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Title: Influence of Human Activities on Some Medium and Large-Sized Mammals' Richness and Abundance in the Lacandon Rainforest

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Abstract

We evaluated the influence of six human activities (related variables) on the richness and abundance of large and medium-sized mammals in the southern portion of the Lacandon Rainforest, including protected and non-protected areas. The human activities measured have different influences on mammal richness and abundance. Our results show that some human activities (human density and anthropogenic land cover, and agriculture/cattle ranching) had no effect on large and medium-sized mammal populations, but community-based protection, such as medium levels of tourism and hunting, had a negative influence on richness and abundance. Those variables negatively influencing the mammal community were reported in one of the study sites. Data indicate both an opportunity for applied integral conservation actions that involve people and their activities, as well as an opportunity to support biodiversity conservation in agricultural landscapes by integrating human activities with protected areas and conservation.

Keywords:
Human activities, abundance, richness, mammals, conservation, Lacandon Rainforest, Montes Azules Biosphere Reserve, Mexico.

Introduction

The human population has grown and expanded to the point that the whole planet has been considered human-dominated for more than 15 years (Alessa & Chapin 2008). Most of the threats affecting biodiversity are related to human activities which can act as a source of disturbance and stress for natural populations, influencing ecological processes and resulting in changes in the abundance of species, among other negative outcomes (Benedetti-Cecchae *et al.,* 2001; Munguia *et al.,* 2016, Valenzuela *et al.,* 2008, Vuyiya *et al.,* 2014). The conversion of natural habitats for agricultural, forestry, and grazing activities has been considered the major threat to biodiversity conservation and the principal disturbance agent for natural communities, and as such, an important cause of species extinction (*e.g* Ochoa-Gaona 2000; Ceballos *et al.,* 2005, Munguia *et al.*, 2016, Valenzuela *et al.*, 2008, Urquiza-Hass *et al.*, 2009). Studies have demonstrated that human activities have a significant influence on the global extinction risk of mammals (Kerr & Currie 1995, Ceballos & Ehrlich 2002). Cardillo *et al.* (2004) point out that all ongoing declines of mammal populations are caused by human population growth, resulting in several activities of negative impact for biodiversity, such as subsistence hunting, which has been related to the decline of mammal populations for several decades (Kerr & Currie 1995).

Natural areas affected by human activities show differences in species abundance and composition compared to natural protected areas where human pressure is low (Caro 2002), but there are cases on a local level in which human activities may be favorable for some species because of the habitat heterogeneity it promotes (Caro 2001, Ahmadi *et al.,* 2014). Some areas embedded in a forest matrix could be beneficial to some species because of the "primary productivity taking place at ground level in treefall gaps or other open habitats". For example, studies performed in southern Mexico basically found no differences in species richness and community structure between oldfield and forest habitats, arguing that the sort of relatively small clearings (*ca*. 3 ha) commonly found at the study sites (the Lacandon Rainforest) and when within a forest matrix allow forest-dependent mammal species to enter them, some of those species are *Tapirus bairdii*, *Cuniculus paca*, *Dasyprocta punctata*, *Tayassu pecari*, *Pecari tajacu* and *Mazama americana* (Medellín 1994, Medellín & Equihua, 1998).

In the specific case of agricultural activities, it is known that some practices can contribute to species conservation (Medellín & Equihua, 1998; Daily *et al.*, 2003). For example, Declerck *et al.* (2010), proposed an approach for conservation in Mesoamerica, which addresses conservation challenges in human- dominated landscapes characterized by constant human disturbance through such means as the integration of sustainable agricultural systems with existing efforts in protected areas (also see Harvey *et al.,* 2008).

A key strategy for protecting biodiversity from external pressures has been the establishment and maintenance of protected areas, which can have a positive influence on mammals because they are able to maintain higher population densities of mammalian species or other species, in comparison with unprotected areas, partly due to the restriction of human activities (Kerr & Currie 1995). Worldwide, protected areas remain isolated from one another, and in many cases, natural biological corridors for plant and animal dispersal become disrupted by anthropogenic barriers (Epps *et al.,* 2007, Becker *et al.,* 2007). This anthropogenic matrix occupies, in several places, the majority of the landscape and acts as a filter for animal dispersal between forest patches (Gibbs 1998, Gascon *et al.*, 1999).

The Lacandon Rainforest region in Mexico includes protected (federal and community-based) and non-protected areas. Some factors affecting biodiversity conservation in this region include human immigration and colonization, economic development with no environmental impact planning, overexploitation of natural resources, deforestation, poaching and wildlife smuggling (Vásquez-Sánchez *et al.*, 1992; Cuaron 1997, Vleut 2013). It is important to take into account, as it is mentioned by Medellin &

Equihua (1998), that disturbed areas surrounded by a forest matrix can result in an overall higher diversity because of the coexistence of forest and open-area species.

With our research we evaluated the influence of human activities on species richness and abundance of large and medium-sized mammals on a local scale in the Lacandon Rainforest in Mexico. We evaluated sites including federal protected areas, community-based protected areas and non-protected areas.

Methods

Study area

Our study was carried out in the southern region of the Lacandon Rainforest in Chiapas, Mexico, which is mainly a tropical rainforest (Rzedowski, 1978), but also includes some areas of cloud forest, savannah, riparian forest, agricultural land, grassland, plantations, and secondary vegetation (March & Flamenco, 1996). Land tenure is mainly community- based (known in Mexico as ejidos), and the principal economic activities are agriculture and extensive livestock (Vásquez-Sánchez et al., 1992; INE-SEMARNAP, 2000), although fishing and subsistence hunting and gathering are also practiced (Naranjo, 2002).

The Montes Azules Biosphere Reserve (MABR) is located in the Lacandon Rainforest in Chiapas and protects one of the largest areas of remaining tropical rainforest in the country (INE-SEMARNAP 2000). It presents an altitude interval of 200 to 1500 masl, with an annual precipitation of 2300 to 2500mm and a mean annual temperature of 25˚C (INE-SEMARNAP, 2000). Dominant soils are Rendzinas and local climax vegetation is tropical evergreen forest (Miranda, 1998; INE-SEMARNAP, 2000).

Within the MABR (located in the subregion of Montes Azules; INE-SEMARNAP, 2000) we selected two sampling sites (MA1 and MA2) and two more outside the MABR, in two different ejidos (PG and RA; Figure 1) within the subregion of Marques de Comillas. The four sites are located next to the Lacantun River and were selected because of their accessibility, topography and the information available from previous research (Naranjo, 2002; Naranjo et al., 2003).

According to the MABR management program, sites MA1 and MA2 are located within the "restricted use zone" of the MABR, where human activity must be low or non-existent (INE-SEMARNAP, 2000). The two selected areas outside the MABR present different types of human activities and land use. At Playon de la Gloria ejido (PG) there are multiple anthropogenic pressures, including: unrestricted hunting and logging and changes in land use, plus the area does not have a land use plan. In contrast, Reforma Agraria ejido (RA) is characterized by a land use plan with established areas for housing, and agricultural, ranching and conservation practices. Additionally, no extractive activity is allowed in the conservation area.

Data

Determining large and medium-sized mammal richness and abundance

Data were collected from May-August 2008 and February-May 2009 during both the dry and wet seasons. We used Wildiew Xtreme STC-TGL4M digital camera traps (Stealth Cam, LLC, Grand Prairie, Texas) in order to estimate the richness and abundance of large-sized (weight more than 7 kg) and medium-sized (weight between 2 and 7 kg) mammal species (Emmons & Feer, 1997, IUCN 2016). We used two different sample designs according to Chavez *et al.* 2007, one for species with minimum home range greater than 1 km^2, and another for species with home range less than 1 km^2. For the first sample design, we placed one camera every 1.5 km along three line transects of approximately 3.5 km (Figure 2) in each of the four sample sites (Karanth & Nichols, 1998; Sarmiento, 2004; Kauffman *et al.*, 2007). Distance between cameras was decided after analyzing the home range of the expected species and taking into account recommendations from Karanth and Nichols (1998) and Wegge et al. (2004). Total distance of line transects was determined by the site's topography. For the second sample design, we placed two grids of 3x3 camera traps, separated by 100-200 m (Figure 2).

Camera placement for the two designs was implemented following the procedure described by Karanth & Nichols (1998), mounted on the trees at one side of the transect, at approximately 50 cm from the ground. To select the sample sites, we identified places with signs of presence or activity of mammal species.

We sampled all four sites simultaneously, using 22-24 camera traps per site. Cameras were set up to be active for 24 hours, with a minimum time interval between photos of five minutes. The sampling period for each season was 30 days for medium-sized mammals and 60 days for large-sized mammals, but cameras were reviewed approximately every 15 days to download pictures and change batteries. To calculate the total area covered by camera traps we created a buffer area that was the sum of the area of circles of

1.5 km in radius (the distance between cameras) around each camera trap. Therefore the sampling area was 23.16 km2 in MA1, 18.87 km2 in PG, 24.36 km2 in MA2, and 40 km2 in RA.

Human activities

To evaluate the impact of some human activities on mammals, we considered qualitative and quantitative variables related to human presence: tourism, hunting, agriculture/cattle ranching, anthropogenic land cover and human population. Several of these variables have been used in the past in order to represent and quantify human influence (Alessa & Chapin, 2008; Cardillo *et al.*, 2004; Munguia *et al.*, 2016).

Quantitative variables were: hunting, anthropogenic land cover and human population. For hunting, we used extraction rate data from Moreno (2009), who reports rates of animal extraction of 2.3 ind/km^{-2}/year in PG and 0.7 ind/km^{-2}/year in RA for subsistence hunting. Based on MABR restrictions and data presented by Moreno (2009), we assume animal extraction to be zero for MA1 and MA2.

Anthropogenic land cover was measured as a percentage of the total area of each site evaluated, which was obtained by reclassifying the Vegetation and Land Use map of Mexico (INEGI, 2004). Anthropogenic land cover includes: agricultural areas, grassland, human settlement and areas without vegetation. Human population density (number of persons/km^{-2}) was taken from the Localities Map of Mexico (INEGI, 2000).

Qualitative variables were classified for each sample site based on the following criteria: 1) Tourism was measured as low, medium or high, based on site characteristics as follows: PG does not have a tourism project and receives few visitors, mainly students; RA communities have a tourism project with existing designs for infrastructure and tourist packages; and sites located inside the MABR (MA1 and MA2) do not have a tourism program but rather receive visitors, mainly from the scientific tourism sector. Due to a lack of accurate data on the number of tourists visiting each site, the information was obtained from previous knowledge of tourism activities in the area gathered through conversations with community leaders; 2) Agriculture/livestock practices were considered absent at the two sampling sites inside the MABR and as present at the sampling sites outside the MABR.

We also evaluated the influence of the land protection scheme of each site, which was classified as 1) unprotected (PG), 2) community-based protected (RA), and 3) federal protected (MA1 and MA2).

Sampling sites

Montes Azules 1 (MA1) and Montes Azules 2 (MA2) are located inside the MABR, which means they have federal protection. For this reason, there are no people living at these sites (human population density = 0) and no agricultural or cattle ranching activities. MA1 does not have anthropogenic land cover as is expected inside a protected area, but MA2 has an anthropogenic land cover of 0.01%. These sites do not have a tourism program but rather receive visitors mainly from the scientific tourism sector - professors and students from local and regional universities. There is no record of hunting inside the reserve.

Reforma Agraria ejido (RA) is located outside the MABR. The human population density is 6.73 ind/km2 and the anthropogenic land cover is 0.17%. This community has divided their land into areas dedicated to agriculture and cattle ranching, housing and community-based conservation. Hunting is not allowed inside this conservation area. The extraction rate of mammals in the community is 1.20 ind/km2/year (Moreno, 2009). They have a tourism project with existing designs for infrastructure and tourist packages.

Playon de la Gloria ejido (PG) is also located outside the MABR. This community has the highest human population density (12.67 ind/km^{-2}) and also the highest value of anthropogenic land cover (52%), mostly related to agricultural and cattle ranching activities. This site does not have an area designated to conservation, and hunting is allowed. The extraction rate of mammals is 2.86 ind/km^{-2}/year (Moreno 2009). This community does not have a tourism plan or project, but students from universities visit regularly.

It is important to observe that although there are noticeable differences between sites in most of the variables, the values are not as high as they are in other regions within the Lacandon Rainforest.

Analyses

Species richness was reported as the total number of large and medium-sized mammal species recorded at each sample site. Species abundance was expressed as capture frequency (number of pictures of species/100 camera trap days; Rowcliffe & Carbone, 2008; Tobler *et al.*, 2008).

Human activity variables were categorized depending on the intensity recorded for the four sites as follows: hunting, anthropogenic land cover and human population density, and tourism: low=1, medium=2, high=3. Agriculture/cattle ranching: absence=0, presence=1. Variable Protection was classified as unprotected=0, community=2, federal=1.

To evaluate the influence of human activities on mammal populations, richness and abundance were modeled using generalized linear mixed models (GLMM) with a logarithmic link function and a Poisson variance. Due to the sample size (n=4) we used univariate models, using richness and abundance as dependent variables, and tourism, human population density, agriculture/cattle ranching, hunting, anthropogenic land cover and protection as independent variables. All the analyses were done with the open source software R (R development core team, 2010) and Rcmdr package (Fox, 2009).

Results

Species richness and abundance

Total sampling effort was 2618 camera/days: 709 at MA1, 632 at MA2, 650 at PG and 627 at RA. We recorded a total of 18 species of medium and large-sized mammals, beloging to 10 families and 5 orders of mammals. Most of the species recorded belong to the orders Carnivora (9 species) and Artiodactyla (4 species). Table 1 shows the list of species recorded and species abundance (expressed as capture frequency = total number of photos/100 camera trap days) by sample site. The sites with higher species richness and abundance were MA1 (13 species) and PG (12 species), while 11 species were detected in MA2 and 8 in RA. The species that were most recorded *were Cuniculus paca, Mazama americana, Tayassu pecari, Pecari tajacu* and *Tapirus bairdii* (Table 1). Only five species were recorded at all sampling sites: *Cuniculus paca, Dasyprocta punctata, Dasypus novemcinctus, Panthera onca* and *Pecari tajacu* (Table 1).

Influence of human activities

GLM analyses showed that the human related variables analyzed are influencing the richness and abundance of medium and large-sized mammals in different ways (Table 2). Surprisingly, human density and anthropogenic land cover, and agriculture/cattle ranching did not have any influence on richness and abundance of mammals at the local scale considered. However, the level of tourism activity had a negative influence on both richness and abundance that presented smaller values at the site with a medium level of tourism (Table 2). Surprisingly, the response of mammal abundance and richness to the level of protection was not as expected, and there was no significant difference between the sites in the MABR and the unprotected site. However, the site with community-based protection presented smaller values on both dependent variables (Table 2).

A similar surprising result was obtained for the level of hunting, which does not cause a significant difference between sites with no hunting (inside the MABR) and the site with highest hunting intensity; and again, the site with a medium level of hunting showed significantly lower richness and abundance of mammal species.

It is important to highlight that those three variables negatively affecting the mammal community were reported in the same study site: RA.

Discussion

Human influence on the southern portion of the Lacandon Rainforest was related principally to small-scale subsistence activities: hunting, tourism, agriculture and cattle ranching. Results indicate that three of the six variables evaluated had a negative influence on both richness and abundance of mammals. This negative influence is recorded in just one of the study sites: RA. Curiously, RA was not the site with medium levels of hunting, tourism and protection.

In the past, Medellin & Equiua (1998) found that in the Lacandon Rainforest region, a similar richness and abundance of mammals was recorded at old-field and forest sites, a result that was interpreted as a chance to mix conservation and productive activities. Our data also suggests that on a local scale the intensity of human activities found at our study sites in the Lacandon Rainforest are not causing negative impacts on the richness and abundance of mammals. These results also suggest that conservation activities and the type of human activities considered here can be combined.

For populations of medium-sized mammals, previous studies have shown either positive or negative effects of land use changes and human activities in semi-natural landscapes on species abundance, depending on the species´ habitat preferences (for example endemic and specialist versus generalist, Wijesnghe & Brooke, 2005). Our results are similar to results from other studies because they do not reflect a clear influence of human activities on animals (Caro, 2002; Collins & Gleen, 2007). In fact, Caro (2001) points out that differences in mammal richness and abundance between protected areas and human-influenced sites do exist, but he does not identify causes. Similarly, for Mexico, Urquiza-Hass *et al.* (2009) and Tejeda *et al.* (2009) found different responses from large vertebrates to varied expressions of human activities. Our results do not show a clear trend in the influence of the local-scale human activities we considered on the richness and abundance of medium and large-sized mammals.

Similarly, Carter *et al.* (2012) did not find any differences in the abundance of tigers and ungulates between sites inside and outside a National Park in Nepal, although human population density in settlements surrounding the National Park has increased 20% in the past years and is now nearly 212-255 people/km^{-2}. These authors point out that tigers can adapt and thrive in a human-dominated landscape by displacing their spatial and temporal activity from humans (see also Carter, *et al*. 2015). Human density or cattle ranching intensity in the subregions of the Lacandon Rainforest, where our study sites are located, are lower than in other subregions, for example, at the Cañadas or the Zona Norte subregions, where human density is 3 to 9 times higher than at our study sites (INE-SEMARNAP, 2000). Therefore, it might be possible that although there is human pressure at the sites outside the MABR, it is still relatively low in intensity. It is also possible that other aspects of the variables we considered could play a role in how species respond to human activities at the sites studied. For example, monoculture is the typical type of agriculture observed in the study areas, which in turn can have a different impact than other sorts of agricultural practices. This does not mean that agriculture and cattle ranching cannot drive a decline in the richness or abundance of medium and large-sized mammals, but apparently for this to occur, a higher level of both variables is needed.

Additionally, it is necessary to point out that our analysis basically considers the presence of the activity, and it is important to measure the various types and intensities of agriculture and cattle ranching practices in order to determine more precisely the sort of impact these variables have on a local scale on mammal species richness and abundance.

As in other studies, our data indicates that medium and large-sized mammals can persist locally despite the sort of hunting pressure considered, supporting the debate that species can be resistant to human impact and develop certain strategies to survive in areas with human influence (Mugume *et al.*, 2015).

However, it is important to consider that even subtle changes in the abundance of some species could have an effect on the abundance of other species. For example, we found that large-sized herbivores (*Tapirus bairdii*, *Tayassu pecari*, *Pecari tajacu* and *Mazama americana*) were recorded much more frequently at the sites inside the MABR than outside, where two small herbivore species (*Cuniculus paca* and *Dasyprocta punctata*) were more easily recorded.

It could also be that the MABR region is maintaining populations of different medium and large-sized mammal species and that their presence at sites outside the MABR is due to a surplus of individuals that are dispersing to these sites (Naranjo & Bodmer, 2007). This has been suggested to be the case for white tailed deer (Mandujano, 2011).

Results presented here suggest that the environmental heterogeneity caused by human disturbance provides habitats for small and medium-sized mammals, at least for the species recorded in this study. Environmental heterogeneity in PG and RA is related to community land management, given that each human community determines the proportion of their land dedicated to wildlife protection or to agriculture and cattle ranching activities (Wilson, 1994). Some human activities, at a relatively low intensity, such as the agricultural practices and small-scale changes in the forest (principally to open small-scale grasslands) at our study sites, can result in habitats that are favorable for some generalist and opportunistic species (Olifiers *et al.*, 2005), since those activities result in heterogeneous agro-ecosystems (in space and time; Gentile *et al.*, 2000).

Habitats with increased environmental heterogeneity are characterized by a variety of resources and niches and therefore maintain more diverse and abundant animal populations (Caro, 2002). The life history of species is a relevant factor when evaluating the influence of human disturbance (Pickett & White, 1985) because there is no single or particular response for the mammal community.

Species like *Tayassu pecari* and *Odocoileus virginianus* are good examples. T. pecari was not recorded in the sites located outside of the MABR (PG and RA), perhaps due to the high sensibility of this species to human pressure, specifically to hunting and to habitat loss (Tejeda-Cruz, *et al.,* 2009). Moreover, *O. virginianus* was not recorded inside the MABR, probably because this species has a preference for open habitats, which are more abundant in PG (Tejeda-Cruz *et al.,* 2009; Naranjo & Bodmer, 2007; Weber, 2008).

Our results do not mean that the highest values for human disturbance variables will generate the highest values for richness or abundance of large and medium-sized mammals. Human activities affected mammal populations in different ways and to varying degrees; therefore, they should not all be framed within one single category of disturbance.

This means that in human-dominated landscapes there is still a conservation opportunity (Melo *et al.,* 2013). In Mesoamerica, linking conservation inside protected areas to the surrounding agricultural landscape is inevitable (Harvey et al., 2008), and thus it should be considered that protected areas with little or no human presence are increasingly less frequent and most PAs are surrounded by a mixture of areas with different levels of human impact. Therefore, it is important to acknowledge that conservation actions should be directed towards the management of biodiversity in these areas dominated by human activities (Melo *et al.*, 2013).

Although PAs are an important conservation tool and an individual source for animal populations outside reserves (Naranjo & Bodmer, 2007), efforts can be added and directed towards human-dominated landscapes, which have conservation potential due to their roles as biodiversity reservoirs and the synergistic interactions that exist between biodiversity and human related activities (Daily *et al.,* 2003; Harvey & Saenz, 2008; Harvey *et al.,* 2008; Laurence & Cochrane; 2001).

In a world where human-dominated landscapes and habitats are constantly expanding, results like those reported here are very relevant and encouraging if we consider: 1) that some species can be resilient enough to tolerate human presence up to a certain level, and 2) the opportunity for biodiversity conservation in agro-landscapes (Harvey & Saenz, 2008; Melo *et al.*, 2013).

Our data show that some of the large and medium-sized mammals in the southeastern region of the Lacandon Rainforest can tolerate the sort of human activity intensity present at our study sites: for example, species such as *Cuniculus paca*, *Dasyprocta punctata*, and *Dasypus novemcinctus*. It should be noted that we did not analyze species behaviour. This could be the result of a positive influence of hunting and non-protection on mammal populations. Previous studies conducted inside and outside the MABR show that this reserve may be playing a key role as a source of mammals for surrounding areas (Wilson, 1994; Naranjo & Bodmer, 2007).

Although it is recognized that a reduction in human caused disturbances on natural habitats is one of the major conservation challenges humanity is facing (Zeng *et al.,* 2005), it is also of great importance to consider that there is still some value in biodiversity conservation in human-dominated landscapes (Melo *et al.,* 2013). Conservation efforts should consider local people and their activities using a conservation landscape approach (Valenzuela *et al*., 2008). This could contribute to increased chances of species conservation outside PAs if proper land management practices are used to protect or to sustainably manage the flow of species and individuals in large patches of natural habitats like PAs. In the last 10 years a considerable proportion of species have been shown to survive in human-dominated environments (Ceballos *et al.,* 2005). This could be the case for the Lacandon Rainforest region if conservation practices are extended to sites outside the MABR.

Protected Areas are powerful conservation tools and can mitigate local extinction of species (Bruner et al., 2001), and the results presented here support this. But it is also important to strongly point out that management and conservation actions outside PAs should be taken in order to ensure the effectiveness of these PAs, especially considering that current Mexican (and worlwide) protected areas network has gaps left unprotected species and habitats (Valenzuela-Galván and Vazquez, 2008, Vazquez and Gaston 2006).

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Figure Legends

Figure 1. Sample sites and land cover in the Lacandon Rain Forest.

Figure 2. Camera-traps sample design for large and medium mammal species.

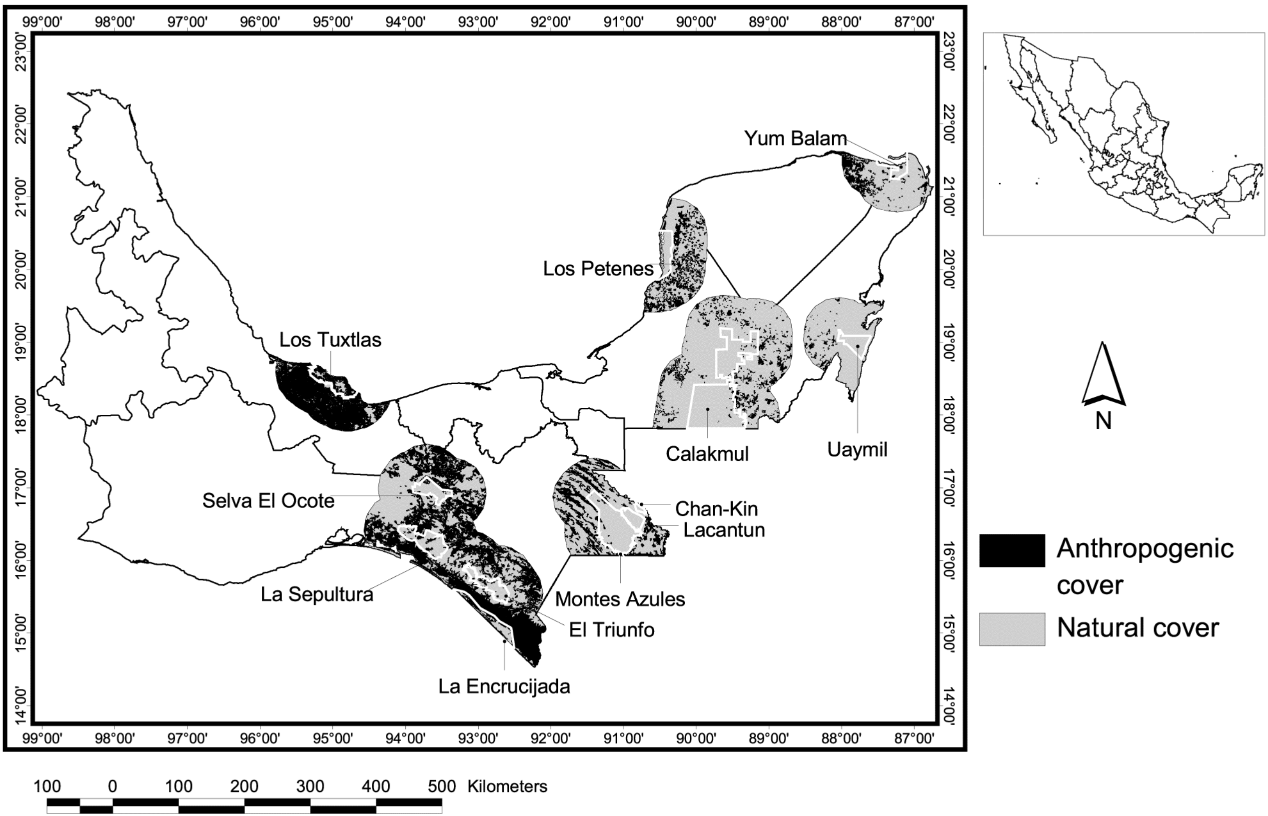
Figure 3. Camera-trapping design for large and medium-sized mammal species used inside and outside Montes Azules Biosphere Reserve, Mexico.

Table 1. Medium and large sized mammal species capture frequency (Total number of photos / 100 camera trap days) in the four sample sites in the Lacandon Forest. Montes Azules 1 (MA1), Montes Azules 2 (MA2), Playón de la Gloria ejido (PG), Reforma Agraria ejido (RA).

Medium sized mammals	Family	MA1	MA2	PG	RA
Cabassous centralis	Dasypodidae	0	0	1	0
Dasypus novemcinctus	Dasypodidae	3	4	15	9
Conepatus semistriatus	Mephitidae	1	0	0	0
Galictis vittata	Mustelidae	0	0	1	0
Dasyprocta punctata	Dasyproctidae	1	1	42	1
Eira Barbara	Mustelidae	0	1	0	0
Cuniculus paca	Cuniculidae	19	12	56	32
Large sized mammals	Family				
Mazama americana	Cervidae	44	27	0	17
Odocoileus virginianus	Cervidae	0	0	4	10
Mephitis macroura	Mephitidae	1	0	0	0
Nasua narica	Procyonidae	5	2	11	0
Leopardus pardalis	Felidae	10	4	1	1
Panthera onca	Felidae	1	1	1	1
Puma concolor	Felidae	1	0	0	0
Puma yagouaroundi	Felidae	0	0	1	0
Tapirus bairdii	Tapiridae	27	21	2	0
Tayassu pecari	Tayassuidae	20	59	0	0
Pecari tajacu	Tayassuidae	14	27	9	7

Table 2. GLM's (with log-link and Poisson variance function) explaining mammal richness and abundance by variable.

		Richness				Abundance			
Variable		Estimate	Std. Error	z value	Pr(>│z│)	Estimate	Std. Error	z value	Pr(>│z│)
Agriculture/Cattle Ranch	(Intercept)	0.9395	0.1072	8.76	0.0000	2.2005	0.0571	38.56	0.0000
	Present	-0.1254	0.1554	-0.81	0.4195	-0.3442	0.0879	-3.92	0.0001
Tourism	(Intercept)	1.1192	0.1429	7.83	0.0000	2.2110	0.0828	26.72	0.0000
	Medium	-0.6625	0.2318	-2.86	0.0043	-0.7987	0.1402	-5.70	0.0000
	High	-0.1797	0.1786	-1.01	0.3144	-0.0105	0.1005	-0.10	0.9166
Protection	(Intercept)	1.1192	0.1429	7.83	0.0000	2.2110	0.0828	26.72	0.0000
	Community-Based	-0.6625	0.2318	-2.86	0.0043	-0.7987	.01402	-5.70	0.0000
	Unprotected	-0.1797	0.1786	-1.01	0.3144	0.1005	0.1005	-0.10	0.9166
Human density	(Intercept)	0.8480	0.1072	7.91	0.0000	2.0967	0.0578	36.30	0.0000
	Human density	0.0061	0.0149	0.41	0.6810	-0.0121	0.0085	-1.42	0.1555
Anthropogenic landcover	(Intercept)	0.8085	0.1038	7.79	0.0000	2.0367	0.0566	35.97	0.0000
	Anthropogenic landcover	0.3913	0.3707	1.06	0.2912	0.0233	0.2138	0.11	0.9132
Hunting	(Intercept)	2.0638	0.0570	36.33	0.0000	2.0638	36.23	36.23	0.0000
	Hunting	-0.0237	0.0383	-0.62	0.5372	-0.0237	-0.62	-0.62	0.5372



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Yum Balam
Los Petenes
Los Tuxtlas
Calakmul
Uaymil
Selva El Ocote
Chan-Kin
Lacantun
La Sepultura
Montes Azules
El Triunfo
La Encrucijada
N
Anthropogenic cover
Natural cover
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0
100
200
300
400
500
Kilometers


90°59'30"
90°54'00"
90°48'30"
90°43'00"
16°16'30"
16°11'00"
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MA2
RA
MA1
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Anthropogenic cover
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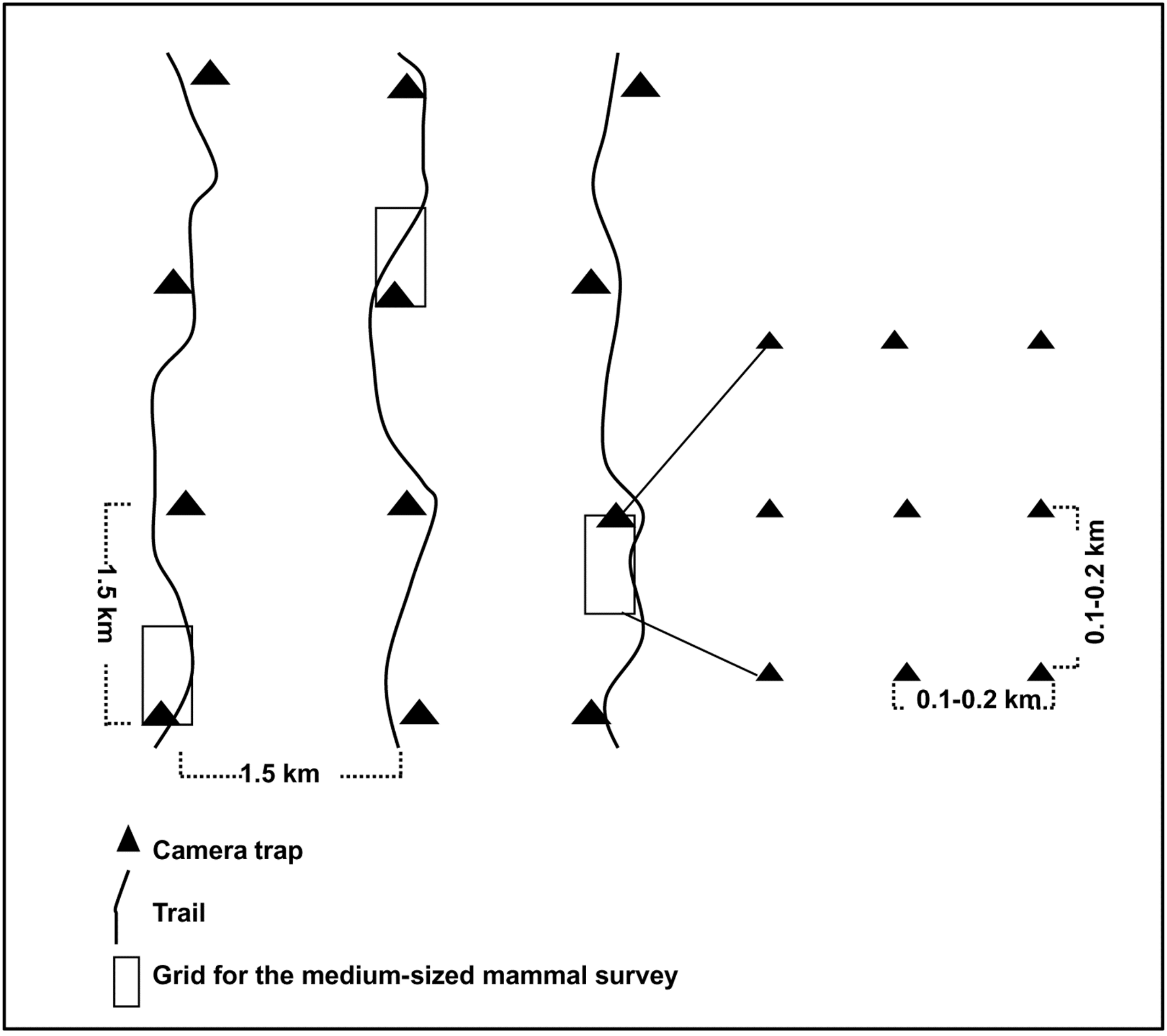
1.5 km
1.5 km
0.1-0.2 km
0.1-0.2 km
Camera trap
Trail
Grid for the medium-sized mammal survey