

Combining ecological aspects and local knowledge for the conservation of two native mammals in the Gran Chaco



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ABSTRACT

Land use changes in the South American Gran Chaco affect native fauna and the ecosystem services (ES) they provide. The consequences of defaunation and the empty forest syndrome have been identified in tropical and subtropical forests, including the Gran Chaco. Local knowledge regarding native species and the provision of ES can be integrated with scientific research for a better understanding of the system and the consequences of species loss. The aim of this study was to explore whether the Pampas fox (*Lycalopex gymnocercus*) and the collared peccary (*Pecari tajacu*) use six distinct natural and modified habitat types available in the arid Chaco, their role as seed dispersers, and the rural community's perception. We found that the Pampas fox used all habitat types except intensive annual cropland, while the collared peccary used only primary forest within a protected area. Both species exhibited a highly frugivorous diet and were seed dispersers of several native plant species. Interviewees hunted both species; they perceived the Pampas fox as a pest and the collared peccary as a source of food or income. The campesino's perception and involvement is essential for the conservation of the Chacoan forest and the ES provided.

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1. Introduction

The Gran Chaco has a long history of colonization, changes in land use and interactions between wildlife and humans (Morello and Saravia Toledo, 1959). In Argentina, the Chaco is considered one of the poorest regions where small scale farmers and local people (also called criollos or *campesinos*), live in ranches interspersed throughout the forest, maintaining a subsistence economy based on goats, cattle and hunting of wild animals (Bucher and Huszar, 1999; Altrichter, 2005, 2006; Camino et al., 2016). The recent rapid expansion of the agricultural frontier has caused the loss and fragmentation of the native forest with deforestation rates as high or higher than any recorded worldwide (Zak et al., 2004;

Boletta et al., 2006; Hoyos et al., 2012). As a consequence of these rapid changes, the associated fauna and local people that depend on forest resources are also affected (Cáceres et al., 2010).

Some scientific studies carried out in the Gran Chaco have included indigenous communities and their relationship with the environment (Martínez, 2013; Camino et al., 2016), while a few have also incorporated the knowledge of *campesinos* (Altrichter, 2005, 2006). In this region of Argentina, *campesinos* still live from the collection and consumption of different forest fruits and wildlife and the local fauna is an important source of protein for many groups living outside urban areas (Barbarán, 2003; Altrichter, 2006). Previous studies have been oriented to evaluate which fauna species are hunted and their importance in *campesino* reproduction strategies, providing valuable data on socio-economic aspects and uses of the different animal species by indigenous and rural populations (Barbarán, 2003; Altrichter, 2006). In this sense, the knowledge of a natural system, its components and species, acquired through extensive observation, utilization and management, derived from the experience and traditions of long-time

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users and residents, is interesting to complement ecological studies. This traditional ecological knowledge refers to all types of experiences and ideas learned about the environment, which are passed down through oral tradition or shared among users of a resource (Huntington, 2000). This knowledge of the role of animals in ecosystems, which reflects the values and attitudes adopted by a community regarding their local fauna, should be considered especially when designing conservation strategies (Camino et al., 2016; de Melo et al., 2014). Multidisciplinary studies generate ethno-ecological knowledge that is important in understanding the interests of local communities, and at the same time, broaden the ecosystem view of human actions in the territory (Renoux and Thoisy, 2016).

Native mammals provide different ecosystem services (ES) to humans, including food, cultural values, as well as the regulation of ecosystem dynamics (Carpenter et al., 2009), for example as predators or dispersers of seeds in the landscape (Cardinale et al., 2012; Galetti and Dirzo, 2013). The loss of these ES is a consequence of rapid land use changes taking place in forests worldwide, with defaunation and the empty forest syndrome being widely documented (Redford, 2009; Wilkie et al., 2011; Corlett, 2012; Dirzo et al., 2014), including for the Gran Chaco (Periago et al., 2015). Hunting and habitat loss are the main threats to Chacoan mammals, with most medium-to large-sized mammals suffering from some level of threat internationally or nationally, and negative population trends (Periago et al., 2015). Subsistence hunters in the Chaco prefer peccaries, deer and armadillos, among several other species (Bolkovic, 1999), whereas foxes and other carnivores are heavily hunted because they attack domestic species and, historically, for their skins when these were commercially valuable (Periago et al., 2012; Tamburini and Cáceres, 2012).

However, there is a lack of information regarding the presence of native mammals and the functional roles they play in the Chaco, as well as the consequences of their potential loss. Local knowledge regarding these species and their relationship with the provision of different ES can be integrated with scientific research for a better understanding of the ecosystem and the consequences of species loss. Two species that provide ES in the Chaco that are currently threatened by habitat loss and hunting in the Chaco are the Pampas fox *Lycalopex gymnocercus* and the collared peccary *Pecari tajacu*.

The Pampas fox inhabits the grasslands, wooded savannas, deserts and open forests of Argentina, southern Bolivia and Brazil, Paraguay and Uruguay (Jiménez et al., 2008). Despite its occurrence all over Argentina, few studies describe its general ecology, habitat use and diet in the Chaco (Varela et al., 2008). Its diet includes invertebrates, fruits of domestic as well as native wild plants, carion, and household refuse (Lucherini et al., 1995; Varela et al., 2008). Foxes are considered legitimate dispersers, since germination is often found to be equal or higher among seeds defecated by foxes (Bustamante et al., 1992; Campos and Ojeda, 1997; Varela, 2004). Foxes are intensively hunted as a means of reducing predation on domestic animals and small livestock, and to a lesser extent for their skins, although the latter depends on hunting regulations at the national level and international market prices (Funes et al., 2006; Ramadori, 2006; Porini and Ramadori, 2007; Tamburini and Cáceres, 2012). For example, during 2006, the exports of hides of several species of foxes increased significantly, with approximately 30,000 of the 334,000 fox skins exported corresponding to *L. gymnocercus*, obtained mostly from the central and northern regions of the country, including Córdoba Province, and the species is currently listed in Appendix II of the CITES Convention (Porini and Ramadori, 2007). However, foxes have shown resilience to intense hunting pressure in some areas (Funes et al., 2006) and the Pampas fox is listed as of “least concern” in national and international Red Lists (Jiménez et al., 2008; Ojeda et al.,

2012). In Córdoba province, hunting of foxes for skins is practically non-existent since the commercial value of fox skins has decreased and there are more government controls based on national regulations (Tamburini, 2016).

The collared peccary is distributed from southwestern United States to central Argentina, with records in all countries except Chile and Uruguay, and in a variety of environments from deserts to tropical forests (Gongora et al., 2011). It is currently found in the north and center of Argentina, particularly in forests, humid savannas and dry forests of the Chaco and Monte ecoregions (Ojeda et al., 2012). However, peccary populations are declining throughout the Neotropics (Beck, 2005), with hunting and deforestation in the Argentine Chaco threatening populations in their southernmost distribution (Altrichter, 2005). Therefore, while the collared peccary is considered of “least concern” at an international level (Gongora et al., 2011), it is considered “vulnerable” at a national level (Ojeda et al., 2012). Despite being considered an omnivorous species, the collared peccary has a preference for food of plant origin, particularly in the forested parts of its distribution (Keuroghlian and Eaton, 2008). Throughout its distribution, the species consumes fruits, leaves, flowers, stems and roots of various native, and sometimes cultivated plant species, with a marked selection of succulent plants in drier regions (Beck, 2005). Across its distribution, the collared peccary is considered both a seed predator and disperser, depending on the size of the seed consumed (Beck, 2006; Keuroghlian and Eaton, 2008; Lazure et al., 2010). However, the role of the collared peccary as a seed disperser in the Gran Chaco has not been evaluated.

Peccary species (*Catagonus wagneri*, *P. tajacu* and *Tayassu pecari*) are most commonly hunted for food and hides by rural and indigenous people of Latin America (Altrichter, 2006). In the Argentine Chaco, studies have found that habitat destruction and hunting can devastate peccary populations, especially when acting together (Altrichter, 2005). The presence of the collared peccary in the Argentine Chaco has been associated with high forest cover and low number of settlements (Altrichter and Boaglio, 2004), with mean population density more than three times higher within protected sites (Altrichter, 2005).

The aim of our study was to gather information regarding ES provided by the Pampas fox and the collared peccary, using a combination of evidence-based science and surveys to local people. Our specific objectives were: (1) to explore whether different habitat types available in the arid Chaco, with varying degrees of human intervention, are used by populations of the Pampas fox and the collared peccary; (2) if so, to determine if the species are seed dispersers; and (3) to incorporate local knowledge regarding the Pampas fox and the collared peccary, including the habitat types they occupy and the ecosystem services they provide.

2. Methods

The study area covers approximately 2100 km² and is in western Córdoba Province, Argentina (Fig. 1). It is located in the south-western semi-arid portion or “arid Chaco” (Cabido et al., 1994), with a large water deficit and a climate characterized by high summer temperatures and mild winters with broad thermal amplitude. The original vegetation is dry woodland with predominance of woody evergreen and deciduous species (Cabido and Pacha, 2002). Six habitat types present in the study area were included, identified as being derived from a matrix of vegetation, topography and soils that were initially homogeneous and then subjected to different land use regimes (Conti and Díaz, 2013). Habitat types were identified by vegetation structure, composition and biomass: primary forest (PF), secondary forest (SF), closed species-rich shrubland (CS), *Larrea* shrubland (LS), logged pastureland (LP) and intensive

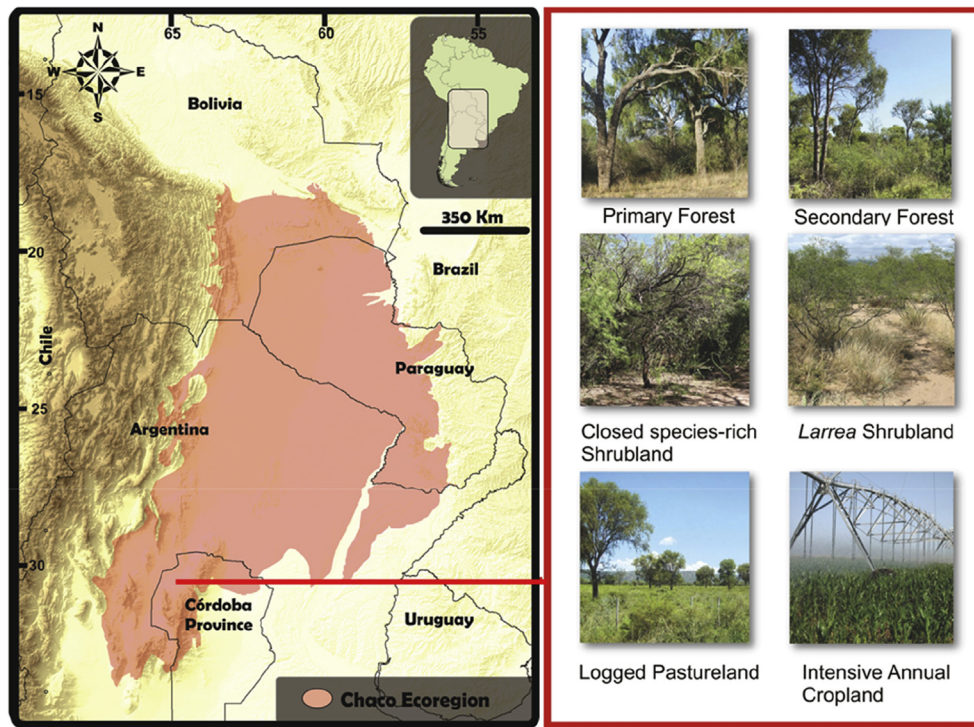


Fig. 1. Study area and habitat types of the arid Chaco of western Córdoba province (Argentina).

annual cropland (IC) (Fig. 1). Plots were surveyed in winter (dry season), spring (driest season) and summer (wet season) for two years (2009–2011). Four permanent plots of 3.14-ha were set up within each habitat type, covering the largest possible heterogeneity within each, and separated by at least 1 km. PF plots were all located within Parque Natural Provincial and Reserva Forestal Natural Chancaní. Permission to access Chancaní Reserve was granted by the Secretary of the Environment of Córdoba province and permission to access private lands was granted by the landowners.

2.1. Animal data

Fresh feces belonging to the Pampas fox and collared peccary were collected in each plot, stored in paper envelopes and transported to the laboratory. Vegetation characteristics were concurrently estimated by averaging measurements taken at four random points within each plot: % bare soil, canopy and herb cover, distance between trees, number of trees and shrubs. Additionally, distances from each plot to the closest road, settlement and water point were calculated using ArcGis (9.3). Since the count data did not present a normal distribution, habitat use was analyzed using generalized linear models with Poisson and quasi-Poisson distributions (if dispersion > 2) (ver Hoef and Boveng, 2007). The selected variables were not correlated ($|r| > 0.7$; Dormann et al., 2013) and the best model was determined using the dredge function *MuMIn* in R (R Development Core Team., 2013).

Site selection was determined as being preferred, rejected or random using resource selection functions (RSFs) (R Development Core Team., 2013). RSFs are functions that are proportionate to the probability of use by an organism (Manly et al., 2002) and are a type of habitat suitability index with statistical rigor, since they are estimated directly from data. *Use* is defined as those plots where feces were found and *available* are those in which they were not. If what is available is equal to what is used, then there is no selection;

if the use is greater than that available, then there is selection and if it is less, then there is rejection. If the confidence intervals do not overlap 1, then the selection or rejection is statistically significant (Aho and Bowyer, 2015).

Each fecal sample was dried at room temperature and sieved to separate seeds from other fecal matter. To avoid overestimating the amount of each item in the diet, the number of seeds found in each sample was divided by the average number of seeds in a fruit of each species (averages were obtained from literature and collections: Varela, 2004; FAO; Universidad Nacional de Salta; Universidad de La República-Uruguay). Ten seeds of each species from each sample (or the total amount found if <10) were germinated following ISTA rules (ISTA, 1985). The tetrazolium test was carried out in seeds that did not germinate in order to determine viability (Peters and Lanham, 2005).

2.2. Interviews

This region of the dry Chaco (Pocho department, Córdoba province) has a very low rural population (1.68 habitants per km²; Instituto Nacional de Estadística y Censos, 2012). The study area, which includes the town of Chancaní and 12 rural communities, is inhabited by approximately 1200 people, distributed in some 400 families. Most live in small settlements scattered in the forest with a subsistence economy complemented by livestock and firewood sales. For this study, 40 *campesinos* (heads of families) between 25 and 77 years of age that live near the habitat types sampled were interviewed. Semi-structured interviews were conducted to explore their perceptions regarding native fauna and the Chaco forest. The interviews used general guiding questions, allowing the interviewee to expand on the subject of their knowledge (Valles, 2002; Silvetti, 2010; Albuquerque et al., 2014). A non-probabilistic, intentional sampling was performed using the snowball technique for the selection of interviewees (Guber, 2004; Manzano-García and Martínez, 2017). Only males were interviewed

since hunting is almost exclusively performed by males (Alves et al., 2009; de Melo et al., 2014).

Previous data on the social valuation of ES by the local community in the region provided a basis for the survey questions (Silveti, 2010; Tapella, 2012). Survey questions (S1 Appendix) focused on (1) the perceived usefulness or value of each species; (2) the purpose of hunting activities; and (3) which of the six habitat types present in the area they thought the species inhabited. The last question included the use of photo panels of each habitat type. The objectives of this approach were, on one hand, to unify criteria when referring to each habitat type, and on the other, to learn if the interviewees could recognize the most important sites for the fauna, the reasons why the species choose one or the other (according to the requirements of the species perceived by the interviewees and by the recognition of tracks, feces, direct observations and other signs of presence), as well as the sites chosen for hunting purposes. It is important to emphasize that the interviewee could choose more than one site. Answers were then classified into benefits (e.g. uses, aesthetic value) and costs (e.g. harm). Consent for the interviews was given verbally since most subjects interviewed do not know how to read or write. All subjects were informed that their information would be anonymous and that their answers were going to be used for research. The interviewees were very knowledgeable about native fauna and many of them hunted peccaries and foxes, as well as other native species. The data were analyzed using descriptive statistics, represented by frequencies or percentages in each category of answers.

3. Results

3.1. Animal data

In total, 78 fresh fecal samples belonging to the Pampas fox and 8 belonging to the collared peccary were collected. Pampas fox feces were found in all habitat types except intensive annual cropland (IC), while collared peccary feces were only found in primary forest (PF) (Fig. 2), reason for which we were unable to analyze peccary habitat use.

The Pampas fox habitat use showed significant differences in the

seasons sampled ($p < 0.05$). Secondary forest (SF) was used more in winter than in spring, which was used more or in the same proportion as summer ($p < 0.01$). *Larrea* shrubland (LS) was used more in winter than in summer, and was used more or in the same proportion as spring ($p < 0.05$). The model that best explained presence included distance to human settlements ($p = 0.02$), roads ($p = 0.02$), shrub cover ($p = 0.003$) and distance between trees ($p = 0.042$). Distance to settlements showed a positive relationship, while the other three variables were negative, with the model explaining 32.49% of the habitat use. We did not find significant differences in the selection of different habitat types using RSFs, although there was a tendency to select SF, LS and closed species-rich shrubland (CS), avoiding PF and IC.

The Pampas fox fecal samples included a total of 6040 seeds (average 81.6 ± 82.23 seeds per sample) belonging to woody plants (trees and shrubs), herbs and corn, *Zea mays* (Fig. 3). Average volume and weight of the samples were 31.7 ml and 11 g, respectively, with seeds representing an average 37% of the total volume and 48% of the total weight. One vertebra and two feathers (unidentified) were found in three samples, with no animal parts being found in the rest of the samples. Seeds of *Acacia aroma*, *Prosopis flexuosa* and *Ziziphus mistol* were found in samples from all habitat types (Fig. 3).

Two fecal samples belonging to the collared peccary were found in spring and six samples were found in winter. For diet analysis, seven fresh samples found in other parts of the Reserve collected in winter were also analyzed. Average volume and weight of the samples were 145.2 ml and 43.4 g, respectively, with seeds representing an average of 11% of the total volume and 16% of the total weight. A total of 2079 seeds (average 138.6 ± 99.7 seeds per sample) belonging to seven different plant species were found (percent total in parenthesis): *A. aroma* (5.3%), *Acacia gilliesii* (0.1%), *Bromelia urbaniana* (0.7%), *C. ehrenbergiana* (1.8%), *P. flexuosa* (25.6%), *P. torquata* (34.4%) and *Z. mistol* (32.2%). *P. flexuosa* seeds were found in 13 of the 15 samples, while *A. gilliesii* and *B. urbaniana* seeds were only found in 2 samples. The remaining species were found in less than 2% of the samples.

In PF, the Pampas fox and collared peccary consumed a total of 5 and 7 species, respectively. Four species were consumed by both animals, with *Z. mistol* being the most consumed, and *A. aroma* and

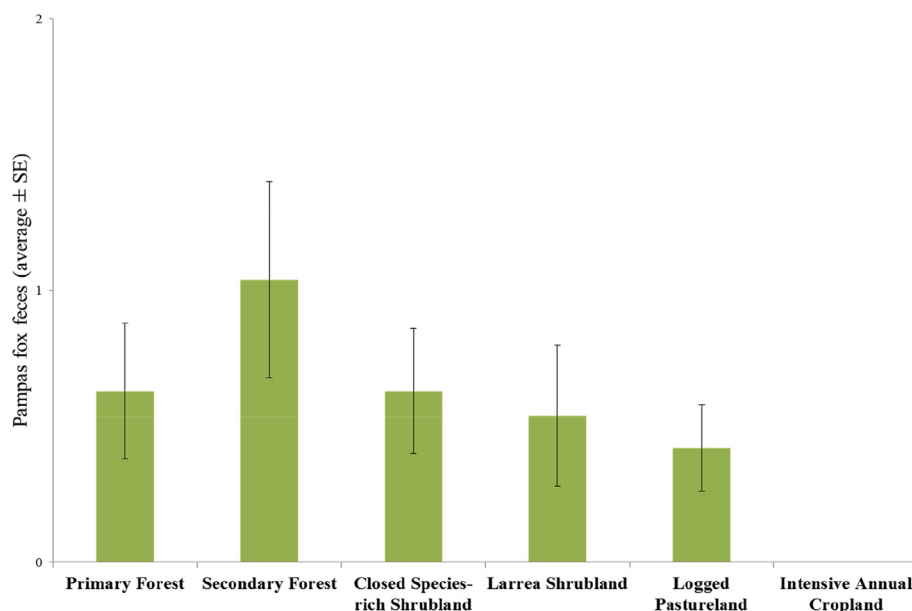


Fig. 2. *Lycalopex gymnocercus* intensity of use (average number of feces \pm SE) in six habitat types of the arid Chaco of western Córdoba province (Argentina). Differences were not significant.

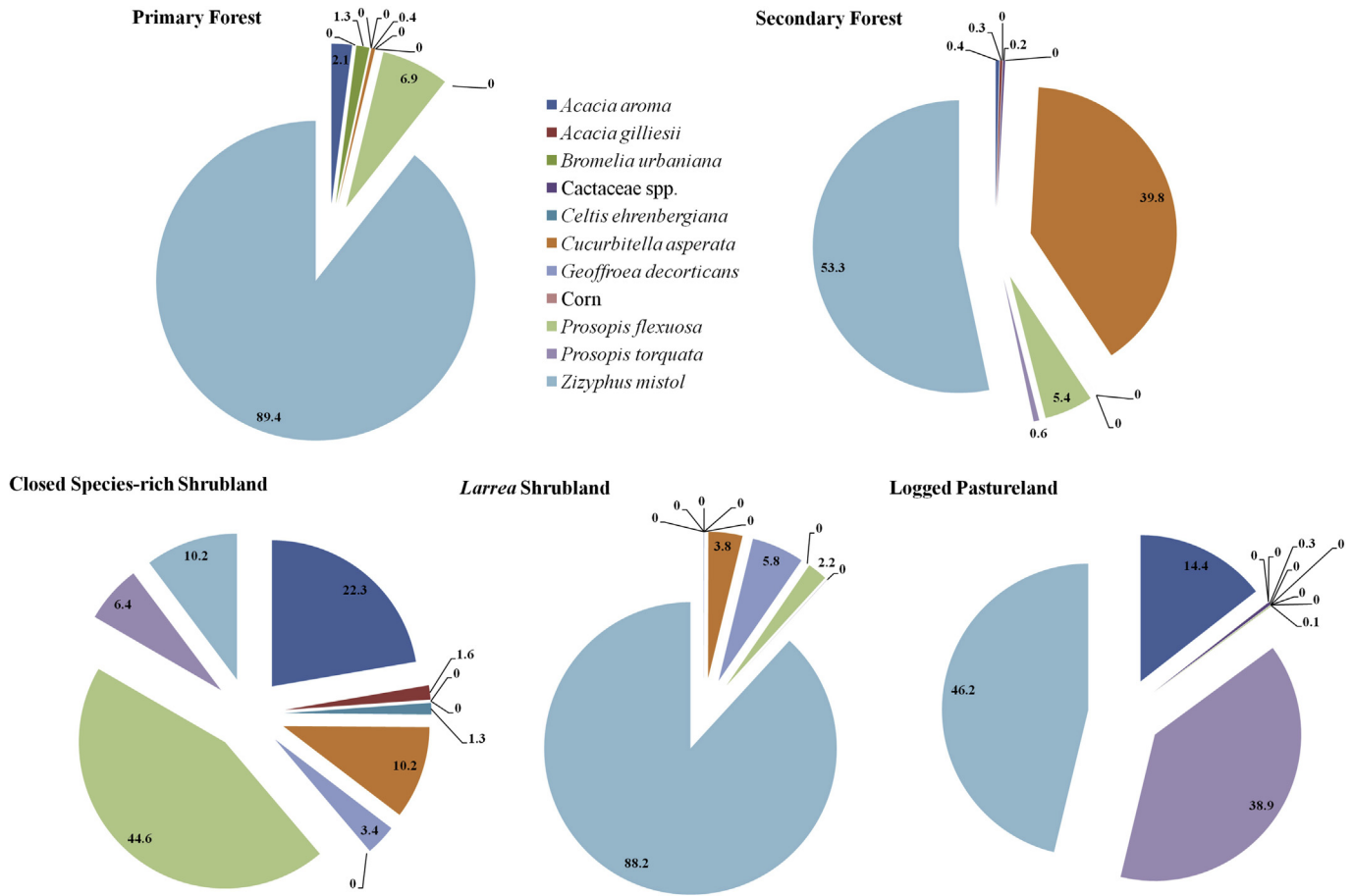


Fig. 3. *Lycalopex gymnocercus* diet (%) in five habitat types of the arid Chaco of western Córdoba province (Argentina).

B. urbaniana being consumed in small proportions. *A. gilliesii*, *C. ehrenbergiana* and *P. torquata* were only consumed by peccary, and *C. asperata* was only consumed by fox. Both mammals acted as dispersers (seeds were viable) and predators (seeds were unviable), depending on the plant species (Table 1). Viability of *A. gilliesii* and Cactaceae (viability rates >80%) and *A. aroma*, *B. urbaniana*, *Cucurbitella asperata*, *P. flexuosa*, *P. torquata*, and *Z. mistol* (viability rates >40%) were not affected by fox consumption. None of the seeds belonging to *C. ehrenbergiana*, *Geoffroea decorticans* and corn were viable, although <10 seeds where included in the germination experiments. Viability of *C. ehrenbergiana* (viability rate = 90%) or *A. aroma*, *B. urbaniana*, *P. flexuosa*, *P. torquata* and *Z. mistol* (viability

rates >20%) was not affected by peccary consumption. None of the seeds belonging to *A. gilliesii* were found viable, although <10 seeds where included in the germination experiments.

3.2. Interviews

Approximately 28% of the *campesinos* interviewed diversify their income by also raising goats and producing honey and goat milk. Around 90% of the families also receive government assistance (subsidies) (Tamburini, 2016). Only four of the *campesinos* interviewed have a formal job, as ranch hand or field manager. The *campesinos* reported hunting several native species as bushmeat or because they are considered prejudicial (Tamburini, 2016), including the Pampas fox and collared peccary. Although all species were traditionally used in the dry Chaco, the interviewees stated they consumed them significantly less today than historically. In the interviews, the Pampas fox represented one of the most unwanted animals, with 95% reporting that it kills chickens, turkeys and young goats. Also, 7.5% stated that foxes kill other wild animals that they consider food sources (i.e. rabbits). However, 27.5% also mentioned some benefits, including the commercial value of its skin in the past, and 7.5% valued its role as a regulator of other harmful animals (e.g. killing carnivore cubs, poisonous snakes). Some (42.5%) stated that they kill foxes only when foxes harmed their domestic animals. The collared peccary was valued positively for its meat (in terms of quantity and quality) by 87.5% of the interviewees, nevertheless, only 27% stated that they hunt peccaries at present (55% less than historically), mainly because hunting is an

Table 1
Percentage of viable seeds from different plant species found in Pampas fox and Collared peccary feces in the arid Chaco of western Córdoba province (Argentina). NC: not consumed.

Plant species	Viable seeds (%)	
	Pampas fox	Collared peccary
<i>Acacia aroma</i>	64	53
<i>Acacia gilliesii</i>	89	0
<i>Bromelia urbaniana</i>	40	65
Cactaceae	89	NC
<i>Celtis ehrenbergiana</i>	0	90
<i>Cucurbitella asperata</i>	44	NC
<i>Geoffroea decorticans</i>	0	NC
<i>Prosopis flexuosa</i>	78	19
<i>Prosopis torquata</i>	55	36
<i>Zizyphus mistol</i>	70	54

activity that requires certain skills and trained dogs. At the same time, they stated that with the arrival of the wild boar (*Sus scrofa*), which has expanded its range in the area in the past 10 years, collared peccary populations seem to have retreated towards mountainous or marginal areas, forcing the *campesinos* to walk longer distances to hunt peccary. In relation to the wild boar, few hunters are trained to hunt it, since it requires skill, firearms and trained dogs. Only 10% reported that they have never hunted peccaries.

The interviewees associated Pampas fox presence with all six habitat types, and considered it a highly adaptable animal that consumes a variety of food and can find shelter in a variety of habitats (Fig. 4). Nevertheless, PF was mentioned as the main place where foxes can obtain refuge. When asked about ES provided by the foxes, none of the interviewees mentioned the possibility of seed dispersal; they considered foxes to be carnivores, even though they recognize fox feces by its large seed content.

On the other hand, interviewees considered PF as the ideal ecosystem type for the collared peccary, which provides refuge and food (Fig. 4). CS was also considered an important ecosystem for this species. Some stated that collared peccaries could use IC only for food (potatoes, for example), but do not remain there for prolonged periods of time. The interviewees also described the collared peccary as a shy and surly animal that feeds mainly on cacti (leaves, fruits and roots) and fruits of *A. aroma*, *Prosopis* spp. and *Z. mistol*. 7.5% of them mentioned that collared peccary presence has decreased in some areas and attributed it to deforestation. Another threat mentioned by 10% of the individuals was the presence of the exotic wild boar (*Sus scrofa*), as mentioned before.

4. Discussion

The Argentine Chaco is inhabited by 17 native large and medium-sized mammalian frugivores and omnivores, of which nine are near threatened, vulnerable or endangered at the Argentine national level (Periago et al., 2015). However, since most of those species are not found in the area, the Pampas fox and the collared peccary are the only large-sized omnivorous mammals left. Our results coincide with that of Di Bitetti et al. (2009), which recorded more sightings of the Pampas fox in grassland and

shrubland habitats than in gallery forests. However, in our study, no feces were found in or around IC plots. Therefore, while the Pampas fox may tolerate some land use changes (Jiménez et al., 2008), complete conversion of the forest does not seem to provide the Pampas fox the resources it needs. This is in agreement with Pineda-Guerrero et al. (2015) who highlight the importance of forest cover within livestock systems and the potential of silvo-pastoral systems for wildlife species and tropical dry forest conservation in fragmented landscapes. The Pampas fox exhibited a highly frugivorous diet and it appears to play a significant role in the dispersion of dominant species of the native forest. This also coincides with studies in the region, which found fleshy fruits in almost all samples analyzed (Varela et al., 2008), and that the species was a disperser of *A. aroma*, *P. torquata* and *Z. mistol* (Varela and Bucher, 2006; Boero, 2009).

The collared peccary appears to be the least susceptible of the three peccary species to human perturbations (Altrichter and Boaglio, 2004). However, in our study, collared peccary signs were only found within Chancaní Reserve. This is worrisome in an ecosystem where the larger native herbivores and omnivores have already disappeared and considering that it was once widely found in the Chaco ecosystem (Periago et al., 2015). Even if peccaries persist temporarily in fragmented forests, they are likely to experience reduced genetic diversity, inbreeding depression, reduced adaptive potential, and accumulation of deleterious mutations (Keyghobadi, 2007). Furthermore, the potential loss of the peccary would have cascading effects on plant and animal communities in the remaining fragments (Harrison, 2011; Michel and Sherry, 2012; Galetti and Dirzo, 2013). We found that the collared peccary exhibits a frugivorous diet consisting of seven native species, although it is possible that this is underestimated (small sample size). In his review, Beck (2005) found that the collared peccary consumed up to 128 plant species in the Neotropics. In contrast, the arid Chaco only presents 64 plant species in the better conserved parts of Chancaní Reserve (Cabido et al., 1994). Still, although most of the literature has focused on peccaries as seed predators (probably due to the location of study sites and the size of the seeds analyzed), our findings, in agreement with Varela and Brown (1995), highlight the dispersal capacity of the collared peccary for six native plant species (ES).

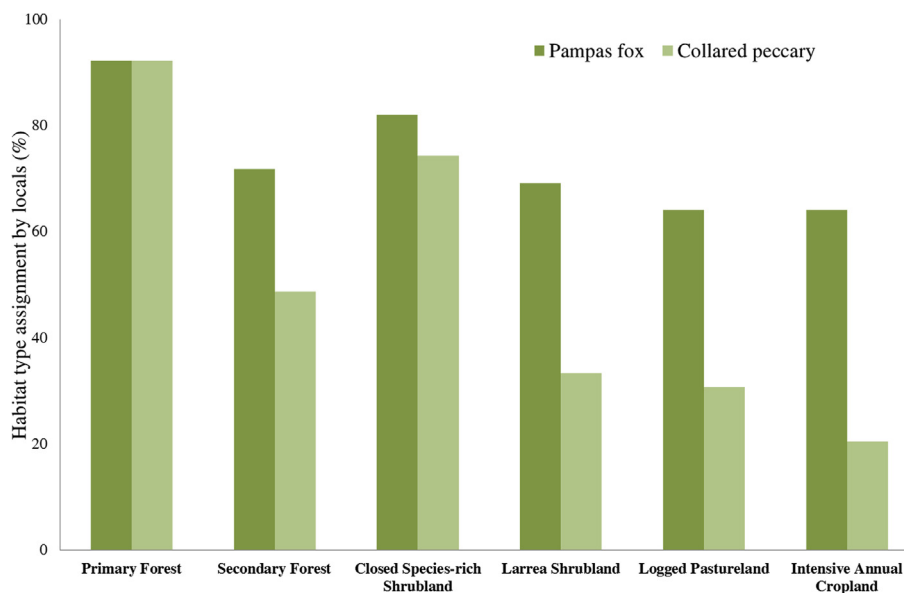


Fig. 4. Habitat types assigned to *Lycalopex gymnocercus* and *Pecari tajacu* by *campesinos* in the arid Chaco of western Córdoba province (Argentina).

In general terms, the results obtained in the field coincided with those from the interviews and indicate that *campesinos* possess a good understanding of the different habitats and associated biodiversity. In terms of age, no differences were found in the *campesinos'* perceptions regarding the species' diet, habitats preferred or general requirements. As in other similar studies (de Melo et al., 2014; Camino et al., 2016), males have more contact with the different habitats types due to the type of activities they realize, i.e. cattle care, fence repair, search of firewood, and hunting. However, we noted that, although the general information was similar among all the interviewees, there were some differences in the details given. Some *campesinos* were very meticulous in the description of the species and their habits as well as in the way they use each habitat type, while others were limited to rather general descriptions with few details. Although all the *campesinos* interviewed were hunters and knew the species and their characteristics, not all hunt with the same frequency, nor do they have the same intentionality or motivation when deciding to go to the forest in search of a prey, which is mostly for consumption. In terms of preferred habitat types for the collared peccary, while interviewees noted its presence in all habitat types and recognized that they may cross between habitats, they highlighted that PF would be preferred by the species, coinciding with the ecological findings. While the Pampas fox feces were found in five of the six habitat types, avoiding intensive annual cropland, interviewees pointed out that the species can use all ecosystems, including agriculture, as stepping stones to other habitats.

The interviewees' perception of the ES provided by these mammals (e.g. fruit and seed dispersal) differed from our scientific findings. The fox was identified mostly as a damaging species to domestic animals but also identified as an important regulator of populations of other harmful animals (ES), although its consumption of fruits and seeds or its associated dispersal role was not mentioned. In contrast, we did not find any vertebrate parts in the diet and seed dispersal (ES) was provided by the fox for five important woody species and several species of cacti. According to the interviewees, the collared peccary does not seem to be suffering a great deal of hunting pressure, with land degradation and deforestation being the driving factors most commonly identified. In the northern portion of the Argentine Chaco, peccaries are used for consumption in lower proportion than in tropical areas and other regions of the Chaco (Bodmer et al., 1993). However, since hunting of native species is prohibited, individuals may not be reporting actual hunting and consumption rates. According to Altrichter (2005), if the collared peccary is harvested only by local people, and current harvest rates do not increase, then these populations could be used sustainably (ES). On the other hand, the Pampas fox is important for local communities for regulating other harmful species, playing a key role in the ecosystem (ES), although sometimes the species can be considered a detriment. Our findings coincide with those of other authors (Camino et al., 2016), who emphasize that the rural population consider foxes (and other predators) to be a serious threat to their domestic animals.

Our study highlights the dispersion capabilities of the Pampas fox of eight native species and of the collared peccary of six native species found in the Chaco, many of which are highly used by local people in their daily lives (for firewood, to make brooms, for their own or livestock consumption of fruits, among others). The function of frugivory in maintaining the dynamics of the Chaco forest could be threatened, especially as there seems to be no compensatory alternative among medium-sized native mammals, since many of these are also threatened and suffer from declining populations (Periago et al., 2015). Further research regarding competition with or compensation of domestic livestock in ecosystem functioning and regulation is necessary to fully understand the

consequences of losing native frugivores.

5. Concluding remarks

Understanding the effects of changing land use on ecosystem functioning has become a challenge during the last decade (Herrera and Doblás-Miranda, 2013). Together with the net loss and fragmentation of habitats, land use change can also have negative impacts on the landscape such as loss of connectivity (Fahrig, 2003). In this scenario, the mammals of these ecosystems are of great importance not only because of their species richness and body size, but also for the roles they have in ecosystem processes (Varela and Brown, 1995). Studies of this type, in which local knowledge is combined with scientific research, result in an integrated analysis of the ecosystem, its functions, and the factors that affect the entire system as well as the responses of key species to changes in the environment.

Our results highlight the importance of primary and secondary forests in the conservation of the native fauna assembly. This is reflected in the use of habitat types by the species, which avoid more degraded environments, but also in how their feeding habits can influence changes in vegetation. Here, we present the dispersal capacity of the Pampas fox and the collared peccary of several native species found in the arid Chaco. Sympatric large-sized seed dispersers of the Gran Chaco are not found in the study area and present declining populations elsewhere due to habitat fragmentation and hunting (Periago et al., 2015). Our results identify differences between the ecosystem processes that can be researched via evidence-based science, and the benefits and costs of those processes as perceived by the local community. Combining both research techniques leads to a better understanding of ecosystem functioning in human-dominated landscapes, where the recognition of an ecosystem service can alter activities that negatively affect the environment, which in turn, can have negative future effects on the people themselves.

The consumption of wild meat (of peccary and other species) is still a frequent source of protein in the diets of rural communities, especially for economically-disadvantaged families, and is considered a resource that ensures food security (Fa et al., 2003). However, currently most families receive government assistance (subsidies), which allows them access to other foods (meat) obtained in the local market, and which may decrease the pressure on native fauna as bushmeat. The Pampas fox and the collared peccary are integral parts of the Chacoan socio-ecological system, not only as a direct source of food or income for local people, but also as seed dispersers of native plant species which in turn are significant components of the vegetation and indirect providers of benefits to people (such as food for livestock). Our results are a first step towards evaluating habitat use and dispersal capacity of the Pampas fox and the collared peccary in the arid Chaco, and highlight the important roles these species play in the local community and in the regeneration of the Chacoan forest.

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Appendix A. Supplementary data

Semi-structured interview questions.

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.jaridenv.2017.07.017>.

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