SHARING THE NATURE: MAMMALS AND NEIGHBOR HUMAN POPULATION OF A PROTECTED AREA IN THE ATLANTIC FOREST, BRAZIL

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Abstract: The establishment of protected areas is central for biodiversity conservation, but it may cause conflicts between the environmental agencies and the local citizens. In this study we aimed to survey the medium and large sized mammals in an Atlantic Forest protected area located in the state of Rio de Janeiro, Brazil. We also aimed to understand how the local citizens felt about the establishment of the Paraíso Unit. Between June and December 2015, we used 1,754 camera-days to record the mammals of Três Picos State Park – Paraíso Unit. To assess the citizens' felling about the Paraíso Unit, we conducted 22 interviews. We recorded 10 species, belonging to seven orders, classified into four dietary guilds. Among recorded species, four species are considered vulnerable in the state of Rio de Janeiro: *Puma concolor, Leopardus pardalis, Pecari tajacu*, and *Cuniculus paca*. A part of the citizens claimed losses in their activities. The main complaints were about the lack of dialogue with the park administration, the restricted access to waterfalls and trails inside the park and downturn in local commerce. According to the interviewed residents, the poaching pressure was greater on *C. paca, Dasypus novemcinctus*, and *Dasyprocta leporina*. To minimize the conflicts Paraíso Unit must improve the protected area governance, implementing its management plan in a participatory, inclusive and equity way.

Keywords: species inventory; environmental conflicts; anthropogenic impacts.

INTRODUCTION

The Atlantic Forest has 321 mammalian species (Graipel *et al.* 2017) and is one of the most diverse and threatened biomes of the world (Myers *et al.* 2000, Mittermeier *et al.* 2011). Originally, it covered an area between 1.01 and 1.62 million km² from the states of Rio Grande do Norte to Rio Grande do Sul in Brazil (Muylaert *et al.* 2018). The intense degradation and fragmentation reduced this biome to approximately 28 % of its original extension (Rezende *et al.* 2018). The habitat fragmentation (Lindenmayer & Noss 2006), poaching (Cullen Jr. *et al.* 2001), and invasive species, such as domestic dogs and cats (Lessa *et al.* 2016), are considered the greatest threats to the biodiversity of this biome. These anthropogenic pressures affect population demography and other ecological processes (Fischer & Lindenmayer 2007). Poaching is one of the main factors that promote species local extinction (Redford 1992, Carrillo *et al.* 2000, Cullen Jr. *et al.* 2000, 2001, Escamilla *et al.* 2000). This is even more problematic for species with long life cycle and low intrinsic growth rate (Bodmer *et al.* 1997), like top predators and large herbivorous. Interactions with domestic dogs and cats also negatively affect mammalian populations (Srbek-Araujo & Chiarello 2008, Lessa *et al.* 2016), as domestic animals

compete for territory, transmit pathogens, and predate on native wildlife (Gompper 2013, Lessa *et al.* 2016). Dogs are considered the most abundant carnivores in several natural areas (Hughes & Macdonald 2013), including in the Atlantic Forest (Paschoal *et al.* 2012).

The establishment of protected areas (PA) is one of the central strategies for biodiversity conservation (Rodrigues *et al.* 2004, Chape *et al.* 2005). The Convention on Biological Diversity aims the conservation of at least 17 % of terrestrial areas with an effective and equity management by 2020 (CBD 2010). The establishment of new PA may cause conflicts between the environmental agencies and the local citizens. Besides, people who have experienced some kind of negative interaction with wildlife tend to be less receptive to conservation actions (Ericsson *et al.* 2003, Jonker *et al.* 2006). The lack of management plan and monitoring systems in most of the Brazilian PAs (Cerqueira *et al.* 2001) make conflict minimization difficult.

In this study, we aimed to describe the mammalian fauna of medium and large size in the Paraíso Unit of the Três Picos State Park, the largest protected area of the state of Rio de Janeiro. We also aimed to understand how the residents felt about the establishment of the Paraíso Unit and estimated the threats (poaching intensity and abundance of domestic animals) to mammals in this protected area.

MATERIAL AND METHODS

Study area

The present study was focused on the Paraíso Unit of the Três Picos State Park (Núcleo Paraíso do Parque Estadual dos Três Picos; 22°29'41.1"S, 42°54'34.5"W), Guapimirim, state of Rio de Janeiro (Figure 1). The Paraíso Unit is the former Paraíso State Ecological Station (Estação Ecológica Estadual do Paraíso) and covers an area of 4,920 ha, located next to the foothills of the Serra dos Órgãos (INEA 2013). The Paraíso State Ecological Station was established in 1987, but in 2013 it was incorporated by Três Picos State Park. Nowadays the Três Picos State Park (PETP) is the largest PA in the state, with an area of 65113.04 ha (INEA 2013). The entrance to the Paraíso Unit is located in the neighborhood of the same name, in a rural zone. Small crops – mainly cassava and maize - and cattle pasture dominate the surroundings of PETP. The climate of the region is wet and warm, the total annual rainfall
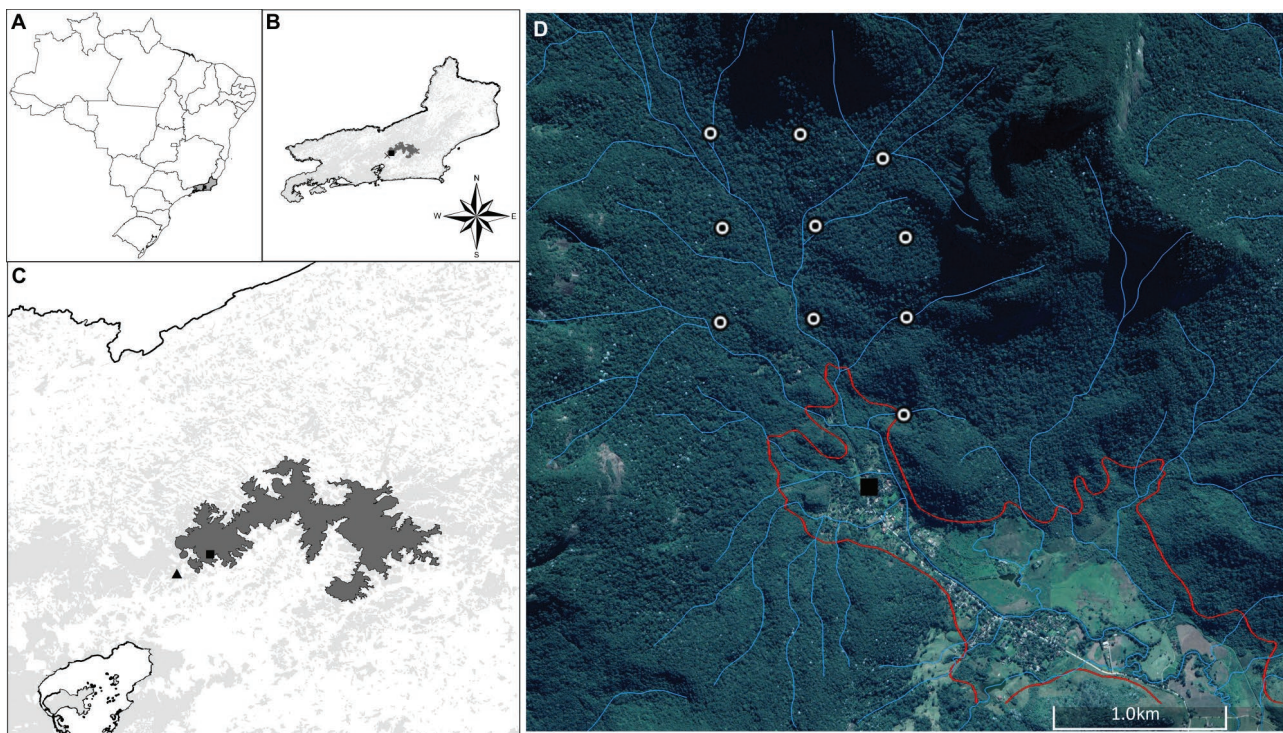

Figure 1. A) Location of the study area in Brazil and B) in the state of Rio de Janeiro; C) The PETP (dark grey) with the sampled area (black square) and the nearby city (black triangle); D) Sampling points (White dots) and the headquarters of the Três Picos State Park – Paraíso Unit (black square).

varies between 2.000 a 3.000 mm and the mean annual temperature is 23 °C (Kurtz & Araújo 2000). The vegetation is composed of montane and sub-montane ombrophilous dense forests (INEA 2013) in different stages of conservation.

Data collection

Camera traps

We established 10 sampling points, spaced approximately 500 m apart, between 100 m and 290 m altitude, each containing one camera trap (Bushnell, models 119436, 119438 and 119439), in the Paraíso Unit (Figure 1). Sampling points were fixed at animal trails in the forest. There was no road or human trail in most part of this area of the park. We recorded the geographic coordinates of each sampling point using a GPS receiver. Camera traps were installed on trees 45 cm above the ground, facing the trails with mammal tracks or broken branches. No baits were used to lure mammals to the sampling point. Camera trap were programmed for continuous operation from June to December 2015. We checked the camera traps monthly to replace batteries and memory cards. We identified the recorded species to the lowest possible taxonomic level according to the nomenclature followed by Paglia *et al.* (2012).

Interviews

We used a semi-structured questionnaire (Supplementary Material 1) to determine possible conflicts between the residents of Paraíso neighborhood, which is adjacent to the park. The interviews were conducted for adult residents only and lasted approximately 30 minutes. We asked the interviewees about the identity of the hunted mammals in the area; the number of domestic dogs and cats they owned; and their opinion about the park implementations and restrictions for the local population. Due to the differences in poaching habits between men and women we separated the interviews by sex in order to detect if the poaching habit leads to different views of the Paraíso Unit. We conducted a total of 22 independent interviews. The interviews were considered independent when they were not performed among the members of the same family nucleus.

Data analysis

Richness of medium and large sized mammals was estimated monthly throughout the sampling period. The sample effort was defined as: number of camera traps × number of sampling days (Srbek-Araujo & Chiarello 2007). For a same species, independent records where those which had at least an hour of interval among each other (Goulart *et al.* 2009). The sampling effort sufficiency was determined by species-accumulation curve from the non-parametric estimator Jackknife 1 (S_j; Magurran 2004). We characterized species according to their food habits based on Paglia *et al.* (2012). The relative frequency of the species records was calculated as: (the number of records per species / number total of records) * 100. Regarding the interviews, we used Mann-Whitney U test to verify if there was difference in satisfaction with the park establishment between men and women. The poaching intensity (P_I) was estimated by the relative frequency citation of each species by the residents in the interviews. We used the packages vegan (Oksanen *et al.* 2019), BiodiversityR (Kindt & Coe 2005), ggplot2 (Wickham 2016), devtools (Wickham *et al.* 2019) in R 3.5.2 (R Development Core Team 2018) to perform all analyses.

RESULTS

With a sampling effort of 1,754 camera-days, we obtained 280 records of medium and large sized mammals, with a sampling success of 16.0 %. We identified 10 different species, four omnivores, two carnivores, three herbivores, and one insectivore, belonging to seven orders and nine families (Table 1; Supplementary Material 2). We also recorded two small mammals: *Philander frenatus* and *Metachirus nudicaudatus* (Didelphimorphia, Didelphidae). Another mammal species registered was the domestic dog. The sampling effort was considered sufficient to characterize the medium and large mammalian species of the Três Picos State Park – Paraíso Unit (Figure 2), because the observed species number represented 83.5 % of the expected richness (S_j = 11.98 ± 1.40). Five to eight medium and large mammalian species were recorded each month. Among the recorded species, four are classified as vulnerable in the state of Rio de Janeiro: *Puma concolor*, *Leopardus pardalis*, *Pecari tajacu*, and *Cuniculus paca*.
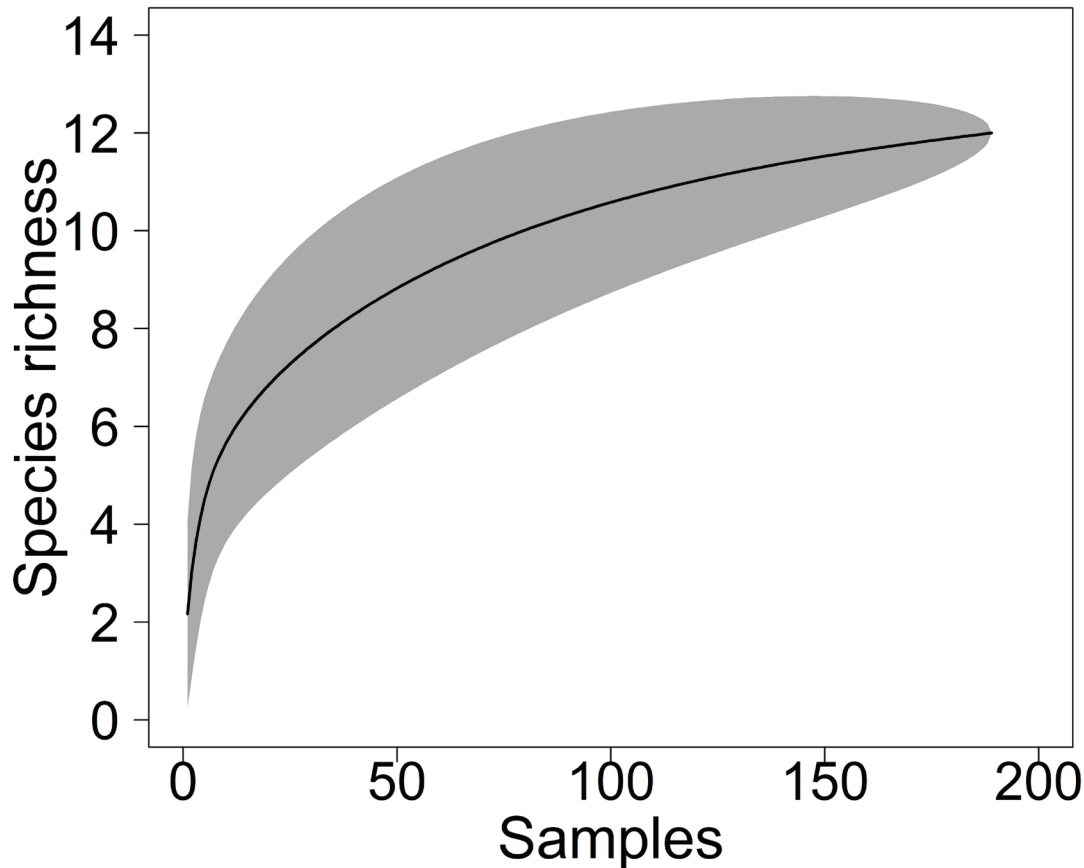
Figure 2. General accumulative curve for the sampled sites and the first order Jackknife estimator of species richness at the Três Picos State Park – Paraíso Unit. Expected species richness (continuous line) and the grey area indicates the standard deviation.

The species with the highest number of records was *Didelphis aurita* (N = 95), followed by *Dasyprocta leporina* (N = 90), *Dasypus novemcinctus* (N = 46) and *Cuniculus paca* (N = 22). The species with the lowest frequency were the felids *Leopardus pardalis* and *Puma concolor*, and *Tamandua tetradactyla*, with only 0.1 % occurrence in the records (Figure 3).

Regarding the interviews (N = 22), there was no difference between men (N = 14) and women (N = 8) in satisfaction with the park (U = 39.5, n = 22, p = 0.228). For this reason, we group the data from both sexes. In general, the adult residents were satisfied with the establishment of the park in the region (mean satisfaction = 6.8; Table 2), and 12 residents rate the park 10 out 10. However, there had been several complaints about the park (Table 2). The main complaints were about the lack of dialogue between park administration and the neighbor citizens (86.3 %), the restricted access to waterfalls and trails inside the park (68.2 %) and

downturn in local commerce (22.7 %).

In the view of the residents, the park faces problems of lack of staff (63.3 %) and poaching (59.1 %). Only 13 residents reported on animals being hunted in the region (Table 1). Poaching intensity was higher on *Cuniculus paca* (P_I = 0.62), followed by *Dasypus novemcinctus* (P_I = 0.54) and *Dasyprocta leporina* (P_I = 0.46). Most of the residents (N = 15) owned dogs or cats. Among the 22 residents interviewed, 14 had one or more dogs and six had cats. In total, there were 33 dogs and 25 cats in the park vicinity.

DISCUSSION

Medium and large terrestrial mammals observed in the Paraíso Unit, a former ecological station, represents approximately 3.1 % of all medium and large mammal species in the Atlantic Forest biome (Graipel *et al.* 2017). The species recorded in Paraíso Unit were present in other areas of Central

Table 1. Medium and large sized mammals of the Três Picos State Park – Paraíso Unit, Guapimirim, Rio de Janeiro. Threat status: LC = least concern, NT = near threatened, VU = vulnerable; Ex = exotic. Taxonomic names and trophic guild according to Paglia *et al.* (2012). Poaching intensity was estimated based on the responses of the interviews with the inhabitants of the region. Threat level according to Bergallo *et al.* (2000; Rio de Janeiro); ICMBio (2018; Brazil); IUCN (2019; World).

Species	Common Name	Trophic guild	Number of records	Relative frequency (%)	Poaching intensity	Threat level		
						RJ	BR	World
Order Didelphimorphia								
Family Didelphidae								
Didelphis aurita	Big-Eared Opossum	Omnivorous	95	33.9	0.38	-	-	LC
Philander frenatus			1*	0.35*		-	-	LC
Metachirus nudicaudatus			2*	0.71*		-	-	LC
Order Pilosa								
Family Myrmecophagidae								
Tamandua tetradactyla	Collared Anteater	Insectivorous	2	0.71	-	-	-	LC
Order Cingulata								
Family Dasypodidae								
Dasypus novemcinctus	Commom Long-Nosed Armadillo	Omnivorous	46	16.42	0.54	-	-	LC
Order Carnivora								
Family Canidae								
Canis lupus	Domestic dog		2*	0.71*		Ex	Ex	Ex
Family Felidae								
Leopardus pardalis	Ocelot	Carnivorous	1	0.35	-	VU	-	LC
Puma concolor	Cougar	Carnivorous	2	0.71	-	VU	VU	LC
Family Procyonidae								
Nasua nasua	South American Coati	Omnivorous	6	2.14	-	-	-	LC
Order Cetartiodactyla								
Family Tayassuidae								
Pecari tajacu	Collared Pecari	Omnivorous	8	2.85	0.08	VU	-	LC
Order Rodentia								
Family Cuniculidae								
Cuniculus paca	Spotted Paca	Herbivorous	22	7.85	0.62	VU	-	LC

Table 1: Continued on next page...

Table 1: ...Continued

Species	Common Name	Trophic guild	Number of records	Relative frequency (%)	Poaching intensity	Threat level		
						RJ	BR	World
Family Dasyproctidae								
Dasyprocta leporina	Brazilian Agouti	Herbivorous	90	32.14	0.46	-	-	LC
Order Lagomorpha								
Family Leporidae								
Sylvilagus brasiliensis	Forest Rabbit	Herbivorous	3	1.07	-	-	-	LC

(*) Small mammals and exotic species recorded in the study area

Rio de Janeiro Atlantic Forest Mosaic (Alves & Andriolo 2005, Carvalho *et al.* 2014, Aximoff *et al.* 2015, Travassos *et al.* 2018) and vicinities (Modesto *et al.* 2008, Bastos-Neto *et al.* 2009, Aximoff *et al.* 2015). In this way, Paraíso Unit helps to maintain the populations of these species in the region. This is even more important for the four endangered species (Rio de Janeiro Red List, Bergallo *et al.* 2000) recorded in the area: *Puma concolor, Leopardus pardalis, Pecari tajacu,* and *Cuniculus paca.*

Other studies (N = 4) in Central Rio de Janeiro Atlantic Forest Mosaic and vicinities recorded a higher number of species in camera traps than the present study (Table 3). The differences may be related to sampling issues, such as a lower sampling effort or the location where the camera traps were installed. Many medium and large mammals, like *L. pardalis* and *P. concolor,* commonly use large trails, and are frequently recorded in roads (Weckel *et al.* 2006, Goulart *et al.* 2009, Harmsen *et al.* 2010). However, the study area did not have roads or open trails and we had to sample in natural trails inside the forest. Therefore, the increase in sampling effort, distance between the sampling points and the installation of camera traps on main tracks and dirt roads could together lead to an increase in the number of species detected (Weckel *et al.* 2006, Srbek-Araujo & Chiarello 2007, Goulart *et al.* 2009).

The differences between our study and the other four studies in Central Rio de Janeiro Atlantic Forest Mosaic also could be caused by anthropogenic disturbances, such as poaching and presence of domestic animals. These disturbances could represent a filter leading to lower richness and to the dominance of the generalist species (Lessa *et*
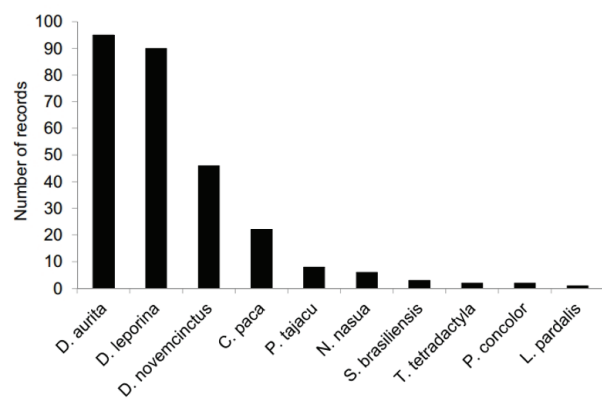

Figure 3. Number of records obtained for each species using the camera trapping method at the Três Picos State Park – Paraíso Unit.

al. 2016, Doherty *et al.* 2017). Dogs were recorded in one sampling point, and during fieldwork, direct observations revealed the presence of several dogs and poachers inside the park. The residents of Paraíso neighborhood own a large number of domestic animals, which wander in the forest.

Dogs and cats may affect the wildlife (Hughes & Macdonald 2013, Gompper 2013, Lessa *et al.* 2016), since they can prey on (Campos *et al.* 2007, Srbek-Araujo & Chiarello 2008, Vanak & Gompper 2009, Ferreira *et al.* 2014) or compete with native species (Atickem *et al.* 2010, Carvalho *et al.* 2019). They can also be disease reservoirs or vectors (Filoni *et al.* 2006, Furtado *et al.* 2013, Lessa *et al.* 2016). The spatial overlap between domestic and wild mammals represent a risk for endangered species (*e.g.* Lessa & Bergallo, 2012, Hughes & Macdonald, 2013, Lessa *et al.* 2016, Doherty *et al.* 2017, Ferreira & Genaro 2017, Ferreira *et al.* 2014, 2018). A review based on the IUCN Red List database pointed

Table 2. Opinion of the residents of Paraísos neighborhood about the establishment of the Três Picos State Park – Paraíso Unit.

Questions	Interviewees (N = 22)	
	Totally agree / Partially agree	Partially disagree / Totally disagree
Degree of satisfaction with Paraíso Unit	6.8 / 10	
There are dialogue between park administration and the neighbor human population	13.6%	86,3%
The park is receptive to community leisure activities.	31.8%	68.2%
The establishment of the Paraíso Unit has harmed you somehow.	22.7%	77.3%

out that the domestic dog has contributed to the extinction of 11 vertebrate species and poses a threat to 188 others threaten species (Doherty *et al.* 2017). Another threat to the wildlife is zoonoses (Primack & Rodrigues 2001). Many zoonoses – like rabies, canine distemper virus, toxoplasmosis, cutaneous larval migrans and plague – can be transmitted from domestic animals to wildlife (*e.g.* Schloegel *et al.* 2005; Gerhold & Jessup 2013, Medina *et al.* 2014).

Poaching is an important driver of mammal assemblages (Cullen Jr. *et al.* 2001, Naughton-Treves *et al.* 2003, Laurance *et al.* 2006). According to the local residents, there is still poaching inside the Paraíso Unit. The location of the Paraíso Unit near Rio de Janeiro city favors poaching. The study area is located approximately 120 kilometers from Rio de Janeiro city and the Paraíso neighborhood is a common tourist location, leading to the movement of a large number of people and vehicles in the area. According to the local citizens, *C. paca, D. novemcinctus*, and *D. leporina* are the most poached species in the Paraíso. Poaching of these species is common in other areas of the Atlantic Forest (*e.g.* Pianca 2004, Hanazaki *et al.* 2009, Dantas-Aguiar *et al.* 2011, Sousa & Srbek-Araujo 2017). Although in some cases local citizens suspend pouching during reproductive periods (*e.g.* Hanazaki *et al.* 2009), poaching has been linked to the extinction of these species in different areas of their distribution (*e.g.* Canale *et al.* 2012, Cid *et al.* 2014, Galetti *et al.* 2016a).

The Paraíso Unit, together with the other units of the Três Picos State Park, form the state's largest conservation unit in the Central Rio de Janeiro Atlantic Forest Mosaic. Thus, this is an extremely important region for the conservation of the fauna of the state. However, the lack of dialogue between the park administration and the residents can jeopardize the efficiency of wildlife conservation. Most of the residents claimed that they would want to be part of the conservation projects in the park. The development of a governance system based on multiple stakeholders and rights holders with different views and interests is a worldwide challenge (Zafra-Calvo *et al.* 2019). In face of our results, we recommend the following management actions: (I) improve the protected area governance, implementing its management plan in a participatory, inclusive and equity way; (II) development of an environmental education program to increase awareness about local fauna and the importance of the park and its activities; (III) inform people about diseases transmitted by free-ranging dogs and cats; (IV) spay/neuter and vaccination campaigns of domestic animals as a way to control the population growth and diseases dissemination; (V) surveillance and monitoring program to reduce free-ranging animals and poaching inside the park. We believe that the implementation of these measures could improve the effectiveness of the main function of this and other protected areas.

ACKNOWLEDGEMENTS

Table 3. Camera trap records of medium and large sized mammals obtained in the present study and from other protected areas.

Species	Três Picos State Park - Paraíso Unit	Guapiaçu Ecological Reserve	Serra dos Orgãos National Park	Araras Biological Reserve	Farm Forest	Desengano State Park	Itatiaia National Park	Serra da Bocaina National Park	Serra do Mar State Park - Santa Virgínia unit	Serra do Mar State Park - Caraguatatuba unit
Reference	This Study	Carvalho et al. 2014	Aximoff et al. 2015	Alves & Andriolo 2005	Bastos-Neto et al. 2009	Modesto et al. 2008	Aximoff et al. 2015	Delciellos et al. 2012	Rocha-Mendes et al. 2015	Norris et al. 2012
Species richness	10	13	14	5	10	1	21	4	16	10
Sampling effort (camera-days)	1754	1598	9197	221	NA	120	3885	78	1063	223.2
Distance to PETP	-	15 km	28.2 km	35.8 km	90 km	118 km	177 km	186.6 km	247.7 km	285.6 km
Order Didelphimorphia										
Family Didelphidae										
Didelphis aurita	X	X	X	X	X		X		X	X
Order Pilosa										
Family Myrmecophagidae										
Tamandua tetradactyla	X	X	X		X		X	X	X	
Family Bradypodidae										
Bradypus torquatus										
Bradypus variegatus										
Order Cingulata										
Family Dasypodidae										
Dasypus novemcinctus	X	X	X		X		X	X	X	X

Table 3: Continued on next page…

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Species	Três Picos State Park - Paraíso Unit	Guapiaçu Ecological Reserve	Serra dos Orgãos National Park	Araras Biological Reserve	Farm Forest	Desengano State Park	Itatiaia National Park	Serra da Bocaina National Park	Serra do Mar State Park - Santa Virgínia unit	Serra do Mar State Park - Caraguatatuba unit
Dasypus septemcinctus							X			
Cabassous tatouay		X	X				X			
Euphractus sexcinctus		X					X			
Dasypus sp.				X						
Order Carnivora										
Family Felidae										
Leopardus pardalis	X	X			X		X		X	X
Leopardus wiedii			X				X		X	
Leopardus guttulus			X				X		X	
Leopardus tigrinus										X
Puma concolor	X	X	X		X		X		X	X
Puma yagouaroundi			X				X		X	
Family Mustelidae										
Eira barbara		X	X	X	X		X		X	
Lontra longicaudis					X					
Family Procyonidae										
Nasua nasua	X	X	X	X	X		X	X		
Procyon cancrivorus					X				X	
Potos flavus							X			

Table 3: Continued on next page...

Table 3: ...Continued

Species	Três Picos State Park - Paraíso Unit	Guapiaçu Ecological Reserve	Serra dos Orgãos National Park	Araras Biological Reserve	Farm Forest	Desengano State Park	Itatiaia National Park	Serra da Bocaina National Park	Serra do Mar State Park - Santa Virgínia unit	Serra do Mar State Park - Caraguatatuba unit
Family Canidae										
Cerdocyon thous		X	X				X		X	
Chrysocyon brachyurus							X			
Order Cetartiodactyla										
Family Cervidae										
Mazama americana							X			
Order Perissodactyla										
Family Tapiridae										
Tapirus terrestris									X	X
Family Tayassuidae										
Pecari tajacu	X	X	X						X	X
Tayassu pecari							X		X	
Order Rodentia										
Family Cuniculidae										
Cuniculus paca	X	X	X	X	X	X	X	X	X	X
Family Dasyproctidae										
Dasyprocta leporina	X	X								
Dasyprocta iacki									X	
Dasyprocta azarae										X

Table 3: Continued on next page...

Table 3: ...Continued

Species	Três Picos State Park - Paraíso Unit	Guapiaçu Ecological Reserve	Serra dos Orgãos National Park	Araras Biological Reserve	Farm Forest	Desengano State Park	Itatiaia National Park	Serra da Bocaina National Park	Serra do Mar State Park - Santa Virgínia unit	Serra do Mar State Park - Caraguatatuba unit
Family Cavidae										
Hydrochoerus hydrochaeris			X				X			X
Order Lagomorpha										
Family Leporidae										
Sylvilagus brasiliensis	X						X			

in the identification of the recorded species. This study was part of the Projeto Refauna, and it was supported by Fundação de Auxílio à Pesquisa do Estado do Rio de Janeiro and by Instituto Federal do Rio de Janeiro. RPCA was supported by a FAPERJ fellowship and ALAMR was supported by a CNPq fellowship.

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