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Artículo

LARGE AND MEDIUM-SIZED MAMMALS FROM CHANDLESS STATE PARK, ACRE, BRAZIL.

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ABSTRACT. The Neotropical region hosts the greatest diversity of mammals in the world. Western Amazonia, where the State of Acre is located, harbors one of the highest mammalian species diversity in the Neotropics. Mammals are considered important biodiversity components and play a key role in regulating and structuring forest ecosystems. However, there are considerable knowledge gaps regarding species distribution and richness in the Amazon region. This study aims at documenting the medium and large-sized mammal species in Chandless State Park (PEC - Parque Estadual Chandless) giving special attention to those classified as rare or threatened. Four different methods were used in two years of research, 2008 and 2013: linear transect, camera trap, interviews and spoor counts. PEC is highly rich in medium and large-sized mammals in comparison to adjacent conservation units. Fifty-one species were recorded, of which 13 are listed as endangered. Primates, Carnivora and Rodentia were the most species-rich Orders. Because of its high richness and high degree of protection, PEC plays an important role in the protection and conservation of endangered species in a landscape formed by a block of protected areas with different levels of anthropogenic activities.

RESUMO. Mamíferos de médio e grande porte do Parque Estadual Chandless, Acre, Brasil. A região neotropical abriga a maior diversidade de mamíferos do mundo e a região oeste da Amazônia, onde está inserido o estado do Acre, é uma das regiões com maior riqueza de espécies no Neotrópico. Os mamíferos são considerados importantes componentes da biodiversidade, desempenhando papel fundamental na regulação e estruturação de ecossistemas florestais. Contudo, ainda existem lacunas no que concerne a distribuição e riqueza de espécies na região Amazônica. Em vista disso, o objetivo deste estudo foi listar as espécies de mamíferos de médio e grande porte ocorrentes no Parque Estadual Chandless (PEC - AC), destacando aquelas classificadas como raras ou ameaçadas. Foram utilizados quatro métodos diferentes em dois anos de amostragem, 2008 e 2013: transecção linear, armadilha fotográfica, entrevista e contagem de vestígios. O PEC possui elevada riqueza de mamíferos de médio e grande porte, quando comparado com outras unidades de conservação adjacentes. Foram registradas 51 espécies de mamíferos, das quais 13 estão listadas como ameaçadas de extinção. Primates, Carnivora e Rodentia foram as Ordens com maior riqueza de espécies. Devido à alta riqueza e elevado grau de conservação, o PEC exerce importante papel para a proteção e conservação de espécies ameaçadas, em uma paisagem composta por um bloco de áreas protegidas com diferentes níveis de atividades antrópicas.

Key words: Camera trap. Conservation Units. Linear transect. Species richness. Tracks.

Palavras chave: Armadilha fotográfica. Rastros. Riqueza de espécies. Transecção linear. Unidades de Conservação.

INTRODUCTION

The Neotropical region is home to the largest diversity of mammals in the world (Brown 2014). Near 701 out of the 5487 known mammal species (Schipper et al., 2008) are found in Brazil. The Amazon region is the most diverse one in the country, with 399 species, of which 57.8% are endemic to the region (Paglia et al., 2012). Western Amazon, where the state of Acre is located, is one of world's richest areas, housing approximately 40% of Brazil's mammals; 4.5% of the world's mammals are known to occur in the state (Acre, 2010).

Many mammal species play fundamental roles in structuring and regulating forest ecosystems, driving a variety of ecological processes, including seed dispersal, seed predation and pollination, whereas others are apex predators (Wright, 2003). Despite their importance, the knowledge on mammalian species is still very limited. Paglia et al. (2012) show a surprising increase in the new species discovery rate in Brazil in the last 20 years, with approximately 34% increase in the number of known species, including large species, such as the tapir (*Tapirus kabomani*; Cozzuol et al., 2013). Surveys and inventories are important tools to describe the species habitat, to expand the known distribution of species and to record rare and even new species.

Studies on the diversity of medium and large-sized mammals have focused on the eastern and central Amazon regions, mainly in the Solimões River tributaries (Voss and Emmons, 1996; Patton et al., 2000; Pitman et al., 2003; Trolle and Kéry 2003; Tobler et al., 2008). Most studies on western Amazonian medium and large mammal assemblages were performed in the Great Basin of Rio Madre de Dios (Peru), mostly in areas within or nearby the Manú National Park and adjacent protected areas. Studies on medium and large mammal assemblages in Acre, Brazil, have focused on rapid inventories (Calouro, 1999; Botelho et al., 2012), hunting effects (e.g. Calouro and Marinho-Filho, 2005; Rosas and Drumond, 2007; Constantino et al., 2008) and primate autecology (e.g. Peres, 1988, 1993; Bicca-Marques and Garber, 2003; Regh, 2005) and habitat preference (Borges et al.,

2014). However, as Tobler et al. (2008) have correctly stated, knowledge on the presence and distribution of mammal species is essential in order to plan and evaluate regional biodiversity conservation strategies.

Within this context, the current study aims at listing the medium and large-sized mammal species in Chandless State Park, as well as highlighting the endangered species and the role played by the Park regarding regional conservation strategies.

MATERIAL AND METHODS

Study site

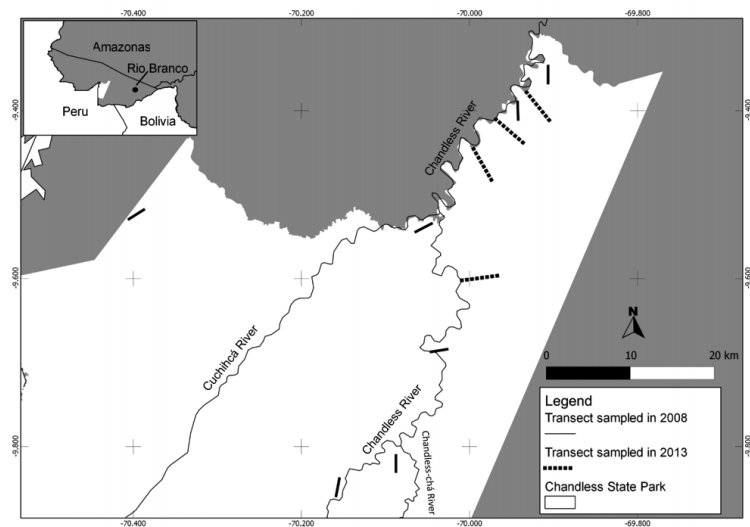
PEC is located in southwestern Acre State (**Fig. 1**) on the Brazilian border with Peru, and it has an area of 695 303 ha (SEMA, 2010). The Park is located in the Purus River basin. This region is composed of an array of Brazilian and Peruvian protected areas that together form a large block of approximately 40 000 km². These areas are very important because they occur in a region that is extremely diverse in biological, ethnic and cultural terms. The annual precipitation is 1900-2000 mm, and the least rainy period extends from June to September (SEMA, 2010; Acre, 2010). The altitude ranges from 180 to 370 m a.s.l. (SEMA, 2010).

Sixty-seven people from 11 families live in the Park, distributed along the banks of the Chandless River, in its northern-central portion. In addition to a relatively concentrated distribution, the hunting pressure is probably of low overall impact, because the Park has less than 0.5 inhabitants/km². According to Robinson and Bennett (2000), the subsistence-hunting activity may be considered sustainable in the Amazon when human density does not exceed 1 human resident/km².

The Park has a mosaic of vegetation types, mostly forests with more open canopy (e.g. Deciduous Open Forest with Bamboo and/or Palm trees). The dynamic nature of Chandless River shows extensive forest areas in different successional stages along the riverbank (Open Evergreen Forest on flooded terraces, Evergreen Rainforest, Deciduous Forest—sometimes with either dominant bamboo or palm tree) with areas at different successional stages due to bamboo post-fruitlet death (SEMA, 2010).

One of the main determinants of vegetation successional gradients in Acre State is the predominance of bamboo (species from genus *Guadua*) in open forests. The Park is located in the center of the largest patch of *Guadua* sp. in Amazonia (McMichael

Fig. 1. Location of Chandless State Park, in Acre State, Brazil, and the location of transects sampled in 2008 and 2013.



et al., 2013), and much of the vegetation mosaic and different successional stages of the vegetation in the area result from the dynamics exerted by the presence of bamboo. The species from this genus are clonal, with opportunistic growth and pronounced capacity to invade disturbed areas. These factors, along with a life cycle with synchronized mortality and mast flowering and fruiting, have direct impact on the forest dynamics, thus affecting the appearance and structure of the forest, as well as reducing the abundance and richness of tree species (Silveira, 2005; Griscom and Ashton, 2006; Smith and Nelson, 2011).

Mammalian sampling

Data collection was conducted during the dry and wet seasons to create a list of medium and large-sized mammals found in Chandless State Park. A Rapid Ecological Assessment was done in February and August 2008, in order to prepare the park management plan (RAP: Sobrevilla and Bath, 1992). The RAP was conducted on previously cleared 1-km transects, sampled at least for five times each. Transects were distributed along the Chandless River, in the different vegetation types within the landscape. Transects were walked at the standard average speed of 1.25 km/h, usually between 06:30 and 11:30 h. In 2010, data was supplemented with observations performed along the riverbanks near the sampled transects. The observations were conducted in flying boats with the engine off. Direct sightings and indirect evidence of the species occurrence (vocalizations, tracks, feces, bones and hair) were recorded. Concurrently, interviews were conducted with residents to investigate the existence of undetected species during transect and riverbank search. As part of the research, residents were shown pictures of mammals taken from Emmons and Feer (1997) and Eisenberg and Redford (1999).

From April to November 2013, four 5-km transects were surveyed using direct observation and camera trap (Fig. 1). Transects were traveled at the standard

average speed of 1.25 km/h, usually at 06:30 h. Each transect was sampled at least twelve times, throughout five months. Tracks and other indirect evidences were opportunistically recorded when the census was conducted. Indirect records were identified using field guides (Becker and Dalponte, 1999). Six camera traps were installed in each of the four transects to record the most cryptic species (Trophy Cam Bushnell USA). The traps were installed within 1-km interval from each other. A total of 24 camera traps was used to monitor all trails from April to November 2013.

Data analysis

The species accumulation curve was developed according to the number of species recorded on the line transect and camera trap, to quantify the relation between species richness and sampling effort in the 2013 survey. The curve was done in the R software (R Core Development Team 2011). A Jackknife first order richness estimator was calculated using specpool function (package Vegan) to predict the total number of potentially detectable species in the Park using the two sampling methods in 2013.

RESULTS AND DISCUSSION

Fifty-one species of mammals were recorded, distributed in 10 Orders and 27 families after a total effort of 691-walked km, 3213 trapping nights and 12 interviews with local residents (Table 1; Fig. 2). Forty-nine species were recorded in 2008, and 44 in 2013. Two aquatic species were recorded on both occasions. Forty

Table 1

Mammals of Chandless State Park, Acre, Brazil. Methods used in both years of the survey. VC= Visual Contact=; CT=Camera Trap, T=Track; V=Vocalization; F=Feeces; B=bones; I=Interview. Status of mammal species in the Chandless State Park present on the two main lists of endangered animal species. Categories according to the International Union for Conservation of Nature and Natural Resources (IUCN - acronym in English), Ministry of Environment (MMA): EN=Endangered, VU=Vulnerable, NT=Near Threatened, LC= Least Concern.

Order	Family	Scientific Name	Common Name	Method		MMA 2014	IUCN 2015
				2008	2013		
DIDELPHIMORPHIA							
Didelphidae							
		<i>Didelphis marsupialis</i>	Common Opossum	VC	VC, CT		LC
		<i>Micoeurus regina</i>	Mouse Opossum	VC			
PILOSA							
	Bradypodidae	<i>Bradypus variegatus</i>	Three-toed Sloth	VC	I		LC
	Megalonychidae	<i>Choloepus</i> spp.	Two-toed Sloth	B			LC
	Myrmecophagidae	<i>Cyclopes didactylus</i>	Silky Anteater	I			LC
		<i>Myrmecophaga tridactyla</i>	Giant Anteater			VC, CT	VU
		<i>Tamandua tetradactyla</i>	Tamandua	VC	CT		LC
CINGULATA							
	Dasypodidae	<i>Dasypus kappleri</i>	Greater Long-nosed Armadillo				LC
		<i>Dasypus novemcinctus</i>	Nine-banded Armadillo	T	T, CT		LC
		<i>Cabassous unicinctus</i>	Southern Naked-tailed Armadillo	I			
		<i>Priodontes maximus</i>	Giant Armadillo	T	T, CT	VU	VU
PERISSODACTYLA							
	Tapiridae	<i>Tapirus terrestris</i>	Tapir	VC, T, B	VC, T, CT	VU	VU

ARTIODACTYLA						
Cervidae	<i>Mazama americana</i>	Red Brocket Deer	VC, T	VC, T, CT		
Tayassuidae	<i>Pecari tajacu</i>	Collared Peccary	VC, F, B, T	VC, T, CT		LC
	<i>Tayassu pecari</i>	White-lipped Peccary	B, T	T		VU
CETACEA						
Iniidae	<i>Inia geoffrensis</i>	Boto	VC	VC	VU	DD
Delphinidae	<i>Sotalia fluviialis</i>	Tucuxi	VC	VC		DD
PRIMATES						
Aotidae	<i>Aotus nigriceps</i>	Night Monkey	V, VC	VC		LC
Callitrichidae	<i>Callimico goeldii</i>	Goeldi's Monkey	V, VC	VC, V		VU
	<i>Saguinus weddelli</i>	Weddell's Saddle-backed Tamarin	V, VC	VC, V		LC
	<i>Saguinus imperator</i>	Emperor Tamarin	V, VC	VC		LC
Pitheciidae	<i>Callicebus cupreus</i>	Titi Monkey	V, VC	VC, V		LC
Cebidae	<i>Cebuella pygmaea</i>	Dwarf Marmoset	I	I		LC
	<i>Saimiri boliviensis</i>	Squirrel Monkey	VC	VC, V, CT		LC
	<i>Cebus unicolor</i>	White-fronted Capuchin	VC	VC, V, CT		
	<i>Sapajus macrocephalus</i>	Robust Capuchin	VC, V	VC, V, CT		LC
Atelidae	<i>Alouatta puruensis</i>	Howler Monkey	B, CT, V, VC, F	VC, V		
	<i>Ateles chamek</i>	Spider Monkey	VC, V	VC, V	VU	EN
CARNIVORA						
Felidae	<i>Panthera onca</i>	Jaguar	F, T	T, F, CT	VU	NT
	<i>Puma concolor</i>	Cougar		T, F, CT	VU	LC
	<i>Leopardus pardalis</i>	Ocelot	T	T, F, CT		LC
	<i>Leopardus wiedii</i>	Margay	T	CT	VU	NT
	<i>Puma yagouaroundi</i>	Jaguarundi	I		VU	LC

Canidae	<i>Atelocynus microtis</i>	Small-eared Dog	I	I, CT	VU	NT
	<i>Speothos venaticus</i>	Bushdog	I	I	VU	NT
Mustelidae	<i>Eira barbara</i>	Tayra	VC	VC, CT		LC
	<i>Lontra longicaudis</i>	Southern River Otter	I			NT
	<i>Pteronura brasiliensis</i>	Giant Otter	VC	I	VU	EN
Procyonidae	<i>Procyon cancrivorus</i>	Crab-eating Raccoon	T	T, CT		LC
	<i>Nasua nasua</i>	Coati	VC	VC, CT		LC
RODENTIA						
Erethizontidae	<i>Coendou prehensilis</i>	Porcupine	I			LC
Echimyidae	<i>Dactylomys dactylinus</i>	Bamboo Rat	V, VC			LC
Sciuridae	<i>Guerlinguetus ignitus</i>	Variable Squirrel	VC	CT		
	<i>Microsciurus flaviventer</i>	Amazon Dwarf Squirrel	VC			
	<i>Urosciurus spadiceus</i>	Southern Amazon Red Squirrel	VC	CT		
Dasyproctidae	<i>Dasyprocta cf. punctata</i>	Agouti	VC, T	VC, T, CT		LC
	<i>Myoprocta pratti</i>	Agouchi	VC, T	VC, CT		LC
Caviidae	<i>Hydrochoerus hydrochaeris</i>	Capibara	VC, T	VC, T, CT		LC
Cuniculidae	<i>Cuniculus paca</i>	Paca	T	T,CT		LC
Dinomysidae	<i>Dinomys branickii</i>	Pacarana	I	I		VU
LAGOMORPHA						
Leporidae	<i>Sylvilagus brasiliensis</i>	Brazilian Wild habbit	VC	CT		LC

(Table 1 cont.)



Fig. 2. Photographs of mammals registered at Chandless State Park, Acre, Brazil. (A) *Panthera onca*; (B) *Puma concolor*; (C) *Prionodontes maximus*; (D) *Myrmecophaga tridactyla*; (E) *Cuniculus paca*; (F) *Dasyprocta cf. punctata*; (G) *Tapirus terrestris*; (H) *Ateles chamek*.

two direct records of occurrence were achieved. The most species-rich Orders were: Primates (n=11), Carnivora (n=9) and Rodentia (n=8).

The species richness curve based on the line-transect data did not reach an asymptote and it indicates that the number of species could increase with further sampling effort (Fig. 3). The effort curve with camera traps tended to stabilize at 190 days or 2500 trapping nights (Fig. 3). Based on the first-order Jackknife species richness estimator, the number of species that could be potentially recorded by camera traps was 27, based on the 24 species photographed, and the number of species that could be potentially recorded by the linear-transect method was 29, based on the 24 species sighted.

According to the literature, 53 medium and large-sized Neotropical mammals were expected to be found in the region (Eisenberg and Redford, 1999; Wilson and Reeder, 2005). The orders Didelphimorphia and Cetacea, as well as small rodent families (except for Sciuridae), were not considered in both the species and the review list because our methods will not document them properly.

This high species richness followed the pattern observed in this region of the Amazon, such as Manú National Park and Park of Alto Purus, both in Peru, and is similar to sites in Acre, such as Serra do Divisor National Park and Resex Cazumbá-Iracema (Table 2), in spite of differences in the survey methods. Oliveira (2012), for instance, recorded the species number and composition in Resex Cazumbá-Iracema (Brazil) species lists, which are very similar to that from Chandless; probably due to the geographical contiguity of the two sites and the similarity of the. All protected areas

listed in Table 2 occur in a region considered to have the highest diversity of terrestrial and arboreal mammals in the Amazon basin (Emmons and Voss, 1996).

Chandless State Park is home to 11 primate species distributed in five families, of which Cebidae and Callitrichidae are the most species-rich ones (Table 1). The presence of two large species, *Ateles chamek* (Fig. 2H) and *Alouatta puruensis* is very important to the ecosystem structure and to the mammal community in the Park. Both species are targeted by hunters in the Amazon, and they are susceptible to local extinction under strong hunting pressure areas (Peres and Lake, 2003). This is especially true for *Ateles* spp., which have the lowest reproductive rate among all Amazonian primates (Redford and Robinson, 1986). Peres (1987 apud Boubli et al., 2008) suggested that *Pithecia* spp. and *Lagothrix cana* do not occur in the Purus-Iaco interfluvium, although the distribution of these species includes much of Acre State (Iwanaga and Ferrari, 2002). Fieldwork and interviews with local residents confirmed that these species are not found in the study area. Further research is needed to assess the species' distribution and use of habitats in Acre and how they are affected by abundant bamboo forests (tabocais). Regh (2005) found that *Callimico goeldii* (Goeldi's monkey) occurs mainly in bamboo forests in Acre. The species always forages in "tabocais" when it is searching for fungi and insects, a fact that was also observed in other southwestern Amazonian areas (Ferrari et al., 1999; Porter et al., 2007). We associate the occurrence of *C. goeldii* in Chandless State Park to the presence of bamboo patches within the park.

Four recorded rodent species deserve special attention; three of them were first recorded in the park area (two species of squirrel, and one agouti species that was not known to occur in Brazil). The agouti species occurring in the Park is not *Dasyprocta fuliginosa*,

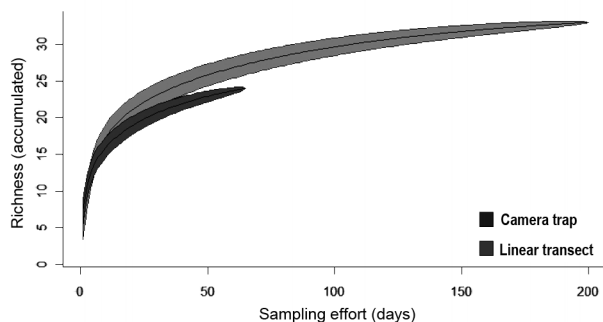


Fig. 3. Accumulation curve of mammal species recorded by camera traps and linear transect at Chandless.

Table 2

Number of species recorded in different protected areas in the main basins of southwestern Amazonia. Area in hectares (ha), methods used in the study: C=Census (km traveled), P=Photos (Trap effort nights=TN), TC=Track Count, I=Interview (number of residents interviewed), HC=Hunting Calendar number (calendars), and their respective sampling efforts, respectively.

Location área	River Basin	N° of species		Method	Effort	Study
		Primates	Non primates			
Chandless State Park (AC)	Purus	11	40	C/P/TC/I	691 km/3213 TN/11 I	This study
Resex of Cazumbá Iracema (AC)	Caeté/Purus	11	41	C/P/TC/I/HC	956 km/24 HC	Oliveira (2012)
Cosha Cashu, Pakitza and National Park of Alto Purús (Peru)	Purus	15	44	C/P/TC	–	Pitman et al. (2003)
Lake Uauaçú (AM)	Purus	13	*	C	4600 km	Haugaasen & Peres (2005b)
Lake Uauaçú (AM)	Purus	12	32	C	2192 km	Haugaasen & Peres (2005a)
Humaitá Reserve Forest (AC)	Acre/Purus	9	16	C/P	220 km/850 TN	Botelho et al. (2012)
Middle Juruá River(AM)	Juruá	21		C	1564 km	Peres (1997)
Serra do Divisor National Park(AC)	Juruá	14	29	C/TC/I	33 I	Calouro (1999)
Manú National Park(Peru)	Madre de Dios	1	20	P	3780 TN	Tobler et al. (2008)
Los Amigos Conservation Concession (Peru)	Madre de Dios	10	27	C	1495 km	Endo et al. (2010)
Bonanza, Manú National Park(Peru)	Madre de Dios	12	38	C/I	270 km	Salvador et al. (2010)

as described in this region of Acre State. According to the features described by Gilson Iack-Ximenes (pers. comm.) and Bonvicino et al. (2008), it may instead be *D. cf. punctata*. (**Fig. 2F**), given the color pattern observed in specimens recorded by the camera traps and sighting. However, the collection of specimens is required to a more accurate identification. Two squirrel species (*Notosciurus pucheranii* and *Microsciurus flaviventer*) were observed in the Park, even though their known distributions do not include this area. *Notosciurus pucheranii*'s distribution ranges from the Colombian Central and Eastern Andean forests to the Western Peruvian Andes, and from the lowlands in Peru to the Western Brazilian and Bolivian Amazon, as well as to the Northwestern Argentina (Panton et al., 2015). This species is just found in the west of Acre State, in the upper Jurua River. It is also possibly found in the Northwest of Mato Grosso State, according to Bonvicino et al. (2008). There are records of *M. flaviventer* in the west of Amazonas State and Northwest of Acre and Rondonia States (Bonvicino et al., 2008; Patton et al., 2015). The record of both species in Chandless State Park region extends their distribution to the eastern region of Acre State. At least one species of *Dactylomys* occurs in the Park. Species identity is currently unresolved but, based on the known distribution, it could be either *D. dactylinus* or *D. boliviensis*.

The ungulates, tapir (*Tapirus terrestris*) (**Fig. 2G**), red brocket deer (*Mazama americana*) and collared peccary (*Pecari tajacu*), were all visually recorded. This fact highlights the rareness of white-lipped peccary (*Tayassu pecari*), since the species was only indirectly recorded, and its presence was indicated via tracks, skulls of hunted specimens and residents' reports. According to residents, *T. pecari* were abundant throughout the Park five years prior to 2008. Possible factors associated with *T. pecari* local population decline include changes in the dominant vegetation type, the species' migratory habits and the species' association with a wide variety of forest types, and diseases (Bodmer, 1990; Altrichter et al., 2002; Altrichter and Boaglio, 2004; Fragoso, 2004). As noted by Keuroghlian and Eaton (2008), the patchy

availability of food and water in naturally heterogeneous landscape leads to the use of extensive home ranges by *T. pecari*. Considering the factors likely to affect *T. pecari*'s distribution and the species requirement of large home ranges, we suggest that their presence and eventual migration in Southwestern Amazonia is related to the bamboo presence and fruiting dynamics. *Guadua* spp.'s death and regrowth drastically change the local habitat structure, since it has strong impact on vegetation density and species richness (Silveira, 2005). *Guadua* spp. dynamics drastically changes local food resources, such as seeds, fruits and rhizome, thus forcing species with broad home ranges, such as the white-lipped peccary, to move among different areas.

The Order Carnivora is represented by eleven species, distributed in three families. Felidae was the most species-rich family, with three species (**Table 1**). Members of this Order are often considered to be key species for ecosystem functioning. They are essential to keep ecosystem services, mainly to control prey populations.

Thirteen out of the 51 mammal species recorded in the Park are listed as endangered by the International Union for Conservation of Nature and Natural Resources (IUCN, 2014), and eight of them are listed by the Brazilian Ministry of Environment (Machado et al., 2008) (**Table 1**). *Dinomys branickii* and *Callimico goldii* are listed as Vulnerable by the IUCN (IUCN, 2014), because they are naturally rare and suffer from habitat loss and fragmentation in several locations within their ranges. Once combined, these factors enhance the possibility of local population extinction. The Brazilian Ministry of Environment lists six species of the Order Carnivora as vulnerable. It underscores the importance of Chandless State Park as a protected area, reinforcing the conservation and protection of a high diversity of species, including many endangered species.

CONCLUSIONS

Only three out of the 21 Conservation Units in Acre are strictly protected: Chandless State Park, Serra do Divisor National Park and Rio Acre Ecological Station. Together, these reserves

represent approximately 10% of the total state territory. On a regional scale, they comprise, together with other Brazilian and Peruvian parks, extractive reserves, communal and indigenous lands, a large mosaic of protected areas that is extremely important for biodiversity conservation. The Chandless State Park region harbors high richness of mammal species. The low human population density and the almost irrelevant hunting pressure in Chandless State Park may be the main factors leading to this high richness of species, compared to protected areas with more hunting pressure. Thus, the Park helps conserving a diverse mammal assemblage and protecting endangered species.

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