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ATTITUDES AND INTERACTIONS OF INDIGENOUS AND NON-INDIGENOUS PEOPLE WITH WILDLIFE IN THE NORTHERN TALAMANCA MOUNTAINS OF COSTA RICA

A Dissertation Presented

by

CAROLINA SÁENZ-BOLAÑOS

Submitted to the Graduate School of the
University of Massachusetts Amherst in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

September 2021

ENVIRONMENTAL CONSERVATION

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ATTITUDES AND INTERACTIONS OF INDIGENOUS AND NON-INDIGENOUS PEOPLE WITH WILDLIFE IN THE NORTHERN TALAMANCA MOUNTAINS OF COSTA RICA

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CAROLINA SÁENZ-BOLAÑOS

Approved as to style and content by:

Todd K. Fuller, Chair

Eduardo Carrillo, Co-Chair

Lynnette Sievert, Outside Member (Anthropology)

Curtice R. Griffin, Head

Department of Environmental Conservation

DEDICATION

To my mom for being the person who you are and the strength you have. For everything you went through to keep us in the right way.

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First to all thanks to God for giving me the opportunity grow up and do what I enjoy. I want to thank to my mentor Eduardo Carrillo who trusted me and gave me the first opportunity in the field that I always wanted to be in, encouraged me to complete my PhD, and for being there with his support. I also am grateful Todd Fuller for his kindness and guidance during all these years as scientific mentor. Thanks also to Emiliana Cruz who was on my guidance committee and to Lynnette Sievert helping me with the social side of this research.

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ABSTRACT

ATTITUDES AND INTERACTIONS OF INDIGENOUS AND NON-INDIGENOUS PEOPLE WITH WILDLIFE IN THE NORTHERN TALAMANCA MOUNTAINS OF COSTA RICA

SEPTEMBER 2021

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In this study I investigated wildlife and human use of landscapes in the northern Talamanca Mountains of Costa Rica (Pacuare-Barbilla sector), including three contiguous protected areas (a national park, a forest reserve, and an indigenous territory), as well as surrounding unprotected areas. I describe and compare perceptions of wildlife by different social actors in the Pacuare-Barbilla sector, collecting information with a questionnaire as an instrument. I also inventoried and monitored the abundance and distribution of a variety of wildlife species occurring throughout the area using camera traps. The species with greater abundance or only occurrence in the national park were mammals and birds commonly hunted, and species present in the forest reserve are species related with perturbed or human presences areas. The park and indigenous territory still keep good forest cover, as well as some important mammal species (e.g. jaguar, paca, red brocket, white-lipped peccary), despite high hunting rates. I also used these data to investigate the potential correlations of human behaviors with differences in biodiversity among different landscapes. A total of 91

questionnaires were applied and 59 wild species were reported by interviewees (33 mammals, 20 birds, 6 amphibian and reptiles); more species were reported by non-indigenous than indigenous interviewees. Moreover, the cited species cataloged as problematic because they attacked cattle, pigs, chickens, or pets, caused crop losses, and posed some risk for humans, were also higher for non-indigenous people. Jaguars and coyotes were cited most often as problem species by both groups. In particular, 68% of indigenous interviewees cited either jaguar or puma as causing attacks to their animals (pigs and cows mostly), with a total of eight species as poultry predators and six more as crops eaters. Both groups perceive less rainfall and higher temperatures, as well less forest cover and smaller jaguar populations, compared to 10 or more years ago. The feelings and attitudes about big cats changed in relation to how close people think they are or by their view of their negative impacts. Indifference and fear were the most named feelings, and relative intensity of feelings varied by ethnicity and gender. This geographical area is a very good example of how different regulations could result in differences in some mammal and bird species abundances and occurrences, and thus need to be considered when assessing the overall effectiveness of protection as a conservation strategy. Moreover, is necessary involve, learn from and work with local communities, especially concerning attacks on domestic animals, to better address conservation projects generating long-term benefits for humans and the wildlife.

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PREFACE

Large natural areas such as national parks and reserves are important for conserving wildlife populations (Bruner et al. 2001, Peres 2005). In addition, indigenous territories also can provide ecological connectivity in large landscapes, ensuring substantial environmental benefits such as water, nutrient flows and soil protection, while also providing survival and livelihood benefits to millions of people (Kothari, 2013).

Biocultural places where nature and culture are integrated, such as indigenous peoples' and local community conserved territories and areas (ICCAs), are seamless landscapes of wild and domesticated biodiversity, linking two crucial parts of human life that have been artificially separated in modern times (Salmon 2000, Kothari 2013, Wall Kimmerer 2013). More than 25% of the world's land surface are in the lands of indigenous peoples that overlap with about 40% of terrestrial protected areas in the world (Garnett et al. 2018). In the Neotropics, intact forest landscapes represent 36% of landscapes, and 41% of these are in lands of indigenous peoples (Fa et al. 2020).

In Costa Rica, 32% of the land area is under some level of protection, including indigenous territories (6%) and other protected areas (26%; Ortiz-Malavasi 2014). The land under protection in Costa Rica especially helps top predators and large herbivores to thrive because they usually provide relief from human persecution and anthropogenic habitat changes (Galetti et al. 2009). Even so, protected areas by themselves are no longer sufficient to sustainably protect large mammals. Humans can cause the defaunation syndrome, where the forest seems to be doing well but is devoid of large predatory vertebrates (Beck et al. 2013), and a major task of conservation is to avoid empty forests. Also, it is often necessary to establish or maintain landscape connectivity between multiple protected areas to protect large carnivores (Soulé and Noss 1998, Di Minin et al. 2013, Castilho et al. 2015).

The National Parks of Costa Rica were set aside exclusively for conservation and research, so "consumptive" human activities are prohibited within their boundaries. In contrast, development activities such as raising cattle, forest plantations with exotic species for harvesting lumber, human settlements, and agriculture are allowed in Forest Reserves which are also counted as protected areas. Finally, Indigenous Territories, the category of land for indigenous peoples, are autonomous. Location-specific regulations apply (e.g., only the indigenous population is allowed to hunt) and any land-use is allowed without government permission under Indigenous Law (Ley Indígena 1977).

The important role that indigenous peoples play in forest conservation must be recognized, as well as the importance of involving these populations in conservation projects in order to achieve global conservation goals (Fa et al. 2020). I consider it essential to include inhabitants of lands wherever researchers conduct any study in order to reach these goals. For that reason, it is necessary that practitioners of conservation projects become more familiar with the local communities. It is common for professionals in biological sciences to be unfamiliar with the most useful and pertinent techniques or processes for working with local or indigenous communities. Consequently, many conservation research projects have not produced the most useful recommendations. Saberwal and Kothari (1996) noted that in developing countries a lack of integration of human dimensions with conservation biology and wildlife management exists because many scientists do not have adequate training on these important issues. We seem to approach questions from our trained point of view and focus only on the wildlife species of interest and not on what native/local people think of our research or our goals (Tuhiwai 2012).

In this study I investigate wildlife and human use of landscapes in the northern Talamanca Mountains of Costa Rica (Pacuare-Barbilla sector), including three contiguous protected areas (a national park, a forest reserve, and an indigenous territory), as well as surrounding unprotected areas. The entire Pacuare-Barbilla sector (Fig. P1) is an area of 405 km^2 located in the Volcánica Central-Talamanca Biological Corridor between Limón and Cartago provinces (Ortiz-Malavasi

2014). Precipitation occurs throughout the year, with relatively more rain during November-December and less in March, and averages ~4,000 mm annually (Bernal and García 2007). It includes three different protected areas (Barbilla National Park [BNP], Río Pacuare Forest Reserve [RPFR], and Indigenous Territories [IT]), each one with a specific category of regulations and management, as well as surrounding unprotected lands (Fig. P.1).

The national park (BNP) has as its main objective the conservation of the tropical humid forest that provides a large proportion of water production along the Caribbean slope of the Talamanca Mountain Range (SINAC 2017). The forest reserve (RPFR), located to the north of the Park, was logged in the mid-1970's by means of 15 km of new unpaved roads which subsequently allowed for additional roads and settlements in the area (Hedström 2006). Nowadays, the forest reserve contains some grasslands for cattle, forest plantations (exotic and native species), human settlements, and eco-lodges. The indigenous territories surrounding the national park at the four cardinal points, belong to the Cabécar, the second largest indigenous group in the country. The three territories surrounding the BNP are the Nairi Awari Indigenous Territory (NAIT) on the northwest and northeast, Chirripó Indigenous Territory (ChIT) to the northwest and south, and Bajo Chirripó Indigenous Territory (BChIT) to the east. In these three areas there is a population of 7,737 Cabécars (Bernal and García 2007, INEC 2013, Mideplan 2015, Sáenz-Bolaños et al. 2015, SINAC 2017). In these territories there are relatively few settlements. The Cabécar mainly hunt, plant bananas, cassava and grains, and also raise pigs, chickens and cows. However, I only worked in the NAIT and ChIT, where people are willing to accept the research in their territories. The surrounding non-protected areas include a mix of forest, plantations, agricultural lands, and populated communities with a somewhat larger road-network and thus higher accessibility than the protected areas.

In this dissertation I describe perceptions of wildlife by different social actors in the Pacuare-Barbilla sector, collecting information with a questionnaire as an instrument. I also inventoried and monitored the abundance and distribution of a variety of wildlife species

occurring throughout the area. I use these data to investigate the potential correlations of human behaviors with differences in biodiversity among different landscapes. My goal is to suggest or recommend what activities should be modified by managers of protected areas in Costa Rica in order to conserve jaguar populations, and species they rely on, in the long-term. Establishing an important link between jaguar presence and indigenous territories will help focus the importance of such areas in conservation planning.

More specifically, this dissertation includes the following sections. In Chapter 1, I describe the general wildlife diversity and relative abundance among the variety of adjacent protected areas in the Northern Talamanca Mountains of Costa Rica by using data collected via camera traps. I show that varying regulations and management practices result in major identifiable differences among areas. In Chapter 2, I describe local perceptions of wildlife in the area and compare them between indigenous and non-indigenous people. My purpose is to assess important indigenous and local knowledge about the species that live in the area because by understanding the ontology, relevance, respect for, beliefs about, knowledge, and meaning of species, we will be able to generate better wildlife management action plans. In Chapter 3, I focus on human-wildlife conflict in indigenous communities of the Nairi Awari Indigenous Territory. Domestic livestock, particularly pigs, are husbanded such that they are vulnerable to predation by wild carnivores, and potential for retaliatory killing, and thus adverse effects on the predators, may be high.

In Chapter 4, I compare the relative abundance of wildlife species across a variety of protected and unprotected lands. I focus on wildlife species considered to be food sources by inhabitants in the Northern Talamanca Mountains of Costa Rica. Such species are both more important to, and more susceptible to overhunting by, local people (indigenous and not indigenous) than other species, and thus should be a focus of conservation concern. Finally, in Chapter 5, I summarize the findings of the previous chapters to better outline potential conservation actions that will sustain both local peoples and wildlife into the future.

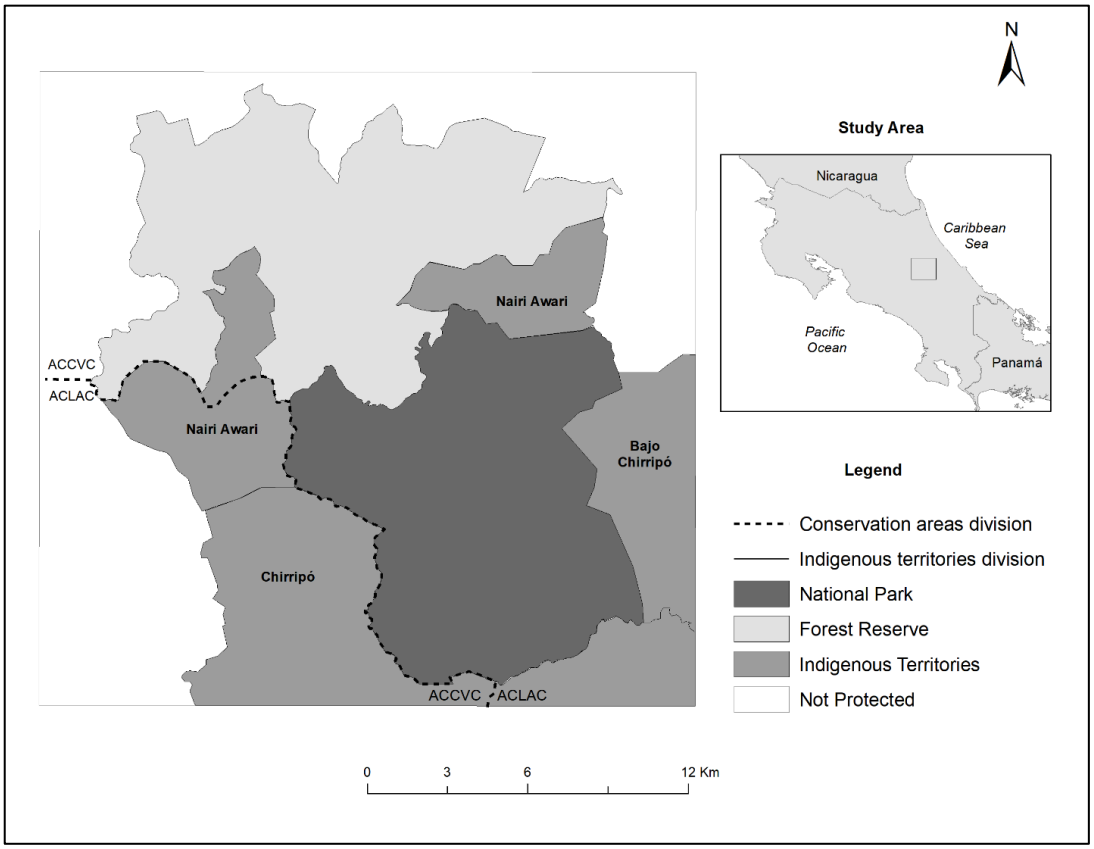

Figure P.1. A mixture of protected areas in the Pacuare-Barbilla area of the northern Talamanca Mountains of Costa Rica.

CHAPTER 1

WILDLIFE DIVERSITY AND RELATIVE ABUNDANCE AMONG A VARIETY OF ADJACENT PROTECTED AREAS IN THE NORTHERN TALAMANCA MOUNTAINS OF COSTA RICA

Abstract

Protected areas are intended to achieve the long-term conservation of nature, but not all such areas are equal in their effectiveness because of their varying regulation of human activities. In Costa Rica, we assessed mammal and bird species presence and relative abundance in three protected areas in the northern Talamanca Mountains. In this humid tropical forest area, we placed camera traps in an adjacent national park, forest reserve, and indigenous territories, each with a different mix of human activities. In 10,120 trap nights we obtained 6,181 independent photos of mostly mammals (34 species other than humans) and birds (34 species). Species with greater abundance or only occurrence in the national park were mammals and birds commonly hunted outside of the park, large carnivores rarely documented in other areas, and poachers. Species found more often outside of the park were medium-sized mammals, some birds, and domestic mammals. We conclude that even in the same ecological area, varying regulations related to type of protected area have significant effects on some mammal and bird species abundances and occurrences, and thus need to be considered when assessing the overall effectiveness of protection as a conservation strategy.

Keywords: bird; conservation; forest reserve; humans; indigenous territory; mammal; national park

Introduction

The IUCN (Dudley, 2008) defines a protected area as a "clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values." Thus, protected areas are considered important for maintaining biodiversity and the integrity of the ecosystems (Geldmann *et al.* 2013, Gray *et al.* 2016). Large natural areas such as national parks and reserves are essential for conserving wildlife populations (Bruner *et al.* 2001, Peres 2005); large mammals, especially top predators and large herbivores, are often able to thrive in these protected areas because they are intended to provide shelter from human persecution and anthropogenic habitat changes (Galetti *et al*. 2009). There are, however, several categories of protected areas, each of them having different restrictions on human activities (Ferraro et al 2013, SINAC 2020). Right now, in Costa Rica and other countries, some protected areas are no longer sufficient to provide protection to large mammals (Pringle 2017), though establishing or maintaining landscape connectivity between multiple protected areas can mitigate inadequate protection in a single area (Soulé and Noss 1998, Di Minin *et al.* 2013, Castilho *et al.* 2015).

Costa Rica has nine official types of protected areas [Ortiz-Malavasi 2014, SINAC 2020], as well as indigenous territories that are often considered a kind of protected area (Hedström 2006), each of which has different restrictions on anthropogenic activities. For example, national parks are "areas [intended] to protect outstanding natural and scenic areas of national and international significance for scientific, educational, and recreational use. They are relatively large natural areas not materially altered by human activity where extractive resources use is not allowed" (Hedström 2006). Forest reserves are forests in which the main function is the production of timber and those forest lands that by nature are especially suitable for that purpose (FAO 2010); here, the variety of human activities allowed is clearly higher than national parks. The aim for indigenous territories is "conservation of cultures and their environments and the protection of life systems in these

communities and the way natural resources are used" (Hedström 2006); they are autonomous, there are location-specific regulations (e.g., hunting is allowed only for the indigenous population), and land can be used in any way without the need for governmental permission (Ley indígena 1977).

Costa Rica has designated about 32% of its territory as some sort of protected area. Many of these areas encompass humid ecosystems (Huston 1994) where herbivores play an important role as seed dispersers and thus predators not only affect prey populations, but also shape patterns of plant distribution and diversity (Terborgh *et al.* 2001, Galetti et al. 2006, Stoner *et al.* 2007). The population density of tropical forest vertebrates largely depends on climatic factors such as elevation, floristic composition, and net primary productivity sources. Human disturbance (e.g., hunting pressure and land-use change) also affects the density and distribution of vertebrate species (Galetti *et al.* 2009, Peres and Palacios 2007), and thus variation in such disturbance among different types of protected areas can result in variation in the density and distribution of vegetation (Ferraro et al 2013) and wildlife (Carrillo et al. 2000).

Here we report the results of an assessment of mammal and bird species presence and relative abundance in three protected areas in the northern Talamanca Mountains of Costa Rica. In this area of humid tropical forest, we placed camera traps in an adjacent national park, forest reserve, and indigenous territories, each with a varying mix of human activities. We anticipated that, in this area of similar basic ecological conditions, the effects of varying levels of protection would result in higher diversity and abundance of mammals and birds in the areas with more protection (Gray *et al.* 2016), and a change in species presence in some areas as the result of hunting of certain species by humans (Abrahams *et al.* 2017) followed by an ecological cascade effect (e.g., mesopredator release; [Crooks and Soulé 1999]).

Materials and Methods

Study Area

The Barbilla Sector in the northern Talamanca Mountains of Costa Rica is in the Volcánica Central-Talamanca Biological Corridor between Limón and Cartago provinces (Ortiz-Malavasi 2014) and includes three different kinds of protected areas, each one with a specific category of management; they include a national park (NP), a forest reserve (FR), and indigenous territories (IT; Fig. 1.1). In Barbilla National Park (BNP) 120 km^2, the main objective is the conservation of the tropical humid forest that provides a large proportion of water production along the Caribbean slope of the Talamanca Mountain Range (SINAC 2017). Precipitation in the national park and the surrounding areas occurs throughout the year, with relatively more rain during November-December and less in March, and averages ~4,000 mm annually (Bernal y García 2007). In the Pacuare River Forest Reserve (PRFR) to the north of the Barbilla National Park, an area of virgin forest was logged in the mid 1970's by means of 15 km of new unpaved roads which subsequently allowed for additional roads and settlements in the area (Hedström 2006) Currently the forest reserve has some grasslands for cattle, forest plantations, human settlements, and eco-lodges. We also sampled in adjacent indigenous territories, including the Nairi Awari Indigenous Territory and the Chirripó Indigenous Territory to the west and northwest of the national park. In both these areas there is a population of 6814 Cabécar, the second largest indigenous group in Costa Rica (Crooks and Soulé 1999, Bernal and Garcia 2007, INEC 2013, Saenz-Bolaños et al 2015, MIDEPLAN 2015 SINAC 2017). There are relatively few settlements, and the Cabécar mainly hunt, plant bananas, cassavas and grains, and also raise pigs, chickens and cows.

Quantitatively, we calculated landscape characteristics (using geographic information system data from ArcMap 10.2.2; ESRI 2014) of areas within 2 km of all camera traps set inside each of three adjacent protected areas in the northern Talamanca Mountains of Costa Rica (Table 1). Elevations in each of the areas overlapped greatly, though on average the forest reserve is at lower

elevations. There are no roads within the national park, and almost three times as many roads in the forest reserve compared to the indigenous territories, and as a result of logging and clearing. The forest reserve was least forested. Because cameras were often located near borders of the protected areas, the proportion of protected area type within each of our categories varied, and the forest reserve cameras likely had some influence for outside unprotected areas, as well.

Camera Deployment and Data Collection

We placed cameras (Bushnell Trophy Cam®) on two different trail types to maximize the captures, because both types are well known for wildlife transit (Blake and Mosquera 2014, Blake *et al.* 2017). Human trails were trails regularly used by tourists, researchers, rangers, and local people to travel and were 2-3 m in width. Animal paths were trails used by mostly by wildlife and were narrower (1½-2 m) than human trails. Of the 55 camera traps we deployed, to maximize the captures 26 were on human trails (NP=7, FR=7, IT=12) and 29 were on animal paths (NP=14, FR=10, IT=5); two of 17 camera stations in the IT were moved to within 100 m of the location the previous year. Another camera location on the map appears as if it was in FR (Fig 1) but it was actually in reclaimed indigenous territory land but was not yet actualized in the Atlas Digital.

At each deployment location (camera station), an unbaited camera was placed 0.5 m above the ground, 2-4 m from the center of the trail, and with an unobstructed view of the trail. Cameras were active 24 hours per day and when activated they recorded a 30-sec video with a minimum of 1 min between consecutive videos (2014-2017), or a series of 3 still photos taken two sec apart (2012). Cameras were set on video mode in the national park year-round during 2013 through 2016, and photos mode in the forest reserve during Apr-May 2009 and Sep-Dec 2012, and in the indigenous territories during Apr-May 2009 and Sep-Dec 2011. In the first 2 years cameras were checked every month to change batteries and collect files because the cameras were not as technologically advanced as in the next years, when we checked every 3 months to change batteries.

During all years of study, we lost some cameras because some stopped working due to high humidity, some were broken by jaguars or vandalized by people, and at least 10 were stolen. For each camera station that was checked we determined the number of trap nights; trap nights are the total days a trap camera worked.

Analysis

Photos or videos were considered an independent record of a species if they were: (1) taken at least 30 min apart (e.g., a series of three photos of the same species taken in consecutive seconds = 1 photo event); (2) consecutive photos of the same species could be identified as different individuals (spots, scars, horns/antlers, sex) and not part of the same group (e.g., 15 min apart, going in opposite directions = two photo events); or (3) photos of the same species separated by photos of a different species (e.g. species 1, followed 2 min later by a species 2, followed 5 min later by species 1 = one species with two photo events and another species with one photo event). Mammal and bird species were identified and named using local field guides (Wainwright 2007, Garrigues and Dean 2014). Photographs of humans were classified as: 1) Research-Protection - researchers and park rangers, 2) Local - persons who live, work, or transit an area without hunting equipment or carrying killed wild animals, 3) Poacher - persons with hunting/fishing equipment (e.g., rifle, blowgun, harpoon), or carrying killed wild animals, 4) Tourist - hikers or persons with photo equipment, and 5) Unclassified people – persons that could not be classified as one of the above.

We recognize that our samples are relatively small and do not justify extensive statistical modeling efforts. However, descriptive presentations of the data and simple statistical comparisons are justified and can still both reveal and suggest important distributional differences. Thus, for a basic assessment of species diversity, we tallied up the total number of species for the two seasons (Sep-Apr and May-Aug) in the national park, (we only sampled in one season, Sep-Apr, in the IT and FR), and looked for differences between them. Then we tested for differences

during the Sep-Apr season among the three protected area types. To assess possible total species diversity differences, we plotted accumulation curves by counting how many trap nights were necessary to find a new species in each area, and by season in the national park. For assessing differences in relative species abundances among areas during the same season, we calculated relative abundance indices (RAI; no. of independent photos/100 trap nights; (O´Connell *et al.* 2011) and used Chi-squared tests ($P<0.001$) to compare species specific-differences in the RAI rates among areas and between seasons for the national park.

Results

The total of 55 different camera stations in the three areas were monitored for a total of 10,120 trap nights (Table 1.2). Though the number of camera stations was fairly similar in each area, most effort focused on the national park (8,450), with much less in the forest reserve (796) and the indigenous territories (874). From this effort, we obtained 6,181 independent photos, mostly of mammal (including 2 domestic) and bird species. Agoutis (scientific names listed in the appendices; total n = 2,548 independent photos) and great tinamous (n = 778 photos) were by far the most commonly photographed mammal and bird species, respectively, in all areas (Appendix 1). Three mammal species and 11 bird species were photographed only once.

Seasonal species accumulation curves in the national park seemed similar for mammals (Appendix 2) but were perhaps lower for birds during the May through August period when migratory species may have left for northern breeding ranges. Our sampling comparisons among areas during 8-month September-April season (Fig. 1.2) suggested that, for mammals, there may be fewer species in the forest reserve. Our samples for birds outside of the national park were too small for meaningful comparison, but 2 periods of rapid species accumulations occurred over the course of the multiple year sampling in the Park.

Not counting humans, we documented 34 species of mammals, including unidentified bat, rat, and mouse, and 2 domestic species (dog and pig; Appendix 3). We also documented 34 species of birds, including unidentified nightjar and hummingbird (Appendix 4).

Only a few seasonal differences in species abundance occurred in the national park (Table 1.3). Agoutis and nine-banded armadillos were photographed more often during May-August, and great tinamous were photographed more often during September-April.

Statistically different photo rates among protected areas were identified for 23 species (Table 3). More ocelots, pumas, jaguars, pacas, agoutis, and great tinamous were recorded in the national park; agouti abundance was also high in indigenous territories compared to forest reserves. In indigenous territories, photo rates were also higher for five other wild and two domestic mammals (dogs and pigs), and five bird species. In the forest Reserve, white-nosed coatis and northern raccoons were more common. The chestnut-backed antbird, unknown rats and nine-banded armadillos were also more common in forest reserves than in the national park. Poachers were only recorded in the national park, and Local persons were most often photographed in the indigenous territories. We also note that even though sampling efforts were substantially great in the national park, commonly hunted species including white-lipped peccaries and tapirs (among a total of nine mammal species), and slaty-breasted tinamou, crested guan, black guan, and great curassow (among a total of 24 bird species) were photographed only in the national park, although statistical differences in rates among areas were not identified.

Discussion

We recorded only 30 identified bird species of more than 225 recorded in NP and its surroundings (Hedström 2011) but, as expected, most of those were ground-dwelling birds (Garrigues and Dean 2014). The seven bird species with significant differences are species associated with mature forest, and thus are vulnerable to changes in the ecosystem. Many more mammal species occur in the area than we recorded (Alvarado *et al.* 2017), even though most of

those not documented are bats, small rodents, and primates or other arboreal species. We consider it relevant to include rare species in the analysis because most species with this characteristic of low data are excluded from models and analysis; here we think is important to present them because even with few captures they are in specific places.

Still, the differences in relative abundances of species we did document suggest that anthropogenic forces related to protection area regulation have a large impact on many species. Species with greater abundance or only occurrence in the national park on both types of trails were mammals and birds commonly hunted outside of the park, large carnivores rarely documented in other areas, and poachers. Species found more often outside of the Park were medium-sized mammals, some birds, and domestic mammals. Local people were identified in all areas, but poachers were only documented in the national park, perhaps because the most commonly hunted species (large birds as great curassow, crested guan, black guan, and great tinamou, and mammals such as paca, tapir, red brocket deer, collared peccary, and white-lipped peccary) are only found there.

The higher presence of large birds, jaguars, and pumas in the national park can be related to an area that provides them relief from human pressure, furnishes food (paca, agouti, and tinamou for carnivores and a variety of seeds and small vertebrates and invertebrates for birds), and thus provides habitat resources necessary to fulfill required daily activities. The near absence of jaguars and pumas outside the national park may be due to the pressure lowering other prey species abundance and thus affecting large felid abundance. Moreover, one big threat for big cats outside the national park is retaliatory killing by humans when they lose a cow, pig, or other domestic animal, or even just from fear. This may also be true for ocelots, as well, though they still appear relatively common outside of the Park.

The two mammal species that had higher abundance in the FR were white-nosed coati and raccoon, known to be associated with human settlements and the associated food resources (Prange *et al.* 2004, Schulte-Hostedde *et al.* 2018); in the FR it is possible for them to obtain dog

and cow food, crops, etc. Also, their increased abundance outside of the park may be due to a mesopredator release effect (Crooks and Soulé 1999), i.e., the absence or low abundance of predation by felids (Hass *et al.* 2002) that have been reduced by humans results in increased abundance of smaller competitors.

Bird species do not suffer retaliations as do big cats, but they are persecuted by poachers and indigenous persons and this is likely why they were not detected outside the national park. On the other hand, some species with higher RAI outside the park are species associated with mature forest and we expected to find them more in the NP than IT. However, the forest vegetation is not much different in these two places, and thus their relative abundances may just be due to the food resources available. It will be important for future studies to sample vegetation and see how its composition may influence the interpretation of findings such as ours.

Our results showed that even though the ecosystem is similar among protected areas we surveyed, the amount of forest cover and the influence of human activities vary (Table 1), and the species abundances are not the same. The cover types are similar in the national park and indigenous territories, whereas the forest reserve has less primary forest and some exotic forest plantations, and more human presence and activities such as roads. These differences in the PRFR compared with BNP and IT are also related to the regulations of each area. On the other hand, Cabecar indigenous associations have opted to receive payments for environmental services (PSA by the Spanish abbreviation) as an income for protecting the forest (Borge and Martinez 2009), resulting in an important number of forest hectares under this system, and helping the connectivity and habitat for wildlife.

The characteristics of each area influence the species richness and composition. The national park seems the most diverse place, including very elusive and rare species listed in the IUCN red list. For example, species that require an important and well protected forest such as tapir, white-lipped peccary, oncilla, jaguar and paca are present in this area. Paradoxically, the seemingly well-protected forest shelters important game species and thus appears to currently have more poaching

pressure compared with the forest reserve and indigenous territories. In the long run, the poaching pressure in the national park is something to pay attention to in order to avoid long-term effects (Hunter 2007).

Conclusions

The distribution of mammals and birds identified in this study suggest ways to anticipate the effects of specific kinds of protected area designations. Better protected sites and areas with enough vegetation cover to sustain them, such as the Barbilla National Park, seem optimal. Although indigenous territories had forest cover similar to the Park, the differences observed in wildlife distribution were likely due to the number of people and the activities allowed in each of them. For example, indigenous people can and do hunt in their territories, thus the lower abundance of certain species there. And in the forest reserve, some species that were more common seem related to what might be expected in more populated, or even urban, areas. Therefore, we conclude that even in the same ecological area, varying regulations related to type of protected area have significant effects on some mammal and bird species abundances and occurrences. Even in the same ecological area, varying regulations related to type of protected area have significant effects on some mammal and bird species abundances and occurrences, and thus need to be considered when assessing the overall effectiveness of protection as a conservation strategy.

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Table 1.1. Landscape characteristics of areas within 2 km of all camera traps set inside each of three adjacent protected areas in the northern Talamanca Mountains of Costa Rica.

	National Park	**Forest Reserve**	**Indigenous Territories**
Elevation (m)	729 (295-1,281)[a]	421 (285-630)	665 (303-1,083)
Road density (km/km^2)	0.0	0.29	0.10
Distance to nearest road (km)	0.0	1.38 (0.10-3.30)	2.79(1.49-4.36)
Vegetation cover type (%)			
Primary forest	93	80	93
Secondary forest	4	0	1
Forest plantation	0	1	0
Non-forested[b]	1	4	2
Protected area composition (%)			
National Park	85	5	4
Forest Reserve	10	70	34
Indigenous Territories	4	12	59
Not Protected	0	13	3

[a] Range of values. [b] Includes bare ground and rivers.

Table 1.2. Summary data for camera-trapping efforts during 2009-2016 in three adjacent protected areas in the northern Talamanca Mountains of Costa Rica.

				No. of species detected				
Season	Protected area	No. of camera stations	No. of trap nights	Mammal[a]	Bird	Amphibian	Reptile	Total
May-Aug	National Park	19	2,630	29	17	0	0	46
Sep-Apr	National Park	21	5,820	30	26	0	1	57
	Forest Reserve	17	796	19	5	1	0	25
	Indigenous Territories	17	874	24	8	1	0	33
Both	All	55	10,120	34	34	2	1	71

[a] includes domestic dog and domestic pig, and not humans.

Table 1.3. Areas (and seasons) with highest photo rates (no. of independent photos/100 trap nights) of mammal and bird species, including humans, detected by camera-trapping efforts during 2009-2016 in three adjacent protected areas in the northern Talamanca Mountains of Costa Rica. Statistical differences (P<0.001) between seasons for BNP are indicated in italics; statistical differences among the three protected areas are identified in bold.

		May-Aug	**Sep-Apr**		
Area with highest photo rate	Species[a]	National Park (NP) (19/2,630)[b]	National Park (NP) (21/5,820)	Forest Reserve (FR) (17/796)	Indig Territories (IT) (17/874)
National Park	Agouti[c]	*37.98*	*21.94*	13.19	19.11
	Paca	1.44	**3.21**	**0.25**	**1.03**
	Ocelot	3.95	**4.35**	**2.01**	**2.29**
	Puma	1.14	**1.53**	**0**	**0**
	Jaguar	1.06	**1.29**	**0**	**0.11**
	Great Tinamou[d]	*7.15*	***9.54***	**1.38**	**2.75**
	Human (Poacher[e])	2.51	**2.41**	**0**	**0**
Indigenous	Gray Four-eyed Opossum	0	**0**	**0**	**0.80**
	Nine-banded Armadillo[f]	*2.28*	***1.27***	**49**	**3.09**
	Tamandua	0.08	**0.15**	**1.13**	**0.57**
	Red-tailed Squirrel	1.41	**1.75**	**063**	**3.78**
	Unknown rat[g]	148	**1.53**	**4.65**	**5.95**
	Domestic dog	1.48	**0.84**	**1.01**	**2.4**
	Domestic pig	0.34	**0.15**	**0.13**	**5.26**
	Human (Local[h])	1.98	**1.61**	**0.50**	**5.61**
	Black-earned Wood-Quail	0	**0**	**0**	**0.23**
	Olive-backed Quail-Dove	0.61	**0.57**	**0.13**	**1.72**
	Spotted Antbird	0	**0.02**	**0**	**0.34**
	Streak-chested Antpitta	0	**0**	**0**	**0.23**
	Wood Thrush	0	**0.07**	**0.13**	**2.97**
Forest Reserve	White-nosed Coati	0.57	**0.43**	**2.26**	**0.34**
	Northern Raccoon	0	**0.03**	**0.38**	**0**
	Chestnut-backed Antbird	0	**0**	**0.25**	**0**

[a] Scientific names listed in Appendix 3 and 4. [b] Total number of camera stations/total number of trap-nights in each area. [c] Also higher in Indigenous Territories and during May-Aug in the National Park. [d] Also higher during Sep-Apr in the National Park. [e] Persons with hunting/fishing equipment (e.g., rifle, blowgun, harpoon), or carrying killed wild animals. [f] Also higher in the Forest Reserve and during May-Aug in the National Park. [g] Also higher in the Forest Reserve. [h] Persons not carrying hunting/fishing equipment, or wild animal.

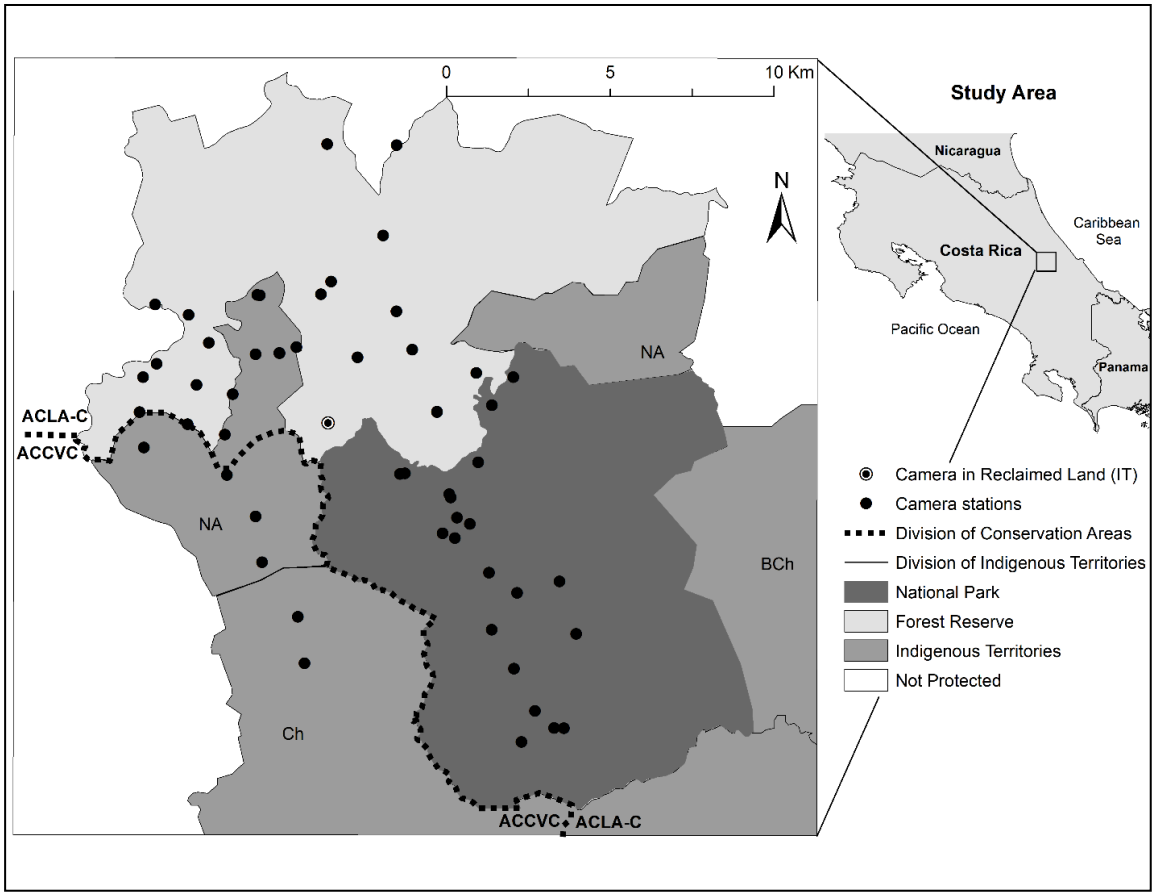
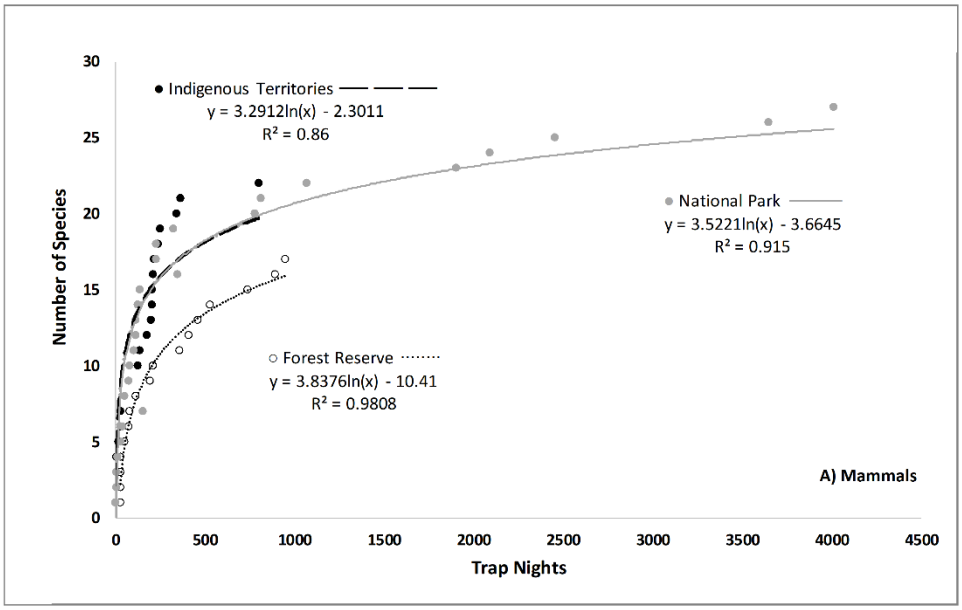


Figure 1.1. Location of camera stations within Barbilla National Park (dark gray), Indigenous Territories (medium gray; Nairi Awari [NA], Chirripó [Ch], and Bajo Chirripó [BCh]), and Pacuare River Forest Reserve (light gray) in the Conservation Area Cordillera Volcánica Central [ACCVC] and Conservation Area La Amistad Caribe [ACLA-C] in the northern Talamanca Mountains of Costa Rica.



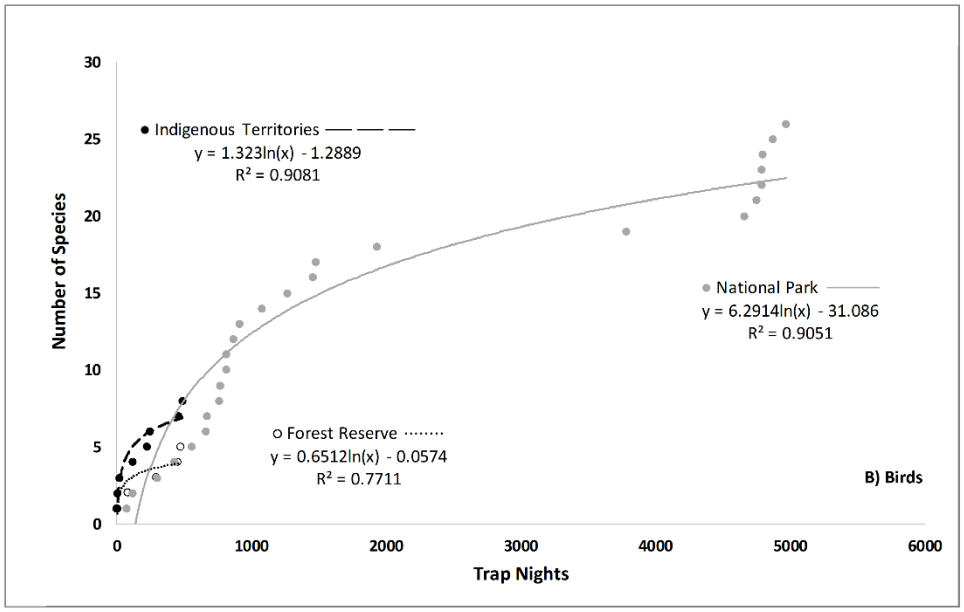


Figure 1.2. Trend lines and correlations for the number of camera trap nights (effort) versus total cumulative number of A) mammal and B) bird species photographed (diversity) in the National Park (solid line, solid circle), Indigenous Territories (dotted line, gray circle) and Forest Reserve (dash line, open circle) during September-April in the northern Talamanca Mountains of Costa Rica

CHAPTER 2

PERCEPTIONS OF WILDLIFE AMONG INDIGENOUS AND NON-INDIGENOUS PEOPLE IN THE PACUARE-BARBILLA SECTOR OF THE NORTHERN TALAMANCA MOUNTAINS OF COSTA RICA

Abstract

The human dimensions of wildlife management in developing countries are not well articulated due to lack of training; nevertheless, in recent years the vision of incorporating human social values and knowledge is growing. This is especially true in countries where biodiversity has an important value. If we put together cultural and local knowledge, they are more relevant. For that reason, I wanted to study the local perceptions of wildlife in the Pacuare-Barbilla sector of the northern Talamanca Mountains of Costa Rica. To do this, I administered 91 semi structured questionnaires among indigenous and non-indigenous people during February-August 2019. By asking "what animals are here in the forest near to the community?" I obtained 59 species cited by the population (33 mammals, 20 birds and 6 reptiles or amphibians). The non-indigenous people cited 17 more species than indigenous people. Moreover 31 species were catalogued as problematic or causing some negative impacts from a human viewpoint, with the jaguar and coyote noted most often. With regard to climate change, both groups perceive less rainfall and higher temperatures, as well less forest cover and smaller jaguar populations compared to 10 or more years ago. The feelings and attitudes about big cats changed in relation to how close people think they are or by their view of their negative impacts. Indifference and fear were the most named feelings, and relative intensity of feelings varied by ethnicity and gender. This knowledge is valuable for understanding and improving the implementation of actions for conservation.

Introduction

In developing countries there is a lack of integration of human dimensions with conservation biology and wildlife management because many practitioners do not have adequate training with regard to these important issues (Saberwal and Kothari 1996). Thus, it is common for professionals in biological sciences to be unfamiliar with the most useful and pertinent techniques or processes to work with indigenous communities or in rural places. We seem to approach questions from our trained point of view and focus only on the wildlife species of interest and not on what native/local people think of our research or our goals (Tuhiwai 2012). As a consequence, many conservation research projects have not produced the most useful recommendations.

Indigenous people have a very strong relationship with nature and animals. During the experience with the Jameikäri, a community within Nairi Awari Indigenous Territory, I observed attitudes and beliefs similar to those shown by Lira (1997) working with the Tairoma group in Colombia. The Tairona see animals in their ontology: *"There is no dividing line between man and animal. Animals are considered essentially as beings endowed with all the characteristics of man with the sole exception of their outward appearance. Animals are believed to speak, think, have souls and live an organized life like humans".* Salmon (2000) concluded that the perception of Kincentric ecology *"... is an awareness that life in any environment is viable only when humans see the life around them as a relative"*.

Even though ecologists know of this strong relationship, in the majority of cases we do not have the skills to start thinking about how to develop research joining the human dimensions with ecology. If we start to do better projects with a mix of methodologies, and more importantly, with respect for indigenous and local knowledge, the conservation process will be much easier to communicate and share with more people in many different fields, and thus be more successful (García-Llorente et al. 2008, Ceballos-Mago & Chivers 2010).

To a certain extent, this is self-criticism because I want to improve my own ability to work in the realm of socio-environmental science and, in particular, to better recognize ways to work with people in rural areas, including indigenous and non-indigenous peoples. This is especially important because conservation is not just about animals and plants - if we really want to conserve and protect the environment for the future, we must work with human beings. As a conservation practitioner, it is necessary to accept other sources of knowledge and the manner in which a person articulates traditions, culture, life experiences, and forms perceptions (Ceballos-Mago & Chivers 2010, Pinto-Marroquin & Serio-Silva 2020). Consequently, perceptions are reflected in attitudes towards wildlife (Decker et al. 2012). One alternative source of knowledge is traditional ecological knowledge in rural areas and indigenous communities transmitted over generations (Rossano 2018).

For these reasons and because of previous research carried out by the Jaguar Program at the UNA Universidad Nacional de Costa Rica (Costa Rica National University), where only small efforts were made to encourage participation of the local communities, I sought a greater integration of ecological and local knowledge about wildlife. Therefore, I needed to make the change in my own mentality and approach, so as to not only obtain the biological information I need for my objectives, but also to assess important local knowledge from the locals about species that live in an area.

Moreover, some studies showed gender differences in how men and women see and analyze some topics. Some authors explored if variations by gender exist in the way nature is seen. For example, Kellert and Berry (1987) exposed differences between gender in attitudes, knowledge, and behaviors to protect wildlife. Deer management alternatives were evaluated differently by men and women (Lauber et al. 2001). As another example, Martino (2008) in Uruguay showed that attitudes toward wildlife varied by gender.

With this background, the purpose of this chapter was to find out and compare the perceptions of wildlife among indigenous and non-indigenous people in the Pacuare-Barbilla Sector of the northern Talamanca Mountains in Costa Rica. This chapter also compares perceptions of wildlife between men and women in the community's samples to identify if there are some gender-

specific differences in indigenous and non-indigenous people. By understanding various components of cultures, such as the ontology, relevance, respect, belief, knowledge, and meaning of wild species, we will be able to generate better wildlife management action plans and approaches for biological and cultural conservation.

My guess was that I would find that the indigenous people are more willing to coexist with the wildlife, so I expected to find more positive feelings about wildlife from indigenous peoples than the non-indigenous population. As to gender, I expected men are more familiar with wildlife so they have fewer negative perceptions about species.

Materials and methods

Study area

I carried out this study in the Pacuare-Barbilla Sector in the northern Talamanca Mountains of Costa Rica between Limón and Cartago provinces (Hedström 2006, Sáenz-Bolaños *et al.* 2020) and covered two protected areas (Barbilla National Park and Pacuare River Forest Reserve) under the Sistema Nacional de Áreas de Conservación (SINAC), an indigenous territory (Nairi Awari Indigenous Territory), as well as non-protected areas surrounding the three designated areas (Fig. 2.1). In the total area covering more than 400 km^2, it is possible to find tropical humid forest, grasslands, forest plantations, human settlements, and eco-lodges near the Pacuare River (Sáenz-Bolaños et al. 2020). Weather conditions in the area are similar in all four places, though rainfall and temperature increase a little bit from southwest to northeast as elevation decreases (Ortiz-Malavasi 2014).

Preliminary steps

In the indigenous territory, before starting any activity, attending an association meeting was mandatory. During the meeting I presented the ideas for the project, including seven basics principles; respect, responsibility, reciprocity, reverence, holism, interrelatedness, and synergy (Archibald 2008). Then I asked if the participants agreed or if they wanted to change or include something that we could work on together. I always tried to involve the territory members to be part of the project. Finally, if they were willing to include their territory in the research, I obtained permission to work in the Nairi Awari Indigenous Territories, but it took time to obtain the letter from the association. I knew I could proceed because I received text messages when they took the consensus vote, though written confirmation via a letter arrived several months later.

For rural communities in the Forest reserve, most of the inhabitants are not indigenous people (some of whom work in the national park), though a few people who live inside are indigenous. I obtained permission from the La Amistad Caribe Conservation Area to do research in the areas under their management, and then I visited residents and asked if they were willing to participate in the survey.

Data Collection

From January to August 2019, I implemented a face-to-face questionnaire (Appendix 6 and 7) as a structured interview (Newing 2011) among different stakeholders, organized with open-ended questions and Likert-scale answers, to collect relevant quantitative and qualitative data. Surveys were conducted across the Pacuare-Barbilla Sector, including in two protected areas (Barbilla National Park and Pacuare River Forest Reserve), the western part of the indigenous territory called Nairi Awari, and surrounding unprotected lands. To recruit participants, I walked or drove on trails or roads and stopped at every house, explained the study, and asked if they were willing to participate. The questionnaire was approved by the Institutional Review Board of the University of Massachusetts, Amherst (Protocol ID 2018-5066). I interviewed persons over 18 years old from a

number of houses or farms located within the 15-km^2 hexagons of the honeycomb grid into which I had divided the Pacuare-Barbilla Sector (Fig. 2.1). I approached these individuals and inquired if they would be interested in participating in the study. Every interviewee was informed about how much time the survey would take, that their participation was voluntary, that their replies were confidential (no names in the instrument), that they could end the survey at any time, and that it was not mandatory to reply to any question. No compensation was provided.

I interviewed both genders, but I did not interview a woman if the husband or partner was present so as to reduce potentially biased answers (Korieh 2006, Baker et al. 2014); instead, I interviewed them separately to obtain independence in the responses (Jenks et al 2014). All the surveys were conducted in the Spanish language. However, in the indigenous territories I employed a Cabécar assistant who spoke the language and translated for us when interviewees did not understand some questions or if they used some Cabécar words that I could not understand. I wrote answers on a printed questionnaire and then tabulated them in an Excel spreadsheet.

The structured-instrument questions focused on obtaining information about the feelings, perceptions, attitudes of different stakeholders towards wildlife, the interactions with the ecosystem, how they perceive climate variations, and their culture. To measure this, I used the Likert scale (Nemoto & Beglar 2014) with questions in scales of three and five levels; to assess the reliability I used the Cronbach alpha (e.g., Cortina 1993, Thorn et al. 2015). To evaluate the changes in the environment were perceived, I asked on a five-level scale if, when they were young or children, there was less or more forest, fewer or more jaguars, and if the temperature and rainfall had changed.

Data Analysis

I used Cronbach's alpha to evaluate the reliability of the questionnaire (Gliem & Gliend 2003, Loo et al. 2001) regarding the attitudes towards the presence of jaguars. I made comparisons between indigenous and non-indigenous participants, and between males and females, using Chi-squared tests ($P<0.05$), with regard to groups of species they see around their influence area (home, community);

location (relative to protection status); respect of wildlife; perception of environmental changes (trends); fear of big cats; and feelings about jaguars.

Results

During six field trips, 91 people were interviewed; 29% were indigenous (38% women and 62% men) and 71% were non-indigenous (37% women and 63% men). The age distribution varied in 2 categories for indigenous people and in three for non-indigenous, [a) Young adult (18-35 years old); n=12 indigenous people, n=13 non-indigenous people, b) Adult (36-65 years old), n=14 indigenous people, n=35 non-indigenous people, and c) Elder (>65 years old), n=17 for non-indigenous people]. Moreover, the distribution of interviewees also varied by category of protection (n = 2 national park, n = 23 in indigenous territory, n = 27 in forest reserve, and n = 39 in unprotected lands).

In total, 59 wildlife species were volunteer refered to the open question what species they can cited that living around or near to the community [33 mammals (27 species by indigenous people and 33species by non-indigenous people), 20 birds (9 species by indigenous and 17 by non-indigenous) and 6 amphibian and reptiles (2 species by indigenous and 5 species by non-indigenous)], and additional ones were included in general group references (i.e., bats, birds, doves, monkeys, snakes; moreover, both groups classified “panther” [black jaguar] as a separate species). The number of species identified by non-indigenous vs. indigenous people interviewees differed (Chi-square=8.75, df=1, p-value=0.003); the non-indigenous interviewees cited 17 more species than indigenous interviewees (Table 2.1). Both groups had 34 species in common.

- Thirty-one species were reported as problematic; 16 were cited by indigenous vs. 25 by non-indigenous participants. Six were cited only by indigenous people and 15 by non-indigenous interviewees, whereas 10 species were cited by both (Table 2.2). The reasons for considering a species problematic, in most cases, were attacks on cattle, pigs, chickens, or pets, but also crop losses and some risk for humans. Seven species (jaguar, coyote, opossum, coati, poisonous snakes, tayra, and puma) were cited more than 10 times as a problematic species. The jaguar was the most

cited species; it was mentioned 51 times, more than double that of the coyote, which was mentioned the second most often (23 times). In total, 54% (n = 49) of respondents considered the jaguar a problem (65% (17/26) indigenous and 49% (32/65) non-indigenous). Moreover, non-indigenous people reported more fear of jaguars because they mentioned that a jaguar can attack people, especially children; indigenous people also mentioned it, but later in the instrument and not during the question about problematic species.

With respect to environmental changes, 53% of local people considered that nowadays there is less or much less forest in the area, whereas 26% of interviewees considered there is more or much more forest, and 21% cited that the amount of forest was equal (Table 2.3). There was no statistically significant difference for forest changes (by ethnicity [p-value = 0.139] or by gender [p-value=0.738]), few indigenous interviewees considered there is more forest now, and none considered there is much more forest now, than there was ten years ago or more (Fig. 2.2a). In comparing by gender, men reported a higher percentage of change in more and much more forest compared to women (Fig. 2.2b). Concerning the jaguar population, 51% of participants considered that there are fewer or many fewer jaguars and 23% said there were more or many more. For temperature and precipitation there is a statistically significant difference by ethnicity (p-value= 0.01 and 0.04 respectively); the non-indigenous perceive the temperature is increasing positively whereas the indigenous perceive it as more constant. A similar situation was presented for rainfall where a majority of non-indigenous affirm there is less rainfall vs. indigenous that perceive less change (Table 2.3, Fig 2.3 a,b).

Feelings about big cats (jaguar and puma)

For each of the three specific questions about big cats, I classified the feelings according to their answers, getting 14 categories. The three most common feelings were indifference, fear, and joy (Fig. 2.4).

*Question 1: What do you feel when you **hear** that jaguar/puma is around the area?* Seven feelings come out, indifference, fear and joy being the three most cited (90% of the respondents). There were statistically significant differences by ethnicity and gender (Table 2.4). Regarding indigenous vs. non-indigenous people, indifference was cited by 46% of non-indigenous people, and only 38% by indigenous, fear was cited by 25% of non-indigenous people and 42% of indigenous inhabitants. Non-indigenous people cited feeling joy more than indigenous people (21% vs 4%). On the other hand, the annoyance and fear of losing their animals were feelings only cited by indigenous peoples, whereas frustration and other feelings were reported only by non-indigenous respondents (Fig 2.5a). By gender, women feel more fear of the big cats (56%); only 9% cited they feel joy when hear about big cats, and 29% of women cited feel indifference. On the other hand, for men the strongest feeling was indifference (53%) followed by joy (21%) and fear (14%) (Fig. 2.5b).

*Question 2: What do you feel if you **see** a jaguar/puma close to your house?* The answers to this question also presented statistically significant differences by ethnicity and gender (Table 2.4). For non-indigenous respondents, fear, joy, and indifference were the most cited feelings, versus for indigenous respondents, who most cited fear, indifference and annoyance (Fig 2.6a). For both genders the values of fear and joy increased and the indifference was less in comparison to when they only heard about the presence of big cats in the area. For men, feeling of joy was the highest value (28%), followed by indifference (26%) and fear (23%), whereas women's highest value was for fear (74%) (2.6b).

*Question 3: What do you feel when you know the jaguar/puma **attacked** an animal in the area?* New feelings came out in response to this question and only the answers by ethnicity were statistically different; by gender they did not vary (Table 2.4). The most common feelings cited non-indigenous respondents were indifference followed by compassion and fear, but some people cited sadness, concern for the felines, impotence and relief. From the indigenous people's side, sadness and fear had the same reporting rates followed by indifference and annoyance (Fig 2.7a). For both genders

the indifference was the most common response. Compassion was more commonly cited by men than women (Fig 2.7b)

Attitudes about jaguars

Perceptions of jaguar abundance did not vary by ethnicity or gender. ($p>0.05$); 51% considered there to be fewer or many fewer jaguars than ten or more years ago, whereas 19% thought there are more jaguars nowadays; also, 26% cited the jaguar population as still the same than in the past and 4% reported that they did not know.

The non-indigenous respondents perceive many fewer or fewer jaguars more than 3 times more often than indigenous people. As well, the percentage reporting more jaguars is higher for the not indigenous population. The comparison by gender shows a similar proportion of both genders perceiving many fewer or fewer jaguars, though a small number of men and women considered there to be more jaguars (Fig 2.8 a, b). Overall, more than 65% of respondents considered the jaguar presence as good or very good for the country versus the 7% that considered it bad or very bad.

The three questions were asked about attitudes toward jaguar presence in: 1) Costa Rica, 2) in the three protected areas and unprotected lands, and 3) in the area types where they resided. For the country, 41% of respondents considered that jaguar presence is very good whereas only 2% considered it very bad. The men and non-indigenous people were most likely to consider jaguar presence a good thing. The same question analyzed by management category, once again, indicated that the indigenous the jaguar presence in any of the different three areas (46% NP, 38% IT and 38% FR) considered as not good-not bad, whereas non-indigenous respondents considered good the jaguar presence in 58% in forest reserve and indigenous territory and 68% for the national park. For the third question, regarding attitudes about the jaguar presence in their property, there was a statistically significant difference by ethnicity (p value=0.0002). The indigenous people had a highly negative attitude, with 50% between bad and very bad, and not one cited jaguar presence as something good, while non-indigenous people reported good at a high percentage with 37% and only 20% said bad and very bad (Fig 2.9).

Discussion

The general outcomes of people's knowledge about the species found in the area revealed the first unexpected result, because I thought the indigenous people would report more species than non-indigenous people because they live "closer" to nature. One of the possible reasons for this is that some species reported only by non-indigenous people are species more related to open areas or associated with some human settlements or human activities; thus, species are more frequently seen in areas outside of the indigenous territory and come to their minds more quickly when we asked about species found there (e.g., flycatcher, Great-tailed Grackle, iguana, Jesus Christ Lizard). On the other hand, of four species cited only by indigenous people, two of them (Black Guan and Harpy Eagle) (Appex 2.1) are ecologically tied to high quality forest, and even the Harpy Eagle has not been a confirmed report in the country for more than a decade. Moreover, can be that because the open volunteer question about species, seems like the indigenous people focused on species they considered important to them (paca, collared peccary, red brocket deer) or even those who cause some negative interactions (jaguar, tayra, ocelot) and did not mention more species that could be in the area, as happened with the non-indigenous people.

Otherwise, when we see the 34 species in common between the two groups, most of them are elusive species, from medium- to large-size mammals and birds, which are more associated with good forest cover. Also, for some of those species, many of the interviewees had never seen one, but the oral traditions, histories, and some beliefs and myths cause people have them in their minds (e.g., the Harpy Eagle, giant anteater, white-lipped peccary, and tapir); still, most of the people who cited them have never seen or even tasted one. Also, some of those species have been recorded by previous research in the area (Sáenz-Bolaños et al. 2020), which may have reinforced what people cited. Some species such as the white-lipped peccary and tapir have had more than 20 years without sightings in the area, until recent years when they were detected (Sáenz Bolaños 2014, Esquivel-Cambronero et al. 2017); however, they have been always in people's minds for their good taste or local stories.

More species considered problematic were cited by non-indigenous people; for example, nine of 25 species were reported to affect crops, or dogs, horses and cows, many of these cited species were also found as problematic by Altricher and Carbonell (2009). The association of these species as negative is related to human activities, but also these are species more familiar to open areas, causing economical losses, as in Nigeria where non-indigenous were less receptive to monkeys presence in their communities (Baker *et al.* 2014). For example, the slug and Great-headed Chachalaca were cited as pests by people who produce *Eryngium foetidum* for exportation (as a food garnish/spice); chacalacas are also reported as common in other Talamanca communities (Gaudrain and Harvey 2003). Or, the Costa Rican Redleg Tarantula was cited by a person who has milk cows, and squirrels, oropendolas, bronzed cowbirds, and leafcutter ants were cited as causing damage to fruit trees or crops. And porcupines and Great-tailed Grackles were cited as causing damage to other animals, such as dogs or birds. As Gaudrain and Harvey (2003) found, the porcupine is associated with open areas, and this is where humans live and have pets.

On the other hand, species cited only by indigenous people were those that caused damage to their crops (rat, agouti, paca, red brocket and collared peccary) and poultry (hawk). Three of those species are difficult to find in open areas (Gaudrian and Harhey 2003) or in areas of reduced forest cover in the Pacuare-Barbilla sector (Sáenz-Bolaños et al. 2020).

The paca and collared peccary were the two most cited species by all interviewees as species that more than 10 years ago were at higher populations than nowadays (30% and 13%, respectively). Altricher and Carbonell (2009) also found these two species were in decline in the Bribrí and Cabécar communities; this was reflected in a statement by an indigenous person who said, “Now to hunt a collared peccary you have to go far”. These two species are highly hunted all over the country and require some forest conditions. Considering that more than half of people perceived nowadays that there is less forest cover (Fig 2.2), this could be the reason why these two species are more commonly reported by indigenous people; that is, in Costa Rica the indigenous territories help with the structural connectivity between protected areas, and some activities deployed inside the forest generate positive

and negative interactions for wildlife and inhabitants. For example, forest cover is greater in indigenous territory than in the forest reserve or un-protected areas, and coupled with the fact that the crops in the indigenous territory are in the middle of the jungle, wildlife are able to move easily from forest to the crop and back.

Concerning the change in perceptions of forest cover, in general, most people report that there is less or much less forest. But in the categories of more or much more forest, the non-indigenous people considered there is more forest cover compared to the indigenous people interviewed. Some non-indigenous interviewees indicated that pastures in the forest reserve and unprotected lands have been used as forest regeneration sites after the timber logging in the 1970s and 1980s (Hedström 2006), whereas some indigenous interviewees said "*now there are more people and houses, so we have to cut the forest".*

This perception of less forest cover could be influencing the perception of fewer jaguars, as some people mentioned. Jaguar population decline was also seen in Altricher and Carbonell (2009). In the past more jaguar footprints were seen on trails or in the forest, but now it is hard to find jaguar tracks or those of important jaguar prey. The population perceived fewer jaguars, but the non-indigenous group is 3 times less than indigenous (Fig 2.8 a), and a 26 years old non-indigenous woman said *"The jaguar is like a myth because it is always spoken of, but now that my husband saw one, it can now be said that it is there".* This comment is what happened in many places where people talk and hear about jaguars but they never or very few rarely see, hear, or find one or tracks of it. Still, in the indigenous territories, it is a little bit more frequent to hear reports of people finding some jaguar tracks. Women more often reported that jaguar numbers were less (Fig 2.8 b), and this could be related to a higher perception of less forest, and thus they do not see jaguars or their sign.

Finally, the perceptions and knowledge about the environment of ten or more years ago revealed the idea that people of the Pacuare-Barbilla sector have their own perception of climate change. For indigenous people in the area much of this is likely derived empirically because they have never heard of or been taught about the topic, they do not have capacitation as other Cabécar

communities (Florian et al. 2014), and thus concluded because of their close relationship with nature and their crops. The inhabitants of the Pacuare-Barbilla sector perceived an increase in the temperature and less rainfall overall (Fig 2.3). Can be that the differences showed by ethnic groups and the patterns on both environmental variables especially on indigenous people is because they life the day by day and probably the variations are not a relevant factor to them, moreover, the jungle provides some relief from hot temperatures and provides them water all year, whereas out of this indigenous territory there are more open areas where the heat could be perceive differently and in occasions the water is limited during the months with less rain. Thus, studying how these recognized changes are reported to affect local human activities and the interactions with wildlife will be useful to help the decisions makers and wildlife practitioners address the actions of all who are affected.

Feelings about big cats

More than 90% of feelings cited when people hear about or see a big cat in the area were shared between indifference, fear, and joy. The non-indigenous people are more indifferent than the indigenous for the three scenarios, but the percentage in the scenarios of hearing and seeing a big cat were lower. For indigenous interviewees, the feeling of joy was low, probably because for them hearing or seeing a big cat represents annoyance and fear of losing their animals (Fig 2.5a, 2.6a). The annoyance and fear of losing their animals indicates that they see these wild cats as competitors as Kelly (2019) also found with Cabécares and Ticos. This could be more present in the indigenous peoples because it is where there is a greater presence of forest and free animals, as well as the presence of greater negative interaction for the inhabitants than outside of indigenous territory. It is also understandable that, if you have few animals and lose them by wildlife interactions, those feelings start to get stronger.

- By gender, same as in Nigeria with monkeys (Baker *et al.* 2014) men are more receptive than women, so they show greater joy or indifference when hearing about or seeing a big cat (Fig 2.5 b, 2.6b). In my study 42% of the total sample (38/91) answered that the jaguar or puma

can attack people, (45% [17/38] and 55 % [21/38] for men and women respectively). This may be due to the fact that in Costa Rica the belief that big cats attack pregnant women or children are deeply rooted throughout the country, and in this study of the total percentage that thought jaguars or pumas can attack people 17% indigenous and 25% non-indigenous of those interviewed mentioned. It is common to hear histories about this around the country; here are two examples that came from both ethnic groups and also different genders, a 28 years old indigenous said *"The tiger does not forgive pregnant women"* and a 48 years old non-indigenous women indicated *"The cougar chases the pregnant woman because he is looking for the baby".* Children are also in many of people histories, so they must be accompanied by men since felines respect men a little more, this was also reported by Zinn and Pierce (2002) where women and participants with children were more concerned about the risks of wildlife, here other examples from the Pacuare-Barbilla sector *"The jaguar sniffs the children, you have to go out in a group"* expressed by an indigenous man of 56 years old whereas a 35 years old indigenous women said *"Children cannot go to the mountain alone."*

These are other three responses selected from the questionnaires:

- *"The jaguar and panther kill the pregnant woman and take the baby from her" (40 years old indigenous woman)*
- *"Cat eats a pregnant woman's breast" (69 years old non-indigenous women)*
- *"Women have no power that's why they have to hang out with a man" (41 years old indigenous woman)*

In the scenario about the feelings when a big cat attacked an animal in the community, indifference was once again the most recurrent feeling both by ethnic group and by gender. The non-indigenous population and men are more indifferent, and women have more fear than men (Fig 2.7 a, b); once again this may be related to the issue of beliefs, and myths, as Guerrero (2015) exposed for a Mexican indigenous group. For example, the population outside indigenous territories have better

conditions to move (roads, motorcycles, cars) this can generate more security by not having to walk in the forest.

Attitudes about jaguars

Overall, more than 65% of respondents considered the jaguar presence for the country as good or very good versus 7% that considered it bad or very bad. This showed that when a population perceives an ample distance from these felines, they have more acceptance for them, and when we turn to more proximity to the specific areas where people live, the attitudes were changing (i.e., Jacobs et al. 2014, Engel et al 2014.). Moreover, if people have less interaction with these felines then they are more willing to consider their presence as a good thing, as non-indigenous people describe in this case. Whereas the big cat presence in their properties elicited a negative attitude from indigenous people especially for annoyance or fear of the damage it of can cause to their animals (Fig 2.9).

Conclusions

Mammals were the group with more species reported by interviewees, followed by birds. The non-indigenous interviewees reported a greater number of species in the area, though some of the species mentioned only by the non-indigenous population are species that are not common within the indigenous territory. Both populations cited the black jaguar (panther) as a different species, so it is necessary to improve the knowledge about the species as well as the role they play in the ecosystem. Species that are considered negative by the inhabitants are those that cause damage to domestic animals and crops, with the jaguar being the most referenced by both indigenous and non-indigenous populations.

Both populations thought that there is less forest cover and a lower population of big cats compared to 10 or more years ago. In addition, the interviewees saw changes in the climate, specifically an increase in temperature and a decrease in precipitation. So, in the future it could be

interesting a study to see how these and other changes can affect the human activities and the interactions with wildlife to help to address the next conservation actions.

There are differences between the perceptions of the indigenous and non-indigenous population of the Pacuare-Barbilla sector towards wildlife. The main reasons for these are associated with interactions considered negative by the indigenous population but also with myths that are deeply rooted in people (indigenous and non-indigenous people) and that continue to be transmitted through generations.

Finally, the feelings and attitudes to big cats' change depending on how close people think they are and how their animals can be attacked. Indifference and fear were the two feelings that most prevailed in both indigenous and non-indigenous populations; however, sadness was also reflected when there is an attack by wild cats on domestic animals, either with regard to the animal that was attacked or for the retaliation the big cat is going to have on the part of the settlers.

To conclude, these outcomes about how people of Pacuare-Barbilla sector think and behave is a good beginning to understand them, but also suggests that improvement in environmental education is needed, and that there is a need to include more social studies, for example, to include the local knowledge, what are their opinions about conservation or species on study?, how the society can apport to the conservation?, this kind of things can supply better recommendations in the future to the decision makers.

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Table 2.1. Number of wild species which live in the area near the community, as reported by indigenous and non-indigenous interviewees in the Pacuare-Barbilla sector during 2019.

Categories		No. of species	No. of general groups[a]	Total
Group	Indigenous peoples	38	1	39
	Non-indigenous	55	4	59
Management Type				
	National Park	11	0	11
	Forest Reserve	40	2	42
	Indigenous Territory	35	1	36
	Unprotected	51	4	55
Gender				
	Women	46	3	49
	Men	51	3	54

[a] monkeys, birds, snakes, bats or doves

Table 2.2. List of species considered problematic by the indigenous and non-indigenous population in the Pacuare-Barbilla sector during 2019. The X indicates when the species was cited by the population; X=cited only by men, <u>X</u>= cited only by woman, X= cited by both genders. Bold common names are species cited more than 10 times as problematic.

Taxon	Common name	Scientific name	Indigenous	Non-indigenous
Mammals	**Common Opossum**	*Didelphis marsupialis*	X	**X**
	Gray Four-eyed Opossum	*Philander opossum*		X
	Armadillo	*Dasypus novencinctus*		X
	Squirrel	*Sciurus sp.*		**X**
	Porcupine	*Sphiggurus mexicanus*		<u>X</u>
	Agouti	*Dasyprocta punctata*	<u>X</u>	
	Paca	*Agouti paca*	X	
	Rat*	*spp*	**X**	
	Ocelot	*Leopardus pardalis*	**X**	**X**
	Puma	*Puma concolor*	X	**X**
	Jaguarundi	*Hepailurus yaguoarundi*	X	X
	Jaguar*	*Panthera onca*	**X**	**X**
	Coyote	*Canis latrans*	X	**X**
	Tayra	*Eira barbara*	**X**	**X**
	Coati	*Nasua narica*	**X**	**X**
	Raccoon	*Procyon lotor*		**X**

	Collared Peccary	*Pecari tajacu*	**X**	
	White-lipped Peccary	*Tayassu pecari*		*X*
	Red Brocket Deer	*Mazama temama*	X	
Birds	Great-headed Chachalaca	*Ortalis cinereiceps*		X
	Hawk	*spp*	**X**	
	Parrots *	*spp*		**X**
	Bronzed Cowbird	*Molothrus aeneus*		X
	Great-tailed Grackle	*Quiscalus mexicanus*		X
	Oropendola	*Psarocolius montezuma*		X
Reptiles	Green iguana	*Iguana iguana*		*X*
	Poisonous Snakes *	*Various but Bothrops asper*	*X*	**X**
	Snake (Boa)	*Boa constrictor*	X	X
Gastropoda, Arachnida, Insecta	Slugs	*spp*		*X*
	Costa Rican Redleg Tarantula	*Megaphobema Mesomelas*		*X*
	Leafcutter ant	*Atta cephalotes*		*X*

***** *Include different species such as rat and mice, fer-de-lance and coral, parrots and parakeets, or for jaguar people cited panther (black jaguar) as a different species.*

Table 2.3. Overall perceptions of environmental change by local people interviewed in the Barbilla sector.

	Forest cover (%)	Jaguar population (%)	Temperature (heat) (%)	Rainfall (%)
Much less	24	8	2	24
Less	29	43	9	31
Equal	21	26	24	27
More	22	19	34	15
Much more	4	0	31	3
Unknown	0	4	0	0
Total	100	100	100	100

Table 2.4. Results from Chi-square test for questions about big cats feelings by ethnicity and gender. Statistical differences (P<0.05) are indicated in bold.

	Ethnicity		Gender	
	Chi-square	P value	Chi-square	P value
If hear about it	**17.73**	**p=0.006**	**20.37**	**p=0.002**
If see it	**14.13**	**p=0.028**	**24.01**	**p=0.0005**
If attack	**19.38**	**p=0.012**	11.16	p=0.192

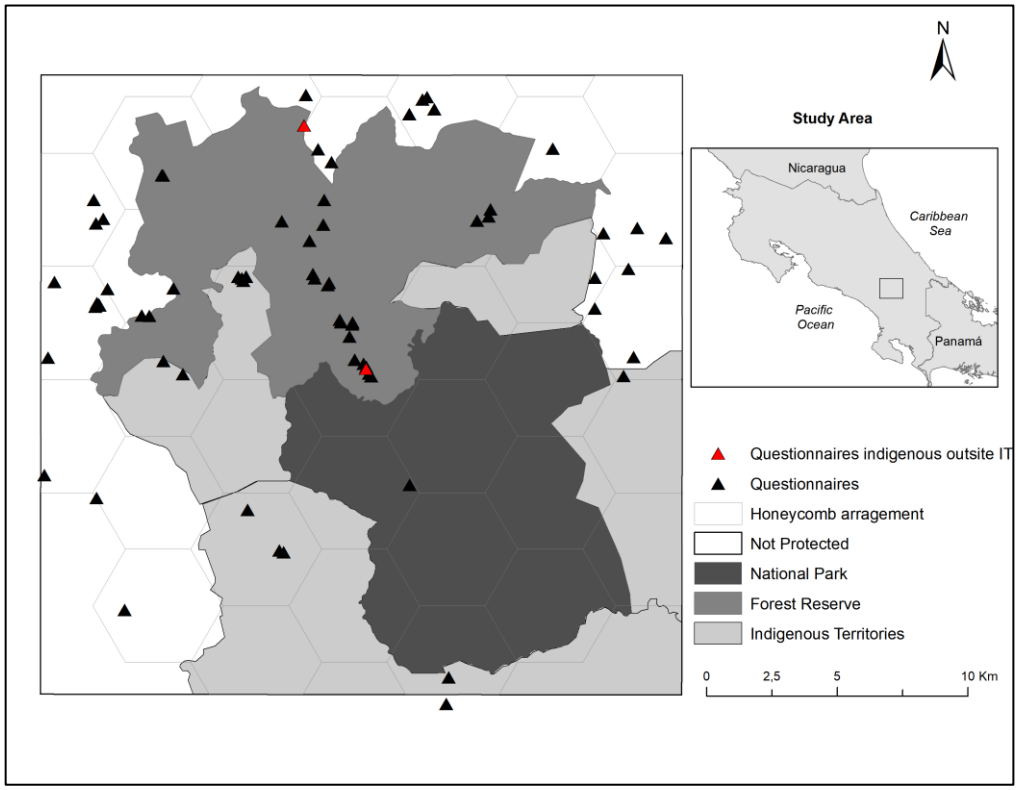
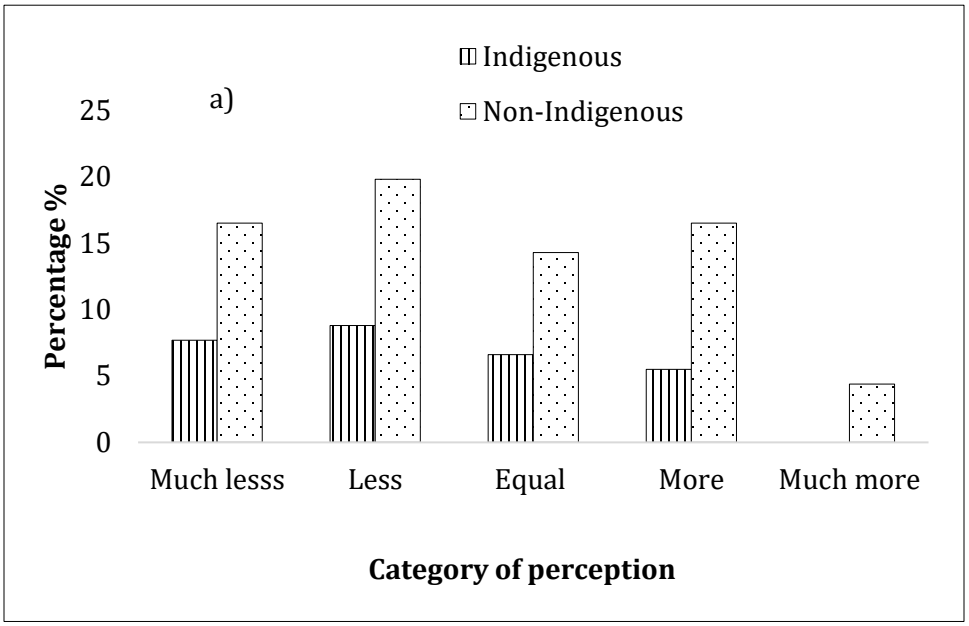


Figure 2.1. Area covered with the questionnaires applied within the Barbilla Sector in the northern Talamanca Mountains of Costa Rica.



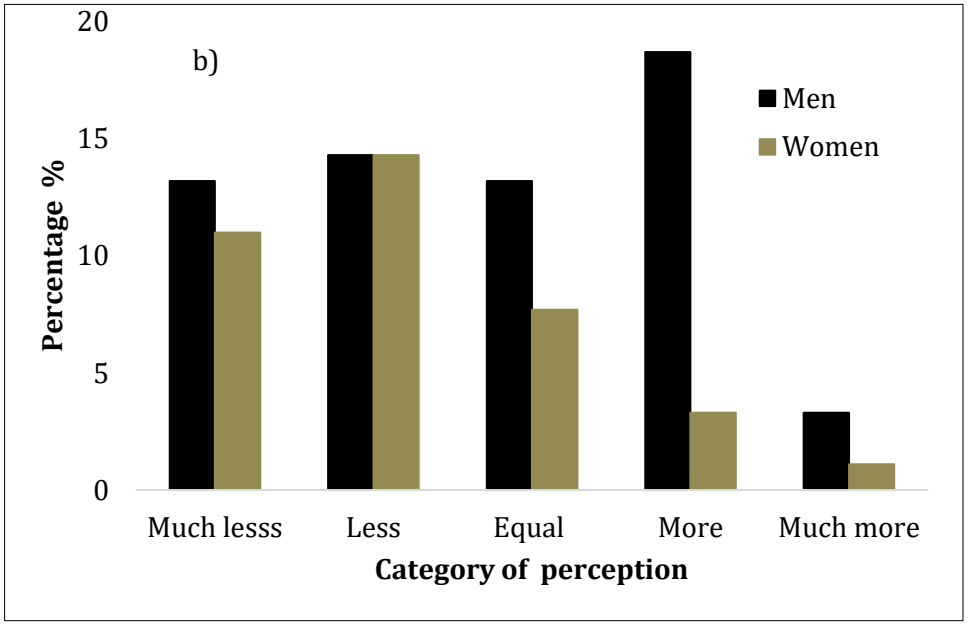


Figure 2.2. Perception about switch forest cover 2019, against 10 or more years ago a) ethnicity, b) gender.

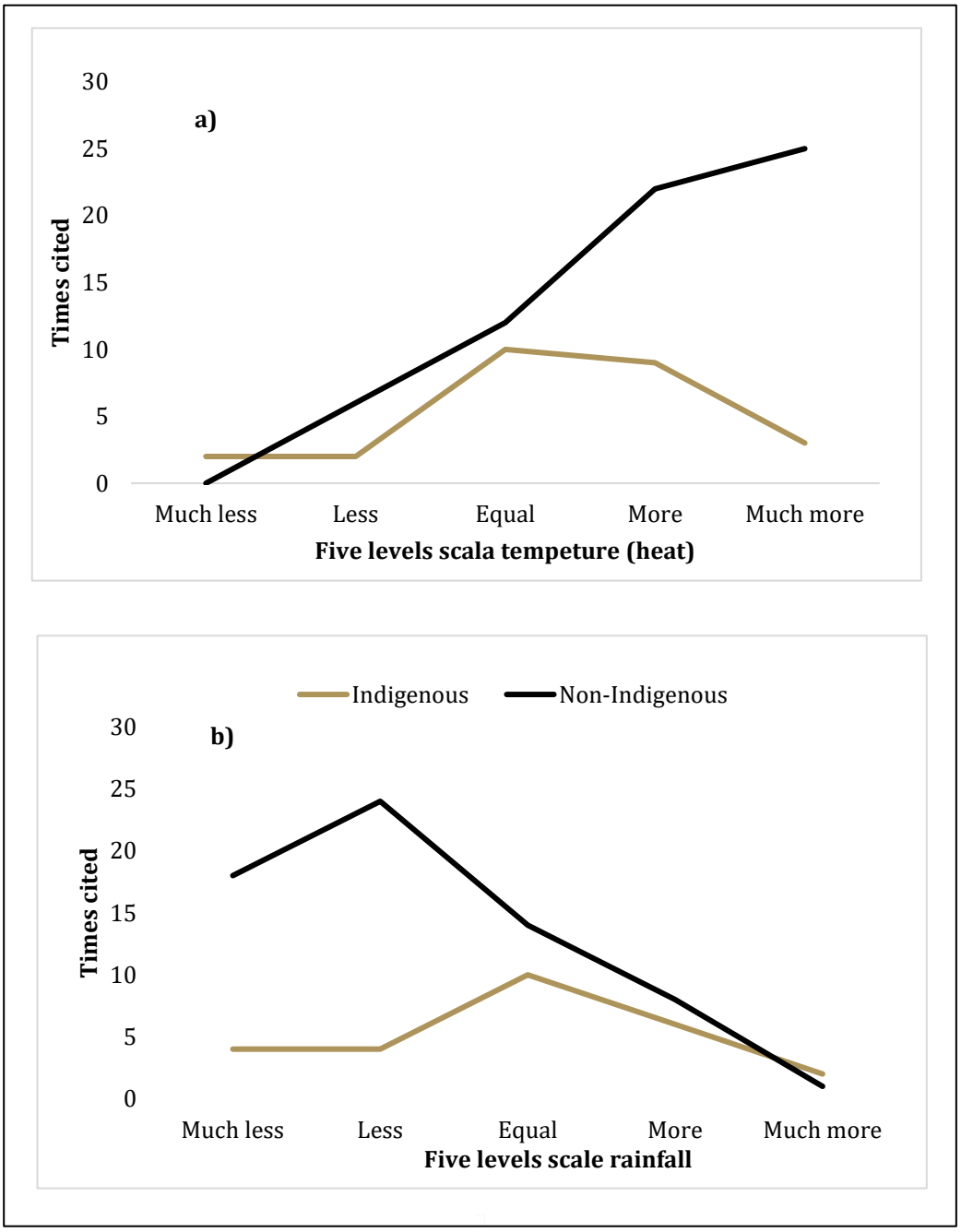


Figure 2.3. Perception about weather changes in the last 10 or more years by the interviewees in the three protected areas and unprotected lands, a) temperature and b) rainfall.

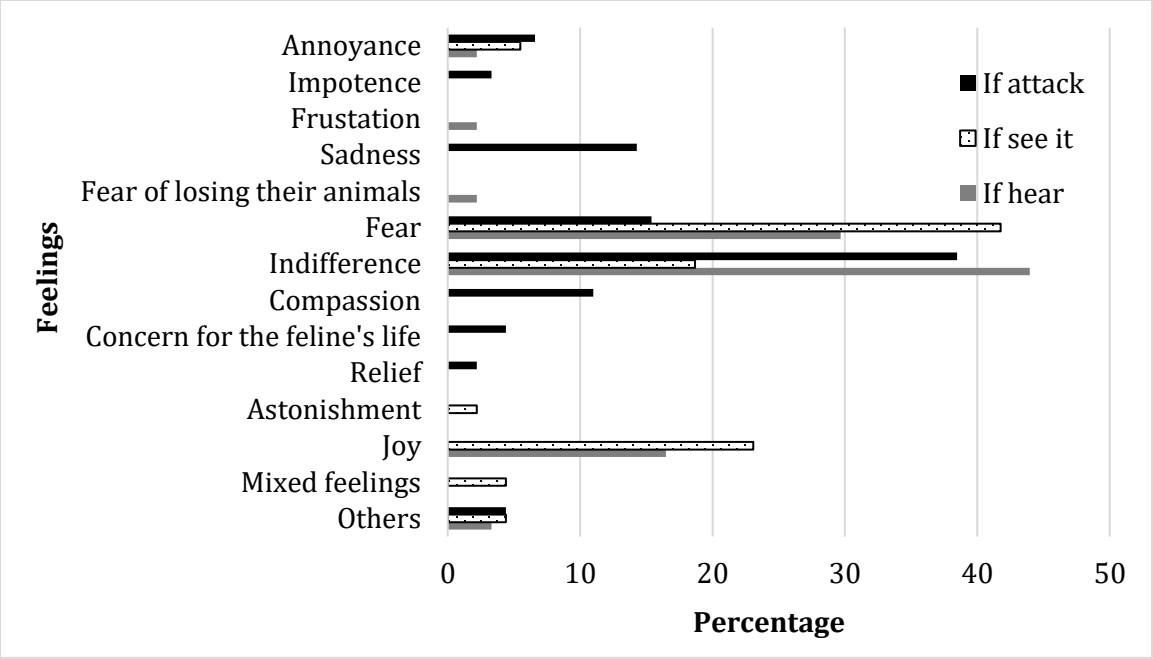


Figure 2.4. Feelings and percentages for each of them according to the three main questions about hypotactic scenarios with big cats.

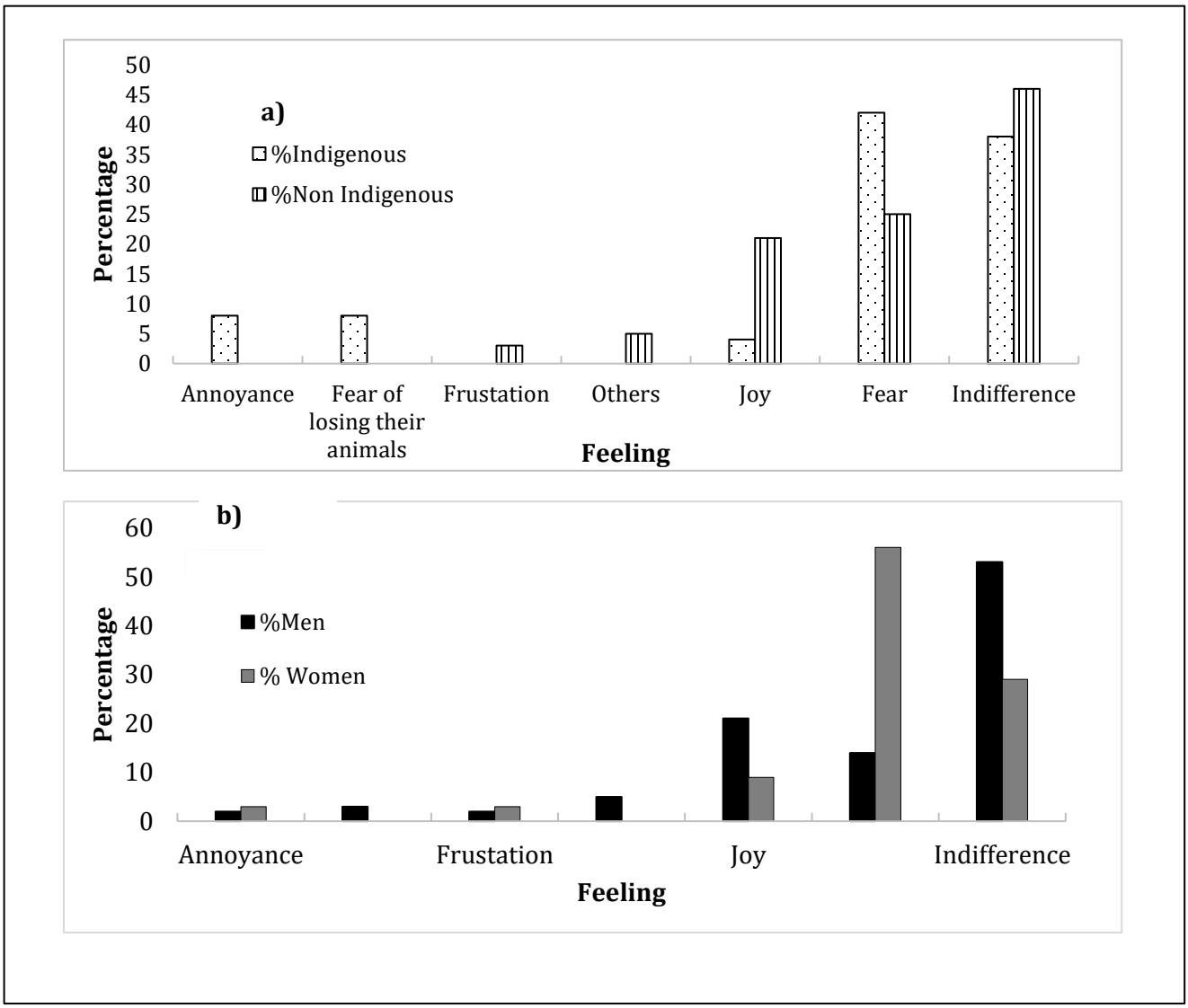


Figure 2.5. Feelings expressed in question What do you feel when you hear that jaguar/puma is around the area? a) by ethnicity type and b) by gender.

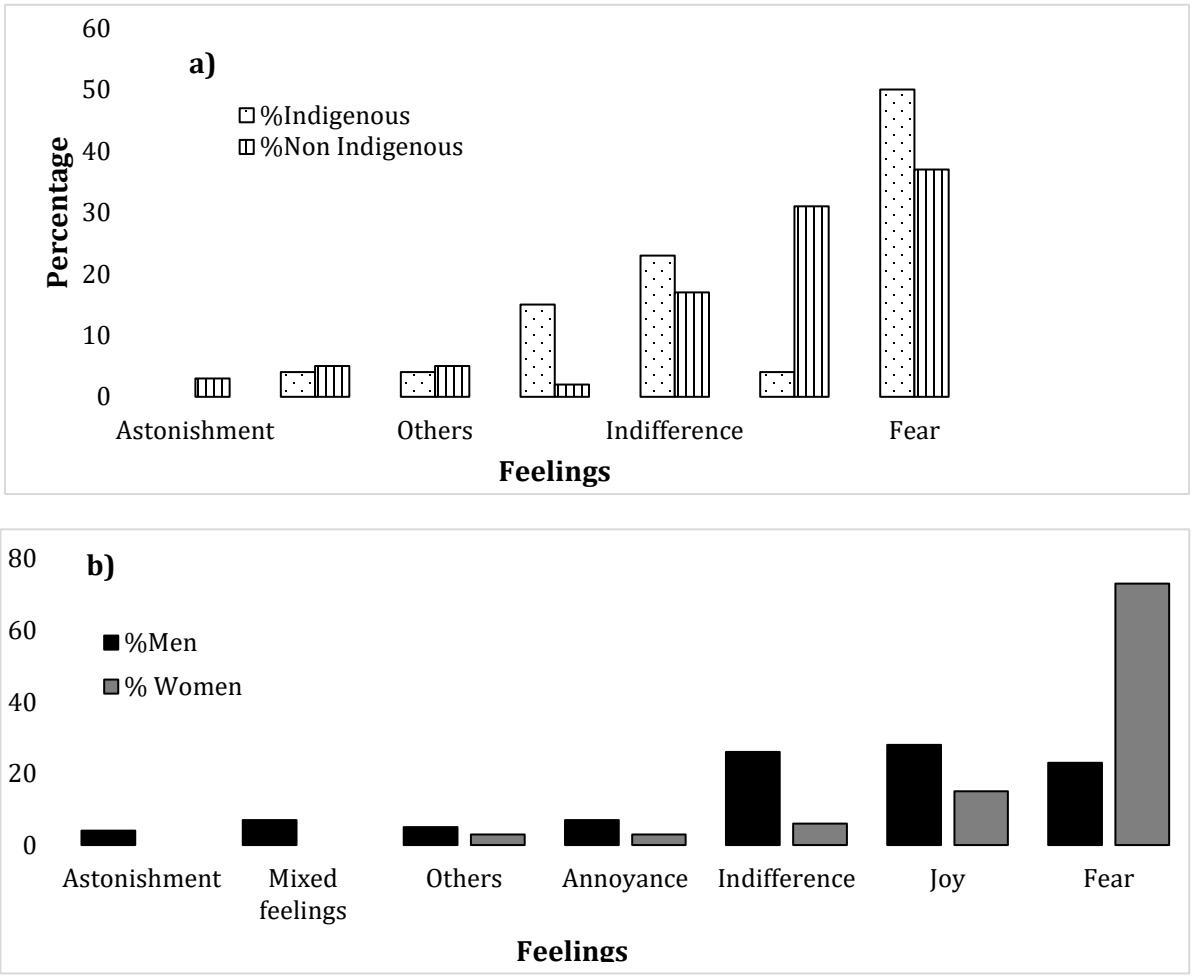


Figure 2.6. Feelings expressed in questions What do you feel if you see a jaguar/puma close to your house? a) by ethnicity and b) by gender.

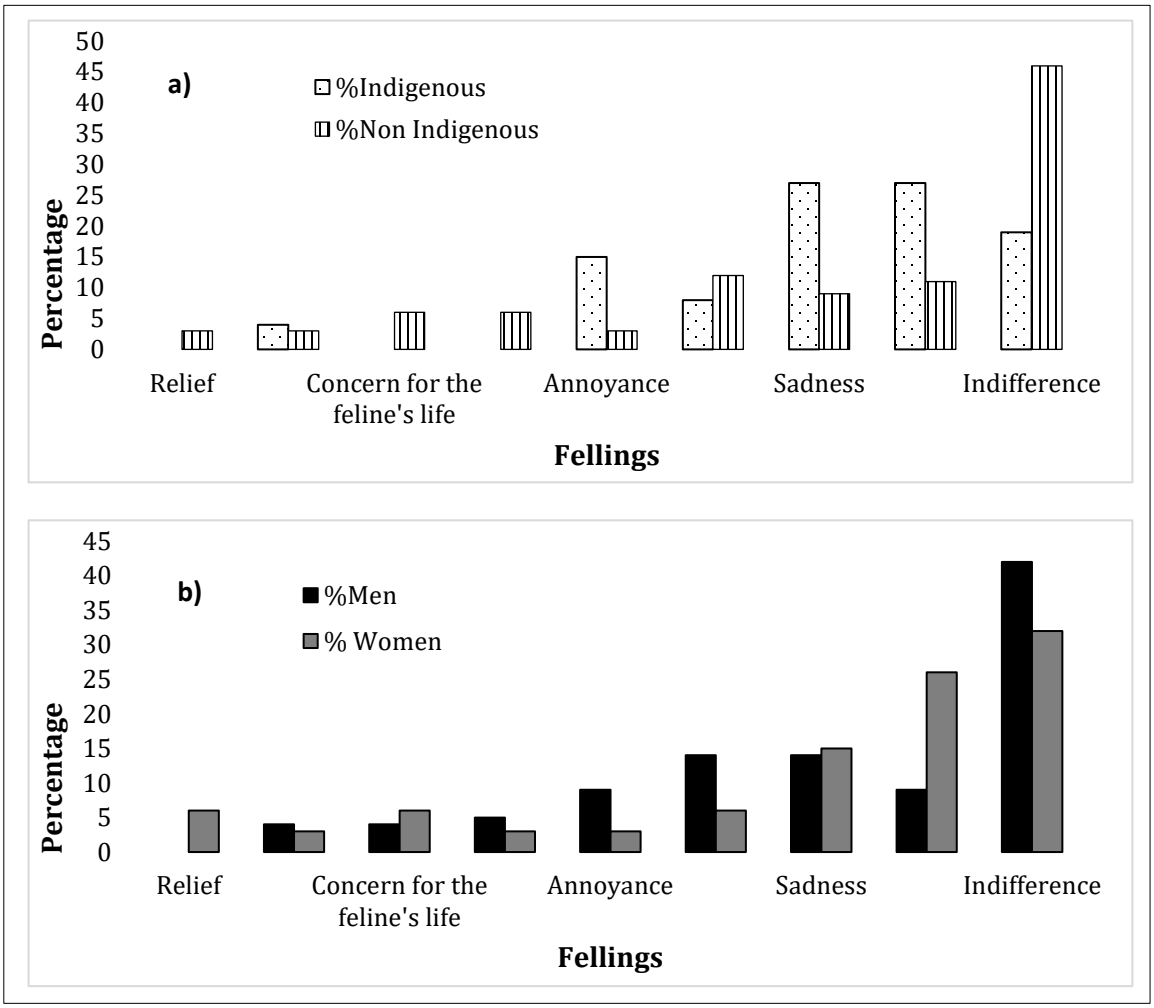


Figure 2.7. Feelings expressed in question what do you feel when you know a jaguar/puma attacked on an animal in the area? a) by community type and b) by gender.

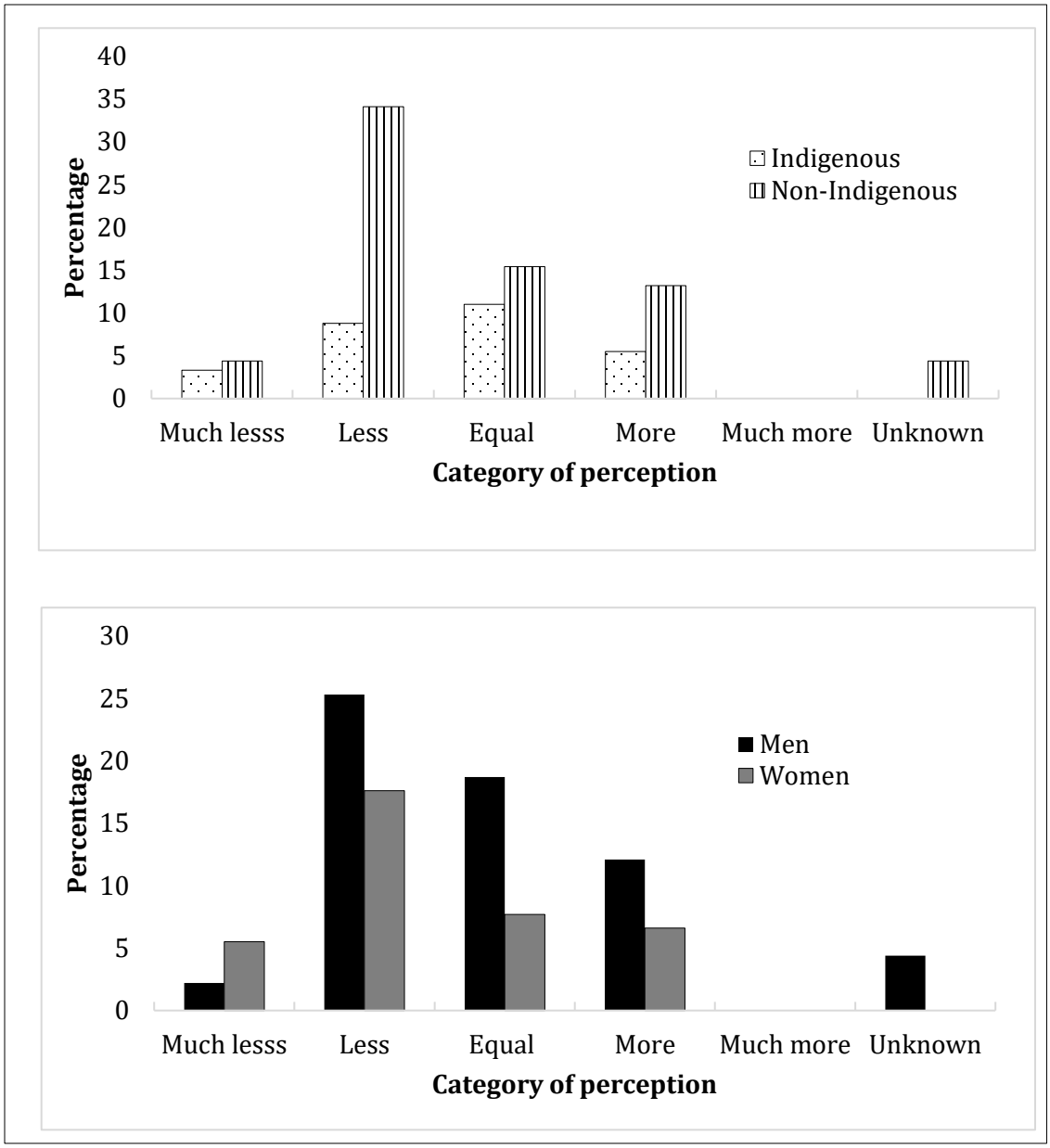


Figure 2.8. Perceptions of recent change in jaguar population by a) population type and b) by gender.

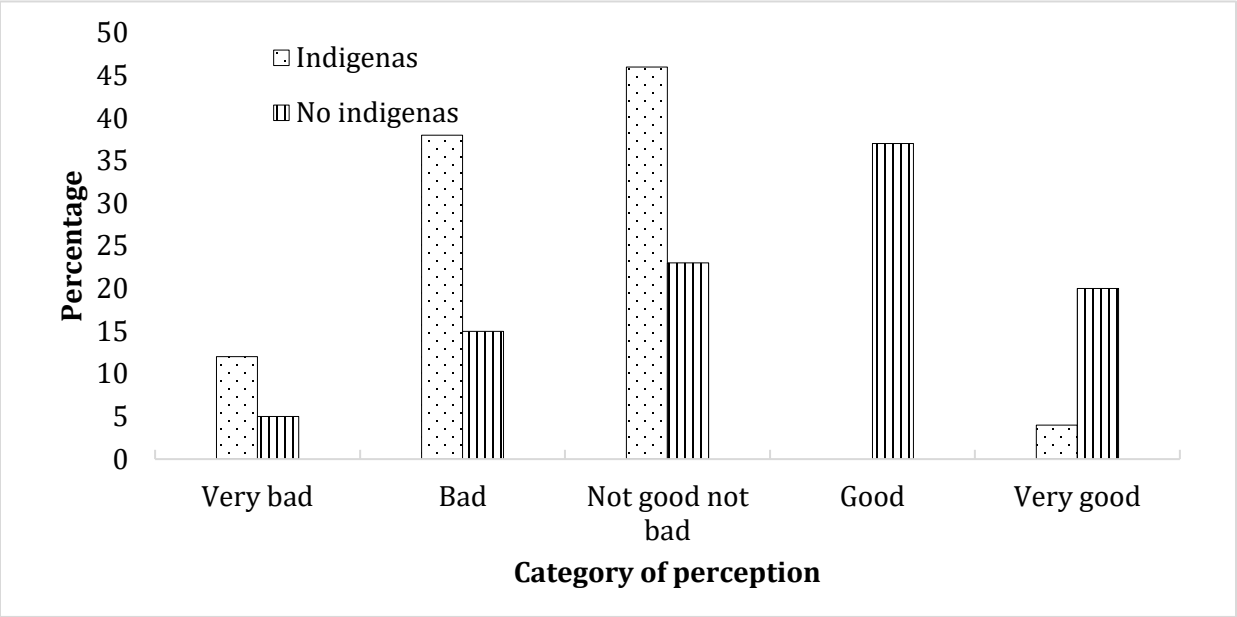


Figure 2.9. Attitudes about jaguar presence in properties of interviewees at indigenous peoples and not indigenous.

CHAPTER 3

HUMAN-WILDLIFE CONFLICT IN INDIGENOUS COMMUNITIES OF THE NAIRI AWARI INDIGENOUS TERRITORY OF EAST CENTRAL COSTA RICA

Abstract

Human-wildlife conflict is an essential topic for conservation nowadays because it is necessary to maintain the balance of requirements needed by humans and wildlife. Indigenous territories are not exempt from interactions with wildlife, and in this study I focus in one indigenous territory of the Cabécar Indigenous Group of Costa Rica called Nairi Awari. I wanted to know which are the most common species, which interactions with these species they consider negative, and what are the possible solutions to these interactions. To do this I applied 25 semi-structured questionnaires to indigenous people during March-August 2019. The results showed 16 species as "problematic animals", the jaguar being the most common, followed by hawks. Of six problem categories identified, predation on poultry was the most cited category but it had fewer negative feelings by respondents than some other problems. Possible solutions to pig or cow predation, problems which most maddened respondents, included improved management (48%), scaring animals (12%), and killing big cats (16%). It is important to understand these perceptions in order to address future management to benefit conservation and human welfare. In particular, there is potential to work in the long term to improve management of domestic animals.

Introduction

More than 10% of the 37.9 million km^2 of indigenous territories around the world are in Latin America (Garnett et al 2018). In these territories there are more than 826 Indigenous Peoples groups that in 2010 represented more than 8% of the human population in Latin America (United Nations

2020). Moreover, the five great masses of tropical forest in the world occur in a large part of indigenous territories, and this is true in Central America, as well (Euroclima 2019). In Costa Rica and Panama, widespread tropical forest occurs in the Talamanca region, which includes considerable area of indigenous territories.

In Costa Rica there are a total of 24 indigenous territories covering 6.6% of the national territory (UNICEF-Costa Rica 2010, Ortiz-Malavasi 2014) and representing 2% of country's human population (Guevara and Ovares 2015). The indigenous territories of Costa Rica are home to the eight native groups, the two largest of which are the Bribri and Cabécar that have marked differences language, customs, and traditions. My focus is on the Cabécar group, the second largest in size, with a population of 13,993 (12,707 indigenous and 1,286 not indigenous) people distributed over eight territories in approximate 1800km^2 (MIDEPLAN 2015, Ortíz-Malavasi 2014).

For the Cabécares, animals are very important in their culture because of their role in stories as spiritual guides. Nature also plays an important part in the harmonious and respectful way that they live with the environment. Moreover, domestic animals such as cows, sheep, chickens and, especially, pigs are also valuable to them, as they are an important part of the diet, economy, and/or spiritual traditions (MEP 2014, Maly et al. 1998, Ayalew et al. 2011). The way pigs are raised in the Cabecar culture is free-ranging, but like the pua'a (Polynesian pig) they have a very strong relationship with human families (Male et al. 1998). For example, Cabécar houses are raised on posts, allowing the area under the dwelling to house animals. Animals roam free in the grasslands or in the jungle where they search for food during day, they return to the houses at night; for that reason, they are seen as members of the family.

This way of pig management allows pigs to go inside the forest for a number of kilometers, where wild predators are also looking for food. This situation sometimes causes some losses for the people and therefore they become annoyed with predators. For that reason, I want to know if inhabitants of Nairi Awari Indigenous Territory feel that wildlife generates negative impacts to them and if they consider big cat predation on pigs as a big issue. I would like to know if they use methods

to repel the wildlife from their properties to protect their animals. If they use such methods, then how efficient is the method or if they do not use it, why not? It is important to understand human relationships with nature, but it is also important to work together for the well-being of communities, domestic animals, and the wildlife; it is important to keep a healthy and balanced ecosystem but also a thriving culture of native people. In this chapter I focus on human-wildlife conflict and possible useful solutions to conflicts in the area. I want to know what species are considered problematic and what problems they cause. Also, I want to know what people perceive the trend will be in the future for the problems, what some possible solutions to the problems are, and how management can be changed to create better conditions for all the pieces of the big puzzle.

Materials and methods

Study Area

This study was focused in one Cabécar territory called Nairi Awari Indigenous Territory (NAIT) that is located in northern part of the Talamanca Mountains between Cartago and Limón provinces (Fig. 3.1). Annual rainfall ranges from 3,000-5,000 mm, elevation ranges from 170-1,107 m, and temperatures range from 20-24°C (Ortiz-Malavasi 2014). This territory has an area of just over 50 km^2 and a population of 473 inhabitants (MIDEPLAN 2015). With very few sources of employment, most inhabitants live from their crops and raise animals (Sáenz-Bolaños et al. 2015). Some work as day laborers or for the few tourism companies in the adjacent Forest Reserve.

Data Collection

After a mandatory meeting with Nairi Awari association where I presented the ideas for the project, I asked if they agreed and they were willing to be part of the study. After some months I obtained permission to work in the Nairi Awari Indigenous Territories, first by message text and then several months later by formal letter.

From March to August 2019, I conducted a study using a face-to-face questionnaire in structured interviews (Newing 2011). Respondents were indigenous people ≥18 years old, and the majority of them were interviewed inside of the Nairi Awari territory, but others in their work places (Fig 3.1). The questionnaire was organized as open-ended questions and Likert scale answers, and I collected relevant quantitative and qualitative data. The questionnaire was approved by the Institutional Review Board of the University of Massachusetts, Amherst (Protocol ID 2018-5066).

Once in the field, I walked in the jungle or gravel roads, and when I found a house, I approached the residents and explained what the survey was about and inquired if they would be interested in participating in the study. Every interviewee was informed about how much time the survey would take, that their participation was voluntary, that their replies were confidential (no names in the instrument), that they could end the survey at any time, and that it was not mandatory to reply to any question. I interviewed both genders, but I did not interview a woman if the husband or partner was present to reduce potentially biased answers (Korieh 2006, Baker et al. 2014); Thus, I interviewed women separately to obtain independence in the responses (Jenks et al. 2014). All the surveys were conducted in the Spanish language. However, in the indigenous territories I employed a Cabécar assistant who speaks their language and translated for us when they did not understand some questions or if they used some Cabécar words that I could not understand. I wrote answers on a printed questionnaire and then tabulated them in an Excel spreadsheet.

Data Analysis

I grouped all answers about wild species they consider causing some problem to people of the community and which problem type they referenced. In this case, the community is a set of properties from different owners in areas inside the indigenous territory. To categorize the problems, I grouped the answers into six categories according to the problems caused by the animal they considered as problematic (i.e., livestock attacks, poultry attacks, crop impact, pig attacks, physical risk for human, and other; Table 3.1).

I conducted a descriptive analysis of the species cited as problematic and what problems that wildlife cause. For both questions concerning attacks (When was the last time a big cat caused an attack in the community? When was the last time a big cat caused an attack to your animals?), I grouped the answers into four periods when the attacks happened: a) Never, b) < = one month ago, c) > one month ago but < one year ago, and d) > one year ago.

To know what indigenous people of the Nairi Awari Indigenous territory consider to be possible solutions to reduce wildlife interactions and negative impacts for the inhabitants, I categorized the answers into 5 groups according to their similarities.

Results

In total, 24 questionnaires were completed for 16 indigenous men and 8 indigenous women. Sixteen species were cited in relation to some problem or negative opinion voiced by the respondents (Fig 3.2). Only the two big cats (jaguar and puma) were considered as a problem in different categories. Overall, 70% of indigenous people interviewed (5 women and 12 men) considered jaguar (including "black panther", the melanistic color phase of jaguars) or puma as problematic. On 12 occasions jaguar/black panther or puma were stated as a pig predatory species, 7 times as a livestock predator and once each for poultry attacks, hazard for humans, and other. The big cats represented 86% of the respondents' answers to the cause of problems with livestock and pigs (Fig 3.3). Only two people indicated jaguars and pumas as problematic species in more than one category (i.e., both livestock and pig attacks). Thirteen respondents cited eight species as poultry predators (hawk = 5, boa = 4, opossum = 4, coyote = 3, ocelot = 3, tayra = 2, jaguar = 1, and jaguarundi = 1). Eight persons referred to six species (coati, agouti, mice/rats, collared peccary, paca, and red brocket) as crops eaters, and two people cited poisonous snakes and jaguars as species that are a hazard to human beings (Fig 3.4).

To evaluate the perception of risk or losses I first asked about ownership of livestock or pigs; 79% responded positively having mostly cows or pigs but in low numbers (Table 3.2). The person

who had more cows owned 21 individuals and for pigs the highest number was 35. Horses and sheep were also owned by some interviewees, but on much fewer properties and the numbers were much lower, too. For example, those interviewed with the most horses had only 8, and those with the most sheep had only 7 animals (Table 3.3).

Only two people that considered jaguars/black panthers or pumas a cause of predation on livestock or pigs also cited them as other problems, too (i.e., risk for humans and others). Regarding the timing of the last attack, only 5 respondents indicated either never or that they did not know if that problem happened, whereas 21 indicated some timing of occurrence in the community.

Referring to how they perceive the situation in the future, 68% of respondents considered the problem will be the same, 20% opined there will be less (number of attacks will decline), 8% considered interaction will be greater (attacks will go up), and 4% indicated did not know. What they considered as possible solutions were to improve management (48%), kill the feline (16%), scare it away, do nothing (12% each one) (Fig 3.5).

Discussion

The interviewees identified problematic species as those which attack their animals, feed on their crops, or are a hazard to humans. The 16 species considered responsible for causing negative impacts commonly are problem species in many areas; for example, the species cited as causing poultry attacks are well known to cause it in most places where poultry occur (Andelt 1976, Amador-Alcalá et al. 2011, Lloyd 2020). Nevertheless, the majority of this happens because people do not have a place with the adequate conditions to avoid the interactions, especially at night when it is more common to have visits of wildlife to the areas with poultry (Amador-Alcalá et al. 2011, Jacob et al. 2017, Ohioline 2018,). But interestingly, even when the poultry attacks were more cited, people had fewer negative feelings about the predators, perhaps because the chickens are easier to replace and culturally are not important as a pig. To have few cows or pigs and lose one due to the big cat's

predation more strongly affects the owner, and probably that is one of the reasons they have more negative feelings compared to individuals with poultry predators.

Most people considered big cats as a problem for pigs and cattle, but a few people considered them a hazard for humans or poultry, as well. As in many countries with wild big cat-human interactions, problems occur as a result of the management of domestic or production animals (Polisar *et al.* 2003, Amador *et al.* 2011, Tiger Guard 2020). For example, domestic animals are allowed to enter the forest searching for food or water, or people do not control their animals during the calving or farrowing season. This study in the Nairi Awari Indigenous Territory is no exception. The culture of this indigenous group is that they believe that pigs must be managed as free-ranging, as their ancestors did. And though cultural legacy is one reason for this practice, these people also find that this kind of management is an easy way to have animals and not think too much about what you are going to feed them. One interviewee said, "*In my home community that it is also Cabecar, my people hard work to keep animals fed and so they produce what the animals eat. But here, people do not want to work on that; they know it is necessary but prefer to not do it*".

On the other hand, free-ranging pig management forces people to raise crops far away from their houses (for some, kilometers away up or down mountains) to avoid having their livestock destroy and eat the crops. This, however, has consequences; people have less control in monitoring the crops, thus making it easier for some wildlife to cause crop damage. Also, it is more difficult for some elders to carry what they harvest over long distances.

k, most of the owners of pigs who lost pigs to predation by big cats were those that also had relatively low numbers of cattle (Chi square = 4.39, df = 1, p=0.036; Table 3.3). This suggests that husbandry practices differed depending on the relative number of cattle owned, and those practices affected vulnerability of pigs to predation.

As many authors suggest, to reduce the negative impacts of wildlife it is necessary to change the way owners manage their animals (Polisar et al. 2003, Escobedo 2011, Quigley et al. 2015). This study area, like many others in the world, is important for wildlife conservation because there is structural connectivity for wildlife and cultural values and traditions of indigenous people that are also important to conserve. Given that the majority (68%) of respondents considered the trend in attacks on livestock or pigs will stay the same, and only two people (8%) considered the trend will be higher in the coming years, we must work on management options to prevent these negative interactions, based on the information we get from interviews. For example, more than half of interviewees considered that the better solution to keep the balance in the ecosystem and the livelihood of inhabitants of Nairi Awari is to improve the management of pigs by using enclosures and feeding the pigs. I agree that it is necessary to install enclosures for animals in the indigenous territory, but always keeping large areas to move them from place to place on a regular basis. Nevertheless, the building of enclosures will require indigenous people to also implement systematic food production for the animals. This will be a hard task to do but it will be an interesting long-term project to implement in some communities and see the effects having some "model" properties, that is, those that have implemented new prevention methods. Another very important action to take is that the indigenous people must know how many pigs they have and control their age distribution. In the words of one interviewee *"they have a lot of pigs that go to the jungle, so they have to sell some and keep only little ones and lock them up*". Another said "*is necessary to reduce the number of animals, and plant closer to have food for them (pigs)".*

A not negligible percentage (16%) of people think the best solution is to kill the feline. It is no typical from conservation point of view, maybe sounds as something bad for felines populations, however, many other cultures and even the beginning of wildlife management had the goal keep game species, so selective remove some individuals was the purpose. My experience with the Cabecar people, some of them explained me, when they decide to kill a feline or other animal, they ask for permission to the owner (God) of this species, once they get the permission they have to kill

the animal quickly to avoid the animal suffer, so in that way when the hunter pass away, he will not to fight with this owner or other feline souls before find the peace of his soul. So for that reason indigenous could been keeping this survival technique to maintain their livelihoods and also respecting the nature and their functionality.

I think it will be important to achieve real involvement of a group of committed owners that want to implement some enclosures, and to evaluate the effectiveness of such changes to be able to realize the long-term coexistence of big cats, indigenous peoples and their culture.

Now, after having surveyed some of the population, I want to implement a test corral study in a community, even by improving old corrals to keep animals (pigs) inside, so that people could also plant some feed crops for the animals (e.g., sugar cane, cassava, banana and other roots) close by. At the beginning, people will need assistance with getting supplementary food until the crops mature, but after initial guidance there should be people ready and willing to do the work by themselves with limited guidance.

Conclusions

We now know what the most common negative interactions with which species are in the indigenous territory; jaguars are the most common livestock and pig predator, hawks and opossums are the main poultry predators, and collared peccaries cause the most crop damage. Moreover, people know what they have to do to reduce the conflict, especially with big cats and with nocturnal attacks to poultry. The majority of them cited improved management and the most common method was keep the animals in enclosures and also to reduce the animal numbers (especially pigs) to make crop production and the feeding process easier, and scaring the predator using dogs as was also reported by Schauer (2021) or the rifle to make noise as prevention methods, though an interesting percentage indicated that killing the animal is an important management technique. From the conservation point of view, this is not an appropriate way to solve the interactions, but as Manfredo et al. (1998) and Jacobs et al. (2014) argue, the context can change the acceptance of killing a big cat. In this current

situation for the Nairi Awari, they may have an attitude or cultural norm that, in their context, removing an animal is seen as a correct option in order to keep maintain their livelihood. Having this overview is important because it permits a better understanding of the social context and people's thoughts about management that could be implemented to reduce domestic animal losses while also conserving wildlife and human welfare (Peterson et al. 2008, Peterson et al. 2010). Wildlife managers and practitioners have to understand social constructions in order to address the future actions to be deployed in support of wildlife conservation and human welfare (Chan et al. 2007), and thus work closely with the owners by giving guidance and support to ideas they could develop together.

Finally, in the future a long-term comparative management project in communities with high pig predation by big cats will be an important study to do, especially if the inhabitants show interest and are willing to make changes that they believe can help to conserve their culture, livestock, and wildlife.

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Table 3.1. Six categories of negative interactions identified according to the indigenous respondents' answers.

Problem type	**Responses included**
Livestock attacks	cows, calves, sheep, horse (other than pigs – see below)
Poultry attacks	when wildlife eat chickens or turkeys
Crop impact	when wildlife eat corn, sugar cane, cassava, banana, malanga, or any other crop or fruits on private properties
Pig attacks	I decided to do not include pigs in livestock because, for indigenous people, pigs are more than meat; pigs are a kind of coin, trade, even used for spiritual ceremonies
Physical risk for the human being	Included answers like eat people, attack people, risk for kids, risk for human being
Other	bothering other animals, go into houses and other places, come to trash cans, eat “everything”, make a mess in trash can or in kitchens

Table 3.2. Summary of owner-managed livestock

	No. of owners	Only pigs	Only cows	Pig/cow	pig/cow/horse	pig/cow/horse/sheep
With livestock	19	3	3	8	3	2
With predation	8	2	0	3	1	2

Table 3.3. List of head numbers of livestock per owner. The asterisk represents the properties with jaguar or puma attacks to specific livestock and in bold are the properties with attacks but more than one year ago.

Own pigs?	Relative no. of cows owned	Interviewee ID n°	No. of hoofed livestock owned			
			Cow	Pig	Horse	Sheep
Yes	High	36	21	15	0	0
		38	20	25	8	0
		81	17	10	0	0
		82	17	10	0	0
		37	15	15	0	0
		83	13	20	7	0
		49	13	**2***	0	0
		Mean	16.6	13.9	2.1	0
		Range	13-21	2-25	0-8	0
	Low	35	6	6	2	0
		4	4	30*	1	7
		89	4	20*	3	5
		39	3	12*	0	0
		40	3	12*	0	0
		84	2	1	0	0
		48	0	35	0	0
		79	0	**28***	0	0
		78	0	**16***	0	0
		Mean	2.4	17.8	0.7	1.3
		Range	0-6	1-30	0-3	0-7
No	Low	87	8	0	0	0

88	5	0	0	0
77	1	0	0	0
Mean	4.7	0	0	0
Range	1-8	0	0	0

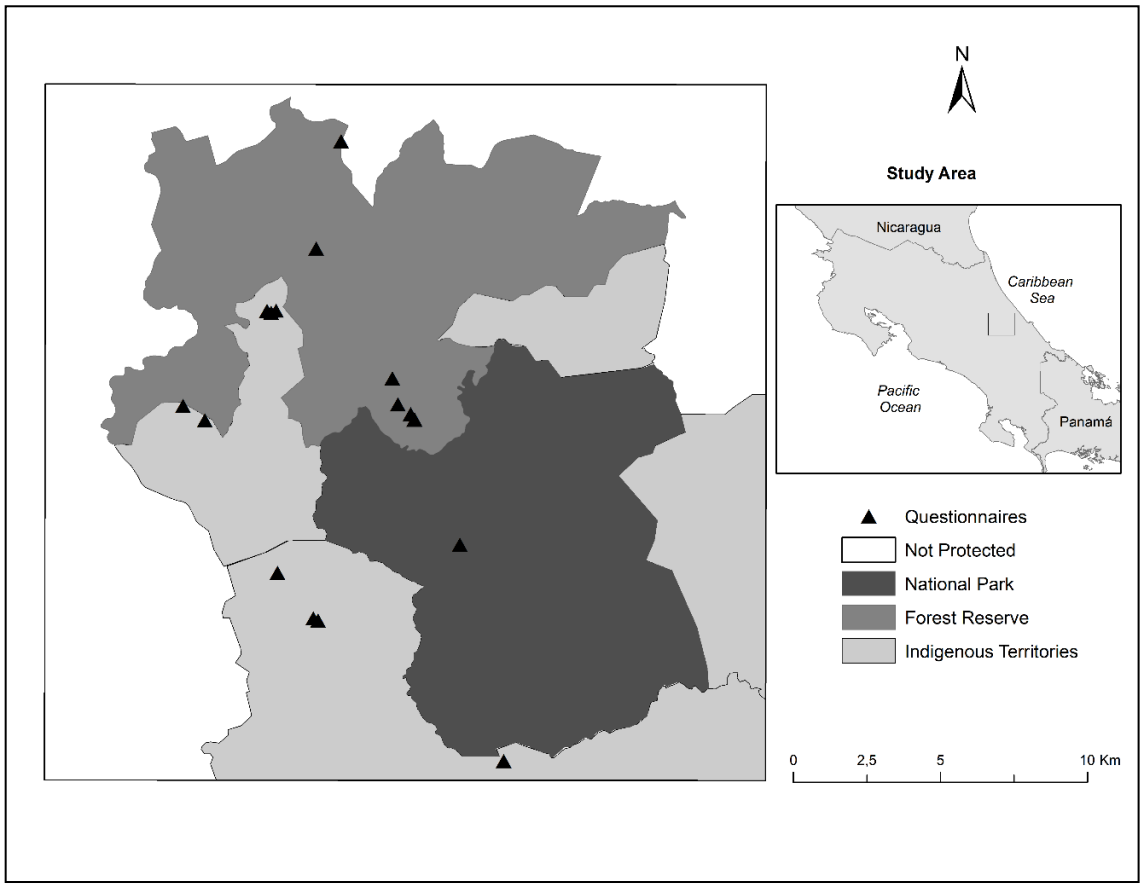

Figure 3.1. Area covered with the questionnaires applied within the Barbilla Sector in the northern Talamanca Mountains of Costa Rica.

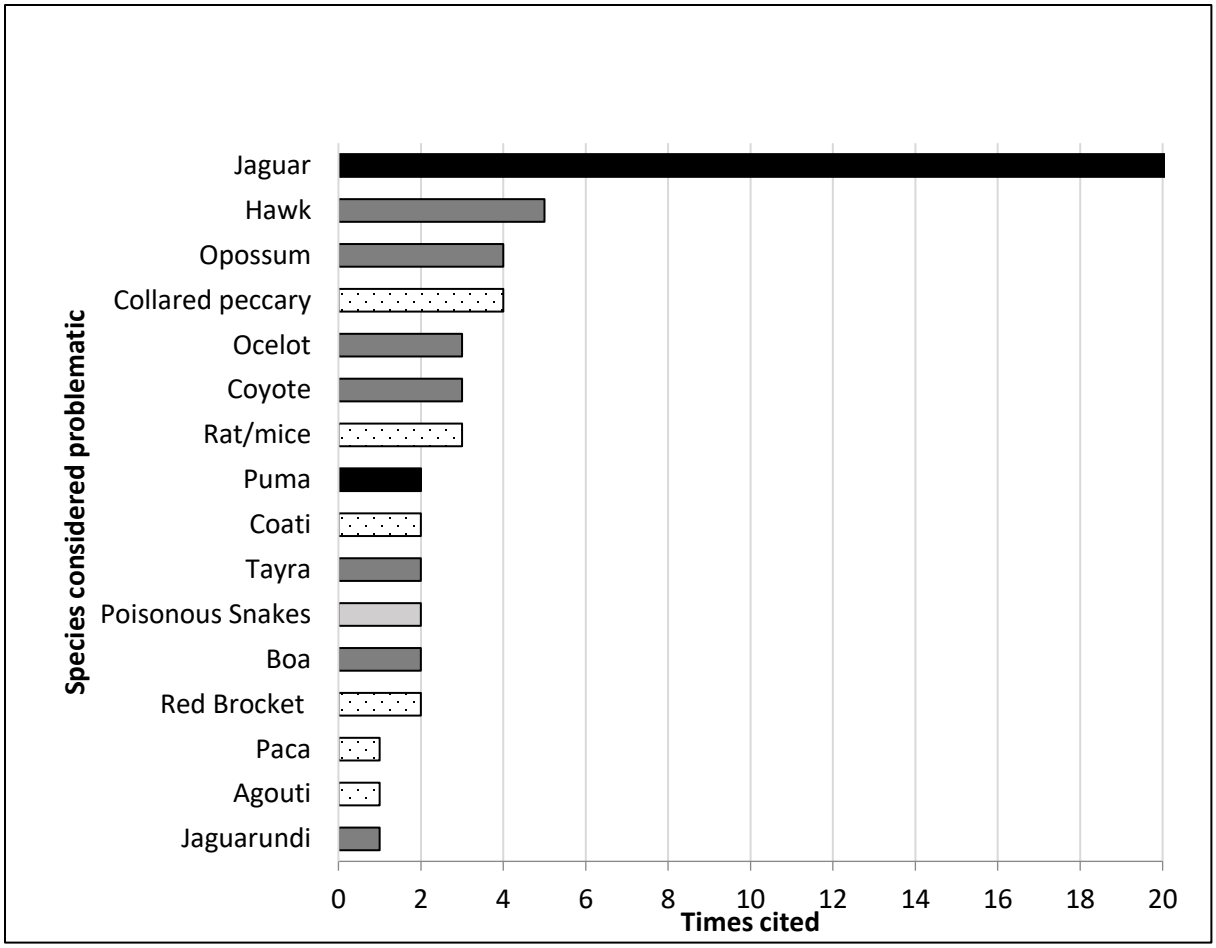

Figure 3.2. Species considered as problematic by inhabitants of Indigenous Territory. Black bars indicate more citations for livestock attacks, dark grey bars poultry attacks, light grey bars cited as hazard to humans. Spotted bars species more cited as crop eaters.

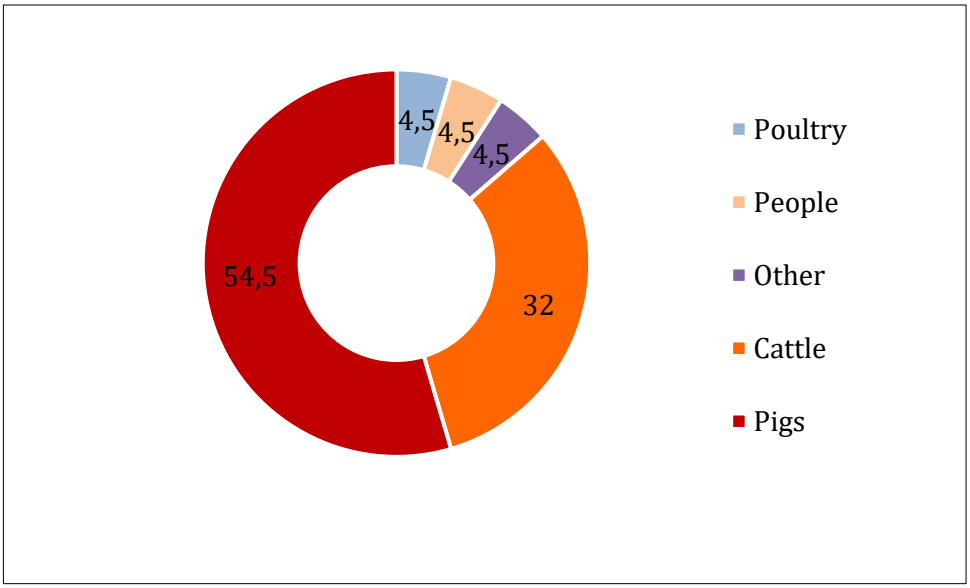

Figure 3.3. Type problem percentage caused by big cats according to those interviewed in the Nairi Awari Indigenous Territory.

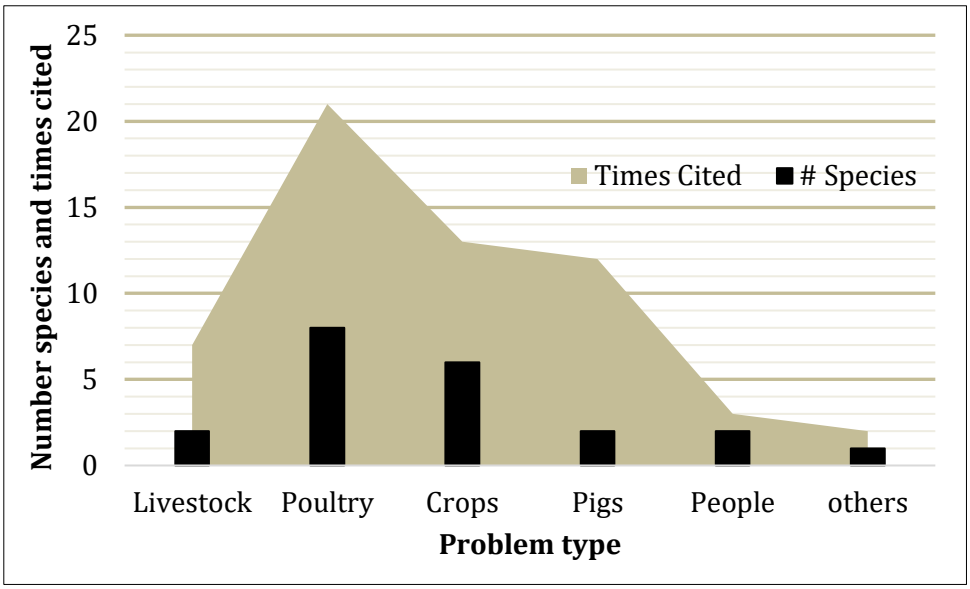

Figure 3.4. Number species related by problem category and times a specific problem were addressed by inhabitants of Indigenous people.

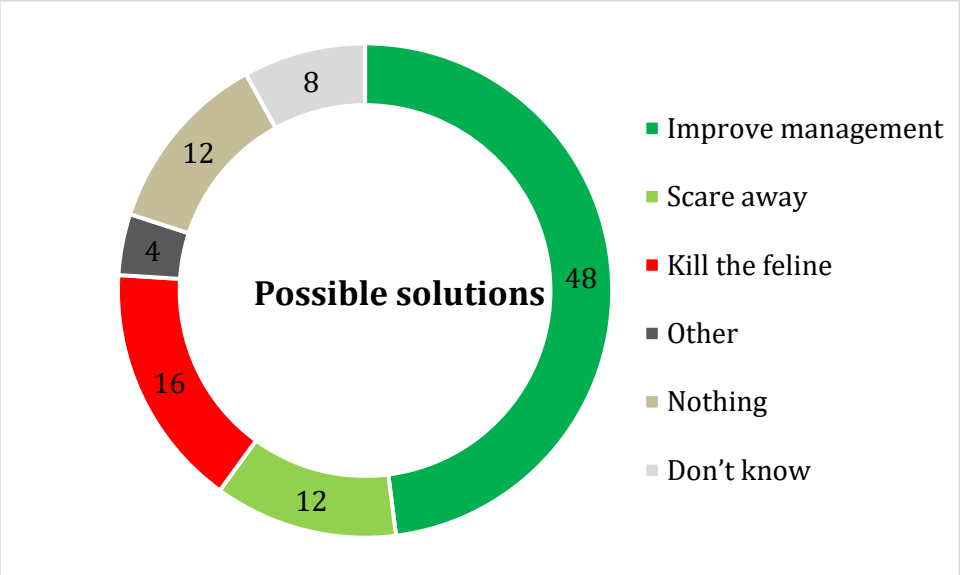

Figure 3.5. Percentages of possible solutions cited by the inhabitants of Nairi Awari Indigenous Territory to avoid jaguar/black panther or puma attacks on livestock and pigs.

CHAPTER 4

COMPARISON OF RELATIVE ABUNDANCE OF WILD TERRESTRIAL MAMMAL SPECIES CONSIDERED FOOD SOURCES AND PEST SPECIES DUE TO LOSSES OF ANIMALS OR CROPS AMONG INHABITANTS IN THE NORTHERN TALAMANCA MOUNTAINS OF COSTA RICA

Abstract

Wildlife has been an important protein source for local communities worldwide, especially where there are tropical forests in developing countries, few job opportunities, and poverty. Moreover, humans are less willing to protect wild animals when they consider that they are losing their domesticated animals or suffering getting economic losses. Here is when poaching by retaliation is also more acceptable by society rules. For that reason, I wanted to evaluate if the mammalian species that are more often used as food sources or considered problematic because of damage to crops or animals have a less relative abundance index in the different places of the study area. To do this I administered 91 semi structured questionnaires to indigenous and non-indigenous people during February-September 2019 to learn which species people cite more. At the same time, a design to sample the mammal species in the area was deployed with 27 camera trap stations between two areas with different wildlife protection rules: an indigenous territory and adjacent unprotected areas. From the questionnaires, a total of 23 mammalian species were cited by the population as a food source (4), as negative (10), or as both a food source and negative (9). The paca and collared peccary were cited most often as food sources, whereas the negative or problematic species were the jaguar and coyote. From the camera station design, 76 species were detected, including 28 mammalian species, and the relative abundance index varied for some species between the categories of management. It seems like the abundances of food source species in the indigenous territory are few influenced by demand

and removal. The abundances of food source species that are more sensitive to forest quality and to human presence was lower in the other areas. Finally, this first approach within the Pacuare-Barbilla sector opens the options to promote a better management of domestic animals and crops in the sites with negative impacts in order to avoid bad attitudes towards wildlife on the part of the population, to protect species that still are in the area, and to restore or maintain healthy ecosystems.

Introduction

Wildlife is an important food source for local humans in tropical forests (Robinson & Redford 1991, Carrillo et al. 2000), but poaching of wild species in developing countries is an important factor that affects their conservation (Hayward 2009, Ashayeri & Newing 2012). In many cases, illegal hunting is a consequence of poverty and few employment opportunities (Kümpel et al. 2010, Ashayeri & Newing 2012, Altrichter and Carbonell 2013), thus increasing the threat of wildlife extinction (Cowlishaw et al. 2005, Grey-Ross et al. 2010).

In Costa Rica, hunting activity is illegal any place outside of indigenous territories: indigenous peoples are the only ones licensed and allowed to hunt, and only within their territories (Art 6, Law No. 6172, year 1977, Sáenz-Bolaños et al. 2020). However, poaching is common in many Costa Rican places, with both economic and noneconomic factors as motivations (Robinson and Bennett 2000, Altrichter and Carbonell 2013).

The Pacuare-Barbilla sector in the northern Talamanca Mountains of southcentral Costa Rica is a key area for large wild cats such as jaguars and pumas and is especially important for connectivity of Jaguar Conservation Units (Salom et al. 2010, Salom et al. 2021). That also means that the area is likely important for other mammal and bird species, as well.

In this region, where human activities play an important role (e.g., habitat fragmentation), different management regulations have implications for species richness and relative abundances (Sáenz -Bolaños et al. 2020), but there is a lack of information about the effects of hunting. It is

common to hear people talking about the how good some wild game species taste, and this is most likely the result of hunting. With regard to jaguar conservation, those same food species are likely important jaguar prey (e.g., Ghoddousi et al. 2010), and a reduction in prey will affect jaguars. Also, predation on domestic livestock (including pigs) might also cause increased retaliatory hunting of the predators responsible for the losses. The Pacuare-Barbilla area has important interactions among wildlife and the human settlements and lifestyle, and for that reason is important to have a better knowledge of the situation here.

Linking sociological and biological data is key in conservation efforts (Jacobson & McDuff 1998). As Ashayeri and Newing (2012) noted, conducting hunting research is difficult, and is even more difficult when it is poaching-related, because people are not willing to participate, or responses are not honest for fear of recrimination. In the Pacuare-Barbilla sector, it can be complicated to get people to participate in research because of the closeness of a national park (with park rangers), but may be less difficult because I have worked in the area for several years and I know many people from ecological work.

A number of studies have reported that places with more hunting activities have different species abundances and occurrences than non-hunted areas (e.g., Lopes & Ferrari 2000, Carrillo et al. 2000). Moreover, a negative relationship between big cat attacks on domestic animals and nearby prey richness and abundance was found by Burgas et al. (2014) in northern Costa Rica. Through careful interviews, I wanted to identify species that are hunted and used as food sources by the local inhabitants of these areas, and species that are considered pests, and then compare the abundances of those species in indigenous lands with a variety of adjacent lands with differing protected status and thus animal interactions. I expected some species abundances and occurrences to be least in unprotected lands, the forest reserve, and indigenous territory, and highest in the national park.

Methods

Study Area

This study was conducted in the Pacuare-Barbilla Sector, in the northern part of the Talamanca Mountains, in the Costa Rican provinces of Limón and Cartago (Sáenz-Bolaños et al. 2020) (Fig. 4.1). The landscape contains a mixture of forest plantations, primary forest, secondary forest, grasslands, and human settlements. Precipitation and temperature remain similar in the area throughout the year, with slightly higher rainfall and temperature in the northern part of the covered area (Ortíz-Malavasi 2014).

Data collection

From January through December 2019, camera traps (Bushnell Trophy Cam® and X-Lounger Cam®) were deployed in the field, covering more than 400 km^2, and under four different types of land management. The area was divided into a honeycomb of hexagons, each covering 15 km^2, in which I placed a camera trap station composed of single camera. A total of 27 camera stations were deployed (National Park = 6, Forest Reserve = 8, Indigenous Territory = 4, and Not Protected Areas = 9). One camera location in Fig. 4.1 is actually on reclaimed indigenous territory land but it is not yet updated in the Atlas Digital.

Cameras were operational 24 hours a day. Every activated event took a sequence of 2 photos with a one-minute interval between events. Cameras were checked on average every four months to collect data and change batteries.

In addition, a questionnaire survey was conducted from January to September 2019 in the area covered by the honeycomb (see Chapters 2 and 3; NP = 2 respondents, FR = 27, IT = 23, and Not Protected Areas = 39). Only persons older than 18 years old were targeted. I asked participants to cite species that have some benefit to humans. The respondents cited the species and then described what they consider beneficial and those species they consider not good for humans and why.

Data Analyses

Based on data from the social instrument and camera traps, I wanted to see if the relative abundances of species considered an important food source or pest species was different in places where people reported more or less positive or negative values of wildlife, and then assess the magnitude of variation and try to explain it. For camera data, the identification of independent records of species was established using three rules: (1) photos taken at least 30 min apart (e.g., two consecutive photos of the same species = 1 photo event); (2) if consecutive photos of the same species could be identified as different individuals (spots, sex, scars, etc.) (e.g., <15 min apart, 2 photos of species A, but one individual had a broken tail = two photo events); or (3) photos of the same species separated by photos of a different species in a window < 30 min. (e.g., species B, followed 8 min later by a species C, followed 15 min later by species B = species B had two events and species C had one event)(Sáenz-Bolaños *et al.* 2020).

To estimate the relative abundance of species, I used the formula to calculate the relative abundance index (RAI), where all detections for each species are summed up for all camera traps over all days, multiplied by 100, and divided by the total number of trap nights (Jenks *et al.* 2011):

$$RAI = \frac{\#total\ events\ per\ species}{\#\ total\ trap\ night} * 100$$

I calculated an average RAI by species and then did three categories of low, medium and high RAI based on previous findings (Sáenz-Bolaños *et al.* 2020). So, the relative abundance index for 2019 was classified in each category, identify by color (red= low RAI, yellow= medium RAI and green=high RAI). Moreover, using the R package "vtree 5.1.9" a factorial analysis was applied to species cited more than 10 times by interviewees, to see if the number of references by indigenous and non-indigenous people corresponded to the relative abundances index category.

The responses concerning the beneficial and negative aspects of species were classified into categories according to their answers (Ashayeri & Newin 2012, Ghoddousi et al. 2019); I classified

the benefits of each species into eight categories: 1 = food source, 2 = ecological role, 3 = tourism importance, 4 = notify or warn about something, 5 = economic value, 6 = conservation, 7 =spiritual, and 8 = other. Consequently, I picked all the answers that were in the category of food sources. I grouped species considered negatively by the people into four groups: 1 = Predation on their animals [pets, livestock, pigs, poultry], 2 = crop eaters, 3 = hazard to humans and 4 = others.

Results

A total of 5,628 trap nights (NP = 1,516, IT = 412, FR = 1,660, and Not Protected = 2,040) provided 25,768 photo files representing 8,986 independent events. In total, 76 wild species and 5 domestic species were recorded in this survey (Appendix 8).

Cameras at five stations were stolen (two in indigenous territory, and one for each of the remaining categories) and one in indigenous territory was vandalized. The station in the forest reserve was only one relocated because it happened at the beginning deployment stage. Of the other four stations, I obtained data from three; one station in the indigenous territory I had to delete from the study because I did not get any files because the camera was stolen before our only check.

A total of 91 questionnaires were answered (NP = 2, FR = 27, IT = 23, and Not Protected = 39) generating 226 references between beneficial and problematic species; 39% referenced 13 species as food source and 61% to 19 species of cause some negative impact to them (107 citations for predation on their animals and 31 for crops eaters). There was not statistical difference in species number by category of protection and classification of beneficial, problematic by the interviewees (Chi-square=8.73, df=6, p-value=0.19). Of 13 species cited as a food source, only jaguar was also cited as preying on their animals, and seven were identified as crop eaters (Table 4.1 and Table 4.2). The two main species cited as food sources were paca (N = 26) and collared peccary (N = 20). For problematic species, five species were identified more than 10 times, including jaguars (N = 41), coyotes (N = 19), opossums (N = 15), coatis (N = 13), and tayras (N = 12) (Table 4.1).

Jaguar and the coyote were the most cited problematic species in the three categories with more interviews whereas the paca and collared peccary were the most cited food source species, as well as problematic by indigenous people in the national park and in the indigenous territory because they cause crop losses.

The relative abundance index for the most cited species by category of protection (more than 10 times cited) (Table 4.3, Fig 4.2 a, b) indicates variation by area. For the indigenous group, most responses (73%) were focused on eight species, of which 43% were identified as beneficial and 57% as problematic species. Of all (7) of the species indigenous respondents cited as food source, four had high RAI values inside of their territory, whereas for the other three, one had medium value (red brocket) and two with low. On the other hand, the species that were cited as problematic varied between the category of protection, being the jaguar the most cited species as problematic it presents low RAIs at the indigenous territory and forest reserve (Appendix 9). Interestingly, species that are valuable for protein but also identified as crops eaters still had high RAIs in the indigenous lands and national park (Table 4.3, Fig 4.2a) (Appendix 10).

The answers of non-indigenous people focused on the same eight species but with 28% identified as beneficial 28% and 47% as problematic species. The species identified as food sources had more varied abundances outside of the indigenous territory; for example, only coati had high RAI whereas agouti, paca, and collared peccary occurrence was medium or low depending on the area (Fig 4.2b). It seems that species considered to cause negative impacts and that have high RAIs are those with flexible habitat needs and can live in more human-altered areas (e.g., coati, coyote, opossum). On the other hand, the jaguar was photo-captured only in the national park with a medium RAI (Table 4.3, Fig 4.2b).

Discussion

As Martin (1983) said, in rural areas the wild meat is the most accessible animal protein, and this is still the situation for some places of Pacuare-Barbilla sector. Because indigenous people are

allowed to hunt in their territory, I could look at how the harvest or removal by retaliation of wild mammal species in the Pacuare-Barbilla sector might be influencing mammal abundances.

Moreover, places are also influenced by non-hunting human activities, such as logging which is also a threat to tropical forest species richness and abundance (Wilcove et al. 2013, Brodie et al. 2014). Additionally, illegal activities are present in the area (e.g., the stolen camera), and this is something to pay attention to and a cause to begin work with new generations about the value that wildlife has in the wild and in areas where it is possible to keep wildlife harvesting as a traditional management technique. Cultures hunting wisely can still maintain or improve species numbers and, as a consequence, still harvest animal protein for people in this rural area, especially for indigenous people who live deeper in the forest. As one indigenous man told me *"I have to feed my family so I go hunt and when I need sugar, coffee or something and I cannot go out to buy it, sometimes I hunt and exchange meat for what I need with some neighbor."* For example, the paca and collared peccary cited in this study as food sources are well known for local people in the area, and also are species used in most of their distribution range as food sources by local communities (Gongora et al. 2011, Emmons 2016). For that reason, is not surprising that the paca was the most cited species here. Studies in Peru, Colombia, Mexico, and Brazil, report that the paca also plays an important role in people's diet (Aquino et al. 2009, Asprilla-Perea et al. 2011, Gallina et al. 2012, Valsecchi et al. 2014), and in Costa Rica a study by Altrichter and Carbonel (2009) also shows paca was the favorite species for Bribris and Cabécares communities as meat source in Talamanca.

Still, the paca is a species that does best with good forest cover and low human presence, just as I found here where the paca RAI was higher in the national park and indigenous territory where the forest cover and forest conditions have more the requirements the species' needs. Populations of the collared peccary, the second species more cited as food sources, generally have had decreased from poaching and habitat loss (Tapia 1996, Carrillo et al. 2002,) even as a species that is highly adaptable and that can be found in a variety of habitats (Bodmer and Sowls 1993, Carrillo et al. 2002). In this study, the RAIs also were higher in more forest cover with lower RAIs values in the forest reserve

and non-protected lands, showing it adaptability. And even though indigenous people most often cited these two species as protein sources, the RAI values are still high in their territory, probably because the hunting rate and the forest are maintained at levels that can support the species (Robison and Redford 1991).

On the other hand, the two most cited problematic species that cause negative impacts as attacks to livestock or poultry were the jaguar and coyote. Interestingly, jaguars were the most cited problem species and were only detected in the national park (with a medium RAI value). As previous studies in the area have shown, the jaguar abundances in the areas outside the national park are very low (Panthera 2017, Sáenz-Bolaños et al. 2020).

As with the paca and collared peccary, the jaguar occurrence is linked to forest cover as well, but also to prey availability (Salom et al. 2021), and the national park is the place with more large prey species occur and also has less retaliatory hunting pressure than outside of it. Even though the park had a high relative abundance index of illegal people (poaching and fishing), Barbilla National Park still has medium jaguar RAI, likely because the people that poach there are probably looking for food species and not jaguars.

An opposite situation is the coyote; this species has been expanding their distribution in the country and colonizing some lands (Cove et al. 2012, Hody & Kays 2018). In the area in previous years, the coyote had photo captures in two places (Sáenz-Bolaños 2010, Saenz-Bolaños et al. 2020) with very low RAI. During this study, more photo captures were recorded and also people indicated that coyotes are now more common in the area than only a few years ago. Still, in the national park and indigenous territory, where coyotes were reported in previous years, they did not get photographed, whereas the forest reserve and not protected lands the coyote RAI was relatively high compares with the previous years in this region. It is well known that coyotes occur in places where big predators like jaguars or pumas have disappeared (Oliveira *et al.* 2010) and these two areas with higher coyote RAI are absent of top predators. Thus, it seems a mix of factors, like human activities and lack of tops predators, are benefiting the coyote population in the area.

Conclusions

As I expected, species that require more forest quality got higher relative abundance rates in the national park, followed by indigenous territory, as was the case for paca, red brocket, jaguar. The collared peccary also had higher rates in more preserved lands. Even that in national park with high poaching RAI and at indigenous territory where both species were cited as important protein source, these species still have high RAIs always taking based on data since 2009. Whereas forest reserve and not protected areas have the mixture of human activities that cause less forest cover plus possible poaching pressure have cause the reduction these and other species abundances.

As not statistical differences in species cited by category of protection it is important to work with people in education about important role of species in the ecosystem and show them the local results obtained from years of study in the area but also their opinion about the wildlife mammal species. For example, from indigenous peoples results of beneficial and problematic species the majority species that presented high RAI are in both categories of classification inside of the indigenous territory. So if they indigenous people are beneficiated in keep high populations of these species to get protein, the most important is to keep the forest conditions and to work in implement better conditions to domestic animals (livestock and poultry) to prevent or reduce the negative interaction with the wildlife and the negative perception or attitudes against the species cited could change, for that reason will be interesting to see how receptive are the population to keep the high populations and do improvements in their properties for the different animals they raise or areas dedicated to crops.

The non-indigenous are also beneficiated of animal protein even if they are not allowed to hunt, but there is not real to think they do not hunt after years in the area and this study. So, it is also important they also do improvements in the corrals or enclosures of chickens and cows specially. This because the coyote a species that get benefits of open, modified areas or not top predators' presence is also beneficiated in the Pacuare-Barbilla sector, where the coyote got high RAIs at places at forest

reserve and not protected areas, where I did not get photo captures of big predators as jaguar or puma. Moreover, there are more presence poultry, and open areas by logging and then to cattle farming.

Even if people cited it as a problematic species the coyote has not retaliation pressure in the area to reduce the RAIs, so it will be necessary to keep monitoring the situation, because coyote is getting more common in people mind. If the affectations to poultry, other animals or even crops, it could generate more interactions and negative attitudes and possible retaliation. As a local after finished my field work told me, people were poisoning coyotes because there were a lot and had causing damage.

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Table 4.1. List of total species and total times cited as food source and problematic by inhabitants of Pacuare-Barbilla Sector, divided by category of places where people live. The letters represent how people classified them, B= beneficial, P= problematic

Species	National Park		Forest Reserve		Indigenous Territory		Not Protected		Total
	B	P	B	P	B	P	B	P	B/P
Jaguar	0	1	1	12	0	14	0	14	42
Paca	0	1*	10	0	8	0	8	0	27
Collared peccary	0	1*	8	0	6	2*	6	0	23
Coati	0	0	4	3*	2	2*	3	8*	22
Coyote	0	1	0	2	0	3	0	13	19
Common opossum	0	0	0	5	0	4	0	6	15
Tayra	0	0	0	2	0	2	0	8	12
Agouti	0	0	3	0	5	1*	1	0	10
Puma	0	1	0	2	0	1	0	5	9
Ocelot/tigrillo	0	0	0	2	0	4	0	2	8
Red brocket	0	0	1	0	4	2*	1	0	8
Armadillo	0	0	4	0	1	0	1	1*	7
Raccoon	0	0	0	2*	0	0	1	1*	4
White-lipped Peccary	0	0	0	0	1	0	2	1*	4
Rat/mice	0	0	0	1*	0	2*	0	0	3
Squirrel	0	0	0	0	0	2*	0	0	2
Sloth	0	0	1	0	0	0	1	0	2
Jaguarundi	0	0	0	0	0	1	0	1	2
White-tailed Deer	0	0	1	0	0	0	1	0	2

Tapir	0	0	1	0	0	0	1	0	2
Gray Four-eyed Opossum	0	0	0	0	0	0	0	1*	1
Porcupine	0	0	0	0	0	0	0	1	1
Rabbit	0	0	0	0	0	0	1	0	1

* species cited to cause damage or losses in the crops

Tale 4.2. Summary number species cited as beneficial (food source), problematic (attack on their domestic animals, or by be crop eaters), or both.

Problematic	Type	No. of species cited			
		National Park	Forest Reserve	Indigenous Territory	Not Protected
No	Food	0	8	3	8
Yes	Attack animals	0	5	7	8
	Crops eaters	0	2	2	1
	Food and problem	0	2*	4	4

* Indicate there one species in this row is catalogue as food source and attack their animals the others are considered only food eaters.

Table 4.3. Relative abundance index for eight species commonly identified as of concern to interview respondents in four different kinds of conservation areas in the Pacuare-Barbilla sector, Costa Rica 2019. Green=high RAI, yellow=medium RAI and red=low RAI.

Species common name	National Park	Indigenous Territory	Forest Reserve	Non Protected
Jaguar	0,86	0	0	0
Paca	7,92	3,4	1,51	0,93
Collared peccary	1,72	1,21	0,48	0,69
White-nosed coati	3,36	3,4	5,18	3,68
Coyote	0	0	0,6	0,15
Common opossum	6,13	2,67	6,81	7,16
Tayra	1,12	2,67	1,39	4,46
Agouti	42,68	30,83	14,22	8,04

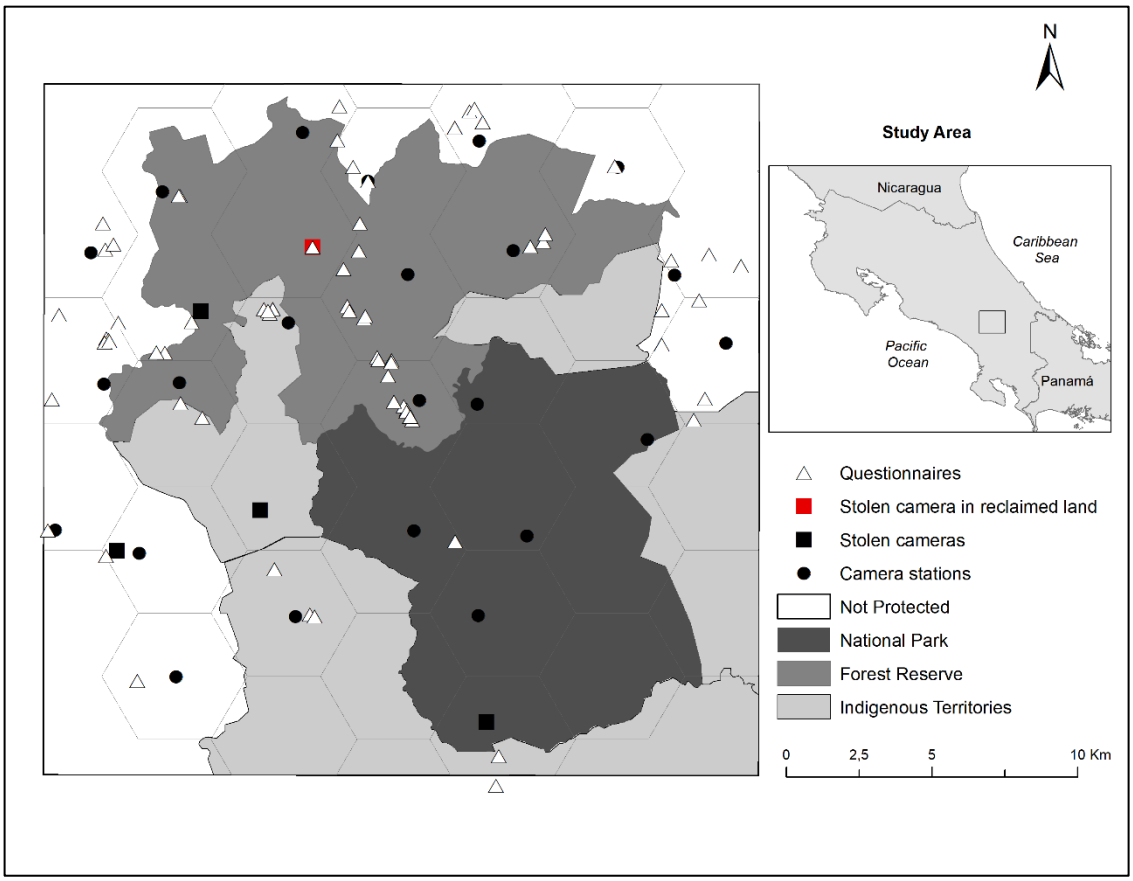

Figure 4.1. Camera stations arrangement and instruments applied within Barbilla Sector in the northern Talamanca Mountains of Costa Rica

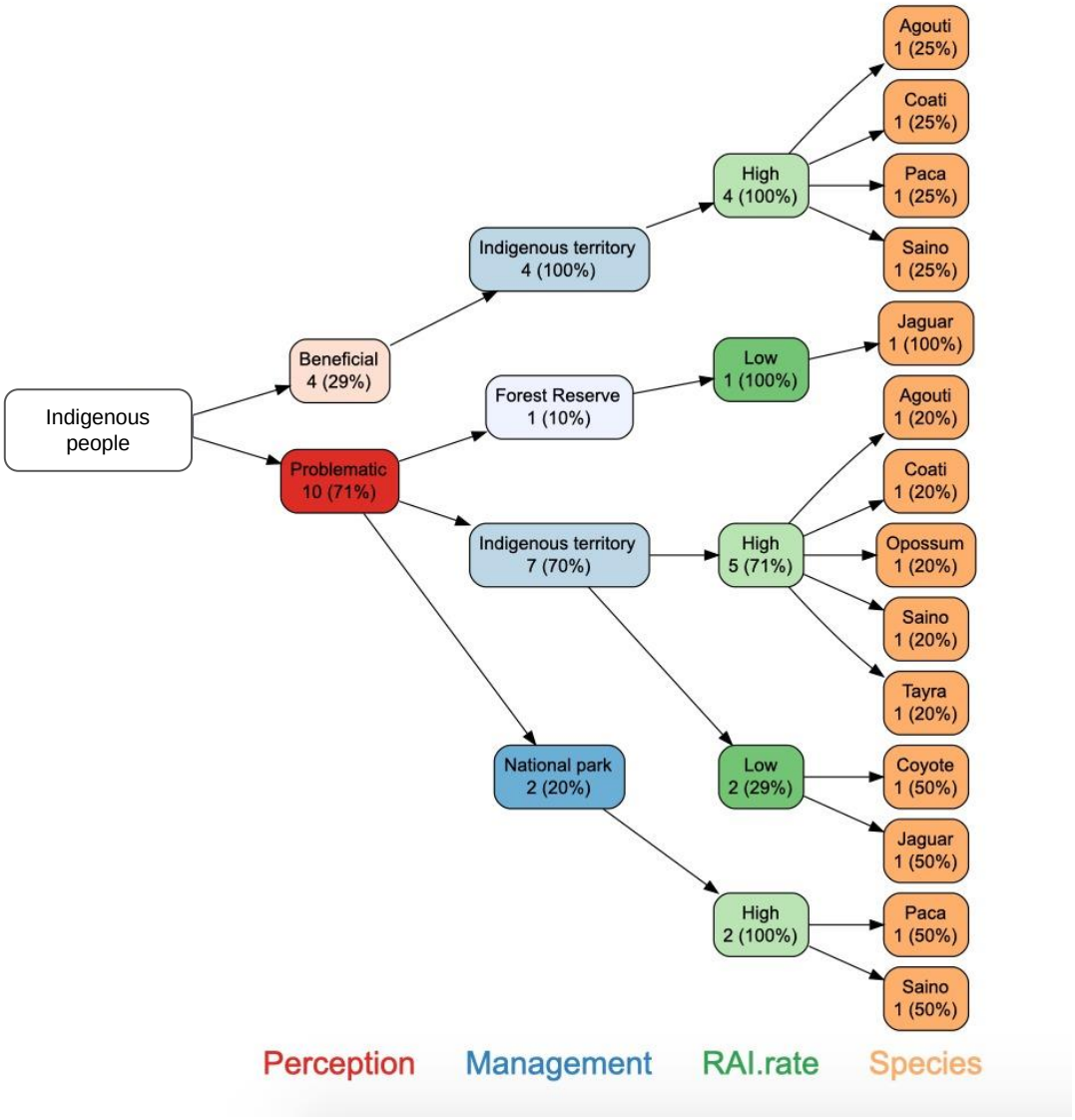

Figure 4.2a. Diagram of answers segregated by beneficial and problematic species considered by indigenous people and by protected area management type of the interviewed, with the relative abundance index to more cited species during 2019, Pacuare-Barbilla sector, Costa Rica.

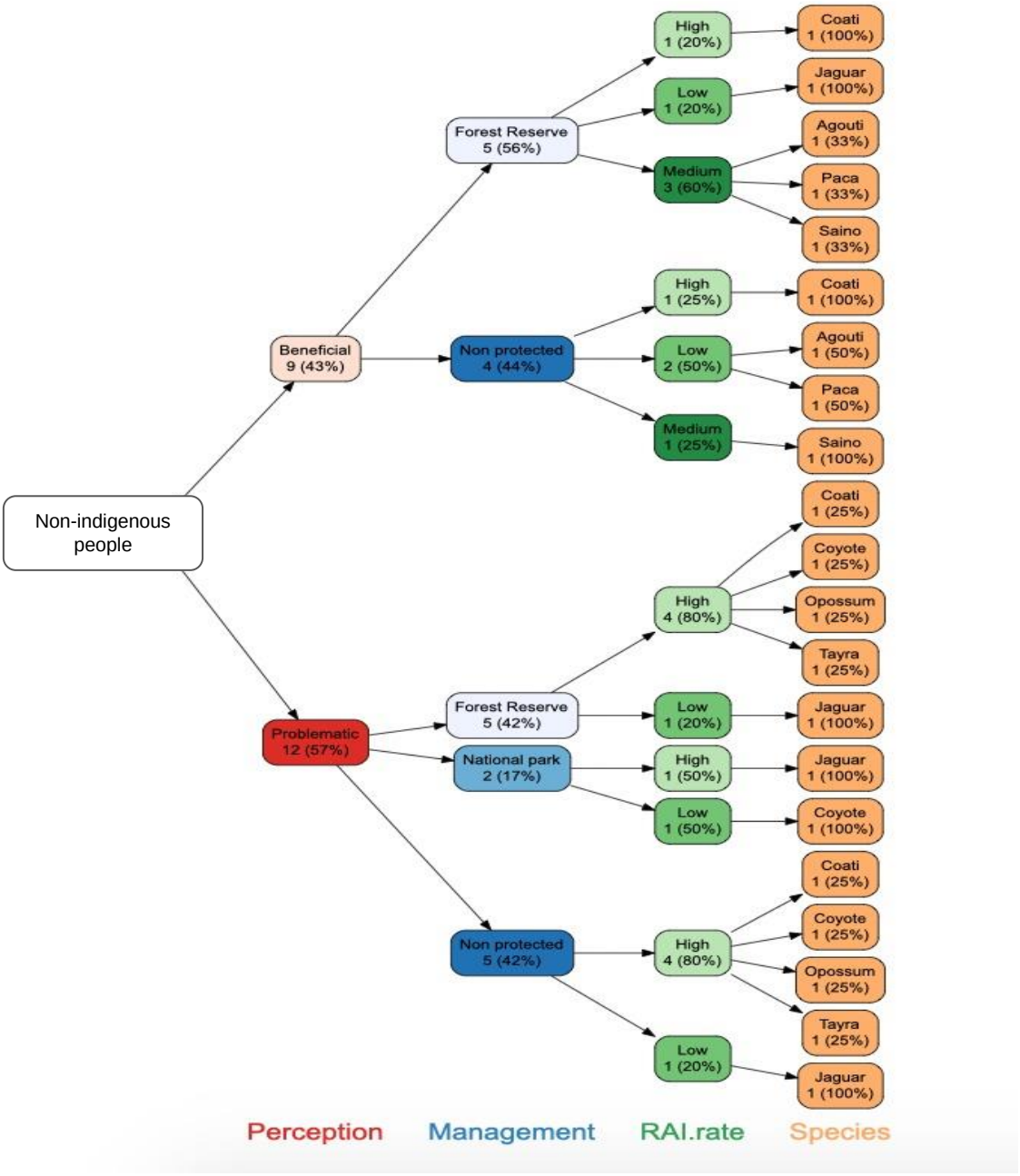

Figure 4.2b. Diagram of answers segregated by beneficial and problematic species considered by non-indigenous people and by protected area management type of the interviewed, with the relative abundance index to more cited species during 2019, Pacuare-Barbilla sector, Costa Rica.

CHAPTER 5

SUSTAINABLE CONSERVATION OF WILDLIFE AND PEOPLE IN THE NORTHERN TALAMANCA MOUNTAINS OF COSTA RICA: A SUMMARY

This study focused on investigating wildlife and human use of landscapes in the Pacuare-Barbilla sector, including three contiguous protected areas, as well as surrounding unprotected areas. Protected areas have the goal to achieve the long-term conservation of nature, but not all such areas are equal in their effectiveness because their sustainability, particularly for wildlife, is strongly linked to the human activities that affect them. I found that in the Pacuare-Barbilla sector in Costa Rica human activities have influenced wildlife diversity, but not all the protected areas work in the same way with respect to wildlife species.

The human activities generate interactions with wildlife and people involved in these interactions develop their own perceptions related to their life experiences in those places but also their beliefs and values take an important role in this construction (Dingwall 2002, Peterson et al. 2010). Thus, it is important to understand people's perceptions about the wildlife and why they perceive the interactions as positive or negative, this better understanding of different contexts and social norms and how them influence in people social constructions (Peterson et al. 2008, Peterson et al. 2010), are vital to keep human livelihood and conservation, implementing better social and environmental approaches in the future. In this case the indigenous people perceived in more percentage than non-indigenous people the jaguar or puma presence in their properties is less positive and the main reason is for the high consequences they consider by lose one of their animals.

For Nairi Awari Territory inhabitants the species that cause negative impacts are classify in three main groups attack their animals, feed from their crops, or they consider a hazard to humans. The future activities to work on reduce the human-wildlife negative interactions is long process but is

the better way to make conservation successful, is trying to change how inhabitants raise their livestock or poultry and consequently to change their behaviors to the wildlife (Peterson *et al.* 2008). There is an important advance because they know what is necessary to do but there is not a management of their animals to provide them better conditions in long term to keep crops closer to their houses and animals safe from wildlife.

Finally, the relative abundance index for mammal species used as food sources and also catalogue as problematic are still high for most of them in the indigenous territory and national park but not outside of these two. The next step to work in the area and with the inhabitants of Pacuare-Barbilla sector is to make improvements in the way they manage they domestic animals, for example, corrals or enclosures to keep animals safe at nights, or reduce number of animals and keep then in enclosures. Thus time later to re-evaluate the human perceptions and attitudes.

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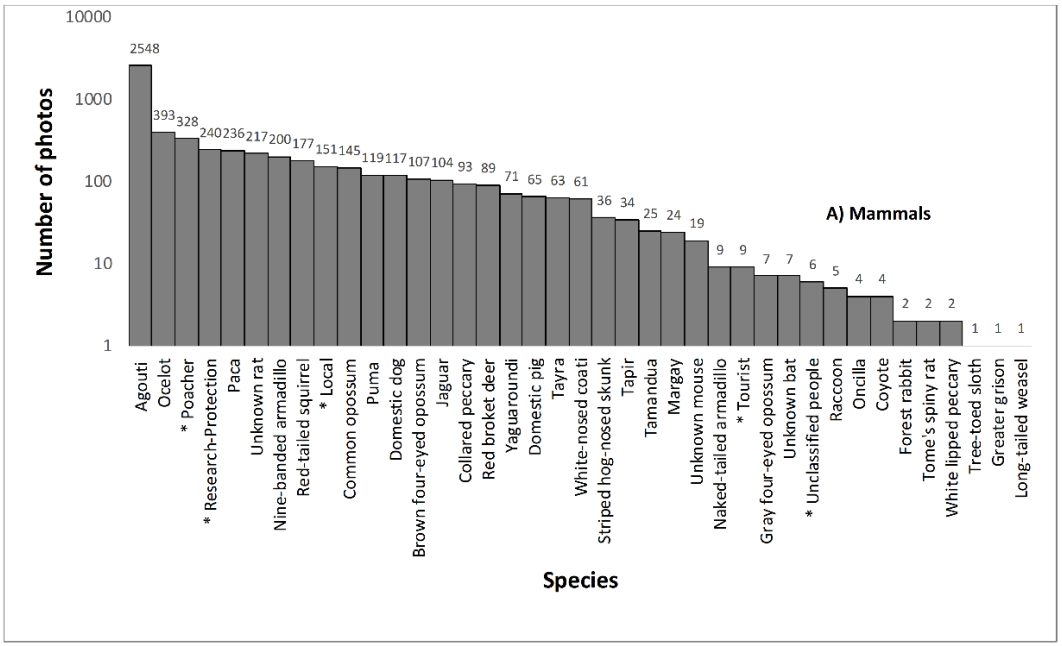
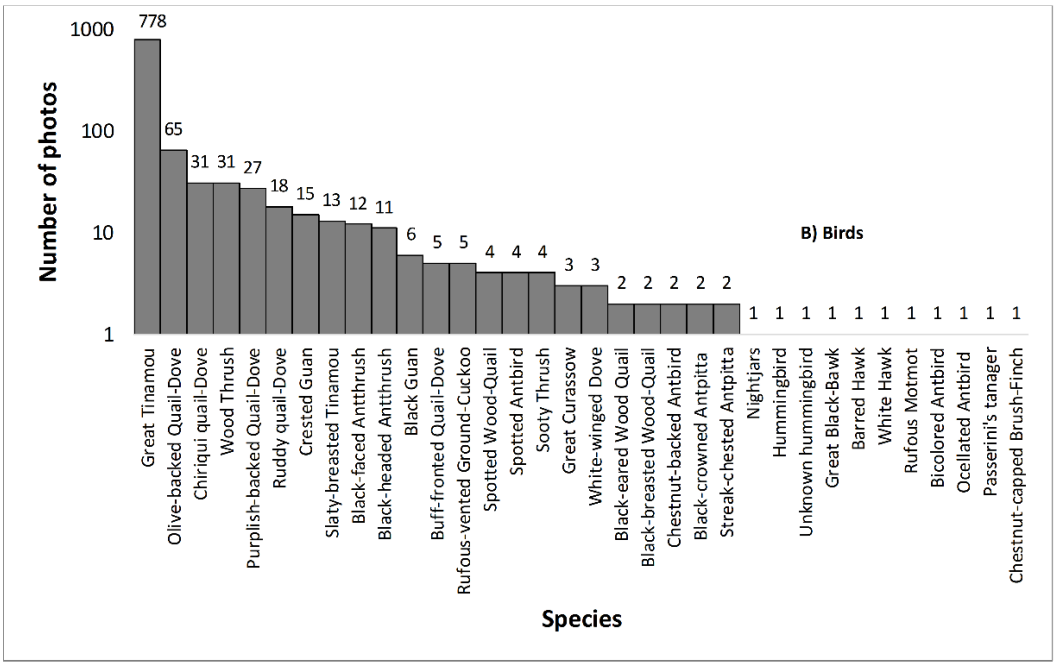
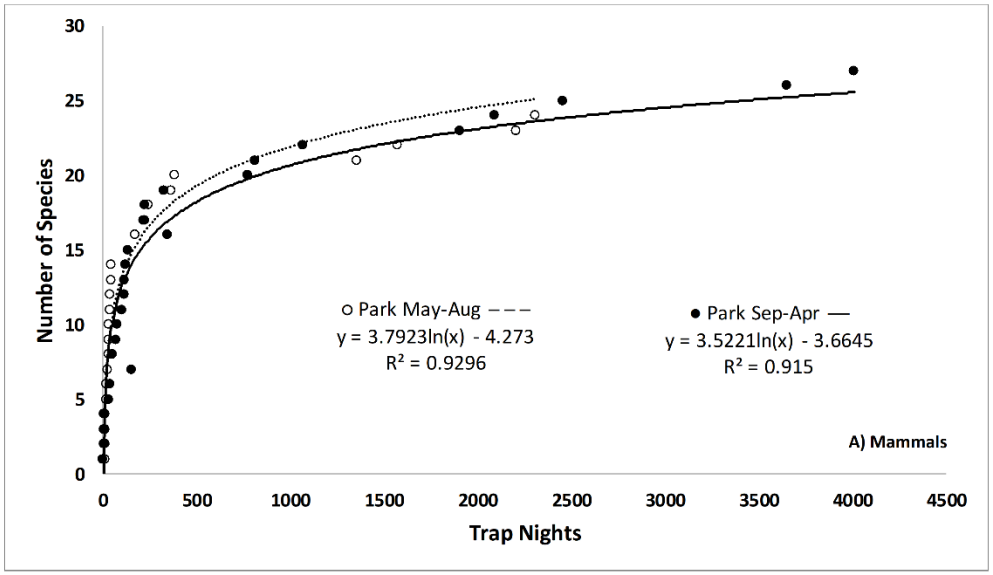
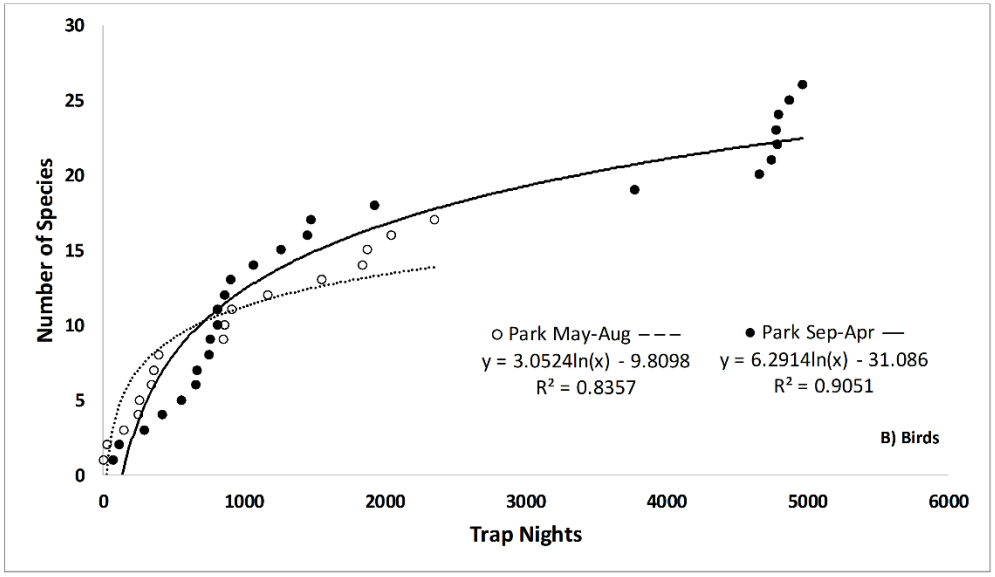
APPENDICES


A) Mammals
Number of photos
Species
10000
1000
100
10
1
2548
393 328 240 236 217 200 177 151 145 119 117 107 104 93 89 71 65 63 61 36 34 25 24 19 9 9 7 7 6 5 4 4 2 2 2 1 1 1
Agouti
Ocelot
* Poacher
* Research-Protection
Paca
Unknown rat
Nine-banded armadillo
Red-tailed squirrel
* Local
Common opossum
Puma
Domestic dog
Brown four-eyed opossum
Jaguar
Collared peccary
Red broket deer
Yaguaroundi
Domestic pig
Tayra
White-nosed coati
Striped hog-nosed skunk
Tapir
Tamandua
Margay
Unknown mouse
Naked-tailed armadillo
* Tourist
Gray four-eyed opossum
Unknown bat
* Unclassified people
Raccoon
Oncilla
Coyote
Forest rabbit
Tome's spiny rat
White lipped peccary
Tree-toed sloth
Greater grison
Long-tailed weasel


B) Birds
Number of photos
Species
1000
100
10
1
778
65
31 31 27 18 15 13 12 11 6 5 5 4 4 4 3 3 2 2 2 2 2 1 1 1 1 1 1 1 1 1 1 1 1
Great Tinamou
Olive-backed Quail-Dove
Chiriqui quail-Dove
Wood Thrush
Purplish-backed Quail-Dove
Ruddy quail-Dove
Crested Guan
Slaty-breasted Tinamou
Black-faced Antthrush
Black-headed Antthrush
Black Guan
Buff-fronted Quail-Dove
Rufous-vented Ground-Cuckoo
Spotted Wood-Quail
Spotted Antbird
Sooty Thrush
Great Curassow
White-winged Dove
Black-eared Wood Quail
Black-breasted Wood-Quail
Chestnut-backed Antbird
Black-crowned Antpitta
Streak-chested Antpitta
Nightjars
Hummingbird
Unknown hummingbird
Great Black-Bawk
Barred Hawk
White Hawk
Rufous Motmot
Bicolored Antbird
Ocellated Antbird
Passerini's tanager
Chestnut-capped Brush-Finch

Appendix 1. Total number of independent photos obtained of A) mammal (including humans; *see footnotes for Appendix 1) and B) bird species in a National Park, Indigenous Territories, and Forest Reserve adjacent to each other in the northern Talamanca Mountains of Costa Rica.





Appendix 2. Trend lines and correlations for the number of camera trap nights (effort) versus total cumulative number of A) mammal and B) bird species photographed (diversity) in the National Park during September-April (solid line, solid circle), and May-August (dash line, open circle) in the northern Talamanca Mountains of Costa Rica.

Appendix 3. Photo rates (no. of independent photos/100 trap nights) of mammal species, including humans, detected by camera-trapping efforts during 2009-2016 in three adjacent protected areas in the northern Talamanca Mountains of Costa Rica. Significant differences (P<0.001) between seasons for the National Park are indicated in italics; differences among the three protected areas during September-April are identified in bold.

		May-Aug	**Sep-Apr**		
Common English name	**Scientific name**	**National Park (19/2,630)[a]**	**National Park (21/5,820)**	**Forest Reserve (17/796)**	**Indigenous Territories (17/874)**
Common Opossum	*Didelphis marsupialis*	1.06	1.43	2.76	1.37
Gray Four-eyed Opossum	*Philander opossum*	0	**0**	**0**	**0.80**
Brown Four-eyed Opossum	*Metachirus nudicaudatus*	1.14	1.27	0	0.34
Nine-banded Armadillo	*Dasypus novencinctus*	*2.28*	***1.27***	**4.90**	**3.09**
Naked-tailed Armadillo	*Cabassous centralis*	0.08	0.07	0.13	0.23
Tamandua	*Tamandua mexicana*	0.08	**0.15**	**1.13**	**0.57**
Three-toed Sloth	*Bradypus variegatus*	0.04	0	0	0
Unknown bat		0	0.03	0.25	0.34
Forest Rabbit	*Sylvilagus brasiliensis*	0	0.02	0	0.11
Red-tailed Squirrel	*Sciurus granatensis*	1.41	**1.75**	**0.63**	**3.78**
Agouti	*Dasyprocta punctata*	37.98	21.94	13.19	19.11
Paca	*Agouti paca*	*1.44*	***3.21***	**0.25**	**1.03**
Tome's Rpiny Rat	*Proechimys semispinosus*	0	0.03	0	0
Unknown rat		1.48	**1.53**	**4.65**	**5.95**
Unknown mouse		0.15	0.17	0.13	0.46
Ocelot	*Leopardus pardalis*	3.95	**4.35**	**2.01**	**2.29**
Oncilla	*Leopardus tigrinus*	0	0.07	0	0
Margay	*Leopardus wiedii*	0.04	0.36	0	0.23
Puma	*Puma concolor*	1.14	**1.53**	**0**	**0**
Yaguaroundi	*Hepailurus yaguoarundi*	0.91	0.74	0.13	0.34

Jaguar	*Panthera onca*	1.06	**1.29**	**0**	**0.11**
Coyote	*Canis latrans*	0.15	0	0	0
Domestic dog	*Canis lupus familiaris*	1.48	**0.84**	**1.01**	**2.40**
Striped Hog-nosed skunk	*Conepatus semistriatus*	0.57	0.36	0	0
Tayra	*Eira barbara*	0.42	0.77	0.38	0.46
Greater Grison	*Galictis vittata*	0	0	0	0.11
Long-tailed Weasel	*Mustela frenata*	0	0.02	0	0
White-nosed Coati	*Nasua narica*	0.57	**0.43**	**2.26**	**0.34**
Northern Raccoon	*Procyon lotor*	0	**0.03**	**0.38**	**0**
Collared Peccary	*Pecari tajacu*	1.14	1.00	0.13	0.46
White-lipped Peccary	*Tayassu pecari*	0.08	0	0	0
Domestic pig	*Sus scrofa*	0.34	**0.15**	**0.13**	**5.26**
Red Brocket Deer	*Mazama temama*	0.84	1.07	0.25	0.34
Tapir	*Tapirus bairdii*	0.49	0.36	0	0
Human	Research-Protection [b]	3.35	2.94	3.64	3.78
	Local [c]	1.98	**1.61**	**0.50**	**5.61**
	Poacher [d]	2.51	**2.41**	**0**	**0**
	Tourist [e]	0	0.10	0.13	0
	Unclassified people [f]	0.38	0.09	0.13	0

[a] Total number of camera stations/total number of trap-nights in each area. [b] Persons in ranger uniform or known researchers in the area. [c] Persons not carrying hunting/fishing equipment, or wild animal. [d] Persons with hunting/fishing equipment (e.g., rifle, blowgun, harpoon), or carrying killed wild animals. [e] Hikers or persons with photo equipment. [f] Persons that could not be classified as one of the above.

Appendix 4. Photo rates (no. of independent photos/100 trap nights) of bird species detected by camera-trapping efforts during 2009-2016 in three adjacent protected areas in the northern Talamanca Mountains of Costa Rica. Significant differences (P<0.001) between seasons for the National Park are indicated in italics; differences among the three protected areas during September-April are identified in bold.

		May-Aug	**Sep-Apr**		
Common English name	**Scientific name**	**National Park (19/2,630)[a]**	**National Park (21/5,820)**	**Forest Reserve (17/796)**	**Indigenous Territories (17/874)**
Great Tinamou	*Tinamus major*	*7.15*	***9.54***	**1.38**	**2.75**
Slaty-breasted Tinamou	*Crypturellus boucardi*	0.15	0.15	0	0
Crested Guan	*Penelope purpurascens*	0.27	0.14	0	0
Black Guan	*Chamaepetes unicolor*	0	0.10	0	0
Great Curassow	*Crax rubra*	0.08	0.02	0	0
Black-eared Wood-Quail	*Odontophorus melanotis*	0	**0**	**0**	**0.23**
Black-breasted Wood-Quail	*Odontophorus leucolaemus*	0	0.03	0	0
Spotted Wood-Quail	*Odontophorus guttatus*	0.04	0.05	0	0
White-winged Dove	*Zenaida asiatica*	0.04	0.03	0	0
Ruddy Quail-Dove	*Geotrygon montana*	0.27	0.15	0	0.23
Chiriquí Quail-Dove	*Zentrygon chiriquensis*	0.23	0.43	0	0
Olive-backed Quail-Dove	*Leptotrygon veraguensis*	0.61	**0.57**	**0.13**	**1.72**
Purplish-backed Quail-Dove	*Zentrygon lawrencii*	0.30	0.32	0	0
Buff-fronted Quail-Dove	*Zentrygon costaricensis*	0	0.09	0	0
Rufous-vented ground-cuckoo	*Neomorphus geoffroyi*	0.08	0.03	0.13	0
Nightjar		0	0	0	0.11
Hummingbird	*Phaetornis* sp.	0	0.02	0	0
Unknown hummingbird		0.04	0	0	0
Great Black-hawk	*Buteogallus urubitinga*	0	0.02	0	0
Barred Hawk	*Morphnarchus princeps*	0.04	0	0	0

White Hawk	*Pseudastur albicollis*	0.04	0	0	0
Rufous Motmot	*Baryphthengus martii*	0	0.02	0	0
Chestnut-backed Antbird	*Poliocrania exsul*	0	**0**	**0.25**	**0**
Spotted Antbird	*Hylophylax naevioides*	0	**0.02**	**0**	**0.34**
Bicolored Antbird	*Gymnopithys bicolor*	0	0.02	0	0
Ocellated Antbird	*Phaenostictus mcleannani*	0	0.02	0	0
Black-crowned Antpitta	*Pittasoma michleri*	0	0.03	0	0
Streak-chested Antpitta	*Hylopezus perspicillatus*	0	**0**	**0**	**0.23**
Black-faced Antthrush	*Formicarius analis*	0.23	0.10	0	0
Black-headed Antthrush	*Formicarius nigricapillus*	0	0.19	0	0
*Wood Thrush	*Hylocichla mustelina*	0	**0.07**	**0.13**	**2.97**
Sooty Thrush	*Turdus nigrescens*	0.08	0.03	0	0
Passerini's tanager	*Ramphocelus passerinii*	0.04	0	0	0
Chestnut-capped Brush-Finch	A*rremon brunneinucha*	0	0.02	0	0

[a] *Total number of camera stations/total number of trap-nights in each area. * only not resident breeding species*

Appendix 5. List mammal, bird, and reptile species cited by indigenous and non-indigenous persons interviewed in the Barbilla area of east central Costa Rica.

Common name	Scientific name	Indigenous	Non-indigenous
Common Opossum	*Didelphis marsupialis*	X	X
Gray Four-eyed Opossum	*Philander opossum*		X
Brown Four-eyed Opossum	*Metachirus nudicaudatus*		X
Giant anteater	*Myrmecophaga tridactyla*	X	X
Tamandua	Tamandua mexicana	X	X
Silky Anteater	*Cyclopes didactylus*		X
Sloth	*spp*	X	X
Armadillo	*Dasypus novencinctus*	X	X
Capuchin Monkey	*Cebus imitator*	X	X
Howler Monkey	*Alouatta palliata*	X	X
Squirrel	Sciurus granatensis	X	X
Porcupine	Sphiggurus mexicanus	X	X
Agouti	*Dasyprocta punctata*	X	X
Paca	*Agouti paca*	X	X
Rat	*Unknown spp.*		X
Rabbit	*Sylvilagus sp.*	X	X
Jaguar	*Panthera onca*	X	X
Ocelot/margay	*L. pardalis/ L. wiedii*	X	X
Puma	*Puma concolor*	X	X
Yaguarundi	*Hepailurus yaguoarundi*		X
Coyote	*Canis latrans*	X	X
Coati	*Nasua narica*	X	X
Kinkaju	*Potos flavus*	X	X
Raccoon	*Procyon lotor*	X	X
Skunk	Conepatus semistriatus	X	X

Tayra	*Eira barbara*	X	X
Grison	Galictis vittata		X
Otter	Lontra longicaudis	X	X
Tapir	Tapirus bairdii	X	X
Collared Peccary	*Pecari tajacu*	X	X
White-lipped Peccary	*Tayassu pecari*	X	X
Red Brocket Deer	*Mazama temama*	X	X
White-tailed Deer	*Odocoileus virginianus*	X	X
Great Tinamou	*Tinamus major*	X	X
Great Curassow	*Crax rubra*	X	X
Gray-headed Chachalaca	*Ortalis cinereiceps*		X
Black Guan	*Chamaepetes unicolor*	X	
Crested Guan	*Penelope purpuracens*	X	X
Wood-Quail	*Odontophorus sp*		X
Vulture	*spp*		X
Laughing Falcon	*Herpetotheres cachinnans*		X
Harpy eagle	*Harpia harpyja*	X	
Hawk	*spp*		X
Parrot	*spp*	X	X
Green macaw	*Ara ambiguus*	X	X
Groove-billed Ani	*Molothrus aeneus*		X
Toucan	*spp*	X	X
Aracari	*Pteroglossus torquatus*	X	
Woodpecker	*spp*		X
Flycatcher	*spp*		X
Clay-colored Thrush	*Turdus grayi*		X
Great-tailed Grackle	*Quiscalus mexicanus*		X
Oropendola	*Psarocolius montezuma*		X
Jesus Christ Lizard	*Basiliscus basiliscus*		X

Green iguana	*Iguana iguana*		X
Frog	*spp*	X	
Bushmaster	*Lachesis muta*		X
Coral	*spp*		X
Fer-de-lance	*Botrops asper*	X	X

Appendix 6. Spanish version of questionnaire used to investigate environmental knowledge and perceptions in the Barbilla Sector of Costa Rica, 2019.

CUESTIONARIO

Investigador: Carolina Sáenz Bolaños (csaenz@umass.edu), Departamento de Conservación del medio ambiente, Universidad de Massachusetts Amherst.

Investigación: Percepciones locales hacia la vida silvestre: factores que influyen en las actitudes hacia la conservación de jaguares entre indígenas y no indígenas en Costa Rica

Factores que influyen en las actitudes hacia la conservación del jaguar (*Panthera onca*) entre indígenas y no indígenas en Costa Rica

I. Información General **Fecha: / /**

Entrevistador _____ Número de entrevista _____

Entrevistado: Femenino ( ) Masculino ( )

Categoría de manejo

( ) Parque Nacional ( ) Reserva Forestal ( ) Reserva Indígena ( ) Fuera de área protegida

Localidad _____ Nombre en GPS _____

Provincia: _____ Cantón: _____

Distrito: _____ Ciudad: _____

Coordenadas N ___ ___ . ___ ___ ___ ___ ___ ° W - ___ ___ . ___ ___ ___ ___ ___ °

¿Desde hace cuánto vive aquí?

II. Percepciones sobre animales en general

1. ¿Qué animales hay aquí en el bosque cerca de la comunidad?

i._____ v._____

ii._____ vi._____

iii. _____ vii._____

iv._____ viii._____

2. Alguno de esos animales trae algún beneficio para la gente? Cuál? Alguno causa problema a la gente de la comunidad? Qué problemas causan?

Animal	Beneficio
i	

ii	
iii	
iv	
v	

Animal	Problema
i	
ii	
iii	
iv	
v	

III. Percepciones de riesgo/pérdida: jaguar

3. ¿Cuándo fue la última vez que vio un jaguar/pantera?

En la comunidad (definir comunidad)	En el bosque

4. (En caso que el jaguar no haya sido mencionado) ¿Considera usted que jaguares o panteras causan algún problema? Cuáles? Cuando fue la última vez?

Problema/peligros/ danos/riesgos	P / A	La última vez		Observación	5. ¿En el próximo año cómo considera que será el problema causado por jaguares/panteras? Porqué?
		En la comunidad	Para Usted		-2 Mucho mayor -1 Mayor 0 Igual 1 Menor 2 Mucho menor

Predación de mascotas						
Predación de ganado			Animal	#		
			Caballo			
			Cerdo			
			Vaca			
			Oveja			
			Cabra			
Ataque a mujeres embarazadas						
Daño a la producción						
Ataque a los niños						
Enfermedades						
Otros:						

6. ¿Cuántos animales perdió en el último año por jaguar/pantera?

Perro	Caballo	Cerdo	Vaca	Oveja	Cabra	Otro

7. ¿Tamaño de la propiedad (ha) _____
8. ¿Tiene ganado? ( ) Si ( ) No
9. N° cabezas Vacas ____ Ovejas _____ Caballos _____ Cerdos _____ Cabras _____

10. ¿}La pérdida económica de animales domésticos a causa del jaguar o pantera es?
( ) Muy alta ( ) Alta ( ) Baja ( ) Muy baja

11. ¿Jaguares o panteras atacan a la gente? en caso de si, cual es el riesgo/peligro para:
Si ( ) No ( )
¿En orden de mayor a menor peligro/riesgo como lo haría usted?

Riesgo/Peligro	Orden
Hombres	
Mujeres	
Niños	
Mujeres embarazadas	

IV. Percepciones de riesgo/pérdida: ambiente

12. ¿Qué cambios en el bosque son los más importantes desde que usted era joven?

13. A Usted le parece que cuando era joven...

	Nombre de especies	Mucho menos	Menos	Igual	Más	Mucho más
Bosque había...						
Jaguares había...						
¿Un animal que había menos?						
¿Un animal que había más?						
Temperatura era.. (frío-caliente)						
Lluvia... (invierno dura más)/ cae más agua?						
Daños por las llenas eran... Mas seguidas,						

14. ¿Hay animales que antes no estaban por la zona? Cuáles?

V. Confianza a las instituciones

(1 poco, 2 mucho, 3 muchísimo)

	Escala (1-3)	MINAE	CCSS	MEP	Panthera	CATIE	UNA	ICT	MAG	
15. ¿Cuáles instituciones trabajan en la comunidad? (Poner en orden numérico)										
16. ¿Cuáles de esas instituciones le han ayudado más? (poner # en que lo va mencionando y marcar con X)	1= poco									
	2=mucho									
	3=muchísimo									
17. ¿Cuáles de esas instituciones le han ayudado menos? (poner # en que lo va mencionando y marcar con X)	1= poco									
	2=mucho									
	3=muchísimo									

VI. Sentimientos

Llenar el cuadro:

P/A	Sentimiento/emoci on (0 nada, 1 poco, 2 mucho)	18. ¿Cuándo usted escucha hablar del jaguar cerca de la casa ? (0-2)	19. ¿Si ve un jaguar o pantera cerca de su casa? (0-2)	20. ¿Si un jaguar o pantera ataca un animal en la comunidad? (0-2)
	Alegría/felicidad/c ontento			
	Amor			
	Chiva/carga			
	Curiosidad			
	Asombro/sorpresa			

	Temor/miedo			
	Tristeza			
	Enojo/rabia			

VII. Control de la situación

Efectividad de las medidas (0 nada, 1 poco, 2 muy, 3 totalmente)

Medidas	21. ¿Sabe usted qué medidas usa la gente de la comunidad para controlar el problema del jaguar o pantera?		22. ¿Qué medidas tiene usted para controlar los problemas que mencionó con el jaguar o pantera ha usado?	
	Marcar con X	Efectividad de la medida (0 -3 efect)	Marcar con X	Efectividad de la medida (0 -3 efect)
Uso de armas				
Uso de venenos				
Uso de cercas				
Niños acompañados de adultos				
Plantas/oraciones /etc				

23. ¿Qué le falta para evitar/resolver su problema con jaguares? ¿Cómo? ¿Porqué?

24. ¿Quién considera usted que le puede ayudar a evitar/resolver el problema con los jaguares?

VIII. Actitudes

25. ¿Si por usted fuera el número de jaguares lo?

	Eliminaría / quitaría	Disminuiría	Mantendría igual	Aumentaría
En el PNB				
En la reserva forestal				
En la reserva indígena Nairí Awarí				

		Muy mala	Mala	Ni buena ni mala	Buena	Muy buena
26. ¿Para usted que haya jaguares en Costa Rica es?						
27. ¿La presencia de jaguares en?	Parque nacional					
	Reserva Forestal					
	Nairi Awari					
28. ¿La presencia de jaguares o pantera en su propiedad es?						

29. ¿Qué tanto toleraría/aguantaría que un jaguar/ pantera esté en su propiedad?
( ) Nada ( ) Muy poco ( ) Poco ( ) Bastante
30. ¿Qué haría usted si llega o aparece un jaguar a su propiedad?

IX. Datos sociodemográficos y de la propiedad
31. ¿Cuántas personas viven en la casa?
Hombres adultos _____ Mujeres adultas _____

32. ¿Tiene mascotas? Cuáles?

33. ¿En orden de importancia de mayor a menor cuál fuente de ingreso le deja más dinero en su propiedad? (ordenar)
( ) Ganadería ( ) Agricultura ( ) PSA ( ) Pesca ( ) Peón ( ) Turismo ( ) Pensión ( ) Madera

34. Llenar el cuadro

Grado de escolaridad	
Edad	

Appendix 7. English version of questionnaire used to investigate environmental knowledge and perceptions in the Barbilla Sector of Costa Rica, 2019

Factors that influence attitudes towards jaguar conservation among indigenous and not indigenous people in Costa Rica

I. General Information **Date: / /**

Researcher _____ Interview number _____

Interviewed: Female ( ) Male ( )

Management type

( ) National Park ( ) Forest Reserve ( ) Indigenous territoty ( ) unprotected area

Location: _____ Name on GPS _____

Province: _____ Canton: _____

Distrit: _____ Ciy: _____

Coordinates

N _____ _____ . _____ _____ _____ _____ _____ °

W - _____ _____ . _____ _____ _____ _____ _____ °

How long have you lived here?

II. Perceptions about animals in general

1. What animals are here in the forest near to the community?

i._____ v._____

ii._____ vi._____

iii. _____ vii._____

iv._____ viii._____

2. Do any of these animals bring any benefit to people? Which? Does any cause cause problems to the people of the community? What problems do they cause?

Animal	Benefit

i	
ii	
iii	
iv	
v	

Animal	Problem
i	
ii	
iii	
iv	
v	

III. Perceptions of risk / loss: jaguar

3. When was the last time you saw a jaguar / panther?

In the community	In the forest

4. (In case the jaguar has not been mentioned) Do you think that jaguars or panthers cause any problems? Which? When was the last time?

Problem / hazards / damages / risks	P/ A	Last time			Observation	5. In the next year how do you think the problem caused by jaguars / panthers will be? Why?
		In the community	For you			-2 Much larger -1 Greater 0 Equal 1 Minor 2 Much smaller
Predation of pets						
Predation of cattle			**ANIMAL**	**#**		
			Horse			
			Pig			
			Cow			
			Sheep			
			Goat			
Attack to pregnant women						
Damage to production						
Attack on children						
Diseases						
Others:						

6. How many animals did you lose in the last year for jaguar / panther?

Dog	Horse	Pig	Cow	Sheep	Goat	Other

7. Property size? (ha) _____

8. Do you have livestock? ( ) Yes ( ) No

9. N° heads Cows _____ Sheeps _____ Horses _____ Pigs _____ Goats _____

10. Is the economic loss of domestic animals because of the jaguar or panther?

( ) Very high ( ) High ( ) Low ( ) Very low

11. Jaguars or panthers attack people? In case of yes, what is the risk / danger for:

Yes ( ) ( ) No

In order of higher to lower risk / risk as you would?

Risk/hazard	Order
Men	
Women	
children	
Pregnant women	

IV. Perceptions of risk / loss: environment

12. What changes in the forest are the most important since you were young?

13. It seems to you that when I was young ...

	Species name	Much less	Less	Equal	More	Much more
Forest had ...						
Jaguars had ...						
An animal that had less?						
An animal that had more?						
Temperature was .. (cold-hot)						
Rain ... (raining season are longer) / drops more water?						
Damages by the floods were ... More followed,.....						

14. Are there animals that were not in the area before? Which?

V. Trust to institutions

(1 little, 2 much, 3 very much)

	Scale (1-3)	**MINAE**	**CCSS**	**MEP**	**Panthera**	**CATIE**	**UNA**	**ICT**	**MAG**	
15. What institutions work in the community? (Put in numerical order)										
16. Which of these institutions have helped you the most? (put # in which you mention it and mark with X)	1= little									
	2=much									
	3=very much									
17. Which of these institutions have helped you the least? (put # in which you mention it and mark with X)	1= little									
	2=much									
	3=muchísimo									

VI. Feelings

Fill the box:

P/A	Feeling / emotion (0 nothing, 1 little, 2 a lot)	18. When do you hear about the jaguar near the house? (0-2)	19. If you see a jaguar or panther near your home? (0-2)	20. If a jaguar or panther attacks an animal in the community? (0-2)
	Joy / happiness / happy			
	Love			
	Nice			
	Curiosity			
	Astonishment / surprise			
	Fear			
	Sadness			
	Anger / rage			

VII. Control of the situation

Effectiveness of the measurements (0 nothing, 1 little, 2 very, 3 totally)

Measurement	21. Do you know what measures the people of the community use to control the problem of the jaguar or panther?		22. What measures do you have to control the problems you mentioned with the jaguar or panther you used?	
	Mark with X	Effectiveness of the measurement (0 -3 effect)	Mark with X	Effectiveness of the measurement (0 -3 effect)
Use of weapons				
Use of poisons				
Use of fences				
Children accompanied by adults				
Plants / prayers / etc				

23. What do you still need to avoid / solve your problem with jaguars? How? Why?

24. Who do you think can help you avoid / solve the problem with jaguars?

VIII. Attitudes

25. If you could do something, the jaguar numbers would be?

	Would eliminate / remove	Would diminish	Would keep the same	Would increase
In the National Park				
IN the Forest Reserve				
In the Indigenous Territory				

		Very bad	Bad	Neither good nor bad	Good	Very good
26. Do you think there are jaguars in Costa Rica?						
27. The presence of jaguars in?	National Park					
	Forest Reserve					
	Indigenous Territory					
28. Is the presence of jaguars or panthers on your property?						

29. How much would you tolerate / hold a jaguar / panther on your property?

( ) Nothing ( ) Very little ( ) Little ( ) Pretty

30. What would you do if a jaguar arrives or appears on your property?

IX. Sociodemographic and property data

31. How many people live in the house?

Adult men _____ Adult women _____

32. Do you have pets? Which?

33. In order of importance from highest to lowest which source of income leaves you more money on your property? (order)

( ) Livestock ( ) Agriculture ( ) PES ( ) Fishing ( ) Labourer ( ) Tourism ( ) Pension ( ) Wood

34. Fill the box

School grade	
Age	

Appendix 8. List of total species detected in the camera trap design at the Pacuare-Barbilla Sector in the northern Talamanca Mountains of Costa Rica during 2019.

Taxon	Common English name	Scientific name
Mammal	Common opossum	*Didelphis marsupialis*
	Gray four-eyed opossum	*Philander opossum*
	Mexican Mouse opossum	*Marmosa mexicana*
	Brown four-eyed opossum	*Metachirus nudicaudatus*
	Nine-banded armadillo	*Dasypus novencinctus*
	Naked-tailed armadillo	*Cabassous centralis*
	Tamandua	*Tamandua mexicana*
	Unknown bat	
	Unknown rabbit	*Sylvilagus* spp.
	Red-tailed squirrel	*Sciurus granatensis*
	Agouti	*Dasyprocta punctata*
	Paca	*Agouti paca*
	Unknown rat	
	Unknown mouse	
	Ocelot	*Leopardus pardalis*
	Margay	*Leopardus wiedii*
	Puma	*Puma concolor*
	Yaguaroundi	*Hepailurus yaguoarundi*
	Jaguar	*Panthera onca*
	Coyote	*Canis latrans*
	Striped hog-nosed skunk	*Conepatus semistriatus*
	Tayra	*Eira barbara*
	Greater grison	*Galictis vittata*
	White-nosed coati	*Nasua narica*
	Northern raccoon	*Procyon lotor*
	Collared peccary	*Pecari tajacu*
	White-lipped peccary	*Tayassu pecari*
	Red brocket deer	*Mazama temama*
	Dog*	
	Cat*	
	Horse*	
	Cow*	
	Pig*	
Bird	Highland Tinamou	*Nothocercus bonapartei*
	Great Tinamou	*Tinamus major*
	Little Tinamou	*Crypturellus soui*
	Slaty-breasted Tinamou	*Crypturellus boucardi*
	Great Curassow	*Crax rubra*
	Gray-headed Chachalaca	*Ortalis cinereiceps*
	Black Guan	*Chamaepetes unicolor*
	Crested Guan	*Penelope purpurascens*
	Black-eared Wood-Quail	*Odontophorus melanotis*
	Sunbittern	*Eurypyga helias*
	Black-breasted Wood-Quail	*Odontophorus leucolaemus*
	Russet-naped Wood-rail	*Aramides albiventris*

	Black Vulture	*Coragyps atratus*
	Turkey Vulture	*Cathartes aura*
	Broad-winged Hawk	*Buteo platypterus*
	Unknown Raptor	
	Unknown Owl	
	Long-billed Hermit	*Phaetornis longirostris*
	Unknown hummingbird	
	White-tipped Dove	*Leptotila verreauxi*
	Olive-backed Quail-Dove	*Leptotrygon veraguensis*
	Chiriquí Quail-Dove	*Zentrygon chiriquensis*
	Purplish-backed Quail-Dove	*Zentrygon lawrencii*
	Ruddy Quail-Dove	*Geotrygon montana*
	Rufous-vented ground-cuckoo	*Neomorphus geoffroyi*
	Lessons Motmot	*Momotus lessonii*
	Rufous Motmot	*Baryphthengus martii*
	Collared Aracari	*Pteroglossus torquatus*
	Keel-billed Toucan	*Ramphastos sulfuratus*
	Unknown Woodcreeper	
	Black-crowned Antshrike	*Thamnophilus atrinucha*
	Thicket Antpitta	*Hylopezus dives*
	Streak-chested Antpitta	*Hylopezus perspicillatus*
	Black-faced Antthrush	*Formicarius analis*
	Black-headed Antthrush	*Formicarius nigricapillus*
	Brown Jay	*Psilorhinus morio*
	Wood Thrush	*Hylocichla mustelina*
	Clay-colored Thrush	*Turdus grayi*
	Montezuma Oropendola	*Psarocolius montezuma*
Reptile	Middle American Ameiva	*Ameiva festivus*
	Common Green Iguana	*Iguana iguana*

* = domestic species

Appendix 9. Relative abundance index (independent photos/100 trapnights) for mammal species and humans in the four areas within Pacuare-Barbilla Sector in the northern Talamanca Mountains of Costa Rica. Number of trapnights per are in parentheses.

	National Park (1,516)	Forest Reserve (1,660)	Indigenous Territory (412)	Not Protected (2,040)
Common opossum	6.13	6.81	2.67	7.16
Gray four-eyed opossum	1.12	0.42	0.24	0.29
Mexican Mouse Opossum	0.00	0.06	0.00	0.05
Brown four-eyed opossum	3.96	0.00	0.00	0.15
Nine-banded armadillo	4.88	5.12	4.85	18.43
Naked-tailed armadillo	1.45	0.00	0.24	0.15
Tamandua	0.79	1.69	0.49	1.47
Unknown bat	0.00	0.00	0.00	0.15
Unknown rabbit	0.26	0.12	0.00	0.10
Red-tailed squirrel	12.80	1.81	5.10	3.97
Agouti	42.68	14.22	30.83	8.04
Paca	7.92	1.51	3.40	0.93
Unknown rat	16.16	6.57	31.31	11.96
Unknown mouse	9.04	0.12	3.16	0.74
Ocelot	7.98	1.20	5.58	3.58
Margay	0.53	0.06	0.24	0.00
Puma	1.39	0.00	0.24	0.00
Yaguaroundi	0.86	0.30	0.49	0.00
Jaguar	0.86	0.00	0.00	0.00
Coyote	0.00	0.60	0.00	0.15
Striped hog-nosed skunk	1.72	0.36	0.00	0.20
Tayra	1.12	1.39	2.67	4.46
Greater grison	0.00	0.12	0.49	0.74
White-nosed coati	3.36	5.18	3.40	3.68
Northern raccoon	0.00	0.96	7.28	2.84
Collared peccary	1.72	0.48	1.21	0.69
White-lipped peccary	0.26	0.00	0.00	0.05
Red brocket deer	2.18	0.42	0.49	0.00
Dog*	2.90	0.66	18.93	2.25
Cat*	0.00	0.00	0.49	0.15
Horse*	0.07	0.00	0.00	0.05
Cow*	0.00	1.20	0.00	1.18
Pig*	0.26	0.06	0.49	0.00
Poacher	3.30	0.00	0.00	0.05
Tourist/Researcher/Local	2.04	3.43	22.09	18.77

Appendix 10. Relative abundance index values range to categorize the results for 2019 sample.

Species	Mean previous years	Low	Medium	High
Common opossum	1.57	<0.79	>0.80<1.57	>1.57
Gray Four-eyed Opossum	0.17	<0.085	>0.085 <0.17	>0.17
Nine-banded armadillo	2.46	<1.23	>1.23<2.46	>2.46
Naked-tailed armadillo	0.16	<0.08	>0.08 <0.13	>0.13
Unknown rabbit	0.03	<0.015	>0.015 <0.03	>0.03
Red-tailed squirrel	2.12	<1.06	>1.06 <2.12	>2.12
Agouti	24.90	<12.4	>12.5 <25	>25
Paca	2.21	<1.10	>1.11<2.21	>2.22
Rat/mice	3.44	<1.72	>1.72 <3.44	>3.44
Ocelot/tigrillo	3.42	<1.71	>1.72<3.42	>3.42
Puma	0.87	<0.42	>0.43<0.87	>0.87
jaguarundi	0.66	<0.33	>0.33 <0.66	>0.66
Jaguar	0.90	<0.44	>0.45<0.9	>0.9
Coyote	0.02	<0.01	>0.01 <0.02	>0.02
Tayra	0.71	<0.35	>0.36<0.71	>0.72
White-nosed coati	1.02	<0.50	>0.51 <1.02	>1.02
Northern raccoon	0.10	<0.05	>0.06<0.10	>0.11
Collared peccary	0.89	<0.45	>0.46<0.89	>0.90
White Lipped peccary	0.01	<0.005	>0.005 <0.01	>0.01
Red brocket	0.91	<0.45	>0.46<0.91	>0.91
Tapir	0.24	<0.12	>0.12 <0.24	>0.24

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