996), and it does not seem likely that the implementation of a CBM project will motivate a change in the way this resource is used.

One of the assumptions of advocates of CBM is related to the conceptualization of community as a distinct, small spatial unit, with homogeneous structure and a common interest shared by its members (Agrawal and Gibson 1999, Leach et al. 1999). However, in some circumstances such communities may not exist. Results of this study suggest it would be difficult to define "the community" that would be in charge of the proposed CBM. Although the highly homogeneous lifestyle of peasants and its rural condition can give the impression of a distinct community, the disconnection and lack of communication among settlements, and the reduced spatial knowledge of people, demonstrate that within this large setting there may be several overlapping communities. Probably a stronger focus on institutions could help to identify these "sub-communities".

None of the conditions that are positively related with the emergence of collective action for successful management of common pool resources (Schlager 2002) exist or are sufficiently developed in the *Impenetrable*. Which of these conditions should be developed first, and whether the existence of all of them is necessary to achieve the desired outcome, is still unknown (Agrawal 2002). It is recognized, however, that changing attributes of resources and users through policies is more difficult than changing or influencing institutions (Stern et al. 2002, Agrawal 2002). In this case, some attributes that are inherent in this resource, such as its high mobility, and attributes of users that are associated with the geographic distribution of settlements, can not be easily changed. However, other conditions such as the lack of understanding and realization of wildlife depletion as a consequence of overhunting, could be changed through awareness and education. In a parallel study it was found that villagers in this region had a more clear understanding of environmental problems than rural people, probably related with higher exposure to the media and to environmental education (Altrichter in prep.).

Barrett et al. (2001) warn about overemphasizing community's role in conservation when more often than not, institutions of local rural communities in third world countries are weak and ill equipped to deal with sustainable use of natural resources. The inexistence of strong local institutions, social capital, organization capacities, and leadership in the *Impenetrable* seems to be the major challenge and should be the focus of future assistance. Although social relationships in the form of informal networks of mutual help exist (Glauser 1996), these networks are limited to family and close neighbors, and are not developed enough to provide social integration and community structure. This lack of community

integration and structure is common in Latin America for new mestizo societies that have been established in a region in a short term. However, it has been observed in other systems that new settlements can, with time, or with external assistance, develop their own organization (Cernea 1985).

Institution building and education has been recognized in previous research as a fundamental step towards a successful CBM (Western 1994, Kellert et al. 2000). Studies have shown that rural people can improve their understanding of the environment at the same time as they develop new social rules, norms and institutions (Pretty and Smith 2004). Growing evidence indicates that when people are well connected and they participate in conservation and development projects, they are more likely to protect the resource over the long term (Pretty and Smith 2004). Thus, before the implementation of CBM it is necessary to invest in training and development of local institutions' capacities (Western 1994) and social capital (Pretty and Smith 2004). This should be done with the awareness of avoiding past top-down, paternalistic approaches, limiting the external assistance to facilitation and support. Furthermore, in a community like the *Impenetrable*, with a history of conflicts and failed attempts of organization, conflict resolution skills would be particularly relevant (Western 1994). Also important is the need to increase the flow of relevant information, which will enable institutions to be effective, responsible and accountable to the community (Western 1994).

Although it is believed that strengthening of institutions should focus on preexisting institutions (Western 1994), in this case, the existing organized groups divide the community into geographic and religious sectors. Therefore, it may be necessary to work on

the formation of groups organized for the common good, such as cooperatives, which can unite a larger portion of the community, focusing on issues identified by locals themselves as of present concern. One such issue is the extraction of resources by non-residents. Large logging companies working in this region under governmental concessions expect their workers to provide meat for themselves through hunting. Because there are no demarcations of property limits, these workers hunt anywhere and in larger numbers than locals. This is a common phenomenon in tropical forests (Bodmer et al. 1988). Promoting organization of local peasants to control hunting by lumbermen and other non-local hunters would help to build local institutions by reinforcing their sense of community, their authority, their capacity to resolve disputes, their communication, and their social networks. Control of access of outsiders has been a practice readily accepted by other rural communities of the Chaco region as a first step to solve conflicts of overexploitation (Noss and Cuellar 2001). Another approach to strengthening institutions and developing a sense of identity and pride, is through incentives that promote expressions of cultures (Kleymeyer 1994). In this case the different types of celebrations, collaborative work for marking livestock, and recreational gatherings are potential activities that can strengthen cultural unity.

Management of peccaries needs to be changed if sustainable use is the goal. The current patterns of hunting are leading to overexploitation (Altrichter and Boaglio 2004), and the proposed solution by the National Government of community based management for the commercialization of peccary hides does not seem feasible at the moment. A more appropriate solution will have to include a mixture of protectionism and co-management, while the propitious conditions for a complete local management of the resource are being

developed. The governmental wildlife agency, which is currently in charge of the implementation and monitoring of local harvest of blue-fronted parrots, could share the co-management of peccaries with the local people. This project for sustainable use of parrots has been in place for eight years and has been successful in terms of controlling overexploitation of parrots and providing an important source of income for local people (Banchs 1996, Barbarán and Saravia-Toledo 2000). The governmental agency could be involved in supporting restrictions of access to outsiders, and providing technical assistance for management, commercialization and monitoring. NGOs or governmental agencies should work on facilitating local communication and providing appropriate arenas for conflict resolution. This co-management should be adaptive and flexible in order to adapt to new situations, especially in a region like the *Impenetrable* that is going through rapid changes on land tenure and land uses (Altrichter Appendix G). An adaptive and flexible regime would allow an ongoing process for revising and testing management practices, based on ecological knowledge and institutional arrangements (Folke et al. 2002, *cited in* Berkes 2004).

As a final conclusion, it is worth remarking that understanding environmental problems requires analyses that go beyond natural resource depletion or degradation (Leach et al. 1999). The theory of common pool resources offers a very useful framework to understand the use of wildlife and the potential for community based management, which has rarely been put in practice in cases of terrestrial wildlife use. Most studies related to use of wildlife have been conducted with fisheries (Naughton-Treves and Sanderson 1995) and generally by political scientists. The integration of this type of social studies with biological studies

offers an immense potential for the advancement in our understanding of the problematic of overexploitation of natural resources.

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Table 1. Summary of the existence in the *Impenetrable* of the conditions identified by CPR theory as increasing likelihood of successful management of natural resources, and suggested actions to develop the desirable condition.

Conditions identified by CPR theory	**Conditions in the *Impenetrable***	**Proposed actions to reach the desirable conditions**
Attributes of the resource		
The resource needs to be sufficiently scarce to motivate behavior change, but sufficiently abundant that can be recuperated.	Peccaries are at low density but can be recuperated if hunting pressure decreases. However, people believe they are abundant.	Awareness and education. Villagers in this region recognize environmental problems, probably as a result of higher exposure to the media and to environmental education.
There are indicators of the condition of the resource that are viable and valid, and can be available at low costs.	Although diminishing population is an indicator of peccary status for ecologists, it is not for local people in the Impenetrable.	Through education people can learn to recognize population trends as indicators of the condition of the resource.
The resource is relatively small and its boundaries can be known.	Peccaries are distributed over a large extension of continuous forest and have large home ranges. The boundaries of the resource cannot be known.	Conditions inherent to the nature of the resource cannot be changed.

Attributes of Users		
Users are dependent on the resource or the resource constitutes an important part of users' livelihoods.	Local people do not depend on peccaries as a source of income, but peccaries provide 25% of all the wild meat consumed.	If people were able to obtain cash from selling peccaries hides, the importance of this resource would increase.
The community of users have a shared understanding of the dynamics of the resource and of the effect that its use has on each other and on the resource.	Local people do not show an understanding of the effects of hunting on peccaries. Locals believe that peccaries are still abundant, but have moved away to uninhabited areas.	Education and mapping exercises to help people recognize the extension of human settlements. Increase the flow of information so that general tendencies can be known.
Users use a low discount rate in relation to future benefits that can be obtained from the resource.	The high mobility and unpredictable location of this resource, and its unknown boundaries, make their present use more valuable than potential future benefits.	Securing land tenure can decrease discount rate. Education and awareness can increase the value that people attach to this resource in the future.

Users have skills of organization and leadership.	Locals have limited experience in organization and leadership. There are few organized groups related to schools and churches, and a small proportion of the population participates. Past experiences with cooperatives have failed.	Institution building, training and development of local institutions' capacity and social capital. Work on the formation of groups organized for the common good, such as cooperatives, trying to unite a larger portion of the community.
Users can trust one another to maintain devised regulations of use, and to relate with reciprocity.	Local people do not share a long common history. Settlements are isolated by long distances and have low interaction and communication. Previous failures to organize and difficulty to control each other generates distrust.	Develop conflict resolution skills. Promote organization of peasants to control hunting by outsiders may help to build local institutions. Promote expressions of local costumes, gatherings, and celebrations, to increase interaction.
Users can determine access and harvesting rules and these rights are recognized by external authorities	Locals cannot determine access because all hunting they practice is illegal. However locals are gaining control of access of outsiders through the individual titling program that is being implemented.	Legalization and regulation of subsistence hunting. Securing land tenure.

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APPENDIX G

CHANGES ON LAND TENURE AND ITS RELATIONSHIP TO COMMON POOL RESOURCES' MOBILITY IN THE ARGENTINE CHACO

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Abstract

The goal of this paper is to explore how different degrees of mobility of common pool resources influence the institutional arrangements that users might be able to adopt to govern them. I assessed this issue in the context of low-income mestizo peasants that live in the driest portions of Argentine Chaco. In this region crop agriculture is not feasible and thus local people rely on a variety of common pool resources such as wildlife and other forest resources for a major portion of their livelihood. Because wildlife and forest resources are being degraded at a rapid pace, privatization of land tenure has been promoted recently by the central government as the preferred policy to address the overexploitation problem. To assess whether privatization can solve problems of wildlife overexploitation, I compared wildlife harvesting practices before and after the privatization, and examined harvesting practices for resources with different level of mobility. I predicted that resources of high mobility would continue to be overexploited, regardless of the land tenure regime. I found that peasants' abilities to capture the productive benefits that private property could potentially offer is differentially affected by the varying mobility of the resources that peasants use to sustain their livelihoods. While private land tenure allowed users to develop a more efficient control of use of forest (trees) and wildlife resources with low mobility or small home range (nesting parrots and armadillos), species of high mobility (peccaries) continued to be used as open access resources, and thus, overexploited. I concluded that adopting a property right regime that promotes resource conservation or efficient use will show best results when

policies are congruent with helping users to address provision and appropriation problems.

Key words: Argentina, Chaco, conservation, CPR, mobility, natural resources, open access.

Introduction

This paper assesses how mobility, a characteristic of common-pool resources (CPRs), influences the management regimes adopted by resource users, regardless of the property rights formally assigned to the resource. The relation between property rights and use and conservation of natural resources has been the focus of extensive debates between development and neoclassic scholars (Scott 1955, Demsetz 1967, Hardin 1968, Ostrom 1990, Baland and Plateau 1996, Dietz, et al. 2002). Some scholars argue that common property can improve conservation and natural resources management through increasing local involvement, decentralizing decision-making, and preserving cultural diversity (McCay and Acheson 1987, Chambers and McBeth 1992, Western and Wright 1994, Etzioni 1996, Gibson et al. 2002, Lyon 2003). Others state that communal property discourages economic growth and social change (Dorner 1972, Anderson and Hill 1975, Harrison 1987, Sas-Rolfes 1998). Under the second perspective the assignment of private property rights is seen as a superior alternative because it internalizes many of the external costs associated with communal ownership, and because owners can appropriate all the benefits by excluding others (Demsetz 1967). This concentration of benefits and

costs on owners creates incentives to utilize resources more efficiently, reducing transaction costs and overcapitalization (Scott 1955). Private property rights lower transaction costs because they minimize the amount of time and effort owners must spend bargaining and negotiating with other individuals about their property, defending it, or making allocation decisions. Overcapitalization is prevented because the owner can then estimate the amount of resources available at the time of harvest and then select the most efficient technology to use.

This debate over property rights becomes especially important in natural resource policy when it deals with common-pool resources (CPRs) such as forests, fisheries, or wildlife, which are characterized by subtractability and costly exclusion. The former refers to the fact that once a unit of the resource is extracted from the common pool, it is not available to anybody else. The latter describes the difficulty of excluding potential users of the resource. Although the literature on CPRs has outlined the important relationship that resource characteristics have with successful governance of use and conservation (Ostrom 2001), not enough attention has been directed to this area (Agrawal 2002). The major advancements in this area so far have dealt with scarcity and value of resources (Netting 1981), aridity of the environment (Thompson and Wisen 1994), and variability in rainfall (Nugent and Sanchez 1998). In terms of wildlife, Naughton-Treves and Sanderson (1995) argue that assigning private property rights to land can be inadequate for the conservation of wildlife because different species vary in their degree of mobility. The role of mobility and storage, as two important characteristics of CPRs, is further illustrated in the work of Schlager et al. (1994) based on numerous case studies of

fisheries, groundwater basins, and irrigation systems. These authors found that mobility affects "the quantity, quality, and the costliness of information users possess about their resource" and the problems they experience to coordinate their activities and capture the benefits created from such coordination (Schlager et al. 1994, 295). Together, the insights provided by these studies provided a good starting point for our understanding of the relationship between biological or physical characteristics and CPR governance. More work needs to be done however, to recognize how such characteristics interact in specific settings (Agrawal 2002) and to improve our understanding of the nature of the institutional arrangements that can achieve successful governance of these types of resources.

The goal of this paper is to explore how different degrees of mobility of CPRs influence the different institutional arrangements that users adopt. I describe the way that some natural resources are perceived and used by low-income mestizo peasants in the Argentine Chaco, in a scenario where land tenure is changing from state property with unrestricted access to private property. A combination of poverty and unsustainable uses of marginal land have produced degradation of the Argentine Chaco's forest and wildlife resources (Saravia-Toledo 1984, Bucher and Huszar 1999). The government is promoting privatization of this land as a way to stop and revert this process of degradation. While the government's assumption is that converting large open land areas to delimited and fenced units will encourage sustainable exploitation of natural resources (Saravia Toledo 1972), the results, so far, are not meeting this expectation. Use of some species of

wildlife, such as peccaries (*Tayassuidae*), continues to be unsustainable (Altrichter and Boaglio 2004).

I argue that securing land tenure in the Argentinean Chaco through privatization is differentially affecting the way that local peasants use forest and wildlife resources. To illustrate this point, I describe how wildlife harvest was practiced before privatization and how it is practiced today. I examine harvest of wild species that have different mobility: Parrots (*Amazona aestiva*), although highly mobile during their adult phase, remain in one specific site during their nesting period, where the chicks are harvested for trading. Armadillos (several species of the family *Dasypodidae*) have small home ranges and live in caves that can be identified easily. Peccaries (Three species of the family *Tayassuidae*) are big social animals (around 30 kg) and herds have large home ranges compared with the size of peasants properties. Armadillos and peccaries are among the preferred game species by local peasants (Altrichter Appendix C). Two of the three species of peccaries, the white-lipped (*Tayassu peccary*) and the Chacoan peccaries (*Catagonus wagneri*), have exhibited steady population declines and the trend continues (Taber 1993, Altrichter and Boaglio 2004). Finally, I compare these wildlife resources with non-mobile resources, trees, which are also harvested, and discuss how timber extraction may be affected by privatization.

Methods

I conducted fieldwork between June 2000 and August 2003, using a variety of techniques. On repeated occasions, I visited 58 local families that were chosen randomly

from different settlements (23% of total number of families inhabiting the study area) and spent time with them participating in their daily activities and in hunting events. I conducted informal and semi-structured interviews with adult members of these families. I recorded socio-economic information such as household size, sources of income and economic situation. Although all households have several sources of income, I identified the main source for each household as originating from livestock, forest exploitation (charcoal and fence posts), or jobs (salaried or wage labor). From this initial sample of local households, I extended to key informants, who for this research were elders that arrived to the region during the first years of colonization. I also participated in several local events such as celebrations and meetings. Additionally, I interviewed local teachers, health workers, veterinarians, and personnel of the Colonization and the Forest Institutes. Oral testimonies provided the main source of data. Elder peasants currently inhabiting this region, called the *Impenetrable*, were the first settlers in this area, arriving 50-80 years ago. Since they arrived, they have experienced changes in land tenure regimes. These elders can recount the evolution of rules, enforcement and monitoring that occurred in this region related to the use of natural resources as they experienced these changes. This was complemented by our own observations, participation and secondary sources. For historical accounts that are not a result of this research, I reviewed existent literature and cite it in the manuscript when appropriate. Scarce published information exists on the process of colonization of this region.

Schlager et al. (1994) studied how mobility affects governance of common pool resources and I used these findings to guide our comparison, when appropriate, among

the different resources used by peasants of the *Impenetrable*. These authors found that mobility affects (1) the severity of the provision and appropriation problems that resource users face, (2) the relative ease with which users can resolve those problems, and (3) the kinds of institutional arrangements (i.e. property right regimes) they are likely to develop and implement. Provision problems originate when the productive capacity of the resource is affected by the harvesting activity. Appropriation problems are those that emerge when it is not possible to attain efficient levels of harvesting. The most common types of appropriation problems are appropriation externalities, assignment problems, and technological externalities. Appropriation externalities refer to the negative effects that one individual using a resource brings to other people. Assignment problems originate when the resource is not homogeneous but distributed in patches. Thus, assigning harvesting locations without regard to the patchiness of the resource generally benefits users inequitably. Technological externalities emerge when individuals' use heterogeneous technologies with different levels of efficiency to harvest their resources. These three mentioned problems emerge in interdependent situations and consequently, require some form of collective action. The end result of collective action may be private property.

The Physical Setting: the Impenetrable

The Chaco is one of the most degraded ecosystems in South America (Bucher 1983). The Chaco is a vast plain of about 1.3 million square kilometers of dry subtropical forest, extending over part of Paraguay, Argentina and Bolivia. The Argentine Chaco is

currently the largest extension of continuous forest and the poorest, least developed region of the country. The reason this region is so poor is due partially to environmental factors and partially to bad management: It is an arid, fragile ecosystem with low productivity that has been degraded by logging and overgrazing (Saravia-Toledo 1985).

The Chaco is divided in three sub-regions based on an east-west rainfall gradient: eastern or humid, central or transition, and western or semi-arid Chaco (Bucher, 1983, Morello and Adamoli, 1968). The study area covers about 12000 km^2 of the *Impenetrable* within the Chaco province, approximately between the Bermejito River at the North and the limit with Santiago del Estero province at the South, and between the limit with Salta province at the west and the road that connects Forte Esperanza and Rio Metro at the east (Fig. 1, $24^o30'$ to $25^o30'$ S and $62^o50'$ to $61^o40'$W) .The *Impenetrable* is located in the semi-arid sub-region, the driest and most markedly seasonal region, with rainfall between 450-700 mm and a dry season that lasts from four to six consecutive months. The vegetation is a medium-tall xerophilous forest (Bucher, 1983). This sub-region has the lowest human density and is one of the most heavily wooded areas within the semi-arid regions of the world (Bucher, 1983). The *Impenetrable* has been the last frontier colonized within the Chaco region.

Communal Setting: Living at the Frontier

The Chaco region presents a particular setting and range of conditions that have not received much attention in the literature. It is a relatively new society (oldest settlements in the region are about 90 years old), it is a non-tribal human population, people live in

constant contact with the natural resources that they use and there is little interaction between neighbor settlements. Furthermore, people's livelihoods depend on their ability to use the surrounding biodiversity. The environment is not suitable for large-scale crop agriculture, therefore, people have to use forests for fodder, fuel, and wood, and wildlife for food and cash income.

Today, most of the *Impenetrable* is forested and inhabited by peasants who live in approximately 210 small settlements (of one to seven households, mode = 1) spread out in the forest. The average household size in the rural area was 5.8 (SD = 2.4, n = 58). A typical ranch has a house built with mud and wood, corrals for cattle and goats, and a small deforested area (from 1 to 20 ha) with crops, mainly corn and squash, that are used for domestic consumption. The rest of the ranch has forest in different levels of deterioration and exploitation. All rural households own cattle, goats, and chickens, and many have pigs, sheep and other farm birds. Livelihoods of rural peasants are based on a combination of a variety of activities: wage-labor, cattle and goat ranching, logging, charcoal production and fuel wood production. Ranching has been the main activity since the colonization of this region. However, forest exploitation started to become more important during the last few years. By 2003 the small-scale commercialization of cattle was the primary means of gaining revenue for about 50% of rural households, and small-scale exploitation of forest for about 40% of households. The rest were obtaining their main income from wage labor and jobs.

Traditional animal husbandry has been a free-range system, without delimitations of grazing areas, water sources, or regulation of number of animals per household. Some

households have fewer than 20 cows whereas others have about 500, however, all practice small-scale commercialization of cattle. Peasants raise cows and goats at the same time, grazing is continuous, and there is minimal cattle management and health monitoring. Cattle survive feeding on the forest and using natural ponds until these dry out. In the dry months, cattle return to the settlements where they use the water that people collect in reservoirs during the rainy season or water obtained from wells. In years of severe droughts, reserves of water are not enough for consumption of households and for cattle resulting in high mortality. Goats also feed on the forest but range close to the settlement and return to it every day. Goats are used for household consumption, and a few families (less than 10%) sell young goats.

Colonization of the Impenetrable

The *Impenetrable* is one of the driest and most unproductive areas of the semi-arid Chaco. This is one of the reasons why it remained as state land until recently (Saravia-Toledo 1984). Provincial Governments have promoted colonization and development of this region through construction of roads, wells, aqueducts and the establishment of villages (Saravia-Toledo 1984). Although the land was state property, access was unregulated and open to everyone who wanted to settle in this region. The largest migration into the *Impenetrable* was between 1920 and 1960 with the expansion of railroads and the logging exploitation by British companies (Saravia-Toledo 1985). Peasants looking for land came from other parts of the Chaco, especially from the south and west neighbor provinces of Santiago del Estero and Salta. Some arrived to the region

as workers of large logging companies and then settled in the region, while others were looking for new land where they could raise their cattle. Many of them were previously living in other regions of the Chaco where food for cattle in the forest was exhausted and human density was increasing to a point where each family was not able to have enough cattle. Elders explained how they would walk long distances into the forest, some times for days, until they decided at some point to settle down and create their new home. The main criteria they had in mind to choose a site was that there would not be other settlements so close that their cattle ranging areas would overlap, and that it would have natural water holes or the possibility to obtain drinkable water from underground reservoirs. The use of this distance criterion created a regular pattern of distribution of settlements with an average distance of 5 km to each other. The government made some wells as an incentive for colonization of the region, also at distances of 5-10 km away from each other, maintaining this scattered distribution pattern. After an initial cleaning of the area, the pioneers brought their families, built homes with wood and mud, brought their livestock, and established their homes. Although the state did not regulate settlements or grazing, peasants were expected to pay to the government a “right to pasture” fee that was proportional to the number of cattle owned. Very few peasants paid this fee and there was no enforcement. This process of colonization is still ongoing, although more slowly, with peasants arriving from other parts of the country or with the descendants of the older settlers who are looking for new land to start their own ranches.

Private Property and Rules-in-Use

Land in the *Impenetrable* has gone through changes in land tenure systems in less than eighty years. Initially, all land belonged to the state but access was unrestricted. Since 1982, the provincial government has fractioned and put up for sale about 2 million hectares (Saravia-Toledo 1985), and promoted privatization in two ways. On one hand, the government provides incentives to local peasants for acquiring the title to the land they have been living in for long time, and on the other hand, it is selling large portions of state land to non-local people and livestock ranch companies. Because this process of privatization is recent, today I have different phases of land tenure. There are peasants occupying land without title, peasants with small portions of land adjudicated, peasants with title to land, and non-local ranchers with title to large properties.

Acquisition of land title by local peasants: During the last two decades, local peasants who live in this region have been given the opportunity by the provincial government to acquire the title to the land. The process is different for older settlers and new comers. Settlers who have been living in the region for more than 30 years can buy 250 ha of land at very low prices (1/4 of daily wage per hectare), and they can buy additional land at higher prices (about two daily wages/ha). Children of settlers and recent settlers (less than 30 years) also can buy land at this latter price. The process has through three phases: Solicitation of land title by peasants, adjudication of the land by the Institute of Colonization, and titling. The land is adjudicated to peasants after the Institute of Colonization has assessed the household situation, the limits of property have been

marked, and peasants have paid a certain portion of the total price. Most peasants acquire the land surrounding the settlements where they have lived for several years. However, some are adjudicated land that is far from where they live. In those cases, some peasants move to their new property and others stay in their existing settlements and continue using the land they occupy. To acquire the final title, peasants have to pay the full price of the land and are required to make "improvements" such as building their houses with bricks and concrete and fencing the property. However, by 2003 none of the local peasants interviewed had fenced their property or changed their house construction. Some people mark the limits of the property by bulldozing a strip of about 5 m around their properties while others leave it unmarked. By 2003, most rural households (70%) owned or were in the process of adjudication of land ranging from 250 ha to 3500 ha, with a mode of 250 ha and a mean of 1029 ha (SD = 934.5, n = 58). Of these, 48% owned or had adjudicated less than 500 ha, 28% between 500 and 1500 ha, and the rest had more than 1500 ha.

Privatization by companies and large absentee owners: The national economic crisis of 2001 increased the value of cattle and agriculture products for export because of the devaluation of the national currency. Thus, previously marginal land such as the *Impenetrable* acquired more value given the high prices and scarcity of land elsewhere. At the time of our fieldwork, the process of acquisition of land by companies and by non-local ranchers was starting and rapidly accelerating. During the last field season in 2003 I observed an extraordinary number of non-local people in the town where the Institute of

Colonization is located. These people buy large portions of land (from 1500 to 10000 ha) from the government or from local peasants. The new owners do not live on site but have employees that can be either local or non-local people. After buying the land, the first things they do are build fences and remove livestock of local people that may be grazing inside. Then, some engage in extractive activities such as forest exploitation or livestock ranching, while others do not use the land in any way. Most of the new large properties I observed had posted signs on their limits prohibiting hunting. According to officials of the Forest Institute, forest exploitation in these properties is subjected to the same regulations as for peasants. I observed however, people on several of these large properties doing intensive deforestation and replacing forest by pastures. Interviews with some of the new owners revealed that their expectations were to eventually replace all the forest with pastures for cattle ranching. The style of livestock management in these properties is different than the traditional system of local peasants. The new system is more intensive, based on fencing and cultivating an exotic grass resistant to droughts, which allows ranchers to have a larger number of livestock. This system requires high investments of capital for fencing, bulldozing, cultivating and obtaining water. For this reason, this intensive livestock ranching it is not within the reach of local peasants.

The role of resource mobility

To understand how mobility influences the governance regimes CPR users adopt, in this section I describe some CPRs that vary in their degree of mobility and that are important parts of peasants' livelihoods. Based in the findings by Schlager et al. (1994) I focus on

how mobility affects the severity of the appropriation and provision problems users face, how users try to resolve those problems, and the institutional arrangements they are able to develop and implement as a result.

Forest and Wildlife harvest before and after land privatization

Forest exploitation

During the colonization of this region resident peasants were not able to exploit the forest legally for commercial purposes. However, the forest was heavily exploited during the 1940s by logging and charcoal companies working under concessions granted by the provincial government, with regions closer to main roads and towns suffering the most intense exploitation (Saravia-Toledo 1985). This forest exploitation largely affected the options that peasants have today. Those settlements where the forest was more intensively exploited cannot profit from forest exploitation today, since most valuable species have been removed and replaced by thorny bush species. For several years, companies were exploiting the forest regardless of the presence of peasants. Peasants said that they were unable to stop these companies from logging next to their settlements. Instead, they found ways to temporarily benefit from this situation by working for those companies or selling products to their workers.

With the process of land acquisition, commercial exploitation of forests became available for resident peasants. Exploitation of the forest is currently been done on a small scale by local peasants, under the regulation and control of the government. Charcoal production and logging for posts is generally a family enterprise, although some

families who do not have enough young males have to hire people. Households that have the title to their land or are in the process of acquiring the title can exploit the forest after presenting to the Forest Institute a forest management plan delineated by a professional. This plan, following governmental regulations, specifies where and how much of the forest will be exploited. Landowners cover the costs of the plan. The forest can be exploited once the land has been adjudicated, without the requirement of having the title. Forest exploitation by locals is encouraged by the government with the acquisition of land so that peasants will obtain enough income to pay for the total price of the land. In recent years, the increased value of forest products for export has provided additional incentives for forest exploitation. However, the scale of forest exploitation practiced by locals is still small, limited in part by economic and logistic constraints, and in part by the need to maintain the forest as forage for livestock. By 2003, many households had not begun to exploit the forest even when they legally have the capacity to do so. Without having started the process of land acquisition, peasants can not exploit legally the forest for commercial purposes. Peasants who have not acquired the land cannot exploit the forest, however, they can cut trees for building houses or corrals, charcoal production, fuel wood or wild honey harvest.

Perception of ownership of the forest has changed concomitantly with the adjudication of properties. While in the past peasants did not hold rights to benefit from forest exploitation and could not control access to it, today trees on their lands are considered private property and recognized as such by most settlers. Even though most property limits are not marked, peasants are now aware of them. As a consequence of

past intensive exploitation of forests by companies, not all peasants have valuable species to log within their properties. For this reason, conflicts among peasants are starting to emerge because of trespassing and illegal logging. Conflicts also emerge when peasants have been adjudicated land that is not the site where they currently live. Thus, they have no means to control and limit access to their property. The most common way that locals are dealing with conflicts among them is to seek third-party intervention. When somebody learns that there are people trespassing and logging within their properties, they contact the Forest Institute and the police. The Forest Institute and the police may send officials to the site to intervene. In other cases, peasants are starting to "patrol" the limits of their property in a regular basis. Those who live far from their property expressed resignation about the loss of trees since they cannot control access to the land. The adjudication of land to peasants has affected also the relationship between locals and logging companies. Logging companies can no longer operate on land that is currently in the process of acquisition by locals or under private ownership, unless they have permission from the owner. Logging companies however, continue operating on the remaining state lands.

Wildlife exploitation

During almost 20 years, commercial hunting of wild species for hides constituted one of the main sources of income for rural people in the *Impenetrable*. This source of income disappeared when the market for hides decreased and the Argentinean CITES authority prohibited export of hides during the 90's (Barbarán 1999). Local men reported that they

dedicated more time to hunting than to their livestock or farming during the time of commercial hunting. They also recalled that there were no rules, either formal or informal, to regulate hunting. Hunters moved in a large range around their homes without recognizing neighbors' properties, and would hunt or put traps anywhere they wanted. People said that they hunted as much as they could because it represented a quick and easy way to obtain income, without much work. For example, trading one skin of a wild cat (*Felis geoffroyi*) would provide enough money to purchase food for one week. People would keep the hides in their houses and wait for buyers from towns who would visit them frequently, often exchanging pelts for merchandise. Hunters from nearby towns and cities also used to hunt and trap animals anywhere in the rural region. These hunters would camp close to a settlement and spend days harvesting wild animals with no need to obtain permission from the locals. Because these hunters had better technologies, worked in groups, and were completely dedicated to this activity, they were able to hunt many more animals than locals. Local peasants said that depletion of species of value was evident after these hunters have been in a site for several days. However, they could not deny access to them because of the absence of ownership of the land: "The land and every natural thing on it belonged to everybody".

After export of hides was banned commercial hunting decreased because of the lack a market rather than governmental control. People, however, continued hunting for food, and hunting declined as hunters harvested fewer individuals and focused on edible species. However, some species continued having commercial value in the black market for pets (parrots) and meat (armadillos) and today they continue to be exploited by local

and outside hunters. Although state laws regulate hunting, due to the lack of enforcement capabilities, locals continued practicing subsistence hunting in an unrestricted way in terms of species, season, number of animals harvested per hunter, and places to hunt.

The acquisition of ownership of land has produced an evident change in how people perceive the right to use different species of wildlife. These different perceptions are related to the commercial value and to the mobility of the species:

a. Stationary

Parrots have high commercial value for export as pets and the government has developed harvest restrictions. Parrots are harvested by local peasants as part of a project designed by the federal wildlife agency. This agency regulates the collection of parrots and their commercial sale. Some locals receive an important amount of cash from this activity, equivalent in 2003, to about two months of work at minimum wages. Only households that have land adjudicated can participate in this project, and they can only harvest a given number of parrots within their property limits. The number of parrots allotted to each landowner is determined by government officials. Although adult parrots are highly mobile, the time for harvesting is when chicks are still in the nest and thus immobile. During breeding season, peasants can adequately estimate the number and location of nests within their property. Peasants were unambiguous when responding that parrots belong to the owner of the land where they are nesting, and can only be harvested by the landowner. It is interesting to notice that people did not show concern about the survival of adult parrots. Adults were often

killed because they were considered pests, and trees that could be potential nesting sites were cut down without special consideration.

As long as peasants can find enough nesting parrots within their private property no appropriation problems emerge among harvesters. However, killing adult parrots and logging practices are creating provision problems that could reduce the size of the reproductive stock and number of potential nesting sites the following year. Conflicts emerge when people cannot obtain the maximum number of permitted parrots within their property limits, and therefore trespass on somebody else's property to complete their allocated quota. Another source of conflict is when households that are not participating in the project harvest parrots for the illegal market. In the illegal market, parrots are worth much less than within the project. Thus, these people need extensive areas of forest to harvest large number of individuals to make their effort worthwhile, and therefore, they often trespass into other people's properties.

b. Low mobility

Allocating private property to land has also changed the way peasants perceive the rights to harvest wildlife species of low mobility and small home range sizes. Some of these species, such as armadillos, are a favorite source of meat. There are six species of armadillos used for food in this region, and their home ranges vary to up to 90 ha (Parera 2002). When people obtain title to their land these species are perceived as a resource that can be privately owned. People clearly stated that armadillos inhabiting their property belong to them. However, the way locals react when they find

somebody hunting armadillos within their property is variable. When confronted with this question, responses varied between letting intruders hunt because it would be rude otherwise, and asking them to leave. Others responded that they negotiate, asking intruders to hunt only a few individuals, or share the harvest.

Although local peasants who have land adjudicated do not always restrict their neighbors from having access to their land to hunt armadillos, they do show a clear change of attitude towards commercial hunters from nearby towns and cities. While in the past these hunters would harvest armadillos anywhere, today they find it more difficult. Most (80%) of the interviewed peasants who have land adjudicated did not allow access to commercial hunters into their properties, recognizing the damage they can do to the local armadillo population.

In sum, by being able to estimate the status of the armadillo population located within their property based on observation and number of burrows, peasants are able to develop use and access rules for different types of users (locals and commercial hunters), and thus avoid provision and appropriation problems in the short term. Peasants expressed concerns for the future of armadillos as an important source of food. This seems to suggest that they have the ability to develop adequate information for the management of this resource. However, it is still unclear whether locals are changing their own hunting patterns within their properties, since variables such as abundance of armadillos and hunters' attitudes are confounded. People mentioned that they are harvesting less armadillos than in the past, and at the same time that armadillos are less abundant.

c. High mobility

For highly mobile species that have large home ranges such as peccaries, the situation is different. The high mobility of peccaries helps to generate severe provision and appropriation problems among users. Home ranges of peccaries are much bigger than each household's land holding and thus local users are unable to develop information about the behavior of the peccary population and of their fellow users. Local peasants did not show a change of attitude and perception towards the rights to use these species related with the acquisition of land ownership. When asked about ownership of peccaries, people unequivocally responded that these animals do not belong to anybody. Peccaries have home ranges that vary between 600 and more than 3000 ha (Sowls 1997, Taber et al. 1994), surpassing the mode property size of 250 ha. White-lipped peccaries are the most mobile of all the game species of the region. This species has been classified as migratory or nomadic, traveling in large herds (Sowls 1997). Local people mentioned that these animals pass by their properties and it is unpredictable where and when they will pass. Therefore, people try to avoid missing the opportunity to hunt them when a herd passes by their property, and they kill as many as they can. The number of individuals killed per event is limited by logistic constraints, such as the capacity to bring the harvested animals back to the house.

Discussion

In establishing systems of property rights in order to solve environmental problems, policies should be designed to fit the cultural, economic, geographic and ecological context (Hanna *et al*. 1996). During the last decades, there has been a strong tendency for the privatization of traditional community land and government-owned land, with one of the objectives being to increase protection and sustainable use of natural resources (Feeny *et al.* 1990, Barnett 2001, McKean 2000). However, privatization is generally implemented without enough assessment of the validity of its assumptions (Gibson et al. 2002). For example, it has been observed that securing private property does not ensure conservation since owners may exploit their resources when doing so brings the highest financial benefits in the short term (Acheson 2000). Although private property can facilitate the emergence of access controls, it cannot be assumed that it will inevitably facilitate the appearance of use controls that will lead to conservation of natural resources.

This study indicates that characteristics of the resource influence the way that natural resources are used, regardless of the property regime. This finding is consistent with the common pool resources theory, which indicates that the appearance of access controls is not related to a single property right regime, but to specific characteristics of the resource and the people using the resource (Ostrom 1990). Depending on the presence and specific nature of these sets of factors, people will be able to find incentives to engage in collective action to manage the resource (Ostrom 2001). In the *Impenetrable*, uses of some resources have changed since land has been privatized and seem to be managed in a

more controlled manner. However, even though land tenure is held privately by many peasants, some species of wildlife continue to be managed under open access, which is generally incompatible with sustainability. I have argued that this is partially determined by the degree of mobility of the different resources.

In the *Impenetrable*, appropriation problems of non-mobile resources such as trees and parrots' nests have been partially solved by privatization of land. Local owners can now control the access of non-local hunters, can negotiate with neighbors and with logging companies, and make decisions about what resources they want to exploit and how. This is an evident change since the times when there were no restrictions on hunting and locals and non-locals exploited all wildlife as open access, and logging companies were operating anywhere. This process of change however, has not been free of conflicts. New conflicts have emerged and are related to assignment problems (Schlager et al. 1994). Valuable trees and parrot's nests are not homogeneous but distributed in patches, as a consequence of past exploitation activities. Thus, by restricting logging and parrot harvests within peasants properties, users do not benefit equitably. Technological externalities also have emerged given the differential technology that local and non-local owners have available. Large owners can make use of natural resources, such as timber and grazing, in a more intensive way. Thus, they are imposing extra operating costs on local peasants because fewer resources, in this case grazing areas, are available for them (Schlager et al. 1994).

Mobility affects the type of information that users can gather about the resource (Schlager et al. 1994). Thus, for species with small home ranges and little mobility,

peasants are likely to be able to develop some indicators of the condition of the resource that allows them to make calculations about harvesting rates, and predictions of future availability. For instance, as they learn that armadillos might remain within their property, their perception of ownership seems to be changing. Peasants are starting to consider armadillos as private property and to manage them as such. This is manifest as an increased tendency to deny access to non-local hunters or to engage in bargaining with other local peasants. Thus, peasants' ownership of land titles allows them to control access to hunters, and thus potentially increase the likelihood of conservation. Acquisition of land title has not yet produced evident changes of individual behaviors in terms of restraining practices with the intention to avoid the overexploitation of armadillos. However, by just controlling access to hunters they may reduce overall hunting pressure, which in turn may lead to a more sustainable use, even in the absence of a change in local hunting patterns.

The privatization of land tenure by locals has not solved the problem of overexploitation of the most highly mobile species. When information on the biology and dynamics of this type of resource (distribution, movements patterns and reproductive rates) and its users (local, subsistence, non-local or commercial hunters) cannot be easily gathered, appropriation problems may be so severe that they preclude any management regime from developing, as has been remarked by Schlager et al. (1994). Thus, the peccary population is subject to the tragedy of open access. Because of their high mobility, peccaries are transitory in people's properties, thus creating only a short-term opportunity to hunt them before they move away on to somebody else's property.

Without the ability to develop information about future returns, private property owners are likely to face incentives to take as many peccaries as possible while these are within their property. Under such conditions, conservation of peccaries will not succeed, unless institutional arrangements are created that allow for the development, sharing, and coordination of information among all users involved.

When considering the situation of small landowners coexisting with wildlife in the *Impenetrable*, it becomes evident that species mobility is an important behavioral characteristic to take into account when designing institutional arrangements for wildlife conservation. Because wildlife vary in their degree of mobility and local people use a variety of wildlife species to sustain their livelihood, it follows that no single property right regime will be sufficient to support wildlife conservation. Similar circumstances have been described for wildlife in Africa (Naughton-Treves and Sanderson 1995).

Privatization by rich absentee owners or companies may produce the most dramatic changes in the use of natural resources in the *Impenetrable*. How this regime of privatization will affect wildlife is unknown, but I can speculate that it may have two opposite influences: directly decreasing hunting pressure within these properties and indirectly increasing hunting pressure outside. New owners prohibit local people from entering their properties. Thus, hunting probably will be reduced to each local hunter's property, whereas the large private properties may act as protected areas providing enough habitat for large home range species if the forest cover were to remain. If, however, they remove the forest, then wildlife will be affected mainly by habitat lost. On the other hand, fencing of large private areas affects local people's livelihoods by

reducing their actual grazing areas and by producing inequality in the distribution of natural sources of water. For example, two of the families with whom I worked had to reduce their livestock by half when the grazing area for their cattle decreased after being surrounded by large properties with fenced boundaries. These people's economic situations may worsen and they may have to increase their hunting activities to obtain food. It has been found that in this region, as well as other parts of Latin America, poorer households tend to consume more wild meat than richer households (Altrichter Appendix D, Ojasti 1996).

Other assumptions of privatization also should be addressed. Overgrazing in the Chaco apparently has been the major factor degrading the ecosystem and lowering productivity since the colonization by peasants (Morello and Saravia Toledo 1959a, 1959b, Morello and Hort 1985, Bucher *et al*. 1998, Bucher and Huszar 1999). However, under the traditional land use system of the rural peasants, the ecosystem has been degraded but not totally transformed into agricultural lands. This transformation is likely to occur under the new privatization regime by large owners. It is unclear how privatization of land in the Chaco by large owners will affect exploitation of natural resources. The tendency however shows that the situation will lead probably to overexploitation of the forest for immediate economic return from commercialization of wood and charcoal and concomitant opening of space for pasture (Torrealba et al. 2003, Zak et al. 2004). On the other hand, the way that privatization by non-locals will affect the use of natural resources and the livelihoods of local peasants is an issue that needs to be further addressed. Whether this form of privatization will lead to sustainable

exploitation of the forest is unknown. It largely depends on the quality of the management plan developed by the government, and its capacity for control and monitoring. If what has been observed in this research and in other research conducted in the Argentine Chaco region (Zak et al. 2004) is an indication of the future, I can predict that this situation of unequal distribution of land and resources may increase poverty of local peasants. This may force peasants to increase pressure over other natural resources, or eventually, sell their properties and abandon their lifestyle.

Conclusion

Securing land tenure is considered an important step towards sustainable use of natural resources (Barnett 2001). This, however, may be conducive to sustainability in some cases but not in others, depending on characteristics of the resource in question, such as mobility. The case of privatization of land tenure and CPR use by low-income peasants in the Argentinean Chaco shows that the degree of mobility of the resource differentially affects the productive benefits that private property regimes can offer. In this setting, the assignment of private property rights has resulted in a more efficient control of use of forest and wildlife resources only when private property rights match the mobility and home range size of the species. Successful conservation of resources of high mobility and large home range will not be able to take place under a private property regime. Adopting an adequate property right regime will show best results when policies can help users to address provision and appropriation problems so that they can organize their use of resources.

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