Chapter 10
Large Terrestrial Mammals

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Abstract The Yucatán Peninsula contains some of the largest tracts of tropical forest in Mexico. These forests host six species of ungulates, including the largest and last survivor of the Neotropical megafauna, the Central American Tapir; one of the rarest ungulate species in Mexico, the White-lipped Peccary; and one endemic species of deer, the Gray Brocket. The Yucatán Peninsula is also home to another peccary species, two more deer species, five felid species, including the jaguar and the puma, and three species of primates. Most of these species face serious conservation threats, as their habitat is increasingly fragmented and because they are among the preferred targets of subsistence hunters. Some of these species require large areas of habitat in good conservation status to fulfill their basic needs for survival. Several research projects undertaken in the past years, and some currently being carried out, have addressed a lack of basic ecological information in this region. Among the ungulates, ecological research has focused on tapir, white-lipped peccary and the three deer species. For felids, scientific attention has been focused on the two largest species, the jaguar and puma; and all three primate species have received scientific attention recently, although more studies have focused on the black howler monkey. This chapter is an attempt to summarize what is currently known about these, the largest mammal species of the Yucatán Peninsula, and to point out gaps in the existing information. Such information is

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absolutely necessary to design conservation and management plans for these highly interesting and endangered species.

Keywords Endangered species • Hunting • Tropical ungulates • Large cats • Mexican primates • Maya forest • Yucatán Peninsula • Coastal ecosystems • Wildlife conservation • Wildlife research

10.1 Introduction

The Yucatán Peninsula is an extraordinary region in Mexico that embraces a vast diversity of habitats and wildlife, mixed with rich cultural traditions and an historical legacy as the center of ancient and modern Mayan civilizations. This area has a rich geological history and has witnessed several wildlife colonization and extinction events. Sixty-five millions years ago an asteroid impacted the northern portion of the peninsula, which caused the Chikchulub crater and a mass extinction that affected the whole planet's biota (Hildebrand et al. 1991). This event changed the composition of biotic communities around the world and is sometimes theorized as the cause of the extinction of the dinosaurs (Vazquez-Dominguez and Arita 2010). The peninsula has undergone several climatic events in its history, changing its profile and biota; the advance and retreat of ice sheets caused sea level to rise and decrease several times. The Yucatán Peninsula and Central America have served as a bridge between communities of North and South American biota (Vazquez-Dominguez and Arita 2010). The wildlife community in this region is therefore a product of these geological and climatic events and is composed of elements of the Neoarctic and Neotropical realms, creating a unique wildlife community (Arroyo-Cabrales and Álvarez 2003).

Evidence of human habitation of the Yucatán Peninsula goes back 7500–9000 years. Since then, humans have always been present in the region, with periods where more than 50,000 people lived in pre-Hispanic cities such as Tikal or Calakmul. According to Vazquez-Dominguez and Arita (2010), the area currently hosts a population similar in size to when Spanish first arrived in 1519. In the Yucatán Peninsula, the community of large vertebrates (the term usually refers to birds and mammals that weigh more than 10 kg) that Spaniards found when they first arrived more than 500 years ago still persists.

This chapter examines the mammals among those large vertebrates, which comprise a wide variety of species, a number of them endangered. Six species of ungulates inhabit the Yucatán Peninsula; one is the last representative of the Perissodactyla order in Central America, the Central American Tapir (*Tapirus bairdii*) and the largest of all Neotropical terrestrial mammals. The Artiodactyla order is represented with two species of peccaries, the white-lipped peccary (*Tayassu pecari*) and the collared peccary (*Pecari tajacu*) and three species of deer, the white-tailed deer (*Odocoileus virginianus*), the grey brocket deer (*Mazama pandora*), and the Central American red brocket deer (*Mazama temama*).

These ungulate species are primary target species among subsistence hunters, and they are a source of high-quality animal protein for many rural families in the area (Jorgenson 1995; Escamilla et al. 2000; Weber 2000; Reyna-Hurtado and Tanner 2007; Urquiza-Haas et al. 2009; Ramírez-Barajas et al. 2012). Five species of felids inhabit the peninsula forests. The jaguar (*Panthera onca*) is the largest of all, followed by the puma (*Puma concolor*), the ocelot (*Leopardus pardalis*), the jaguarondi (*Herpailurus yagouaroundi*) and finally the margay (*Leopardus wiedii*). Three species of primates are also found in this area: the spider monkey (*Ateles geoffroyi*), the black howler monkey (*Alouatta pigra*) and the mantled howler monkey (*Alouatta palliata*). Felids and primates are also target species among sport hunters and illegal pet traders, respectively. Almost all these species need large areas of habitat to maintain viable populations and some of them require large ranges, as individuals cross long distances to fulfill their basic needs (Reyna-Hurtado et al. 2009; Ceballos et al. 2002; O'Farrill et al. 2011; Sarabia-Hernandez and Reyna-Hurtado unpub. data). These species represent the largest Neotropical mammals, and all of them face various threats for their survival.

In this chapter we explore current knowledge on 10 of these 14 species. We also explore their conservation status, and suggest some future directions and research priorities for protecting and conserving these amazing species in the Yucatán Peninsula. Tapirs, jaguars, pumas, deer, and herds of peccaries still roam the forest understory while spider monkeys and groups of howler monkeys find their way through the forest canopy. Currently, the region fosters some of the largest remaining tracts of well-conserved tropical forest in Mexico, and its value for the protection of large Neotropical wildlife is becoming more evident as other areas of the country lose their original forest cover. In addition, for species that require large ranges to maintain viable populations, such as the jaguar, tapir, or white-lipped peccary, the Yucatán Peninsula represents a space of hope for their conservation (Reyna-Hurtado et al. 2009; Naranjo 2009; Ceballos et al. 2002).

10.2 Ungulates

*10.2.1 Central American or Baird's Tapir (*Tapirus bairdii*)*

The common names of this species in the Yucatán Peninsula include *danta*, *anteburro*, or *tzimin* in Mayan. The Central American tapir is the only representative of the order Perissodactyla in Mexico. Tapirs are phylogenetically related to horses and rhinoceros and belong to the family Tapiridae. Baird's tapir is a massive rotund animal that weighs up to 300 kg, reaches up to 1.3 m in length and has a protuberant nose that give them their signature profile (Emmons and Feer 1997).

The distribution of Baird's tapir in the Yucatán Peninsula includes the Biosphere Reserves of Calakmul and Sian Ka'an in the south and east, as well as the communal areas adjoining them in the States of Campeche and Quintana Roo.

There are reports of tapirs in Los Petenes Biosphere Reserve north of Campeche (Naranjo et al. 2015), in the Chenes region of the central areas of Campeche (Zuñiga-Fuentes 2009; GCV pers. observ.), and in coastal ecosystems of northern Yucatán (pers. comm., fishermen from Sisal, Yum Balam, Yucatán). While isolated populations may exist in these ecosystems, these reports have not been confirmed. Baird's tapirs are classified as endangered according to the Mexican list of species at risk (NOM-059, Semarnat 2010), and by the IUCN Red List (http://www.iucnredlist.org).

Baird's tapirs prefer well-conserved forests with available water (Fig. 10.1a), but also use low flooded forest while avoiding dry deciduous forest; they also utilize secondary/perturbed forest to some degree if they are not being hunted (Reyna-Hurtado and Tanner 2005). In fact, in a study using tracks as indicator of relative abundance, tapirs were three times more abundant in communal forests (0.42 tracks/km) contiguous to the Calakmul Biosphere Reserve than within the interior of the protected area (0.03 tracks/km) (Reyna-Hurtado and Tanner 2007). This research showed that communal forests in Southern Yucatán Peninsula may present better habitat quality than some parts of the Biosphere Reserve. The higher abundance of water outside the Calakmul protected area (O'Farrill et al. 2014) and the fact that tapirs are rarely the prey of subsistence hunters in this region might explain why the population persists and even grows more abundant than the one in the nearby protected area (Reyna-Hurtado and Tanner 2007). In the Calakmul Region, some arguments offered against killing tapirs include their excessive weight, which increases the work of butchering the animals and the chance of wasting meat; the unpalatable taste of the meat; and general respect for an animal that is rarely seen by hunters (RRH, GO, S. Calmé unpubl. data). Likewise, in Quintana Roo, Jorgenson (1995) found that local residents did not hunt tapir because they are difficult to kill and to transport.

Tapirs depend on water all year-round, repeatedly visiting water bodies such as *aguadas* (water reservoirs and sinkholes), lakes, streams and rivers. Since 2008 a monitoring effort focused on *aguadas*, using camera traps within Calakmul Biosphere Reserve, has shown that tapir is one of the most frequent species photographed (Reyna-Hurtado et al. 2010), with an abundance of 37.6 individuals/1000 trap-nights (Pérez-Cortez et al. 2012). A recent study suggests that tapirs can also persist in dry areas such as the north of the Calakmul Biosphere Reserve when there are water sources available (Carrillo et al. 2015). Though tapirs are mainly nocturnal in the peninsula (Pérez-Cortez et al. 2012), they will visit *aguadas* during the day in the hottest months of the year.

Tapirs have important roles in the ecosystem. Through seed dispersal, seed predation and herbivory, tapirs shape the structure of the vegetation in their habitat (O'Farrill et al. 2013). In particular, tapirs are the only animals that can disperse large seeds (those once dispersed by extinct megafauna), giving them a unique function in the ecosystem (Hansen and Galetti 2009; O'Farrill et al. 2013). In the Yucatán Peninsula, Baird's tapirs are one of the few known species that can successfully disperse large seeds of tree species such as zapote (*Manilkara zapota*; O'Farrill et al. 2006). In an in-depth study of the relationship between tapirs and

Fig. 10.1 (**a**) Central American tapir (*Tapirus bairdii*) Photo: Rafael Reyna-Hurtado. (**b**) White-lipped peccaries (*Tayassu pecari*). Photo: Rafael Reyna-Hurtado. (**c**) Gray brocket deer (*Mazama pandora*). Photo: Pablo J. Ramírez-Barajas

zapote trees, O'Farrill et al. (2012) found that seeds that pass through the digestive tract of tapir are able to germinate at a similar rate to seeds that did not pass through the tapir's digestive system, therefore facilitating long-distance dispersal of the zapote tree. Despite the presence of what we believe are stable populations of Baird's tapir in the Yucatán Peninsula, the long-distance movement patterns of this species may be under threat, given current rates of habitat fragmentation due to increased human activities (road infrastructure and agriculture), and changes in water resource availability due to climate change (O'Farrill et al. 2013). The disruption of the movement patterns of this species can have detrimental and cascading effects on other species, and on the functional role of this important long-distance disperser of large seeds, putting this species at risk of becoming functionally extinct (McConkey and O'Farrill 2015).

The Maya forest that comprises the forest of the Greater Calakmul Region and the forest in the Peten area in Guatemala may harbor the largest tapir population in its whole distribution range (Naranjo 2009). Although this population may be the largest, several threats to it exist. For example, in the forest surrounding the Calakmul Biosphere Reserve, there has been an increase in tapir conflicts with local residents due to tapirs' crop raiding (M. Sanvicente, RRH, S. Calmé pers. obs.). Future studies aimed at identifying the causes of the increase in conflicts should allow us to suggest whether they are caused by further encroachment of croplands on tapir habitat, by an increasing tapir population, or by a more aggregated distribution of the tapir population. Identifying the cause of this increase in conflicts may help prevent further killing of tapirs in the future. In addition, the isolation of protected areas from communal forest caused by the road network and the subsequent deforestation belt that always accompanies it also presents a major threat. This fragmentation can prevent tapirs from moving between protected areas and the surrounding forests, leading to genetic isolation, which offers a poor scenario for the future of the species. Finally, the central area of the Yucatán Peninsula is predicted to become drier if climate change intensifies, with a predicted reduction of up to 48 % in annual rainfall for the end of the century (Magrin et al. 2007). The effect of this reduction in rainfall may have drastic consequences on the availability of water resources for tapirs (O'Farrill et al. 2014).

Despite an increase in tapir research in the Yucatán Peninsula in recent years, we believe that such research still needs to address the following areas:

1. Movement ecology. This will provide information on areas most frequented by tapirs and therefore areas that need to be conserved to maintain a stable and connected population. In addition, information on how far tapirs are dispersing seeds from parental trees will provide information on their unique long-distance seed dispersal role. Research on tapir's dispersal capacities and connectivity among populations must be given priority due to current habitat encroachment.
2. Population estimates. We need to know the status of the population under different human-induced and ecological conditions. Population estimates

(relative abundance, density, e.g.) are very important information for shaping management and conservation plans and initiatives.
3. Distribution. Research must be carried out in the northern and central areas of the Campeche and Yucatán States with emphasis on coastal ecosystems to confirm the species' presence and to estimate its population status, if possible. Confirmation of tapir presence in areas that are defined as stable tapir habitat is important for understanding the limits of this species' distribution.

*10.2.2 White-Lipped Peccary (*Tayassu pecari*)*

The white-lipped peccary is known in the Yucatán Peninsula as *senso*, *jabalín*, *hauilla* and, in Mayan, *kitam* (Reyna-Hurtado et al. 2014). The white-lipped peccary belongs to the order Artiodactyla and is one of the two peccary species of the Tayassuidae family (known as the New World pigs) that exist in Mexico. White-lipped peccaries are pig-like animals with long black hairs over their entire body except for a white area under the cheeks and the lips that give them its name. At more than a meter in length, 60 cm in height and weighing up to 40 kg, the white-lipped peccary is larger than its congener, the collared peccary, and has longer legs (Emmons and Feer 1997). The white-lipped peccary is a social animal that lives in groups of up to 300 individuals with anecdotal reports of 700 or even 1000 individuals in a single group (Fragoso 2004; R. Bodmer pers. comm.; Mayer and Wetzel 1987).

White-lipped peccary distribution in the Yucatán Peninsula is generally restricted to the large protected areas such as the Calakmul and Sian Ka'an Biosphere Reserves, and the large communal forests that surround these protected areas (Reyna-Hurtado et al. unpubl. data). However, in the last years, three additional populations have been documented, all of them in coastal ecosystems of the Yucatán Peninsula. Two populations have been found in the surroundings of the Laguna de Términos protected area in the Campeche State (Hidalgo-Mihart and Contreras-Moreno 2012), and one in the Dzilam de Bravo State Reserve in the north of Yucatán State (C. Alcerreca pers. comm.). The White-lipped Peccary is classified as endangered by the Mexican list of species at risk (NOM-059, Semarnat 2010), and as Vulnerable by the IUCN Red list (http://www.iucnredlist.org).

White-lipped peccary is among the favorite game species for both subsistence and sport hunters in the area, and it is estimated that its historical distribution range in Mexico has been reduced by 84 % in the last 40 years (Altrichter et al. 2012). The species' complete elimination from some areas outside the Calakmul reserve has been documented, with only small numbers surviving in some communal forests (Reyna-Hurtado 2009). White-lipped peccaries are easily hunted in the dry season at the few remaining water bodies in forests, *aguadas* or savannas, and it has been documented that subsistence hunting combined with sport hunting can eradicate a whole group in a single dry season (Reyna-Hurtado et al. 2010; E. Quijano Hernández pers. comm.).

White-lipped peccaries are specialist animals that prefer humid tall and well-conserved forest with available water (Sowls 1997). In the Yucatán Peninsula the white-lipped peccary disproportionately uses medium semi-perennial forest and low-flooded forest, while avoiding dry semi-deciduous forest (Reyna-Hurtado and Tanner 2005; Reyna-Hurtado et al. 2009; Briceño-Méndez et al. 2014). The diet of white-lipped peccaries is 80 % fruit, while invertebrates are also important food source (Pérez-Cortez and Reyna-Hurtado 2008). These foods are found in greater quantities in the medium semi-perennial forest and in the low flooded forest of the Yucatán Peninsula (Reyna-Hurtado et al. 2009). This species is an assiduous visitor of *aguadas* during the dry season (Fig. 10.1b), and its foraging movements are strongly influenced by water availability in time and space, to such a degree that groups of this species have been classified as "central place foragers" with the central place being the *aguadas* (Reyna-Hurtado et al. 2012).

In a long-term study about white-lipped peccary movement patterns carried out in the Southern Yucatán Peninsula, Reyna-Hurtado et al. (2009) documented that groups move across areas larger than 100 km^2, and that movement patterns are strongly influenced by the availability of water and preferred forest types (Reyna-Hurtado et al. 2009). There is empirical evidence that the groups of this species can travel in a coordinated way and may visit places that they remember, inferring that spatial memory can play a large role in their movements (RRH pers. obs.). The forests of the Yucatán Peninsula hold one of the last and the largest population of white-lipped peccary in Mexico, after the reduction of its distribution in the last 40 years (Altrichter et al. 2012). The only documented estimate of density was 0.43 individuals per km^2 in the southern part of the Calakmul Biosphere Reserve, which would translate into approximately 1500 individuals in that specific area (assuming the forest maintains similar conditions) (Reyna-Hurtado et al. 2010). These findings contrast with research carried in communal forest where this species was very rare and its abundance very low in comparison with that in the protected area (Reyna-Hurtado 2009). These results also raise the possibility of this species becoming isolated in a few protected areas, and locally extinct in the near future in the communal forest where it still persists. This is not the best scenario for the conservation of this endangered wildlife species. In addition, the predicted reduction in rainfall in the center of the peninsula due to climate change (Magrin et al. 2007) will greatly affect the species' persistence in the dry areas of the Yucatán Peninsula. In the Calakmul region, it may force the species to migrate to adjacent communal forests where there is greater standing water availability, and a greater risk of being hunted. In South America, diseases are believed to be one potential cause of the large observed declines in this species, due to contact with domestic pigs (Fragoso 1997). In the Yucatán Peninsula we have no information on this topic, except for some evidence of skin diseases observed recently in wild individuals of white-lipped peccaries in the Maya forest (Reyna-Hurtado et al. 2014).

It will be essential to learn the following information on this species in the near future for conservation and management purposes:

1. Population estimates. Relative abundance and, when possible, density are very important pieces of information for the conservation of this endangered species. We need to document what is happening in terms of population dynamics. This is a species that has particular habitat requirements and is very sensitive to human perturbations, but we do not know the degree of impact on the species from hunting (see Chap. 13), or the effects of seasonal changes, and disease.
2. Movement ecology. Documenting movement patterns and the possible use of spatial memory could be an exciting research program that would contribute to understanding the long-distance movements this species performs, and the decision process in which these movements occur, as well as the ecological conditions that trigger them, providing some guidance for management plans.
3. Water dependence. We need to obtain basic information on the ecological strategies the species has developed to cope with water scarcity. This information may feed models for understanding or predicting the potential impact of climate change on the species in the future.
4. Diseases. An assessment of the health status of wild animals and the domestic animals in the areas where both types of animal overlap will provide sound information on this important issue for white-lipped peccaries.

*10.2.3 Collared Peccary (*Pecari tajacu*)*

In the Yucatán Peninsula collared peccary are locally know as *puerco de monte*, *puerco cinchado*, *coche de monte* and, in Mayan, *kitam*. The collared peccary belongs to the order Artiodactyla and, as mentioned previously, is one of the two peccary species of the Tayassuidae family that exist in Mexico. Collared peccaries are pig-like animals with grey-yellowish hair across their entire body except for the white "collar" that goes around the shoulder area and gives them their name. The collared peccary is significantly smaller than white-lipped peccary: its adult length ranges from approximately 90 to 100 cm, and they weigh between 15 and 28 kg, with a more rounded head and shorter legs than white-lipped peccary (Emmons and Feer 1997). Collared peccaries are also social animals, forming groups of 2–50, but less cohesive than groups of white-lipped peccaries (Sowls 1997). A comparative study of the two species of peccaries found that collared peccary had an average of six individuals per groups with a range of 1–44, for a total of 85 groups observed. Individuals usually remained close to each other, but can travel separated for periods of time, especially when they are in danger of predation and run in different directions, a behavioral strategy different than the stand-and-defend pattern of the larger white-lipped peccary (Sowls 1997).

The collared peccary has the largest distribution range in the Americas of any peccary species, occurring from northern Argentina to the southern United States. In the Yucatán Peninsula it is possible to find it in almost all regions except close to major cities or in the most disturbed areas (Reyna-Hurtado et al. 2014). The collared peccary is classified as No Risk by the Mexican list of species at risk

(NOM-059, Semarnat 2010), and as a species of Least Concern by the IUCN Red List (www.iucnredlist.org).

Collared peccaries use a diverse array of habitats, ranging from humid tall perennial forest to the desert. In the Yucatán Peninsula this species is found in tropical semi-perennial forest with some degree of tolerance to disturbed areas. For example, many reports of hunted collared peccaries come from highly disturbed areas of secondary habitat (*acahuales*) and *milpas* surrounding communities (Ramírez-Barajas and Naranjo 2007). The collared peccary is a common animal in the Yucatán Peninsula, even where it is hunted (Weber 2000; Gonzalez-Marin et al. 2008; Reyna-Hurtado and Tanner 2007; Urquiza-Haas et al. 2009). Reyna-Hurtado and Tanner (2005, 2007) found that collared peccary abundance is similar in a set of areas where they are hunted and within the Calakmul protected area. This finding seems surprising given that some reports point to the collared peccary as one of the most hunted animals in many communities (e.g., Escamilla et al. 2000; Ramírez-Barajas and Naranjo 2007; Weber 2000).

Reyna-Hurtado and Tanner (2005) also found that collared peccaries are habitat generalists, though they prefer tall humid habitats (medium sub-perennial forest) when available, while avoiding the dry forest to certain degree (Briceño-Méndez et al. unpubl. data). In the Yucatán Peninsula no major study has been conducted on this species, therefore it is worthwhile to pay closer attention to the following ecological aspects:

1. Population dynamics. It would be interesting to understand how the species adapt to hunting pressure and other human activities in the non-protected forest.
2. Social behavior. It would be interesting to conduct research on group size and fission-fusion social behavior in this species, and especially to compare behavior in protected versus non-protected areas.
3. Movement ecology. Movement patterns and home range are essential information for the development of management plans for this species, to ascertain the area needed in order to maintain a viable population on a given site.
4. Disease transmission. This is another relevant topic, as we know nothing about the potential transmission of diseases and parasites between collared peccaries and domestic pigs or other domestic species. This topic is becoming more relevant every day, as the borders between wild habitats and disturbed sites increase with the opening of previously forested areas.

*10.2.4 White-Tailed Deer (*Odocoileus virginianus*)*

White-tailed deer is known as *venado* or *venado real* in some areas of the Yucatán Peninsula or *Quej* in Mayan. The white-tailed deer, with a length of 1.1–2.2 m and weighing between 30 and 50 kg, is the largest of the three species of deer in the Yucatán Peninsula. They are brownish with grey in some areas, especially the head (Emmons and Feer 1997). The white-tailed deer is apparently distributed across almost the entire Yucatán Peninsula, with the exception of the most populated

areas, near major cities. White-tailed deer are not classified as being at risk by the Mexican list of species at risk (NOM-059, Semarnat 2010), and are classified as Least Concern by the IUCN Red List (http://www.iucnredlist.org).

White-tailed deer is a very important species for the rural communities of the Yucatán Peninsula (Chap. 13) and despite being one of the most studied animals worldwide, it has been largely ignored by science in the Yucatán Peninsula, with only a handful of studies on diverse topics. For example, Mandujano and Rico-Gray (1991) studied the use of this species by the Mayan of the State of Yucatán and found that white-tailed deer were the most important game species for some Mayan communities there. They also found that hunters had five different methods to hunt white-tailed deer with *batida* (beat hunting) being the most common. In a 2-year study in the Calakmul region, Weber (2005) found that white-tailed deer are browsers, and that 70 % of their diet is comprised of leaves and stems year round, a high contrast to the more frugivorous brocket deer (*Mazama* spp). Also, white-tailed deer have the most diverse diet of the three deer species of the Yucatán Peninsula. Weber (2005) estimated that white-tailed deer were more common than brocket deer in agricultural and secondary forested areas. In addition, this author found that white-tailed deer was the most hunted of the three deer species in the Calakmul region, and provided the highest biomass of all species hunted in terms of kilograms of meat (Weber 2000).

In another study in El Eden Protected Area in the State of Quintana Roo, Gonzalez-Marin et al. (2008) found that white-tailed deer was the most abundant ungulate species with a density of 4.1–5.5 individuals per km^2. Reyna-Hurtado and Tanner (2007) found also that relative abundance of this species was higher in hunting and disturbed areas than in the Calakmul Biosphere Reserve; that white-tailed deer was a common species in secondary forest; and that they prefer low flooded forest in the hunting areas (Reyna-Hurtado and Tanner 2005). Weber (2005) found a much lower density, with 0.021 individuals per km^2, and did not observe variation in relative abundance between a community in which the deer were hunted and Calakmul Biosphere Reserve in the State of Campeche. These findings highlight the persistence of this species in highly disturbed areas, and its potential as a game species given a well-organized hunting and management plan that takes care to conserve populations.

Important information needed for this species for the development of management and conservation plans includes:

1. Movement ecology. It would be interesting to know how this species is able to move through and survive in highly disturbed areas, while minimizing encounters with hunters.
2. Population dynamics. As one of the preferred target species for hunters, this species is at risk of being overhunted despite its potential as a persistent species. We need to pay attention to its population status and any changes in that status, especially in highly disturbed areas in the State of Yucatán.

*10.2.5 Brocket Deer Species (*Mazama pandora *and* Mazama temama*)*

Brocket deer are known as *venados cabritos*, *cabritos* and *chac yuk* for the red brocket deer and s*ac yuk* for the gray brocket deer in Mayan. Brocket deer include two species in the Yucatán Peninsula, the gray brocket deer (which was formerly classified as *M. gouzabira* but was renamed *M. pandora*, Medellín et al. 1998, Fig. 10.1c) and the red brocket deer, formerly classified as *M. americana* (Weber 2005) but recently renamed *M. temama*, based on genetic and morphometric criteria that distinguish it from the former species (Bello et al. 2010). Brocket deer are small deer, 90–120 cm in length and weighing no more than 20 kg. *M. pandora* is slightly heavier then *M. temama;* the weight of 21 individuals of *M. pandora* from Calakmul Biosphere Reserve averaged 17.5 kg for females and 20.5 kg for males (Weber and Medellin 2010), while *M. temama* averaged 16.3 kg for adult males hunted in the Calakmul region (Weber 2014). Brocket deer are also a very important species for subsistence hunters, especially in the southern areas of the Yucatán Peninsula (Escamilla et al. 2000; Weber 2000). Red brocket deer have been subjected to sport hunting in recent years in some communities where sport hunting is allowed under the UMA (Units for Wildlife Management and Conservation) scheme (Weber et al. 2006; RRH pers. obs.).

Red brocket deer inhabit humid tall and medium forests, so their distribution covers only the southern portion of the Yucatán Peninsula and extends to the north of the peninsula along the eastern forest reaching the coastal areas of Quintana Roo (Gonzalez-Marin et al. 2008). The gray brocket deer better tolerates dry areas and is a common inhabitant of most of the peninsula, although no signs of its presence (nor that of the red brocket deer) was found in a study carried out in the coastal ecosystems of the north of the Yucatán Peninsula (Hernández-Pérez unpubl. data). The gray brocket deer is a species endemic to most of the Yucatán Peninsula and the northern areas of Guatemala and Belize (Medellín et al. 1998; Weber et al. 2008). Red and grey brocket deer are not classified as at risk by the Mexican list of species at risk (NOM-059, Semarnat 2010), though the red brocket deer is classified as Data Deficient and the grey brocket deer as Vulnerable by the IUCN Red List (http://www.iucnredlist.org).

Brocket deer are small, shy animals that live in well-conserved forest rarely seen in disturbed areas (Reyna-Hurtado and Tanner 2005), although grey brocket deer can be found in forests with some degree of disturbance, especially in the north of the Yucatán Peninsula (RRH, S. Calmé pers. obs.). These facts make them difficult to study. The home range for the gray brocket deer was preliminarily estimated at less than 50 ha for a single animal during a three-month follow up (Weber and Reyna-Hurtado unpubl. data). Weber (2005) in an in-depth study on the feeding habits found that the gray brocket deer was a generalist, while the red brocket deer was a specialist, with more fruits consumed than the gray brocket deer and the white-tailed deer. This author found that gray brocket deer switch from frugivory to

browsing during the year while red brocket deer specialize in fruits year-round (Weber 2014).

Estimates of the abundance of brocket deer using tracks are difficult to obtain because it is almost impossible to distinguish between the tracks of the two species. Some estimates of density using transects are between 0.90 and 1.5 deer/km^2 for both species of *Mazama* for the Calakmul region (Weber 2005). For El Eden, a protected area in the northern Quintana Roo, an estimate of 1.7 deer/km^2 was found for the two species combined (Gonzalez-Marin et al. 2008). In the Calakmul Biosphere Reserve, Reyna-Hurtado and Tanner (2007) found that brocket deer signs (again, the combination of tracks of the two species) were the most abundant of all ungulate species and that relative track abundance did not vary between hunting sites and the Calakmul protected area. The same authors also found that tracks of brocket deer were the most abundant tracks in dry forest of the protected area and that dry forest was used disproportionately for these species, while in the hunting sites the low flooded forest was used disproportionately (Reyna-Hurtado and Tanner 2005). The question remains as to which species is responsible for these habitat preferences, or whether low flooded forest could merely serve as refuge in hunted areas (see Chap. 13 for vegetation types used by hunters).

The research priorities for these two species include:

1. Population dynamics. The impact of hunting activities and deforestation on the population of the two species would be the most important information for conservation purposes.
2. Movement ecology. Home range size and movement patterns need to be investigated for both species in the protected areas and in sites with a high rate of hunting. If there are major differences in these variables between these two site types, it will have conservation implications, as we can assess the impact of human activities on the species.
3. Habitat use. Habitat preferences at the species level are needed to elucidate the differences between the species in the Yucatán Peninsula, the only place in the world where the two species live sympatrically. It would also be valuable to determine whether habitat preferences vary based on hunting regime.
4. Distribution. It is crucial to delimit the distribution range for the two species at the scale of the Yucatán Peninsula.

10.3 Carnivora

*10.3.1 Jaguar (*Panthera onca*)*

The jaguar is known in the Yucatán Peninsula as *tigre*, *onza* or *balam* in Mayan. This felid is the largest terrestrial predator in the Neotropics. It is unmistakable given its size and yellowish fur covered with black circular spots. The jaguar is the third largest cat in the world, with a length of 110–180 cm and a weight of 31–158 kg,

with heavier individuals inhabiting open areas of Brazil (Emmons and Feer 1997). In the Yucatán Peninsula the average weight is 54 kg for males and 44 kg for females (Chávez 2010). The jaguar is listed as Endangered by the Mexican list of species at risk (NOM-059, Semarnat 2010), and as Near Threatened by the IUCN Red List (www.iucnredlist.org). The jaguar has been used as a charismatic species in the arguments for the conservation of the Mayan jungle, including issues such as impacts of road construction, the creation of biological corridors, and the impacts of infrastructure construction (Conde et al. 2010).

Research in the Calakmul region (southern Campeche and Quintana Roo) on feeding patterns and prey availability showed that jaguars prey on 76 % of the mammal species present in the area (Amín et al. 2004). Analysis of scats found prey belonging to 15 species of mammals, mostly weighing over 1 kg. The dominant prey in that area were coati (*Nasua narica*), white-tailed deer, collared peccary, and armadillo (*Dasypus novemcinctus*) (Chávez et al. 2011). The jaguar is opportunist in its choice of prey, except for collared peccary (*Tayassu tajacu*), paca (*Cuniculus paca*), and armadillo (*Dasypus novemcinctus*), on which it appears to feed selectively (Chávez et al. 2011; Chávez 2010).

Subsistence hunters in the Calakmul region compete heavily with jaguar for the same prey, because considerable overlap occurs between felids and local residents' hunting areas (Escamilla et al. 2000; Chávez et al. 2007, 2011; see Chap. 13 for list of hunted species). Some studies have documented a direct impact on jaguar population size and density, as well as that of other species, as a result of declining prey numbers (e.g. Peres 1990). In extreme cases, mature forests may not harbor large animals due to removal by hunters, a condition known as "empty forest syndrome" (Redford 1992).

In the Calakmul region, jaguars are mainly crepuscular and nocturnal; they prefer sites with good forest cover near water bodies or riparian habitat (Chávez 2006, 2010). In a 7-year study focused on wildlife associated with ponds in the Calakmul Biosphere Reserve using motion-triggered trap cameras, Reyna-Hurtado et al. (unpubl. data) have found that four different male jaguars periodically visited the same pond, and a single individual travelled to three different ponds in an area of approximately 20 km^2. The same researchers have found that jaguars visit ponds on a regular basis, and that the rate of these visits has remained constant since 2008.

Using GPS collars on jaguars, movement pattern estimation showed that they could move up to 20 km in a single night in search of prey, and that home ranges differ between males and females. In Calakmul, a male jaguar had an active range of 700 km^2; in contrast, females moved in areas of 180 km^2 (Chávez 2010). In El Eden Ecological Reserve a radio-collared male ranged across 800 km^2 (M. Lazcano and CC pers. obs.).

Jaguar's habitat use has been assessed using geographic information systems (GIS) and radio telemetry data in the Calakmul Biosphere Reserve. Jaguars favored medium semi-evergreen forest (60 % of the time), followed by tropical deciduous forest (25 %). These results were similar between males and females (Chávez 2006, 2010). In Ejido Caoba, Quintana Roo, jaguars used medium semi-evergreen forest

(49 %), followed by low semi-evergreen forest (25 %); usage rates by males and females were also similar (Chávez 2010).

Zarza et al. (2011) studied the habitat preferences and the use of human-transformed areas in radio-collared jaguars in the southern Yucatán Peninsula. He found that jaguars mostly ranged in areas far from human population settlements (at an average distance of 6.5 km) and roads (4.5 km). This analysis also showed that there were strong differences in habitat use between males and females, though both sexes preferred tall forests and avoided swamps and secondary vegetation. Males avoided low forests, while females used them according to their availability. In some instances, males used farmlands and grasslands less frequently than females (Chávez 2010; Conde et al. 2010; Colchero et al. 2011). A recent study, using satellite telemetry, is focusing on jaguars' movements and the impact of a major new road in the northeast Yucatán Peninsula. Researchers are assessing detailed information on the impact of the new road and its effect on habitat use and connectivity (Mircea-Hidalgo et al. unpubl. data).

Jaguars and humans engage in conflict when felids prey on livestock such as cattle or sheep. This problem is most acute when there is no cattle management and stock range freely. Several strategies to reduce predator-livestock conflicts are underway, including a predator compensation fund for dead animals to discourage ranchers from killing jaguars (*Fondo de Aseguramiento* run by SAGARPA). This strategy is difficult to apply, due to a series of hurdles such as a lack of personnel and bureaucratic delays before the livestock owner receives compensation (S. Calmé et al. unpubl. data; D. Sima pers. comm.). Other strategies include workshops to improve livestock management and keep domestic animals in enclosures instead of allowing them to range freely. The jaguar-human conflict is far from being solved in the Yucatán Peninsula, and will require several strategies for wildlife and livestock management, including political will and scientific attention.

Densities of jaguars in the peninsula have been estimated by various methods (genetic fingerprint, camera trapping, and radio telemetry) and have yielded densities from 1 to 7 individuals per 100 km^2 (Aranda 1998; Ceballos et al. 2002; Chávez 2010; Chávez et al. 2011). For example, in a long-term study on jaguars in the Calakmul Biosphere Reserve and southern Quintana Roo, Ceballos et al. (2002) obtained a density of 3–7 jaguars per 100 km^2 using radio telemetry.

Some potential distribution models in the Yucatán Peninsula (Chávez and Zarza 2009) have showed that nearly half (57,294 km^2; 42 %) of the peninsula is suitable habitat for the jaguar. At the state level, the States of Quintana Roo (24,409 km^2) and Campeche (22,763 km^2), encompass the largest proportion of this habitat, with about 90 % of the total area, while the rest lies in the State of Yucatán (7814 km^2). Taking into consideration the three major vegetation types: tall and medium forest (65 %), medium forest (19 %), and low forest (16 %) it has been estimated that about 1850 individuals inhabit in the peninsula, which accounts for half of the total population in Mexico (Ceballos et al. 2011). It was also estimated, that jaguars are distributed proportionally, with most of the individuals (84 %) in the Yucatán Peninsula dwelling in high and medium forests (1550 individuals) and 16 % (300 individuals) in the lowland forests (Chavez et al. unpubl. data).

The Calakmul region comprises a little more than 14,000 km^2 and includes four protected areas (Calakmul, Bala'an Ka'ax, Balam Ku and Balam Kin). It has an estimated population of 700 jaguars, the largest population in Mexico, which make this region very important for the species. The region is adjacent to the Maya Biosphere Reserve of Guatemala and Rio Bravo-Dos Milpas in Belize, which together encompass an extensive forest tract. They thus contain the largest estimated jaguar population in Mexico, and probably the largest population at the northern limit of the species' distribution.

In northern Yucatán Peninsula, the reserves of Ria Lagartos, Yum Balam, El Zapotal and El Eden Ecological Reserve harbor a population of around 200 individuals (Faller et al. 2007, 2011; Lazcano et al. unpubl. data). In the Yucatán Peninsula, population estimates have been based on criteria such as habitat size and quality, as well as spatial configuration. Six regional areas for jaguar conservation (ARCJ by its Spanish acronym) have been identified: (1) PY-ARCJ-Laguna-Centla Terms, (2) PY-ARCJ-Petenes-Palmar, (3) PY-ARCJ-Calakmul, (4) PY-ARCJ-Ticul-Bala'an Ka'ax, (5) PY-ARCJ-Sian Ka'an, and (6) PY-ARCJ-Dzilam-Yum Balam (CC unpubl. data). Those areas were selected based on their outstanding features and existing actions to conserve the largest populations within the limits of the species' distribution, together with Guatemala and Belize.

The Yucatán Peninsula is a crucial area for jaguar conservation in Mexico. Further scientific information is needed to develop conservation and management plans. Efforts must include:

1. Distribution and habitat change. Obtaining a detailed understanding of the jaguar's distribution range in the Yucatán Peninsula, especially in areas where it has not been intensively sampled, such as mangroves and lowland forests, is a priority. Additionally, the impact of changes in land use and its effect on the spatial distribution of the species must be assessed.
2. Population dynamics. The density and status of populations in the Mayan forest and in the coastal protected areas are necessary data for developing conservation plans, and for a monitoring program of jaguar and prey populations.
3. Corridors. Research in jaguars' use of existing corridors and determining connectivity areas between protected areas will be essential for the maintenance of the species.
4. Jaguar-Human conflict. Information on human-jaguar interactions and strategies to minimize conflicts is urgently needed to reduce losses to local residents' livestock, and prevent unnecessary killing of jaguars.
5. Movement ecology. Continuing investigation of home range and territoriality patterns will provide exciting insight on basic ecological aspects of the species that are only partially known at present.
6. Generate a regional strategy for jaguar conservation in the Yucatán Peninsula, in which various actors, institutions at different levels of government (ejido, municipal, state and regional), and other countries are involved. This strategy should be interagency and international, including especially Guatemala and

Belize, and could be made possible by reactivating the international program, "Jaguares sin Fronteras" (Jaguars Without Borders).
7. Strengthen the alliance, "Voice of the Jaguar", which connects jaguar conservation efforts by private and public reserves with natural protected areas.

*10.3.2 Puma (*Puma concolor*)*

The puma or cougar is locally known as *león* or *leoncillo* and is the second largest cat of America, after the jaguar. Pumas have a relatively small head and large tail; their fur is grey to reddish, and they reach 85–154 cm in length and weigh from 20 to 129 kg across their entire range (Emmons and Feer 1997). In the Calakmul region the average weight of eight males was 42 kg, and 38 kg for one female (Chávez and Ceballos 2014a, b). In the Yucatán Peninsula cougars are usually smaller than jaguars (Chávez 2010). Pumas have a wider distribution than jaguars: they inhabit temperate ecosystems across both American continents, from Argentina to Canada. Pumas show a flexible use of habitat, with records of the species from sea level to 4500 m a.s.l. (Emmons and Feer 1997). Due to their wide distribution, pumas are not included on the Mexican list of species at risk (SEMARNAT 2010) and are classified as of Least Concern by the IUCN Red List (www.iucnredlist.org).

Data on puma diets on the Yucatán Peninsula showed that they prey on 12 species of mammals, mainly *Cuniculus paca,* paca, followed by *Dasypus novemcinctus,* armadillo, and *Tayassu pecari*, white-lipped peccary (Chávez 2010). The same study found that they prey in equal proportion on *Dasyprocta punctata*, Central American Agouti, *Mazama* spp., *Pecari tajacu*, collared peccary, and *Odocoileus virginianus*, white-tailed deer (Chávez 2010). Pumas are common visitors of ponds within the Calakmul Biosphere Reserve (Reyna-Hurtado et al. unpubl data). A monitoring program of wildlife associated with ponds has recorded pumas for seven consecutive years with a relatively consistent visitation rate that is higher than that of jaguars, although visits decreased in the last years of the study (Reyna-Hurtado et al. unpubl. data).

In a radio-tracking study at the Costa Maya site in Calakmul, Campeche, the active range over a 3-year tracking study of a female cougar was 108 km^2, and 135 km^2 for a male (Ceballos et al. 2002; Chávez 2006). Male cougars tend to use dry deciduous forest, while females prefer semi-evergreen forest (Chávez 2010). In a long-term study (2008–2012) in El Eden Ecological Reserve using camera traps, it was found that the puma used medium forest and trails, and were mainly nocturnal (Ávila-Najera et al. 2014a, b).

We are not aware of any study that focuses exclusively in pumas in the Yucatán Peninsula, although one animal has been recently radio collared in the area near Playa del Carmen and is currently being followed by a team of researchers (M. Hidalgo-Mihart pers. comm.). In Belize, another team has studied movement of jaguars and

pumas in a highly fragmented area in the central region of the country. Although the data are still unpublished, preliminary analyses suggest that home ranges of pumas are significant smaller than those of jaguars (O. Figueroa pers. comm.).

In the Private Reserve El Zapotal, Yucatán, the first photograph of a puma was taken in 2004 (Faller et al. 2007), and since then there has been a project to survey populations of jaguars and pumas in the area. A study on the effects of Hurricane Dean on the presence of carnivores in the ejidos X-Hazil and Felipe Carrillo Puerto found that jaguars were not present at the disturbed site but pumas were. In fact, pumas had a higher index of relative abundance in the disturbed site than in other four, non-disturbed sites (Hernández-Díaz et al. 2012). This highlights the puma's flexibility and ability to inhabit disturbed areas.

Cougar densities have been estimated using radio telemetry in an area of 3100 km^2 and it was extrapolated that perhaps 217 pumas inhabit the Calakmul Biosphere Reserve, and approximately 409 pumas may exist in the set of protected areas including Calakmul Biosphere Reserve, Balam Ku and Balam Kim State Reserves and Balam Ka'ax Protected Area (Chávez 2006). In El Eden Ecological Reserve, puma density was estimated at between 2.1 and 4.3 individuals per 100 km^2, using camera traps and spatially explicit models (Ávila-Najera et al. 2014a, b).

In the Calakmul Biosphere Reserve pumas have been observed in courtship during the dry season, and a den with two cubs was found in a seasonal pond in the middle of the reserve, also during the dry season (February–May) (J. Zuñiga pers. comm). There is not clear information on the role that pumas play in the human-large cat conflict due to livestock predation. However, pumas probably focus on different prey species than jaguars, and may prey on sheep or goats rather than calves or cows (CC pers. obs.). Attention needs to be paid to determine the role that pumas may be playing in human-large cats conflicts.

Important information needed on pumas include:

1. Distribution. We need to know precisely the current distribution of pumas, since there is not much detailed information on its distribution across the Yucatán Peninsula.
2. Population dynamics. The puma's population status on the peninsula is unknown, and little is known about variables that affect the population dynamics of the species. Ascertaining the basic parameters of this species in tropical forests is a priority. Population status information will be important for developing management and conservation plans for the species.
3. Movement ecology. Investigation of basic ecological issues such as home range, use of corridors, habitat use, and movement patterns is important for our knowledge of the species' spatial needs and use of connectivity areas.
4. Human-large cat conflicts. Is the puma responsible for livestock losses? Information regarding this point is important for preventing losses for local residents and reducing the unnecessary killing of pumas.

10.4 Primates

*10.4.1 Spider Monkey (*Ateles geoffroyi yucatanensis*)*

The spider monkey is one of the three primate species living in the Yucatán Peninsula; the subspecies *A. g. yucatanensis* is present in the forests of the region. Spider monkeys belong to the family Atelidae, and are the largest of the three species living in Mexico (Emmons and Feer 1997). In the area they are known as *mono araña*, *chango* or *Ma'ax* in Mayan [although see Stross (2008) for a set of names of monkeys at the Mayan archeological sites]. Spider monkeys have a distinctive prehensile tail and relatively long arms and legs in relation to their body and head. Their hair is long, with a dark brown and reddish color in the dorsal areas and white and yellowish color in the ventral areas. The size of the body ranges between 45 and 55 cm in length, but the tail alone ranges in length from 70 to 85 cm. Spider monkey can weigh up to 9.5 kg. This genus of primates has no thumb finger and females have a pink elongated clitoris (Napier and Napier 1967; Reid 1997).

Spider monkeys are diurnal primates inhabiting medium and tall tropical forests and feeding on fruits (Reid 1997). They also can live in dry or semi-dry tropical forest (Chapman 1990), and due to their specific feeding habits and habitat preferences, the presence of this species is used as an indicator of well-conserved ecosystems (Fedigan et al. 1988). Spider monkeys are social animals, forming territorial groups of from 8 to 78 individuals that during the day divide into small subgroups to forage (Fedigan and Baxter 1984; Nowak 1999; RRH pers. obs.).

Spider monkeys are inhabitant of the humid tall forest of the Yucatán Peninsula and their range is restricted to well-conserved forest of the southern areas of the peninsula, extending to the north through the humid forest of Quintana Roo (Ramos-Fernández et al. 2004) and the coastal ecosystem of the State of Yucatán (El Palmar State Reserve, E. Hernández-Perez pers. obs.), and Los Petenes Biosphere Reserve in northwest Campeche (Serio-Silva et al. 2006). Spider monkeys are listed as Endangered by the Mexican list of species at risk (SEMARNAT 2010) as well as by the IUCN Red List (www.iucnredlist.org).

Several studies have been conducted on spider monkeys in the Yucatán Peninsula. These studies detail their distribution (Serio-Silva et al. 2006; Vidal-García and Serio-Silva 2011; Vidal-García and Serio-Silva unpubl. data), and describe several localities where the presence of the species has been confirmed. These areas were localized in the southern and eastern areas of the peninsula and in some coastal ecosystems of the north of Yucatán and Campeche States (Vidal-García and Serio-Silva 2011; E. Hernandez-Perez and RRH pers. obs.). In another study about the movement patterns of this species in the north of the State of Quintana Roo, Ramos-Fernández et al. (2004) found that spider monkeys move through the landscape following a Levy walk pattern, a pattern consisting in several similar-size steps with occasional long steps that displace them to areas that have not been recently foraged (Viswanathan et al. 1996). This paper was the basis for developing

another study that confirmed the same pattern in the Calakmul Biosphere Reserve (R. Reyna-Hurtado et al. unpubl. data.). In a protected area of Quintana Roo State (Punta Laguna Reserve) several studies have been carried out on behavior, including group fission-fusion strategies, the site fidelity this species exhibits (Ramos-Fernández and Morales 2014; Ramos-Fernández et al. 2013) and the male-female behavioral relationship (Slater et al. 2009).

One study aimed at investigating ecological aspects of spider monkeys in Calakmul Biosphere Reserve determined that they have a home range of 1.18–1.80 km^2 using the fixed kernel method at 95 % for a large group of this species inhabiting the forest of the ancient city of Calakmul (Sarabia-Hernandez et al. unpubl data). This group of spider monkeys is one of the largest recorded, with a sighting of 78 individuals heading to sleeping sites one evening (RRH pers. obs.).

Velázquez et al. (unpubl. data) investigate the impact of logged forest on patterns of seed dispersal. They found more types of seeds, and larger quantities, being dispersed by a community of spider monkeys living in unlogged forest than another community living in a logged forest of the Calakmul region, although the differences were not significant. However, it was shown that despite these findings, spider monkeys also disperse large quantities of seeds in logged forests. The same authors found that spider monkeys used significantly larger and taller than average trees as sleeping sites, and that some of the tree species being used as sleeping or feeding sites (*Diospyros* spp*, Bucidas buceras, Manilkara zapota, Swietenia macrophylla, Ficus* spp.) are subject to logging pressure by local residents. Velázquez et al. (unpubl. data) found 34 species that spider monkeys feed on, with *Diospyros*, *Cryosophila argentea, Brosimum alicastrum, Manilkara zapota* and *Ficus* spp. constituting important parts of the species' diet.

Spider monkeys live under pressure as their specific habitat is disappearing wherever humans colonize new areas. In disturbed forest, spider monkeys generally remain in larger forest blocks, because the species is very sensitive to primary forest fragmentation (Sorensen and Fedigan 2000). The main threats to the species are the loss of primary habitat, subsistence hunting, and the capture of newborns as pets or for circuses (Muñoz et al. 2008). Spider monkeys, in contrast to howlers (*Alouatta* spp.), do not tolerate fragmentation well and are generally absent from highly disturbed areas (Serio-Silva et al. 2006). In addition, in some sites, females with newborns are hunted to capture their offspring, so the juveniles can be sold on the black market as pets. This practice, although uncommon, is still practiced in some areas of the southern ejidos of Campeche and Quintana Roo (RRH pers. obs.).

The risk of disease and parasite transmission as well as human impacts on the stress level of spider monkey was studied by Deveaux (2014) in six groups of wild spider monkeys subjected to different levels of human contact. Deveaux (2014) found that increased blood cortisol levels corresponded to increased levels of human disturbance, and that multiple parasite infections as well as the intensity of the infections (number of eggs per gram of feces analyzed) had a direct positive relationship with degree of human disturbance (Deveaux 2014). This study showed that humans could affect spider monkeys via their presence for ecotourism, for

example, the best conserved area in terms of tree coverage (the Calakmul archeological city) was also the area where spider monkeys presented the highest intensity and diversity of parasites (Deveaux 2014).

Research priorities for spider monkeys in the Yucatán Peninsula must include the following issues:

1. Distribution. An update on the species' distribution and the shifts or changes that have occurred in the last 10 years would be a very informative study.
2. Population dynamics. Monitoring the status of the spider monkey population and the groups living in areas subjected to hunting and logging will be essential to developing informed conservation plans.
3. Movement ecology. There are several aspects of movement that have not been explored in this species, such as the relationship of group size and movement patterns, or the movement of groups in highly disturbed areas where they still survive. There is no information on the use of corridors by this species. Therefore we know nothing about its dispersal between protected areas of the Yucatán Peninsula.

*10.4.2 Black Howler Monkey (*Alouatta pigra*)*

In the Yucatán Peninsula, black howlers are known as *mono aullador* or *saraguato,* or *ba'atz* in Mayan (J. Serio-Silva pers. obs.). The black howler is one of two species of howlers living in Mexico, and is the only one that inhabits most of the peninsula. In fact, the Yucatán Peninsula encompasses the majority of its world distribution, as this species lives only there, in the eastern parts of the States of Chiapas and Tabasco, and the northern forest of Belize and Guatemala (Emmons and Feer 1997). Black howlers are large, massive monkeys with entirely black bodies. The males have a large hyoid bone that they use to produce their characteristic howl. Black howlers' length varies from 52 to 63 cm and larger individuals, usually males, can weigh 9 kg, (Emmons and Feer 1997). Black howlers are listed as Endangered both by the Mexican list of species at risk (SEMARNAT 2010) and by the IUCN Red List (www.iucnredlist.org).

Black howlers prefer humid, tall, and well-conserved forest. However, they are tolerant of forest fragmentation and can survive in highly disturbed forest (i.e. Balancan Forest, Tabasco State; Pozo-Montuy et al. 2011; Serio-Silva et al. unpubl. data) better than spider monkeys. Black howlers inhabit different types of habitat, from semi-dry tropical forest to tall humid tropical forest and riparian vegetation (Cuarón et al. 2008; Marsh et al. 2008). They have been reported even in eucalyptus plantations, which demonstrates their great ecological flexibility (Bonilla-Sánchez et al. 2012). Black howlers are diurnal animals that live in the medium and upper strata of the forest and are generally considered folivorous, although they show high preference for fruits (Pavelka and Knopff 2004; Rivera and Calmé 2006).

In the Yucatán Peninsula black howlers are found in the forest of the southern protected areas, such as the Calakmul and Sian Ka'an Biosphere Reserves, and the communal forests that surround them, as well as in coastal ecosystems such as the Laguna de Términos Protected Area and Los Petenes Biosphere Reserve in Campeche State. Although black howlers tolerate forest fragmentation well, it is evident that this activity strongly impact populations of this species. There have been several documented cases in which howlers were hunted by domestic dogs, burned to death when ranchers set fires to convert forests into grasslands, or hit and killed by cars when crossing highways (G. Pozo-Montuy and JCSS pers. comm.).

Black howlers live in cohesive groups of 6 to 12, generally with a dominant male and two or three females, some subadult males, and newborns. In 158 groups of black howlers sighted in a survey of the entire Yucatán Peninsula, Serio-Silva and collaborators (2006) found an average of 5.5 and 6.4 individuals per group in Campeche and Quintana Roo State respectively, while the single troop found in Yucatán State had six individuals (Serio-Silva et al. 2006).

Black howlers are territorial and occasionally patrol the area, sometimes facing off against neighboring groups, although the fights consists of prolonged howling by both sides (K. Rizzo pers. comm.). Home ranges of groups of black howlers are significantly smaller than those of spider monkeys. For example, a study in Calakmul Biosphere Reserve found that over 8 months howlers' home range varied from 0.08 to 0.15 km^2 for two troops (estimated with the fixed kernel method; Hernández-Sarabia 2013). Rizzo studied 4 groups of black howler monkeys during the rainy season over 10 years and found similar home range size. Additionally, the same author found that black howlers show great site fidelity, and their home ranges shifted only slightly during these years (K. Rizzo pers. comm.).

In the most recent study about current distribution of *Alouatta pigra* (Vidal-García et al. 2015) for the State of Campeche, it was notable that black howler monkeys share their geographic range with *A. geoffroyi* (n = 37). This situation is likely because this is one of the sites with the largest extents of tropical forest (39 % of Campeche's territory is protected, Arguelles-Suarez et al. 2007), an area including the Calakmul Biosphere Reserve and the Laguna de Términos Protected Area. These two areas are without doubt of high importance for fostering the conservation of primate species in the Yucatán Peninsula. In the State of Quintana Roo, new data on *A. pigra* presence has been documented in sites with medium semi-evergreen seasonal tropical forest at the Sian Ka'an Biosphere reserve, and towards the western portion of the Calakmul Biosphere Reserve. Due to its location, this entire area is regularly impacted by natural phenomena such as hurricanes, which diminish habitat and food supply for primates (Pavelka et al. 2003, 2007). It is also relevant that the presence of the species was recorded in the northern portion of the State of Yucatán (Kantunilkin and Tizimin municipalities), in zones of high evergreen rainforest and low semi-evergreen seasonal rainforest (Durán-García and García-Contreras 2010). However these areas are especially vulnerable, as ranching and agriculture are the predominant land use activities (López-Castillo 2012).

Despite black howler monkeys status as the most studied species of primate in the Yucatán Peninsula, we still lack information on the following issues to assure the development of informed conservation and management plans for this species:

1. Population dynamics. The status of some populations are unknown, especially those in coastal ecosystems and highly fragmented areas. We do not know how many individuals are killed every year due to forest loss, road crossings, fires, or hunting.
2. Corridor use. Black howlers' potential use of corridors has been studied in Balancan, Tabasco State, but we need to obtain information from many areas about dispersal distances and the best design for a corridor, in order to design areas of connectivity among fragments with black howler populations.
3. Ecological interactions. The species' use of space and resources is a topic that has received scientific attention, but needs more research, as we still do not know if black howlers suffer from interspecific competition with spider monkeys as some observations suggest (Plante et al. 2014) or with mantled howlers (*Alouatta palliata*).
4. Distribution. There is a lack of knowledge of the species in Yucatán State, including whether or not there are viable populations in coastal ecosystems or in the forest that remains in the southern cone of the state.

10.5 Conclusions and Future Research Directions

The Yucatán Peninsula is a region that maintains large pieces of forest in good status of conservation. These forests are the hope for the conservation of large Neotropical fauna that need proportionally extensive habitat to maintain viable populations. In this chapter we have reviewed what is currently known about the ecological aspects of a set of ten species that encompass all large mammals of the Yucatán Peninsula, and are the largest of the Neotropical fauna found in Mexico. Although there are important and substantive advances in the knowledge of ecological relations and behavior of some of these species there is still much to do in terms of research with a focus on conservation goals. One issue, for nearly all species reviewed here, is the need to investigate the degree of human impact on populations. All kind of human activities are taking place in the forest daily: timber extraction, fires, forest fragmentation, hunting, pollution, and tourism, and we lack of information on how these activities are impacting wild populations of large fauna. For example, the synergistic effects of subsistence hunting associated with sport hunting is having a large impact on endangered species, for example the almost complete elimination of groups of white-lipped peccary in some communal forests surrounding the Calakmul Biosphere Reserve (Reyna-Hurtado et al. 2010). Also, in other instances, human impact can be subtle at first glance, as in the finding that tourism and human presence may have a large effect on cortisol level and parasite intensity in spider monkey populations, even in places where forest cover

remains largely intact (the archeological zone of the ancient city of Calakmul; Deveaux 2014).

Another research focus that was highlighted as a priority was movement ecology. The fact that many of these species have large home ranges and high dispersal abilities presents unique opportunities to design research aimed at learning the extent of their movements, their home range, and defining or redefining what is known about their habitat preferences. While these topics are themselves exciting subjects of research, they also provide important information to assess the extent of areas that need protection if we want to conserve a viable population of a species. We also need to know how animals disperse, and what characteristics a potential corridor must have to function effectively for different species.

One pattern that was also consistently observed was that many species inhabit large protected areas (mainly in the southern areas of the States of Campeche and Quintana Roo), and there is an increasing risk of populations becoming isolated if connectivity among these protected areas is not maintained. Road construction, the expansion of cattle-ranching areas, and the establishment of monocrop agriculture (such as African oil palm) are threatening this connectivity in the Yucatán Peninsula. Isolation of populations of any species is not the best scenario for conservation at any level.

In summary, the Yucatán Peninsula is an amazing region that still hosts populations of large fauna. Jaguar, puma, deer, tapir and herds of peccaries still roam in the forest floor while primates find their way through the canopy. However, the entire region presents serious challenges to the maintenance of forest cover, forest connectivity, and to the continued intact functioning of ecological processes. We must assure that human communities living in the area meet all their basic needs without depleting forest resources and the species that live on them. This challenge is becoming urgent to attend as forests are being transformed every day. The task is one that needs to be tackled by all sectors of society: academia, NGOs, rural communities and governmental institutions all need to work closely to address these challenges. If we achieve these tasks successfully, we will assure that future generations can be amazed by the sighting of a jaguar or a puma, by observing a herd of white-lipped peccaries or a tapir visiting a pond, or by watching a spider monkey traveling on the trees, while howler monkeys are howling at the distance.

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