HUNTING EFFECTS ON THE UNGULATE SPECIES IN CALAKMUL FOREST, MEXICO

By

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A THESIS PRESENTED TO THE GRADUATE SCHOOL
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To Edith who shared with me the joy of living in Calakmul, among simple and lovely people.

To my parents who taught me to love nature and simple things and who always worked hard to see their sons happy.

To Maria Jose whose brief existence makes us stronger than before.

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Ungulates are among the preferred prey species for subsistence hunters in the neotropics. The Calakmul region is a tropical forest in southern Mexico that includes a 723,815 ha Biosphere Reserve where no hunting is allowed and several communal lands where hunting activity does take place. The effect of hunting on an ungulate community was studied in Calakmul. Tapir, white-lipped peccary, collared peccary, two species of brocket deer and white-tailed deer were the focal species.

Relative abundance of ungulates was obtained by counting signs along transects in three hunted sites and a non-hunted site. Also, a comparison of white-lipped peccary group size in hunted and non-hunted sites was conducted using direct observations and surveys of hunters. Finally, ungulate signs were related to the forest type where they were found and differences in forest use versus availability between hunted and non-hunted sites were accounted for.

A total of 2169 ungulates signs were obtained along 206.14 km (n= 90 transects) divided into the four sites. Relative abundance for the species was estimated by a sign encounter rate (SER) calculated as the number of signs encountered per km of transect. No differences in the SER of ungulates as a whole were found between hunted and non-hunted areas. Brocket deer SER was similar in hunted and non-hunted areas. SER for both species of peccary was higher in the non-hunted area, while SER for white-tailed deer and tapir was higher in hunted sites.

Very few white-lipped peccary groups were directly observed (n=8) or reported by local hunters (n=14). White-lipped peccary group size averaged 20 individuals. However, group size was higher in the non-hunted area (28, n=7) than in the three hunted sites (16, n= 15).

Ungulates in the non-hunted sites visited all the forest types with a similar frequency as their respective availability. In the hunted areas a major selective use of low-flooded forest was found.

Hunting activity affects the ungulate species in Calakmul differently. Brocket deer, white-tailed deer and possibly collared peccary can support hunting and are possible candidates for management programs. White-lipped peccary and tapir need immediate conservation plans developed for the hunting areas.

CHAPTER 1
INTRODUCTION

Conservation in Neotropical forest is a serious challenge. During the last 50 years, the rate of wildlife habitat loss has increased worlwide (Robinson and Bennett 2000). Forests are being transformed mainly into agricultural fields and cattle ranching in the tropical areas of America. Areas that still conserve tree coverage have been severely perturbed through the extraction of many products, among them the wildlife by hunting activity.

Hunting is one of the most serious threats for wildlife in Neotropical forests. Some conservative estimates report that 14 million animals are harvested each year from the Brazilian Amazon region alone (Robinson and Redford 1991; Alvard et al. 1996). At the same time, hunting is one of the most important components of the subsistence strategies for several human groups in Latin America and has been present for many years (Smith 1999). People rarely hunted in a way that brought extinction to species during the past. At the present, local extinctions have become more frequent, when traditional people have adapted to a new modern technology and suffered external pressure from the market (Bodmer et al. 1997b)

Hunting is an activity that is practiced by indigenous as well as non-indigenous groups in Latin America. In Mexico *mestizo* (non-indigenous) groups that have recently colonized new areas in the humid tropics, are responsible for an important amount of wildlife extraction in those areas (Jorgensen 1998; Escamilla et al. 2000; Weber 2000; Naranjo 2002). Large vertebrates are often the most valued prey for hunters and are also the most affected species when the hunting pressure is high. Among large vertebrates, ungulates represent one of, if not the most valuable, group of animals that account for the majority of meat for subsistence hunting in Latin America (Robinson and Redford 1991).

Ungulate, which is not a taxonomic term, refers to those mammals that have hooves; it includes two real taxonomic orders, Artiodactyla and Perissodactyla. The first order includes mammals with even number of toes, e.g., deer, peccaries, antelopes and bovines, Perissodactyla includes mammals with odd number of toes, e.g., rhinos, horses and tapirs.

Deer (Cervidae), peccaries (Tayassuidae) and tapir (Tapiridae) are Neotropical ungulates, and they account for the majority of meat taken by several groups of hunters. Mena et al. (2000) found collared peccary (*Pecari tajacu*), tapir (*Tapirus terrestris*) and red brocket deer (*Mazama americana*) as the second, third and fifth place in order of importance for Huaorani hunting groups in the Ecuadorian Amazons. Two peccary species collared peccary (*Pecari tajacu*) and white-lipped peccary (*Tayassu pecari*) also were the second and third (species) most hunted just behind the woolly monkey (*Lagothrix lagothricha*) for the Siona-Secoya in the Ecuadorian Amazon (Vickers 1991).

In four study sites at the Peruvian Amazon, Bodmer et al. (1997a) found that the two species of Amazonian peccaries account for 15 to 60 % of the total number of individuals of mammal species hunted. White-lipped peccary has been described as the principal game species for several groups, and several calculations of meat consumption place white-lipped peccary and collared peccary in first place for the Yanomamo (Venezuela-Brazil) and the Siona-Secoya (Ecuador) groups (Donkin 1985). Another study of 430 families in the Lower Ucayali (Peru) revealed that, of the meat obtained for terrestrial animals, white-lipped peccary accounted for the majority followed by collared peccary (Donkin 1985).

Peccaries also are the favorite game species for the Siriono (Bolivia), the Bororo and Chapacura (Brazil-Bolivia), the Campa (Peru), the Akwe-Shavante, Caraja and Caingang groups (Brazil), and peccaries accounted for 60 % of the weight of the total harvest animals for an Achuara-Jivaro community in Ecuador over a one month period (Donkin 1985). Naranjo (2002) studied three communities in the Lacandon Forest (Mexico) and found ungulates to be the most important group for subsistence hunting. Red brocket deer (*Mazama americana*) was highest in total biomass, followed by white-tailed deer (*Odocoileus virginianus*), collared peccary (*Pecari tajacu*), tapir (*Tapirus bairdii*) and white-lipped peccary (*Tayassu pecari*). Quijano (2001) found collared peccary to be the most hunted mammal in the *ejido* Tres Reyes in the Quintana Roo State (Mexico).

In the Calakmul region in southern Mexico there are six living species of ungulates, three deer species: the red and gray brocket deer (*Mazama americana* and *M. pandora*) and the white-tailed deer (*Odocoileus virginianus*); two peccary species: collared peccary (*Pecari tajacu*) and white-lipped peccary (*Tayassu pecari*); and the Central American tapir (*Tapirus bairdii*).

White-tailed deer, collared peccary, two species of brocket deer (*Mazama americana* and *M. pandora*) and white-lipped peccary, account for the first, second, third and fifth place in meat yield for a *mestizo* community in Calakmul Mexico (Weber 2000). Escamilla et al. (2000) found that, for four communities for the same area (Calakmul

Mexico), white-tailed deer, brocket deer and collared peccary provide 35 % of the meat obtained for subsistence hunting.

The Calakmul region is a tropical forest located in the south-central part of the Yucatan Peninsula in Mexico (see Map 1 in Appendix 1). It was the home of ancient Mayan groups who left the area around the 900 A.D.ath the end of the classical Mayan period. Between that time and the middle of the past century, Calakmul was sparsely populated with just a few human settlements. In 1940's the colonization of the area began with the creation of the Zoh Laguna village as a center for logging operations and a base-camp for the extraction of the *chicle* gum (Ericson 1997).

In the 1970's the Mexican government encouraged the colonization of the "last frontier" in Mexico: the humid tropics, Calakmul as well as other parts of Mexico's tropical forests, received a big influx of people coming from the central and southern states of Mexico. This colonization process brought changes to the region, and formed a municipality, that presently includes 114 human settlements and an estimated population of 25,000 persons (SEMARNAP 2000).

In the 1989, the 723,185 ha Calakmul Biosphere Reserve (CBR) was created (by presidential decree). This reserve is the largest protected tropical forest in Mexico and is adjacent to the Mayan Biosphere Reserve in Guatemala and The Rio Bravo Conservation Area in Belize. Together these reserves form an unbroken tropical forest of almost 2,000,000 ha, which is among the largest tropical forests in Mesoamerica. This combination of protected area and relatively new human settlements, makes the Calakmul region very biologically interesting. Calakmul is one of the last places with populations of species (like jaguars, tapir, white-lipped peccary and king vulture) that need large areas of undisturbed forest to sustain healthy populations.

Because of all these characteristics, the Calakmul region as a whole presents a very interesting opportunity to study how humans have affected the wildlife species, especially with the hunting activity in a region that has both protected and intensive use lands.

Question and Objectives

My research focused on describing possible impacts that hunting may have on ungulate species in the Calakmul region. Specifically I sought to answer the following questions:

1. Does hunting activity influencing relative abundance of ungulate species in Calakmul? Is the effect the same for all species?

2. What is the impact of hunting activity on group size of the white-lipped peccary? Does hunting activity reduce group size in this species?

3. Are all the ungulate species using habitat in the same proportion as their availability in the hunted places and non-hunted areas?

In this project I attempted to estimate the effect of hunting activity on the ungulate species present in Calakmul region, by comparing their relative abundances gathered from indirect methods in protected (non-hunted) and communal (hunted) lands. This method has been successfully used by Fragoso (1991), Hill et al. (1997) and Fragoso et al. (2000). Also, I attempted to estimate the impact of hunting on group size of the white-lipped peccary, which exhibit a unique social behavior in ungulates by living in dense tropical forest. Finally, I estimated the forest types use of ungulate species and how it is correlated with its availability in hunted and non-hunted areas.

This thesis is divided into five chapters. The first chapter presents a general introduction, background and description of the study area and the human populations, the natural history of the species included in the research, as well as a description of the questions and objectives of the thesis. The second chapter focuses on estimating the effect of hunting activity on the ungulate species present in the Calakmul region. Estimating and comparing the relative abundance of the ungulate community and individual species among hunted areas and a non-hunted site addresses this objective. The third chapter estimaties hunting impacts on group size of white-lipped peccary. I evaluate and compare group size between hunted and non-hunted sites. The fourth chapter focuses on the use of forest types for the ungulates species in hunted and non-hunted areas. The specific objective was to estimate the relative abundance of ungulates in the four major forest types of hunted and non-hunted areas, and to compare the results with the specific forest type availability.

The fifth chapter presents general conclusions on the ecological conditions of the species and of the Calakmul region. My results are interpreted to formulate wildlife management and conservation strategies and discuss future research in a tropical forest region like Calakmul.

Calakmul Region Description

This study was conducted in the municipality of Calakmul in the southern state of Campeche, Mexico (See Map 1, in Appendix 1). TheCalakmul region is located in the southern-central part of the Yucatan Peninsula (19^{o} 15’, 17^{o} 45’ latitude north and 90^{o} 10’, 89^{o} 15’ longitude west). The region is mostly a semi-deciduous tropical forest mixed with lands cleared for the slash and burn agriculture. This form of agriculture is very common among the rural people of the Yucatan Peninsula, and also results in secondary-growth forests of different ages. The Calakmul region is characterized for the presence of the 723, 185 ha Calakmul Biosphere Reserve (CBR) that was established in 1989 by a presidential decree (SEMARNAP 2000).

History and Social Aspects

The Calakmul region was historically an isolated place where few human populations lived before the 1970's. The oldest town in the area is Zoh Laguna village that was formed in the 1940's as a logging center for processing timber and a head camp for the gum tappers parties. Groups of gum tappers traveled to different locations for periods up to 3 months to collect the gum from the *chicle* tree (*Manilkara zapota*), used in the fabrication of commercial chewing gum. The main transportation systems at that time were a few dirt roads, on which a 120 km trip to the nearest city took around 24 hours (Zoh Laguna Villagers Pers. Comm.).

By 1970, as a result of a new colonization policy by the Mexican government, the region was colonized by peasants coming from central and southern states of Mexico. Today Calakmul municipality has 24,295 inhabitants, originating from 23 Mexicans states. Most residents immigrated from the states of Chiapas, Tabasco and Veracruz. There are 114 human settlements in the municipality, all of them around the Calakmul Biosphere Reserve (Ericson 1997; SEMARNAP 2000). Today, two major roads are the main transportation routes with the larger cities on the Yucatan Peninsula (Campeche, Merida and Chetumal), plus a small airstrip located in the major town (Xpujil). The land tenure in the region, as well in most parts of Mexico, is mostly *ejidos*. Ejidos have communal lands owned by the entire village, and all the people have the same rights over the resources.

Ejidos Descriptions

Nuevo Becal

This *ejido* is one of the biggest *ejidos* in the Calakmul municipality. It encompasses 52,000 ha with 25,000 of these designated as forested. Sporting and subsistence hunting plus timber and non-timber extraction activities are allowed in the forested area. The Nuevo Becal *ejido* is located 30 km from the municipality head-town (Xpujil) on the northeastern side of the CBR. The population of 300 inhabitants includes 80 *ejidatarios* (family heads) and is comprised of peasants coming mainly from Veracruz, Tabasco and Campeche states. The main economic activities include agricultural (mainly maize and hot-pepper), the omnipresent cattle production, logging, and the extraction of non-timber products like *chicle*, *xate-palm* (a palm used as ornament in Europa and U.S.), mahogany seeds and subsistence hunting. In the last two years the *ejido* has been involved in a sport hunting enterprise with little success (Commissary Ejidal; Pers Comm.).

20 de Noviembre

This *ejido* is located 10.4 km east of Xpujil (the municipality head-town) and is on the southeastern side of the CBR area (lat.18° 39' W and long 89° 44' N). 20 de Noviembre encompasses 28,000 ha, 14,000 of which are designated as forested. It is comprised of Mayan families that came from Dzitbalche (north of Campeche) in 1969. The population has been stable, from 343 in 1990 to 328 in 1998 (Ericson 1997). The main economic activities include logging, *chicle* extraction, intensive agriculture (especially hot-pepper and maize), apiculture, and more recently an increasing tendency for cattle production (Ericson 1997). Hunting is a common practice of adult males and is an important source of animal protein for families. With the exception of one or two persons, almost all the hunters use the meat they obtain for self-consumption (Pers. Observ.). Subsistence hunting is practiced in all the forested areas with the exception of 1,000 ha that will be designated as a sporting hunting area in the near future (2002-2003).

Xbonil

The Xbonil *ejido* is located at the northwest side of the CBR and 70 km from the municipality head-town (Xpujil). This *ejido* encompasses more than 40,000 ha, of which 20,000 are designated as forested where subsistence and sport hunting is a common activity. The Xbonil population is around 490 (INEGI 1995). Of those approximately 80 are *ejidatarios* (family head). The family origin is mainly from Campeche state, but approximately 40 % of people came from Tabasco, Veracruz or Michoacan states. The main economic activities include agricultural, cattle ranching, subsistence hunting, and temporary jobs. There is an increase in young members (both sexes) migrating to the biggest and crowded cities in Yucatan Peninsula (Campeche, Merida and Cancun), where they can be hired in temporary jobs. Very recently a migration into the U.S. is becoming common among the young males (INEGI 1995; Reyna-Hurtado et al. 1999).

Calakmul Biosphere Reserve

The Calakmul Biosphere Reserve (CBR) was decreed in 1989 by the Mexican president and covers 723,185 ha of tropical forest, mostly medium semi-deciduous tropical forest. The CBR is comprised of two highly protected cores areas (north and south), which cover 248,261 ha of the total reserve. The CBR is the second largest protected area and the largest protected tropical forest in Mexico. Its importance for wildlife is enhanced because it lies adjacent to the great Maya Biosphere Reserve in Guatemala and the Rio Bravo Conservation Area in Belize. Together these reserves form a continuum of almost two million of ha of contiguous protected tropical forest, which is one of the largest protected tropical forests in Mesoamerica (Mexico and Central-America).

The CBR is bisected by a major east-west road (Chetumal-Escarcega). There are a few human settlements inside of the northern part of the protected area, but the majority of the *ejidos* are located outside to the west and east of the CBR. In the southern core area the access is limited to just one road that was opened in 1995. This road provides tourists access to the archeological ruins of the Mayan city of Calakmul that is located close to the south-central area that is 60 km from the nearest town. The southern area has been naturally isolated, no human settlements exist, and only gum- tappers, jaguar hunters and archeological looters lived temporarily in the region before it was decreed. Now there are two major check points on the only road and forest guards living there permanently all year round.

Geomorphology

At the Calakmul region is the highest physical part of the Yucatan Peninsula more than 380 m above the sea level, Calakmul can be considered a plateau settled on calcareous rocks (called *Karst*), where the rainwater dissolves the calcium carbonate and the water filters underground, forming subterranean rivers. The soils of Calakmul are mainly lithosols and rendzins with an average depth of 10 and 30 cm, respectively. Differences in the drainage capability of the rendzins are responsible for the formation of deep soils (60 cm) which can retain water seasonally, leading to the formation of low-flooded forests. These soils are regionally called *Ak'alche* in the Mayan language (Morales 1999).

Hydrology

The Calakmul region, as well as almost all the Yucatan Peninsula, does not have any large rivers. The majority of the water runs underground and only collects superficially in soil depressions (*cenotes*) or is naturally stored in small lagoons, regionally called *aguadas*. These *aguadas* play an important role in the landscape because they are the only water source during the dry season for many animal species. In the Calakmul Biosphere Reserve more than 3,000 *aguadas* have been identified (Garcia-Gil Pers. Comm.)

Climate

According to Köppen (modified by Garcia 1988) the Calakmul climate is classified as warm and sub-humid (Aw), with a mean annually temperature of 24.6^{o} C. There is seasonal summer rainfall, with an annual average of 1076.2 mm. A clearly demarked humidity gradient decreases from south to north and east to west.

Flora

The region is a mosaic of different kinds of tropical forest, ranging from low-deciduous forest in the north to tall-evergreen forest in the southeastern extreme. More than 1,600 plant species have been found in Calakmul, and this region contains more than 80 % of the entire number of species in the Yucatan Peninsula with 1,936 (SEMARNAP 2000). Of the different forest associations, four of the most important are:

Medium semi-deciduous forest

This forest type covers more than 50 % of the area. This is a forest where 25–50 % of the species are deciduous (loose their leaves seasonally). Tree height ranges between 15 and 25 m, and the dominants species are: *Swietenia macrophylla, Brosimum* *alicastrum, Lysiloma latisiliqua, Bursera simarouba, Cedrela odorata* and *Manilkara zapota.*

Low-flooded forest

This forest type covers around 25 to 35 % of the Calakmul area. It occurs on low-drainage soils called *Ak'alche* in the Mayan language. These forests are seasonally inundated and tree heights are 10 to 15 m. Characteristic species are *Haematoxilum campechianum, Bucida buceras, Metopium brownie, Manilkara zapota* and *Byrsonima bucidaefolia* .

Low semi-deciduous forest

A third common forest type present in the region is the low semi-deciduous forest, where trees average 15 m tall. Usually these forests are present in the slope of the hills or on the tops where there are many stones and dry soils. Among the species present there are *Bursera simarouba, Brosimum alicastrum, Guayacum sanctum, Lysiloma latisiliquia, Cedrela odorata, Vitex gaumery* and *Lonchocarpus xuul* (Pennington and Sarukhan 1998; Ucan et al. 2000).

General Fauna

Calakmul is a region with a high diversity of reptiles, birds and mammals. Fish are not well known, and only 18 species have been identified in the area. Sixteen species of amphibians and 50 reptile species have been reported for the Calakmul Reserve (Pozo et al. in press), and 286 birds' species have been observed in the area. Calakmul has 94 species of mammals. Although is not as diverse as other tropical forest in Mexico, Calakmul represents one of the last remaining natural areas for several species who need large amounts of habitat like tapir (*Tapirus bairdii*), white-lipped peccary (*Tayassu peccary*), jaguar (*Panthera onca*) and king vulture (*Sarcoramphus papa*), among others.

Regarding the ungulate population, Calakmul is one of the most diverse forests from southern Mexico. There are six species of ungulates, including the very recently renamed gray brocket deer (*Mazama pandora*) (Medellin et al. 1998), the red brocket deer (*M. americana*), the white-tailed deer (*Odocoileus virginanus*), two species of peccaries, the collared peccary (*Pecari tajacu*) and the white-lipped peccary (*Tayassu pecari*), and, the last Neotropical megafaunal element, the tapir (*Tapirus bairdii*) (SEMARNAP 2000).

Ungulate Species: Description and Research

Ungulate is not a taxonomic term. It is used to refer to mammal species with hooves. Ungulates include two recognized taxonomic groups, the Perissodactyla and Artiodactyla orders, which are mammals with and odd and even number of toes, respectively. Typical representatives of Perissodactyla include tapir, horses and rhinos. Artiodactyl representatives are deer, pigs, sheep, hippos, and all wild and domestic bovines.

My study focused on the six species of ungulates present in the Calakmul region of southern Mexico. The following description focuses on them:

Brocket deer (*Mazama americana* and *M. pandora*)

Other names. *Temazate, Mazate, Cabrito* (Spanish), *Yuk* (Maya).

Taxonomic classification. Class Mammalia, Order Artiodactyla, Family Cervidae.

Description. There are two species of brocket deer in Calakmul, the red brocket deer (*Mazama americana*) and the gray brocket deer (*M. pandora*). Brocket deer are Neotropical deer with all living members in America. They are small deer; average weight is 20-25 kg for both species. Pelage color is dark red for the red and dark-brown for the gray brocket deer (Weber 2000; Rojas-Flores 2001). Their front legs are shorter and the rump is rounded and higher than shoulders. Males have short straight, unbranched antlers.

Ecological features. No studies have been revealed the precise ecological differences between the species, however both species of *Mazama* are mostly frugivorous, however fungi, fallen flowers and browse are eaten when fruits are scarce. They favor the dense forest vegetation with abundant herbaceous understory. Brocket deer are both diurnal and nocturnal and are normally solitary animals. When resting they are camouflaged in the forest understory (Emmons and Feer 1990).

Distribution. The red brocket deer has a large distribution range from Central Mexico to Northern Argentina. On the Yucatan Peninsula, they only live in the south, and the CBR is the northern range of its distribution. Gray brocket deer are endemic to the Mayan forest, living only in all the Yucatan Peninsula, northern Guatemala and northeastern Belize (Leopold 1959; Emmons and Feer 1990).

Status. The status of the gray brocket deer is unknown as no relevant ecological studies have been made on it. Red brocket deer have received more attention, but mostly in other countries (Brazilian and Peruvian Amazonian). Currently data exist for the gray brocket deer population. Red brocket deer are listed in the Appendix III of CITES for Guatemala. Two studies in Mexico showed that brocket deer can survive some degree of hunting pressure and that they do very well in protected areas (Weber 2000; Naranjo 2002). However, Leopold (1959) pointed out that these species are inhabitants of dense forest, and they can be threatened by the advancement of the agricultural frontier and consequent forest fragmentation.

White-tailed deer (*Odocoileus virginianus*)

Other names. *Venado Cola Blanca*, *Venado Real* (Spanish), *Quej* (Maya).

Taxonomic classification. Class Mammalia, Order Artiodactyla, Family Cervidae.

Description. Body pelage is mostly light brown, with a gray-brown head. In general, they are bigger than brocket deer. The weight range is between 30–50 kg and males have large antlers, branched in mature animals. The tail has bright white hairs on the under surface, which is used as alarm signal for others deer.

Ecological features. White-tailed deer are mostly browser of herbaceous plants. They inhabit of a wide array of habitats from the arid semi-desertic shrubs in northern Mexico and the southern U.S. to the tropical forests in Central America. White-tailed deer favor forest clearings located near forest patches. This species benefits from perturbed forests where secondary growth provides several plant species to eat. This deer is mainly crepuscular, but can become entirely nocturnal when they are hunted. It is solitary almost all year, only seen with company during the reproductive season (Leopold 1959; Eisenberg 1989).

Distribution. White-tailed deer is a typical species of North American forests, and enters only in the northern part of South America. It lives from southern Canada to northern Bolivia. In the Yucatan Peninsula it is present in all forest types, even those closest to the bigger cities as Merida, Cancun and Campeche (Emmons and Feer 1990).

Status. The species is often common in several parts of its range of distribution, especially in North America. The status of the white-tailed deer is not very well known in the tropics, however several studies show that it benefits from the forest perturbations associated with human activities (Leopold 1959; Mendez 1984). Some local populations in Central and South America are at risk of extinction due to overhunting (Emmons and Feer 1990).

Collared peccary (*Pecari tajacu*)

Other names. *Puerco de monte, Puerco Fajado* (Spanish), *Kitam* (Maya).

Taxonomic classification. Class Mammalia, Order Artiodactyla, Family Tayassuidae.

Description. The collared peccary is a pig-like animal of the peccary family (Tayassuidae). It is the smaller of the peccary species, and head and body measure 940 mm. The average weight is around 20 kg. Body color is uniformly grizzly gray-black with a distinctive white collar from the top of the shoulder forward to lower cheek (Emmons and Feer 1990).

Ecological features. The collared peccary is a diurnal animal which forms groups up to 20 animals, usually 6-9; these groups often change in composition. Collared peccary lives in a broad array of habitats from the dry scrub of the Sonoran desert in northern Mexico and the Chaco in Paraguay to the Amazonian rainforest. They show a wide variety of diet strategies, from mainly frugivorous in rainforest to grazing and rooting in dry areas. They are easily seen around crops and become a big problem for some peasants, especially those who cultivate crops near forest patches. Collared peccaries are easy prey for hunters with dogs because they hide in cavities or logs when dogs are chasing them. They have an odor gland on their back, which is used to rub against individuals from the same group for recognition (Leopold 1959; Emmons and Feer 1990; Sowls 1997).

Distribution. Collared peccaries show the broadest distribution range of all peccaries, ranging from the south-central United States to northern Argentina. They are fairly common in many areas with well-conserved forest. They are not observed near large human settlements. In the Yucatan Peninsula they are found almost everywhere except close to large cities. (Leopold 1959; Emmons and Feer 1990).

Status. Collared peccary is on CITES Appendix II, and in some areas is intensively hunted for meat and hides in some areas, but in general, is not threatened (Emmons and Feer 1990).

White-lipped peccary (*Tayassu pecari*)

Other names. *Jabalí, Pecarí Labios Blancos, Saino, Hauilla, Senso* (Spanish).

Taxonomic classification. Class Mammalia, Order Artiodactyla, Family Tayassuidae.

Description. White-lipped peccary is the largest of the peccary species of Mexico. It is 1,100 mm. in body length, and the average weight is 25–40 kg. Their body color is brown-black with a distinctive white beard on the chest of adult individuals.

Ecological features. White-lipped peccary is a diurnal species, which forms the largest groups of ungulates in the Neotropical forest ranging from 20 to 300 animals or even more. The groups are very cohesive and remain together all year, traveling within sight of each other (Emmon and Feer 1990; Fragoso 1994; Fragoso 1998). Usually they travel long distances in non-predictable movements, moving in a line with and alpha male leading the group. Evidence of seasonal movements have been found for some places, however these movements are inside huge home ranges (Fragoso 1994). In other areas its presence is episodic and unpredictable (Bodmer 1990). The white-lipped peccary likes to wallow in muddy soils around water ponds and rivers, especially during the dry season. They are mainly frugivorous and can eat hard nuts not consumed by other species, e.g., *Buriti* palm (*Mauritia flexuosa*). White-lipped peccary as with collared peccary, are prey of great cats like puma (*Puma concolor*) or jaguar (*Panthera onca*), which often follow the herds, waiting for an opportunity to catch one. Small herds of WLP are seen in areas where they seem to be disappearing (Leopold 1959; Emmons and Feer 1990). This species shows little tolerance for humans and avoids or disappears quickly from highly populated areas when the habitat changes dramatically (Leopold 1959; Alvarez del Toro 1991; Sowls 1997).

Distribution. White-lipped peccary distribution once ranged from Veracruz (Mexico) to northern Argentina. However, this species has been reduced in its distribution range from several regions due to over hunting. In Mexico white-lipped peccary have disappeared from Veracruz, Tabasco and Yucatan states, and large healthy populations remain only in Chiapas, Campeche and Quintana Roo (Naranjo 2002).

Status. The white-lipped peccary is on CITES Appendix II, but its status is poorly known. In Central America and Mexico it is threatened by habitat destruction and overhunting. It is becoming extremely rare in Mexico since it is the first species to disappear when the humans colonize a new area. More than 40 years ago, Leopold (1959) pointed out the reduction in numbers and range of this species in Mexico due to habitat loss and excessive hunting (Leopold 1959; Emmons and Feer 1990).

Tapir (*Tapirus bairdii*)

Other names. *Danta*, *Anteburro* (Spanish), *Tizimin* (Maya).

Taxonomic classification. Class Mammalia, Order Perissodactyla, Family Tapiridae.

Description. The tapir is the largest terrestrial animal of the neotropics. The body length is over 2 m in some males with weight reaching 300 kg. Its long nose resembles a proboscis and distinguishes the tapir. Its body is dark-brown, often appearing entirely black in the forest.

Ecological features. The tapir is a solitary and crepuscular-nocturnal animal, which changes its behavioral habits from crepuscular to entirely nocturnal in places where it is hunted. The tapir has a low reproductive rate, producing a single young approximately every 2 years. It is basically a browser/frugivorous species and spends great amount of time consuming selected plant parts (Naranjo 2002). The tapir is an inhabitant of well-protected tropical forests and is frequently found close to water bodies during the day (Leopold 1959; Alvarez del Toro 1991).

Distribution. The Baird tapir originally occupied habitats from the Mexican state of Veracruz to Colombia, but now is restricted to patches of well-conserved forest along its distribution range. In Mexico it has been extirpated from the states of Tabasco, Yucatan and parts of Veracruz (Naranjo 2002).

Status. The tapir is a CITES Appendix I species. Habitat loss and overhunting are the biggest threats to its population. The tapirs appear to be very sensitive to human presence and along with the white-lipped peccary is among the first species in disappear when habitat becomes perturbed (Leopold 1959; Eisenberg 1989).

CHAPTER 2
UNGULATE RELATIVE ABUNDANCE

Introduction

Hunting is a subsistence activity practiced by several human groups around the world. In Latin America subsistence hunting is a very important activity that allows many families to gather high-quality protein to complement their diets. In the Neotropical forests, several indigenous groups and *mestizo* people who live in rural areas harvest millions of animals each year. In the Brazilian Amazon alone, 14 million animals are consumed annually and wild meat is often sold to obtain cash to buy other subsistence items (Robinson and Redford 1991).

The Mayan forest is not an exception. Several studies have shown that hunting is a current and important activity practiced by groups of indigenous and *mestizo* people within the Mexican states of Chiapas, Campeche, Yucatan and Quintana Roo (Weber 2000; Escamilla et al. 2000; Quijano 2001; Naranjo 2002), as well as in Guatemala and Belize (Baur 1998).

The impact of hunting on wild species is well understood; and there are evidences that high hunting pressure can deplete entire populations of wild animals, especially large vertebrates like ungulates, primates, large rodents and large birds such as curassows and turkeys (Fragoso 1991; Alvard et al.1996; Hill et al. 1997; Cullen et al. 2001).

Ungulates are among the preferred species for subsistence hunting because they provide large amounts of good quality meat. Tapirs, deer and peccaries can be considered among the top ten most preferred species of Neotropical subsistence hunters

(Leopold 1959; Stearman 1992; Hill et al. 1997; Bodmer et al. 1997b; Towsend 2000; Peres 2000). The impact of hunting on ungulate populations has been documented in several parts of Latin America. Bodmer et al. (1997b) found that for Amazonian mammals hunting effects are greater for species with long lives and low rates of increase. In Mexico and Central America few studies have been conducted on the topic. Fragoso (1991) studied the effects of hunting on tapirs in Belize and found lower relative abundance of this species in a hunted site compared to a non-hunted site. Weber (2000) found that brocket and white-tailed deer abundance in Calakmul decreased in a high hunting pressure site. Baur (2000) in the Peten forest in Guatemala reports that white-lipped peccary groups were found more frequently at larger distances from the village. Quijano (2001) found that white-lipped peccary are rare in sites closer to a village where hunting pressure is high in Quintana Roo state (Mexico). Naranjo (2002) found lower tapir abundance in hunted sites than in a protected site in the Lacandon Forest (Mexico). This author also found that white-lipped peccary were more abundant and white-tailed deer less abundant in the protected site.

Ungulates have a very important ecological role. They are the largest prey for top carnivores, the largest herbivore and frugivore in the tropical forests, and function as landscape engineers, which transform the soil and terrain in some areas (especially peccaries around water-bodies). The disappearance of ungulate populations can have specific consequences for other ecological processes. For example, they influence seed dispersal and seed germination for many fruit trees, and control some herbaceous populations which otherwise can grow in high numbers and affect the understory structure of tropical forests (Dirzo and Miranda 1991; Fragoso 1997).

The Calakmul region in southern Mexico is one of the last remaining tropical areas in Mesoamerica (Mexico and Central America) with large amounts of continuous habitat. Despite the presence of some jaguar-hunters, *chicle*-tappers and archeological looters, this region has remained almost undisturbed since the Mayans abandoned it 1,100 years ago. Calakmul is a mosaic of different forest types from low-dry to tall-evergreen tropical forest. In 1989, 723,185 ha were decreed as Biosphere Reserve and it was a very important step toward the conservation of many species that require expansive, undisturbed habitat. Calakmul Biosphere Reserve (CBR) is now the second largest reserve and the largest protected tropical forest in Mexico. Adjacent to the Maya Biosphere Reserve in Guatemala, together they represent the largest protected forest in Mesoamerica.

However, Calakmul has experienced colonization since 1970 as a consequence of a program supported by the Mexican government. Today a mosaic of social conditions and land tenures surround the CBR, and hunting as well as other extractive activities are common in the area (Reyna-Hurtado et al. 1999; Weber 2000; Escamilla et al. 2000)

What are the effects of the hunting on the populations of the different species of ungulates in the Calakmul region? To address this question I estimated and compared relative abundance of six ungulate species between three hunted areas and one protected area. I used the indirect method of signs counted in transects. For this chapter the null hypothesis states that there are no differences in the relative abundance of the ungulate species between hunted and non-hunted sites.

Methods

Study Sites

Relative abundance data for six species of ungulates were gathered in four study sites (see Map 2, in Appendix 1). Three sites (*ejidos*: Nuevo Becal, 20 de Noviembre and Xbonil) are classified as hunted sites and the forth site, Calakmul Biosphere Reserve (CBR) is a protected area without hunting since the 1980s.

Three *ejidos* were selected as hunting sites. The selection was based on four factors: presence of hunting pressure (Reyna-Hurtado et al. 1999; Weber 2000, Escamilla et al. 2000); a large amount of unfragmentated habitat (Nuevo Becal: 40,000 ha; 20 de Noviembre: 20,000 ha; and Xbonil: 40,000 ha; the fragmentation that is present is usually within a 5 km radius around the population center, these 5-km areas were avoided during data collection); nearness to the core area of the Calakmul Biosphere Reserve (CBR) (to avoid drastic changes in the habitat); and sufficient dispersion around CBR to allow treatments as separate and independent forests. Hunting activities on the three hunted sites have been previously documented (Reyna-Hurtado et al. 1999; Weber 2000; Escamilla et al. 2000).

Calakmul Biosphere Reserve (CBR) occupies over 700,000 ha of forest. Although the entire area is catalogued as a tropical forest, there are differences in habitat associated with a moisture gradient that increases from north to south and less clearly from west to east. To avoid possible influence from these habitat changes on the ungulate population, the three selected *ejidos* are dispersed enough to cover all the areas around the protected area.

The protected area selected for this study was the CBR southern core area, a 350,000 ha forest region with no imbedded human communities and no fragmentation.

Also, no hunting activity has been recorded in the last 15 years. In this study the CBR is considered the control site (without hunting), and the treatment sites (with hunting activity) are the three *ejidos*. In the same way each *ejido* is considered a replicate of hunting sites and normally all the results are presented as those obtained from CBR and the average of the three treatment sites.

Data Collection

Interviews

The main purposes for these interviews were to determine the locations where hunting occurred and the frequency of hunting trips (see Questionnaire in Appendix 2). I conducted the majority of the interviews. In the Xbonil *ejido,* I had a trained assistant who assisted me with the interviews.

A total of 87 interviews were made within the three *ejidos*: 30 in Nuevo Becal, 29 in 20 de Noviembre, and 28 in Xbonil. Approximately 30% of the adult male population was surveyed in each *ejido*. A random selection was made among males greater than seventeen years old and who had lived in the area for at least three 3 years before the interview date. These criteria were based on several studies (Reyna-Hurtado et al. 1999; Weber 2000; Escamilla et al. 2000), which indicated hunting in this region to be an activity of adult males. Those persons who indicated that they hunt were asked additional questions about the distances traveled to hunt and the actual places and forest types in which they hunted.

I used this information to determine areas with hunting pressure and the frequency of hunting visits. Also, some social-economic questions were included in the questionnaire, such as: number of family members, main economic activity and origin of the person surveyed.

Transects

Transects were used as the main method in this study to gathered data to address the first objective about relative abundance of ungulate species. Transects were straight lines cut in the forest. All the signs (hair, tracks, feces) for the six species of ungulates that were within a meter of each side of the center-line of the transect and that I was able to identify to species with confidence were recorded. The only exception to this rule was tracks of the white-lipped peccary. For this species tracks were counted as a groups of WLP instead of number of individual tracks. At the same time, when an individual of any ungulate was sighted, the species, behavior and sex (when possible) were recorded. In that moment, the angle and distance from the centerline of transects were measured using a compass and range finder, respectively. Weber (2000) used the same method to gathered relative abundance of three species of deer in some specific areas inside the Calakmul region. During three years of data collection he had 46 sightings of the three species combined. Because of this relatively low number of sightings, he used track counts to estimate relative abundance.

Few sightings of individuals were also obtained in my study as well, so all the analyses are based on number and frequency of signs encountered. As a product of transect data, a Sign Encounter Rate (n/km) was obtained by counting the number of signs registered for each species along each transect, divided by the length of the same transect. Fragoso (1991) found that tapir sign correlated with tapir abundance in Belize. Naranjo and Bolaños (2001) found that in 1,908 km of transects walked in the Lacandon Forest for 12 species, the Sign Encounter Rate was positively related with the population density (animals/km^2) and with the frequency of animal observations. Also, Weber (2000) did not found significant differences between track counts among different soils and weather conditions in three sites for the three deer species in Calakmul. Therefore, I assume that the Sign Encounter Rate (SER) is directly related to the abundance of the species and is a reliable method.

SER was used as an index to compare the relative abundance between hunted and non-hunted sites for the ungulate species in Calakmul. It is assumed that the home range and amount of daily movements for the separate species remain the same for both hunted and non-hunted areas.

Transect locations associated with the three *ejidos* were randomly plotted within areas previously selected based on the hunter interviews. Care was taken to avoid the highly fragmented areas, common around the population centers, and transects were plotted randomly within the forested lands in each *ejido*. In the non-hunted area (CBR), the natural features made it very difficult to locate transects far away from the only access road. Therefore, transect initiation points were randomly located along the only existing road, beginning 10 km inside of the CBR boundary.

Once the transect starting point was located, transect orientation was randomly selected for those associated with the *ejidos* and were oriented perpendicular to the road in the CBR. Locations were recorded for the starting and ending point of each transect using a GPS (Geo-Positioning System). Transects were cut into the forests in straight lines using a compass to check the direction. Transects were walked once each by two persons, an assistant and me. I had four different assistants, one for each site. All had lived their entire life in the area and had experience in recognizing tracks and other signs.

Ninety transects totaling 206.14 km in length were randomly located within the three hunted and one non-hunted areas (Table 2-1). Transects were of variable length, ranging from 1.21 to 4.22 km (with an average of 2.30 km). Most of the transects (n=53) were walked early in the morning between 7:00 to 12:00 am. The rest (n=37) were walked early in the afternoons, between 2:00 to 5:00 pm. All transects were walked between March and July 2001, which encompass the end of the dry season and two months of the wet season. The seasonal effect was controlled by sorting all the places and doing transects in one site, then going to different site and so on until all four sites were completed. When an entire cycle was completed I started again at the first site and continued with the consecutive sites. In this way, transects were completed almost at the same time (for the four sites), so the seasonal variation was similar across.

Table 2-1. Number and total length of transects per study site, Campeche, Mexico.

Sites	Hunted/ Non-Hunted	Number of Transects	Total Length of Transects (km)
Calakmul	Non-Hunted	28	56.58
Nuevo Becal	Hunted	24	69.97
20 de Noviembre	Hunted	20	45.05
Xbonil	Hunted	18	34.54

I collected all the transects data. Animal sign was identified based on my previous experience sampling transects and on the assistance of a local hunter/guide who accompanied me. A guidebook on the identification of Mexican wild mammals tracks (Aranda 1981) was also used.

The criteria used to identify the species varied with the individual characteristics of each species. Here I present, by species, the major features on which I based the sign identification when I collected the data.

Brocket deer. The brocket deer were most commonly identified by their tracks, which are 3.5 x 3.5 cm in size. Because of the similar hoof size of the two species, there was not a confident way to distinguish between red and gray brocket deer tracks. Therefore, brocket deer tracks were combined and are referred to as *Mazama spp*. However, brocket deer tracks can be easily distinguished from peccary tracks by the heart shape and sharp point characteristics of the deer tracks. Brocket deer tracks are generally smaller than those of white-tailed deer. Differences between juvenile white-tailed deer and brocket deer tracks some times can be tiny, however the sharper point of brocket deer tracks or the presence of adult white-tailed deer accompanying juveniles allowed me to distinguish between these two species. If in doubt, I registered it as a deer, and this record was not included in the analysis of either species. Other common signs were pellets and fresh marks left on small trees by the antlers. These marks are characteristics of male deer when they are removing the velvet from their antlers. Marks that were found between 10 and 30 cm off the ground were assigned to brocket deer, while higher antler marks were assigned to white-tailed deer.

White-tailed deer. The most common sign of this species was tracks that are easily distinguished by shape and size. They are 6 x 5 cm in size and also have a sharp point in the front. Their pellets are bigger than those of brocket deer, and I was accustomed to differentiating between them. The tree marks were also distinguishable from their height; white-tailed deer normally mark between 50 and 90 cm off ground. I had collected data on the deer species present in the region during the previous three years.

Collared peccary. Tracks of collared peccary are almost the same size of brocket deer, however they are rounded like those of the domestic pig. Hairs left from collared peccaries at wallowing sites were also an unmistakable sign of this species because of the characteristic color combinations (white, black and yellow).

White-lipped peccary. Signs of WLP are unmistakable because of the size of the track, 6 x 6 cm, and a very rounded shape. WLP tracks are not confused with white-tailed deer tracks because of the shape differences and also because large amount of tracks are left for a WLP group. Another feature is that WLP make big holes and dig out roots while they travel. Hairs are also unmistakable in this species by color (black), large size, and shape. WLP feces could not be distinguished of those from collared peccary, so they were not included in the analysis.

Tapir. The large tracks of tapirs (18 x 18 cm) and the three toes made the signs for this species unmistakable. Also, their feces are bigger and resemble those of horses. Additionally, tapir make larger paths in understory vegetation, making their signs the easiest to identify.

Statistical Analysis

To analyze the transect data, the number of signs recorded for each species along an individual transect was divided by the length of that transect. This value is called the Sign Encounter Rate (SER) and has the units: number of signs/km. Values were square root transformed to minimize the variance and meet the assumptions of a normal distribution (Sokal and Rohlf 1995). After that, a one-sample Kolmogorov Smirnov test was run to test the normality of each dataset for each species in all sites.

A Student t-test was utilized for those species whit a normal distribution (brocket deer, white-tailed deer and collared peccary), and the non-parametric Mann-Whitney U-test was used for species that failed to pass the normal distribution test (WLP and tapir). In all tests an alpha level of 0.05 was considered the criterion for statistical significance.

SER values for WLP and tapir were very low. Therefore, their SER data were reduced to just presence or absence along each transect to confirm the results of the non-parametric tests. Then a categorical data analysis was performed using a Chi Square test of homogeneity (2 x 2 contingency table with Yates correction), where the proportion of presence/absence for the non-hunted site was tested against the average proportion found for the three *ejidos* (Sokal and Rohlf 1995). The statistical analyses were done using SPSS (Statistical Package for Social Sciences).

Results

A total of 206.14 km were walked in 90 different transects. Transect lengths were variable, with an average of 2.3 km (range= 1.2 to 4.2 km).

In total 2169 signs of the five ungulates were recorded in all the sites. Brocket deer accounted for the highest ungulate SER (8.4 signs/km), followed by the collared peccary (1.3 signs/km) and white-tailed deer (0.8 signs/km) at moderate levels, and tapir and white-lipped peccary (WLP) at low levels of detection (0.4 and 0.2 signs/km respectively) (Table 2-2).

Table 2-2. Mean Sign Encounter Rate (SER) for the ungulate species from all the sites combined (three hunted sites and one non-hunted site) in Calakmul region, Campeche, Mexico.

Species	SER (No. of signs/km)	Standard Error
Brocket Deer (*Mazama spp*)	8.4	0.33
Collared Peccary (*Pecari tajacu*)	1.3	0.09
White-Tailed Deer (*Odocoileus virginianus*)	0.8	0.11
Tapir (*Tapirus bairdii*)	0.4	0.07
White-Lipped Peccary (*Tayassu pecari*)*	0.2	0.04

* In this particular case the SER is the average number of groups of tracks sighted in a km of transect.

SER values for all the ungulate species combined were not significantly different between hunted (2.2 sign/km) and non-hunted (2.2 signs/km) (Table 2-3) sites (t= -0.05, df=448, p>0.05). Therefore, the hypothesis that hunting has reduced overall ungulate abundance was not substantiated.

Table 2-3. Mean Sign Encounter Rates (SER) of all ungulate species combined and separate from hunted and non-hunted sites, Calakmul region, Campeche, Mexico.

Species	Non-Hunted Site	Standard Error	Hunted Sites	Standard Error	p-value
All Species	2.20	0.30	2.22	0.19	0.47
Brocket Deer	8.87	0.50	8.24	0.43	0.14
Collared Peccary	1.42	0.12	1.23	0.13	0.04
White-Tailed Deer	0.34	0.09	0.98	0.15	0.00
Tapir	0.04	0.02	0.55	0.09	0.00
White-Lipped Peccary	0.33	0.10	0.11	0.04	0.00

Square root transformation of SER values for individual species normalized the data for brocket deer, white-tailed deer and collared peccary according to Kolmogorov-Smirnov analyses (p>0.05). Therefore Student t-tests were used to compare mean SER between hunted and non-hunted areas for these species. SER data for tapir and WLP, however could not be normalized (Kolmogorov Smirnov p<0.05). Consequently SER means for these two species were compared using the non-parametric Mann-Whitney U-test.

Among the individual ungulate species the two brocket deer species accounted for the vast majority of signs encountered in all the sites. Average SER within the non-hunted site was slightly higher than in hunted sites (Figure 2-1), but this differences was not statistically significant (t= -1.06, df=88, p=0.14) (Table 2-3). SER values for collared peccary were significantly higher in the non-hunting area (Figure 2-1) (t= -1.71, df=88, p=0.04) (Table 2-3).

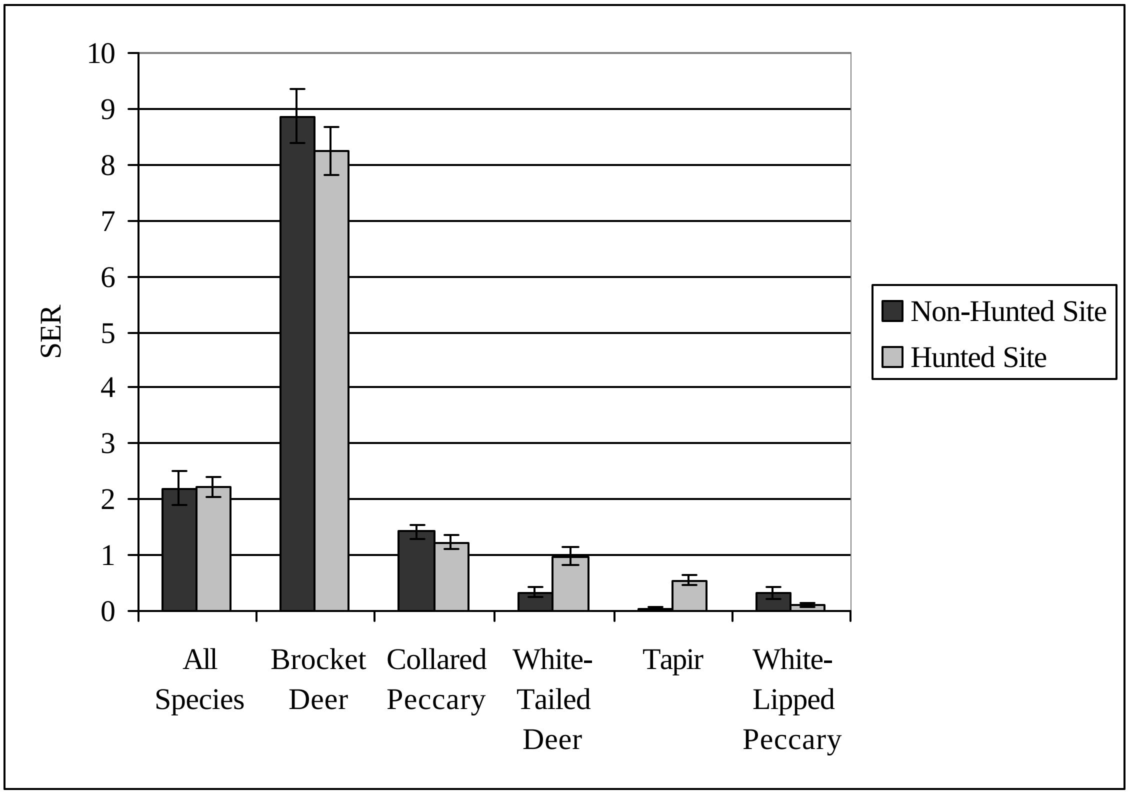

Figure 2-1. Differences in SER (sign encounter rate) for non-hunted and hunted sites for all the species. The bars represented the obtained standard errors. Calakmul region, Campeche, Mexico.

Contrary to collared peccary, white-tailed deer SER values were nearly three times higher in hunted sites than in the non-hunted site (t= 3.07, df=88, p=0.001) (Figure 2-1; Table 2-3).

The relative difference in SER between hunted and non-hunted sites was greatest for the tapir (Figure 2-1; Table 2-3). Tapir SER in hunted areas was more than an order of magnitude greater than in the non-hunted site (Mann Whitney U= -3.88, df=88, p<0.001). In contrast, white-lipped peccary (WLP) SER values were three times higher in the non-hunted area than in the hunted areas (Mann Whitney U=2.74, df=88, p=0.006) (Figure 2-1; Table 2-3).

To confirm the results of the non-parametric test on SER means for tapir and WLP, a categorical analysis was conducted. The transect sign data were converted to just presence/absence, and the proportions found in Calakmul (non-hunting site) was tested against those from the *ejidos* (hunting sites). A Chi Square Test of Homogeneity (2 x 2 contingency table with Yates' correction) (Sokal and Rohlf 1995) was performed on these categorical data, and the results were highly significant for both tapir (X^2=10.2, df=1, p<0.005) and WLP (X^2=19.7, df=1, p<0.005). Thus tapir signs were significantly more frequent in the hunted sites than the non-hunted site and the reverse relationship was true for WLP.

Discussion

Assuming that the Sign Encounter Rate (SER) is directly related to the abundance of an animal species, my results indicate that the ungulate community in the Calakmul region has not been negatively impacted by recent hunting activities. However, analysis of individual ungulate species showed different responses.

There were significant differences in SER values between hunted sites and a non-hunted area for four species of ungulates. White-tailed deer and tapir signs were more frequently found in hunted areas, while signs of both species of peccaries were higher in non-hunted area. Brocket deer did not show a significant difference between sites.

A comparison between species is not possible because it is not known if the large disparity in SER values among the ungulate species was directly related to their respective absolute abundances. For example, both peccary species travel in groups of varying size, but this information is not incorporated into SER calculations. Also, there are reports in the literature of behavioral changes for some ungulates in hunted sites. However, these changes were only related to changes from diurnal to nocturnal habits and are reported only for brocket deer, white-tailed deer and tapirs, not for any species of peccaries (Leopold 1959; Eisenberg 1989; Emmons and Feer 1990). Because no data exist on variation of home range size of the species in hunted and non-hunted areas, I made intra-specific comparisons for species and interpreted the differences found in sites as differences in population abundance, not behavioral changes. Therefore the discussion of the data will focus on differences between SER values in hunted and non-hunted sites of individual species.

The fact that some species had larger relative abundance in hunted sites and others in non-hunted sites can be explained by the ecology and behavioral habits for each one. Hunting as indicated by my data did not have a strong negative impact on brocket deer populations in the Calakmul region. Brocket deer can survive in hunted forests of Central America (Emmons and Feer 1990). Using tracks count Fragoso et al. (2000) found a higher relative abundance of red brocket deer in a heavily hunted area close to Xavante village in Brazil. In the Lacandon Forest in southern Mexico, Naranjo (2002) found that red brocket deer population levels probably exist as a source-sink system between a protected area and hunted sites. Weber (2000), however, reported brocket deer and white-tailed deer abundances to be statistically significant lower in hunted sites than in non-hunted sites in Calakmul, but the difference for brocket deer was smaller than for white-tailed deer. All these studies confirm that brocket deer can support some level of hunting pressure and that they can survive even in highly hunted sites.

I found white-tailed deer relative abundance to be significantly higher in hunted areas than in the non-hunted area. These results are opposite to what Weber (2000) using also tracks counting found for this species in a different place in Calakmul. He found a significant lower abundance in a high hunting pressure site than for low and non-hunting pressure sites. A possible explanation for the discrepancy among the studies may be associated with the exact intensity of hunting that may have occurred in the specific hunted areas where this author collected the data, while in my study I included more hunted areas and over a broader geographic range. Naranjo (2002) also found tracks of this species in hunted and fragmented sites in the Lacandon forest and never in the protected area, which does not possess hunters or fragmentation.

White-tailed deer is a very highly prized species for subsistence hunters and accounts for an important portion of the wild meat consumed in Mexico (Leopold 1959; Weber 2000; Naranjo 2002). Throughout the range of this species, its populations increase in regions of forest fragmentation associated with human settlements, farming and forest clearcuting (Leopold 1959; Rue 1978; Mendez 1984; Emmons and Feer 1990; Naranjo 2002). Therefore, my results of increased abundance of white-tailed deer in hunted areas, especially nearer to hunter sources, is probably related to increased forest fragmentation and farming near human population centers.

I found collared peccary relative abundance to be slightly higher in the non-hunted area than in hunted areas. Collared peccary have been reported as a very persistent and generally common species in hunted sites (Emmons and Feer 1990; Bodmer 1990; Sowls 1997; Hill et al. 1997). Peres (1996) was unable to document a single case of disappearance for this species in several hunted sites in the Amazon basin, and he saw collared peccary all year-round. Fragoso et al. (2000) found signs of this species in similar frequencies between a heavily and lightly hunted site. Naranjo (2002) found similar densities of collared peccary in hunted sites and a protected area in the Lacandon forest. While collared peccary can support some level of hunting according to this study, this species was significantly more abundant in non-hunted sites, which suggests collared peccaries are probably under high hunting pressure in the Calakmul region. This is consistent with the work of Weber (2000), who found collared peccary to be the most harvested species for Calakmul *ejidos.* High pressure on this species is a result of the hunting method combined with the peccary behavior. When hunters use dogs their probability of success is greatly increased. A collared peccary when is chased by dogs looks for a hiding place, which can be a hole in logs or underground, where it turns and faces the dogs. Soon the hunter arrives and kills the cornered peccary (Pers. Obser.). This result may indicate that collared peccary are under a high hunting pressure in Calakmul. However, their populations are not necessarily threatened in hunted sites given the minor differences in SER between hunted and non-hunted areas.

Tapirs in this study were surprisingly found in higher abundance in hunted sites than in the protected area. This result is opposite from what others have reported for this species. Fragoso (1991) found that tapirs were more abundant in a non-hunted forest in the Rio Macal in Belize. Several other reports for tapir found this species to be more common in places with no hunter presence (Leopold 1959; Alvarez del Toro 1991). Hill et al. (1997) found a lower abundance of a similar species (lowland tapir, *Tapirus terrestris*) in Paraguay for hunted sites than for non-hunted areas. Fragoso et al. (2000) found signs of this lowland tapir to be more abundant in a lightly hunted area than in a heavily hunted area in the Xavante Reserve in Brazil. Naranjo (2002) recently found that densities for this species were five times greater at slightly hunted sites in comparison with persistently hunted sites in the Lacandon forest.

Three factors may account for the higher tapir abundance in hunted sites found in this study. First, tapir is surprisingly not a favorite prey for the human groups in

Calakmul. During the 4 years that I have worked in the area, I know of only one tapir killed by a farmer and it was because the tapir was causing repeated damage to his crops. Typically people say they do not hunt tapirs because they don't appreciate the taste of the meat, the amount of meat that a tapir yields is too much to carry long distances, and they can easily harvest plenty of other more preferred wild meat (paca, ocellated turkey, deer and peccaries) (Pers. Obser.). Secondly, it is my subjective perception (which needs to be tested in future studies) that the habitat is better for tapirs in the *ejidos* than in the protected area of Calakmul. Tapirs prefer humid environments with lots of water-bodies (Leopold 1959). In this region, humidity increases from north to south and from west to east, resulting in a more humid forest near the two eastern *ejidos* (Nuevo Becal and 20 de Noviembre) as a result, these *ejidos* may have more water-bodies than the drier forest of CBR, an important factor than can favored a species like tapir. The third factor is that tapirs may prefer perturbed forest as was showed by Fragoso (1991) in Belize where he found that tapir favored the logged forest and avoided the unlogged forest. The same result was obtained by Williams (1984) in Costa Rica, who used radio-telemetry to estimate the tapirs' habitat use. He found that four radio-collared tapirs used secondary forests second only to low-land riverine vegetation. Also, Naranjo (1995) found greater abundance for this species in the lowland, second growth forest in Corcovado National Park, Costa Rica. So it is highly likely that the secondary forest around the *ejidos* in Calakmul region represent a very prized habitat for this species. This, combined with the facts that tapir is not a favorite prey and the possibility that *ejidos* contain better habitats than the drier habitats in the CBR, can explain higher relative abundance of tapir in the hunted sites.

White-lipped peccary was the species that showed the largest difference whereby relative abundance in hunted areas was 1/3 that of the non-hunted site. This result is concordant with what Naranjo (2002) found for the Lacandon forest where WLP abundance was almost seven times larger in a non-hunting area than in a hunted area. Peres (1996) reported WLP to be rare or absent from accessible areas within the hunting range of human settlements and no longer occurred in heavily hunted sites in several forests in the Amazon Basin. On the other hand, Vickers (1991) studied hunting patterns in the Ecuadorian Amazon and found over a ten year period that WLP harvest rates were highly variable. He attributed this to occasional movements of larger herds outside the area rather than depletion due to hunting. While this may apply to areas adjacent to larger reserves or other forested lands, migration movements toward the highly fragmented surrounding the hunted sites in Calakmul seem unlikely.

WLP can be negatively affected by human activities including direct harvest, habitat degradation, and diseases transmission from domestic animals (Fragoso 1997). I was able to document kills of 13 individuals that occurred in a single day for a group of hunters. However, due to the large movements and large home range of WLP (Fragoso 1998), it can also be affected by habitat fragmentation in hunted sites. Among my hunted sites, I found WLP relative abundance to be highest in Xbonil *ejido*, which is adjacent to the CBR. Highly fragmented lands that may have affected WLP movements and population densities surround the other two hunted sites that have huge and continuous forests. Fragoso (1997) found evidence that supports the hypothesis that diseases transmitted to this species by domestic animals were responsible for the disappearance of populations of WLP in the northern Amazon in Brazil in the 1980’s. No data about disease transmission in Calakmul have been collected for any wild or domestic species. This variable in the Calakmul region cannot be controlled and its effects remain unknown for all species.

Can other factors besides hunting be the responsible for the variation in relative abundance of the ungulates species in hunted and non-hunted areas? Several other factors can affect the relative abundance of an ungulate species. Among them are differences in habitat and level of fragmentation, and other kinds of human perturbation, such as logging or non-extractive activities. In this study habitat differences and fragmentation were controlled. Selecting different hunting places distributed over the area to cover all possible variation controlled habitat differences. However, small differences were noticed among the four areas, such as increased humidity and abundance of palms in the understory in two hunted areas (Nuevo Becal and 20 de Noviembre *ejidos*). The CBR and a hunted area (Xbonil) were drier and had no palms in the understory. While these differences can affect comparisons among the areas separately, I assumed the effect of this variable was minimized in this study because the comparison and analysis were made between the non-hunted area and the average of the three hunted areas. My study assumed that this replication covered the habitat variation, existent in the region.

The fragmentation level can also have a big effect on the ungulate populations. However, avoiding the areas near the population center and placing transects in the forested areas in the *ejidos* controlled it. While I assumed that the effect of fragmentation was diminished or nonexistent for four of the species (collared peccary, brocket deer, white-tailed deer and tapir), I cannot conclude the same for the white-lipped peccary.

The WLP moves in a bigger range than the other species and has the biggest home range, sometimes reaching more than 100 km^2 (Fragoso 1998). As already explained, it is possible that in the two eastern *ejidos* (Nuevo Becal and 20 de Noviembre), the fragmentation level has some effect on the groups (and consequently on the abundance) of this species.

Finally, human presence (doing any other activity beside hunting) in the forest can have an effect on ungulate populations by causing behavioral changes or pushing animals to leave the area temporarily. Although there is human perturbation on the CBR by tourist, the degree of perturbation is lower than in the *ejidos* where people conduct daily travel to the forest searching for subsistence resources. This variable cannot be controlled in this study and its effect on ungulate population remains unknown.

The ungulate species showed different patterns of relative abundance between hunted ands non-hunted sites in this study. Therefore the question if hunting pressure affects ungulate species differently can be answered in the affirmative. These differences form the basis for conservation and management plans that can be developed for these species in Calakmul.

CHAPTER 3
WHITE-LIPPED PECCARY GROUP SIZE

Introduction

The white-lipped peccary (WLP) is a social ungulate that lives in large groups normally from 20 to more than 300 animals. Anecdotal sightings of more than a thousand individuals have been reported (Leopold 1959; Emmons and Feer 1990; Alvarez del Toro 1991; Bodmer et al. 1997a; Sowls 1997; Fragoso 1998).

White-lipped peccaries also travel large distances and their movements have been called nomadic (Kiltie and Terborgh 1983) or migratory (Bodmer 1991; Sowls 1997). Fragoso (1994) reported WLP movements to be seasonal and within a huge home range of more than 100 km^2. Other reports show that WLP disappear from some areas and then reappear several months or years later, on a non-seasonal basis (Stearman 1992; Peres 1996).

These are exceptional behaviors for an ungulate that lives in dense tropical forests. In addition to WLP, large group size has only been found only for the bearded-pig (*Sus barbatus*) of Borneo, which forms groups as large as 300 individuals (Caldecott et al. 1993). Collared peccary (*Pecari tajacu*) and chacoan peccary (*Catagonus wagneri*), the other two living species of peccaries, also live in groups. However, groups of up to 20 individuals are rare for collared peccary with 6 to 9 being more common, while groups of 2 to10 are common for chacoan peccaries (Emmons and Feer 1990; Taber 1993). WLP groups are very cohesive and remain together on a daily and annual basis (Fragoso 1994), while collared peccary and bearded pig groups are not strong cohesive and split temporarily into subgroups (Caldecott et al. 1993; Sowls 1997).

WLP group size varies along its distribution range. While some groups consist of as few as 5 animals (March 1993; Pers. Obser.), there is a confirmed report of a group as large as 700 members (Bodmer, Pers. Comm.). Hernandez et al. (1995) reported group sizes of 14 to 60 animals in Venezuela. Fragoso (1998) reports groups of 30-50, and a large group of 100-200 animals for the northern Brazilian Amazon. Sowls (1997) sighted groups of 40, 50 and 60 animals in the Chaco in Paraguay, and he also reported a group of between 300 and 400 animals in the Purus River in Brazil. Peres (1996) studied peccaries close to the Urucu River on the Amazon forests and reports a herd with more than 150 animals. Naranjo (2002) found a mean of 20 individuals for 13 groups sighted in the Lacandon Forest with a range of 5 to 60. This study reports a mean of 20 animals per group with a range of 3 to 50 approximately.

What is causing this variation in WLP group size? There are several hypotheses to explain the variation: hunting pressure, habitat quality and size, habitat fragmentation, human perturbation and disease outbreak are among them. There is evidence that support the hypothesis that, at least in some areas in Northern Amazons in Brazil, diseases transmitted by domestic animals have been responsible for the disappearance of this species for many years (Fragoso 1997).

Some researchers argue that in areas where this species seems to be disappearing, small herds of fewer than 10 are common (Emmons and Feer 1990). Leopold (1959) pointed out more than 40 years ago that in Mexico WLP is among the first species to disappear when a forest becomes perturbed, and that smaller herds are a consequence of this perturbation. March (1993) states that more frequent reporting of smaller groups in some areas is probably correlated with increased hunting pressure.

Hunting pressure is one of the human perturbations that directly affects group size, through the killing of individuals and probably the dispersal of the group when the peccary leader is killed, which results in group behavioral confusion. WLP groups may be split into subgroups when humans chase them for several hours or days. This is a very common technique used by subsistence hunters (Smith 1999; Pers. Obser.).

The WLP social behavior of aggression towards potential danger is used as a defensive mechanism against predators (Sowls 1997). This "stand and fight" behavior can have a negative effect when a hunter-WLP encounter occurs. Once hunters avoid the danger of the face off by climbing a tree, they can kill multiple peccaries while the group remains together in the defensive posture. In some instances, the hunters can eliminate an entire group as Peres (1996) reported when a group of 20 hunters killed 82 WLP in one day.

This study compared WLP group size found in four communal areas (*ejidos*) with documented hunting activity with the group size found for the CBR, where large amounts of habitat remain undisturbed and there has been no hunting for more than a decade. I hypothesized that WLP group size would be smaller in hunted sites than in non-hunted sites.

Methods

Study Sites

For this chapter I conducted direct observations of white-lipped peccary group size in the same three *ejidos* as hunted areas and the CBR as non-hunted area (see description in Chapter 2). However, in this chapter one additional area is aadded.

Observations were made in a pond located just 200 m inside of the border between CBR and the nearest *ejido*. I found recent evidence of hunter presence at this pond, so this place was catalogued as a hunted site, even considering it was inside the CBR. The observations made here were considered to come from a hunted area. This place was called Calakmul Limit.

Data Collection

Direct observation

To estimate WLP group size I conducted direct observation at ponds during the dry season (March, April and May 2001) at the four hunted sites and in the CBR. I took advantage of WLP behavior of visiting ponds during the dry season and spending several days wallowing on the mud (Leopold 1959; Fragoso 1994).

I did a preliminary survey of the ponds in all the study sites for recent WLP signs. An observation period of looking for the groups of WLP was conducted at those ponds with recent signs for several days ranging from 3 to 5 days at each pond. Observation periods usually ranging from 7:00 to 14:00.

When a WLP group visited a pond the group size, number of juveniles (distinguished by size), and behavior were recorded. An attempt was made to record the number of each sex in a group but was not possible because the high mobility of each individual and the density of the vegetation. In each case the precise location of the sighting was recorded with a GPS (Garmin XII). Binoculars and photographic and video cameras were used to record group behavior.

Observations of WLP groups were made in spatially-separated locations, sometimes more than 60 km apart. However the observations within each area were made at a smaller scale and there was no way to assure groups were different from each other.

For the purposes of the analysis I assumed that each group sighted was unique and that there was no seasonal or diurnal variation in the group composition (Fragoso 1994).

Interviews

When the hunting survey was conducted a special section was added (see Appendix 2) to inquire about recent sightings of WLP groups. When an affirmative answer was obtained, additional questions were asked to confirm the species (physical characteristics such as size, presence of the white beard and behavior). After that, more questions were asked in order to confirm the real number of animals actually sighted and the locations of those sightings.

Because the accuracy of the data can change with time only recent sightings (no older than 3 months) of the interviewers were taken into consideration. Most of these records were from persons randomly selected for the interview (n=87 interviews). However in a few cases I knew that a hunter had killed a WLP, and in that case, I interviewed him directly. So, records of WLP sightings were obtained from hunters, farmers, and even reserve workers.

Statistical Analysis

WLP group sighting were divided into two groups, those from the non-hunting area and those from the hunting areas. A square root transformation of the group size was utilized to normalize the data and reduce the variance. The Kolmogorov-Smirnov test was used to test the normality of the data, then parametric and non-parametric tests (Student t-test and Kruskal Wallis test) were performed to test the differences between the hunting and non-hunting areas and between all the sites respectively. Finally a comparison between the non-hunted area and each of the four hunted areas were performed using a Student t-test. Statistical analyses were done with the SPSS (SPSS. 1997) computer package.

Results

A total of 22 groups sizes of WLP were gathered. Groups probably were composed of more individuals, but only those animals directly sighted were recorded. Average group size was 20.0 animals per group (SE = 2.8, n = 22) for all the sites with a range of 3 to 50. Fifteen of those 22 groups were sighted in the hunted areas and 7 in Calakmul. Eight of those 22 groups were directly sighted and 14 were obtained through the hunters' interviews.

According to the Student t test, average group size in hunting sites combined (16.3 individuals, SE=3.19) was significant smaller (t= 2.31, df=20, p=0.015) than average group size in the non-hunted area (28 individuals, SE=4.4).

Table 3-1. Mean white-lipped peccary group size found in five study sites in the Calakmul region, Campeche, Mexico.

Site	Mean Group Size	Standard Error	N
Calakmul (CBR)	28.0	4.5	7
Xbonil	19.3	5.4	7
Nuevo Becal	15.3	9.8	3
20 de Noviembre	14.0	11.0	2
Calakmul Limit	13.3	1.2	3

WLP average group size average ranged between 13.3 and 28.0 among the five study sites (Table 3-1). However, due to a large amount of within site variation, no significant differences were found among the sites using a non-parametric test (Kruskal Wallis test H=6.10, df=4, p=0.19).

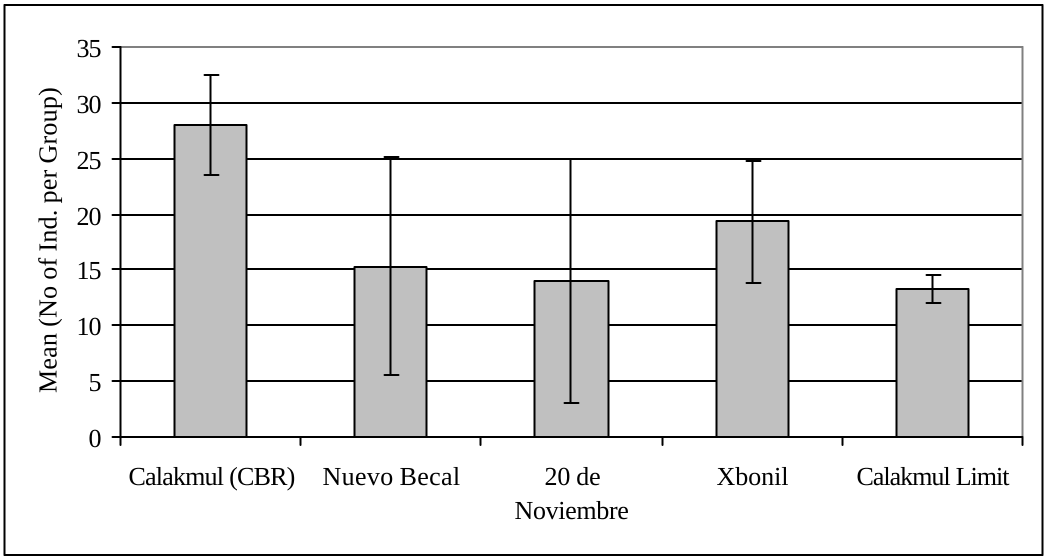

Figure 3-1. Average group size of white-lipped peccary in the five study sites. The bars represented the obtained standard errors. Calakmul region, Campeche, Mexico.

WLP group size in CBR was compared separately to each of the four hunted sites using a Student t-test. The Calakmul-limit site was the only one that was statistically significantly different (t= -2.39, df=8, p=0.02). However significance levels for the other three sites were all less than the 0.10 level (Table 3-3). These levels of significance probably indicated a biological significance given the small sample size.

Table 3-3. Comparison of white-lipped peccary group size between Calakmul and all other sites using Student t-test in the Calakmul region, Campeche, Mexico.

Site vs. Site	T statistic	df	p-value
Calakmul vs. Xbonil	-1.46	12	0.08
Calakmul vs. Nuevo Becal	-1.72	8	0.06
Calakmul vs. 20 de Noviembre	-1.71	7	0.06
Calakmul vs. Calakmul-Limit	-2.39	8	0.02

Discussion

My data suggest that average WLP group size is larger in the protected area than in four hunted sites in the Calakmul region.

This relationship can be a signal that human perturbations are having a negative effect on this species if it is assumed that bigger groups is the optimal condition of this species (Leopold 1959; Kiltie and Terborgh 1983; Emmons and Feer 1990; March 1993). This study was conducted over a large geographical area in the Calakmul region. Therefore habitat heterogeneity was controlled for, and its effects on the results were minimized considering that the WLP can live in semi-dry habitats as well as rainforest (March 1993; Sowls 1997).

Other factors besides hunting pressure could have affected group size. Among them habitat fragmentation (on a large scale), diseases outbreak, and habitat perturbation are very important (Bodmer 1991; Fragoso 1994; Peres 1996; Sowls 1997). In this study the forest fragmentation was partially controlled for because the *ejidos* selected were among the largest community lands on the region and transects were plotted in the forested lands of these hunted sites. However, two *ejidos* (Nuevo Becal and 20 de Noviembre), which have huge patches of habitat without fragmentation (40,000 and 20,000 ha approximately), are surrounded by other communities with highly fragmented forests. WLP moves within a large-scale, landscape-level mosaic of vegetation which sometimes can be as big as 109 km^2 for the home range of one group (Fragoso 1998). It is not known what effect the fragmented forest surrounding these two *ejidos* may have on WLP movements or population viability.

The WLP seems to avoid human presence, and is very rare to find a group in the crop fields or in the vicinity of the villages (Quijano 2001; Naranjo 2002; Pers. Obser.). Among the human activities that could affect WLP behavior and movements are extractive activities such as logging or non-timber products like honey bees, palms, seeds of magohany (very common in the region) and collecting *chicle* from the *zapote* tree. All these human activities include the use of dogs, camping several days, and ultimately using motor vehicles like motorcycles and trucks. The more people that are present in the forest, the more the peccaries are constrained in their movements. Consequently, WLPs look for more isolated areas as indicated by their restricted use of more distant ponds and forests from the human centers in this study. Similar results were reported by Baur (1998) for the Guatemalan Peten, Quijano (2001) for a village in Quintana Roo State (Mexico) and Naranjo (2002) for the Lacandon forest (Mexico).

There are evidences that this species can be affected by disease transmission by domestic animals, as seen in a forest in the northern Amazon of Brazil (Fragoso 1997). However, for the Calakmul region no data exist on diseases transmission from domestic pigs (or other domestic animal species) to peccaries or for disease outbreaks among any wild or domestic animals. The effect of this variable remains unknown.

Clearly hunting pressure exists on this species and group sizes are being reduced in hunted areas compared to the protected area. However, more studies are needed to identify the potential factors in the hunted sites and its influence how those factors can be managed to assure the presence of this species in those areas. Preservation of this species in communal lands will be jeopardized if reduction of group size continues in the *ejidos* of the Calakmul region.

CHAPTER 4
FOREST TYPE USE

Introduction

The Calakmul region is a mosaic of different forest types. Although the whole area is classified as a tropical forest, there are several vegetation types. Martinez and Galindo-Leal (2000) recognize six major vegetation types that are divided into 28 vegetation associations.

Miranda and Hernandez (1963) mentioned 11 associations for the Calakmul Biosphere Reserve (CBR) all of which are variants of tropical forest. Garcia-Gil (in press) described the CBR on the basis of 18 natural and human-made vegetation types based mostly on tree height, humidity and the drainage characteristics of the forest floor. Pennington and Sarukhan (1998) classified the vegetation into four major types on the basis of tree height, humidity and drainage capability of the soils. These major types are medium sub-perennial forest, low-sub-perennial flooded forest, low-deciduous (dry) forest, and secondary-forest.

The six species of ungulates that occur in Calakmul are distributed broadly throughout the region. However, there is evidence that some species prefer some forest types over others. Weber and Reyna (unpublished data) found evidence that gray brocket deer prefer the low-flooded area more than the red brocket deer, which was sighted with more frequency in medium-forest. Tapir and white-lipped peccary are associated with water ponds and the wetter habitat around ponds or rivers, as well as medium-forest (Williams 1984; Fragoso 1991; Fragoso 1994). Tapirs are also associated with secondary vegetation in several locations along its distribution range (Williams 1984; Fragoso 1991; Naranjo 1995). Collared peccaries can be considered habitat generalist and can be found in well-conserved as well as perturbed forest. Finally, white-tailed deer are very well known to favor disturbed sites with clearings close to forested lands (Leopold 1959; Mendez 1984; Alvarez del Toro 1991; Emmon and Feer 1990; Sowls 1997).

Recently, habitat use of ungulates in the Mexican tropics has received attention from researchers. Weber (In prep.) is assessing deer abundance and seasonal habitat use in Calakmul. Quijano (2001) worked in the Sian Ka'an Biosphere Reserve in the vicinity of Calakmul, and found that WLP use only the well-conserved forests closer to water ponds and far away from the human population centers. In the same study, collared peccary were found in every kind of tropical forest, even in the crop fields closer to the human settlement. Habitat use by tapir has received attention in Chiapas State by Naranjo and Cruz (1998), where they found that tapir avoided perturbed forests. However, tapirs were found to prefer the perturbed vegetation in Costa Rica (Williams 1984; Naranjo 1995) and in Belize (Fragoso 1991). Naranjo (2002) also, studied the hunting effect and general ecological aspects of all the ungulates present in the Lacandon forest.

In this chapter, I analyzed the frequency of signs found for all the species of ungulates living in the Calakmul region in each of four major forest types present in the area (medium-forest, low –flooded forest, low-dry forest and secondary-forest) to see if there are differences in forest type use between non-hunted and hunted sites. Assuming that the number of signs is directly related to the abundance of the animals, I estimated forest type preferences in relation to their availability in both hunted and non-hunted areas.

Methods

Study Sites

Data for the six species of ungulates of Calakmul were collected in four study sites (see description in Chapter 2). Three of these sites (*ejidos*) are considered hunted sites and the Calakmul Biosphere Reserve (CBR) is a non-hunted site. A comparison was made between forest type use for ungulates in these areas.

Data Collection

The vegetation of the Calakmul region was divided into four major forest types according to the traditional classification (Pennington and Sarukhan 1998; Ucan et al. 2000). These were: medium sub-perennial forest (medium forest), low-sub-perennial flooded forest (low flooded), low-deciduous forest (low dry), and secondary-forest (secondary).

These four forest types were selected because they are the most commons in the area and accounted for more than 95% of all the vegetation types described for the reserve (Ucan et al. 2000). My previous experience in the area allowed me to easily identify each of these four major types.

Ninety transects were walked in the four study sites. Transects were randomly plotted in the forested areas of the *ejidos* and the CBR, and all the recognizable signs of the six species were recorded (see description of sign data collection on Chapter 2).

Each time a transect was walked, I recorded the forest type at least four times: at the starting point, when we walked around 30%, and 60% of the transect length, and at the ending point. At each point, with the help of an assistant (who in all the cases was a person who had lived in the area all his life), the surrounding trees were identified and recorded.

Tree height was estimated with a laser range-finder and a subjective estimation (high, low) of the density of understory vegetation was registered. These forest type records were taken independently of the presence or absence of any animal signs at those points and were used in the analyses as an estimation of the real proportion of these forests in the area.

Because the transects were plotted at random, the sample of the vegetation can be considered a representative sample of the real proportion of the four major forest types, presents in the study area.

During the transect counts, each time a sign of one of the five species was found, the forest type at that point was recorded and registered together with the animal sign. Therefore, I was able to obtain the frequency of signs for each species in each forest type across all sites.

Data was always collected by myself in order to avoid recorder bias in the classification of vegetation type. No large differences were noticed between the floor of the four forest types in the basis of identify the tracks basically.

Statistical Analysis

The program HABUSE, which calculates the Chi Square and Bonferroni confidence intervals for use vs. availability data according to a technique developed by Neu et al. (1974) and modified by Byers et al. (1984), was used to test if the proportion of signs counted for any species among the four forest types was significantly different from the available proportion of forest types. Using the program HABUSE a comparison between expected and observed values are obtained as well as a Chi Square value for the forest types combined and Bonferroni Intervals for the individual forest types.

Results

Forest types were recorded at a total of 393 points along the 90 transects. These transects were distributed within the four study sites (see Chapter 2), and an average of 4.36 points per transect was obtained.

For the Calakmul Biosphere Reserve (CBR), the most abundant forest type was medium-forest with almost 50% of the area and the least abundant was the secondary-forest with less than 1%. Low-dry forest accounted for 40% and low-flooded forest for 9% in this site (Figure 4-1).

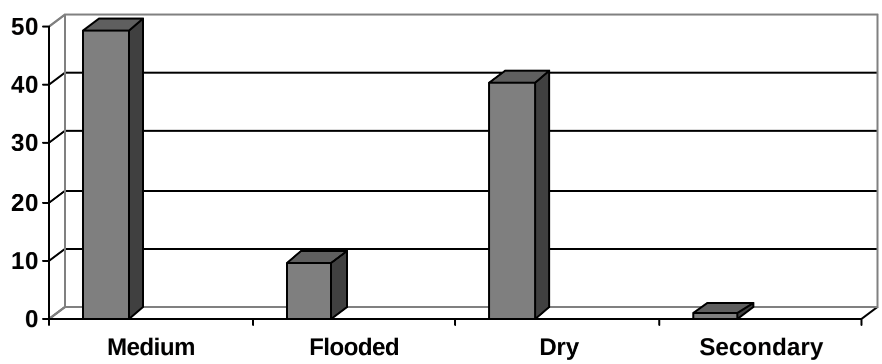

Figure 4-1. Proportion of the different forest types found in transects in Calakmul Biosphere Reserve (CBR) in the Calakmul region, Campeche, Mexico.

In the hunted areas (*ejidos*) medium forest again accounted for the highest proportion with 66% and secondary-forest for the lower proportion with 5%. Low-flooded forest and low-dry forest were found in proportion of 13 and 17% respectively (Figure 4-2).

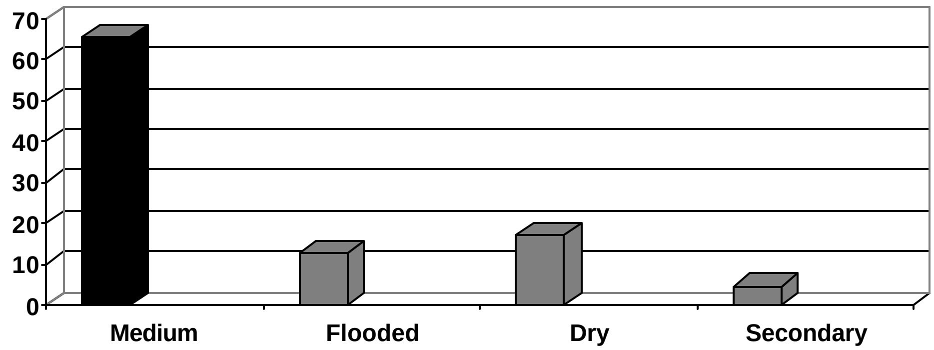

Figure 4-2. Proportion of the different forest types found in transects in the *ejidos* in the Calakmul region, Campeche, Mexico.

A total of 2111 records of the six species of ungulates were related to the forest type in which they were found. Six hundred and twenty four records were found in the CBR (non-hunting site) and 1,487 were found in the three hunted sites (*ejidos*). Based on the already obtained proportions of the different forest types an expected value was calculated for each species according to the total number of signs recorded. These expected values were contrasted between the observed values and a Chi Square test and Bonferroni Intervals were obtained for each species in each forest types for hunted and non-hunted site.

No significant difference (X^2= 2.31, df=3, p=0.51) was found between forest type availability and ungulate sign frequency for all species in the CBR (Table 4-1). Signs of the six species of ungulates combined were found in the same proportion as forest type availability in this area (Bonferroni Intervals).

In contrast, signs of the six species as a whole were found in different proportions than the forest type availability in the *ejidos*. This difference was statistically significant (X^2= 85.28, df=3, p<0.000) (Table 4-1). The main differences between use versus availability were a higher proportion of signs in the low-flooded forest and a lower proportion in the medium and low-dry forest (Bonferroni Intervals).

Table 4-1. Forest type use for the ungulate species in hunted and non-hunted sites in the Calakmul region, Campeche, Mexico.

		Calakmul (Non-hunted Site)			*Ejidos* (Hunted Sites)		
Species	Forest Type	Obs.	Exp.	X^2 (Sig.)	Obs.	Exp.	X^2 (Sig.)
All the Species	Medium	302 (=)	308	p=0.51	920 (-)	975	p=0.00
	Low-Flood.	52 (=)	59		302 (+)	189	
	Low-dry	266 (=)	251		193 (-)	253	
	Secondary	4 (=)	6		72 (=)	68	
Brocket Deer	Medium	230 (=)	247	P=0.01	666 (-)	713	p<0.00
	Low-Flood.	33 (-)	47		212 (+)	138	
	Low-Dry	234 (+)	202		167 (=)	185	
	Secondary	4 (=)	5		41 (=)	50	
Collared Peccary	Medium	49 (=)	41	p=0.2	123 (=)	111	p=0.00
	Low-Flood.	9 (=)	9		26 (=)	21	
	Low-Dry	25 (=)	33		10 (-)	29	
	Secondary	0 (-)	1		10 (=)	8	
White-Tailed Deer	Medium	7 (=)	11	p=0.00	78 (=)	91	p=0.00
	Low-Flood.	8 (+)	2		34 (+)	18	
	Low-Dry	7 (=)	9		11 (-)	24	
	Secondary	0 (-)	1		16 (+)	6	
Tapir	Medium	Not enough data			48 (=)	51	p=0.00
	Low-Flood.				22 (+)	10	
	Low-Dry				3 (-)	13	
	Secondary				5 (=)	3	
White-Lipped Peccary	Medium	16 (+)	9	p=0.00	5 (-)	10	p=0.00
	Low-Flood.	2 (=)	2		8 (+)	2	
	Low-Dry	0 (-)	7		2 (=)	3	
	Secondary	0 (=)	0		0 (-)	1	

Note: The symbols (=), (+) and (-) located beside the observed values mean that those values were found, [according with Bonferroni Intervals (Program HABUSE, Myers et al. 1984)] in equal, more and less proportion than the expected values, respectively.

Relative to the forest type availability, brocket deer signs were found with a high proportion in the low-dry forest and with a low proportion in the low-flooded forest in the non-hunted site (X^2=10.7, df=3, p=0.013) (Table 4-1). In the *ejidos* (hunted areas) the opposite occurred for the low-flooded forest where more signs than expected were found and less in the medium forest (X^2=46.62, df=3, p<0.000). Signs of this species were found in the same proportion for all other forest types in both places.

Collared peccary signs were found in the same proportions as the availability of respective forest types in the CBR, except for the secondary forest where no signs were found (X^2= 4.68, df=3, p=0.2) (Table 4-1). In the *ejidos*, signs of this species were found in a different proportion than expected (X^2=15.18, df=3, p=0.002), and this difference was due mainly to a lower proportion of signs in the low-dry forest. However signs of this species were found in the same proportion for all other forest types in the hunted areas.

White-tailed deer signs were found in higher proportions in the low-flooded forest than expected for both areas (hunted and non-hunted) (Table 4-1). However, in the CBR all other forest types were used in the same proportion, except for the secondary forest where no signs were found for this species. For the case of hunted areas, white-tailed deer signs were found also in higher proportions in secondary forest and in lower proportions in the low-dry forest. In both places, the differences were statistically significant (CBR: X^2=18.72, df=3, p<0.000; *Ejidos*: X^2=38.22, df=3, p<0.000).

Only three signs of tapir were found in the CBR. Two of them were in the medium forest and one was in the low-dry forest. Surprisingly, no signs were sighted in the low-flooded forest of the CBR. The small number of signs did not allow statistical analysis for this species in this area. Tapir signs in hunted areas were found with a higher proportion in the low-flooded forest and a lower proportion in the low-dry forest. These differences were statistically significant (X^2=23.54, df=3, p<0.00) (Table 4-1).

White-lipped peccary (WLP) signs in the CBR were found only in the medium and low-flooded forests. The proportion found in the first type was higher than the expected. In general a statistically significant difference was found for this species at this site (X^2=13.21, df=3, p=0.004) (Table 4-1). Contrary to these results, WLP signs in hunted sites where found with a higher proportion than expected in low-flooded forest and with a lesser proportion than expected in medium forest (X^2=22.75, df=3, p<0.000).

In general, the differences between the hunted sites and the non-hunted site for all the species are based on a more intense use of the low-flooded forest in the hunted sites in comparison with the CBR. Medium and low-dry forests were used with less frequency in hunted sites than in the non-hunted area. Secondary forest was used in the same proportion as expected in both sites.

Discussion

No significant differences between forest type use and availability were found for the six species in the non-hunted area. Weber (2000) found similar results for the three species of deer in the Calakmul region. He found in a non-hunting site that both white-tailed deer and brocket deer used the forest in the same proportion as their availability and avoided certain forest types in the hunting sites.

In this study, for the hunted areas a major use of low-flooded forest and less use of medium and low-dry forest were found for all the species as a whole. No clear explanation exists for these relationships. However, possible cause is that medium forest is the preferred forest type for hunters in Calakmul region (Reyna-Hurtado et al. 1999;

Weber 2000). Consequently, the hunting pressure must be higher than in the low-flooded forest. It is possible that some of the most preferred species for the subsistence hunting (as ungulates) can be looking for a refuge in low-flooded forests, which have a dense understory vegetation, and are among the less visited forest type for hunters.

Low-dry forest seems to be very important for both species of brocket deer in the CBR. Signs of it became a typical finding for us (my assistant and I) when we entered this kind of forest. It was very rare to see sign of other species in this kind of forest. This is an interesting fact since this kind of forest accounted for 40 % of the area sampled in the CBR. Brocket deer seem to take advantage of a habitat infrequently used by the other ungulate species. Now, the question arises as to which one of the two brocket deer species is using more the low-dry forest. As was already explained in this study, it was impossible to distinguish between the signs of the two brocket deer species. However the distribution range of these species (which are sympatric in Calakmul) can help to hypothesized (to be tested in future studies) that gray brocket deer is more abundant in those kind of forest. For example, red brocket deer usually inhabits wetter tall forest, for which Calakmul represent one of its limits in its distribution (Leopold 1959; Emmons and Feer 1990). Its distribution range in other parts of Mexico is almost entirely in tall, wet-tropical forest as present in the Lacandon forest in Chiapas and the Tuxtlas in Veracruz or the Chimalapas in Oaxaca. On the other hand gray brocket deer is an inhabitant of the Yucatan Peninsula and northern Guatemala and Belize (Leopold 1959; Medellin et al. 1998), where most forests, especially in the northern part of Yucatan, are dry-forest that lose all the leaves seasonally, like the low-dry forest of Calakmul. In these forests gray brocket deer is a common species, in some places more abundant than the white-tailed deer. (Leopold 1959; Villagers from Maxcanu, Peto and Tekax Yuc. Pers. Comm.). The differences in habitat preferences favored the gray brocket deer as the species inhabitant the low-dry forest in Calakmul while red brocket deer is possibly an inhabitant of the medium forest. These statements of course need to be tested in the future.

The differences between forest use of brocket deer in hunted and non-hunted areas cannot be attributed to any specific factor yet. Not enough evidence exists to indicate hunting pressure is the only factor responsible for these differences. Red brocket deer is mostly a frugivorous species (Emmons and Feer 1990; Bodmer 1991), while there are no published data on gray brocket deer diets. However, in a very recent study, Weber and Reyna-Hurtado (in prep) found this species to consume less fruit and more vegetative parts of plants than the red brocket deer. Therefore, differences in real abundance, forest type preferences and diet between the two species in hunted sites may be strongly related to these differences.

Collared peccary was the most generalist species in both hunted and non-hunted areas. However, a trend (not statistically significant in the CBR) was evident for this species to prefer medium forest and to avoid low-dry forest. Collared peccary is catalogued as a habitat generalist who can live in several kinds of tropical forest and perturbed vegetation as well as savannas and deserts (Bodmer and Sowls 1993; Sowls 1997). Similar results were found in this study, where collared peccary used all the forest types and was a common species in the area, as well as one of the most hunted ungulates. The differences between hunted and non-hunted sites are based mainly in the lesser proportion of signs found in the low-dry forest in hunted sites than in the non-hunted site.

Contrastingly Quijano (2001) found this species to be more abundant in the secondary vegetation and avoid the low-flooded forest, and Fragoso (1999) found collared peccaries to prefer the higher *terra-firme* forest in the northern Brazilian Amazons. Whether these differences are a consequence of the human factor (in the case of Quintana Roo) or an ecological adaptation to the different site (in the case of the Amazons) is a question to be tested in future studies, but that shows again that this species can have a higher variability in habitat preferences.

Results for white-tailed deer showed this species preferred the low-flooded forest in both hunted and non-hunted areas. In hunted areas this species also was found in higher proportion in secondary forest and the opposite occurred for the low-dry forest. These results, combined with the fact that white-tailed deer's relative abundance was three times bigger in hunted sites than in the CBR, supported the fact that this species is a habitat generalist that favors perturbed habitats. Recently white-tailed deer has become a common species in tropical forests where it once was rare (Leopold 1959; Eisenberg 1989; Emmon and Feer 1990). However, white-tailed deer's preference of low-flooded forest is an interesting fact that needs further scientific attention. Probably white-tailed deer are looking for shelter and refuge in this kind of more dense forest. Similar results were obtained for Weber (2000) who found a strongly preference of this species for the low-flooded forest in different hunting sites of the Calakmul region and Quijano (2001) in the Sian Ka'an Biosphere Reserve in the Quintana Roo State, who found white-tailed deer more abundant in secondary vegetation and in low-flooded forest.

Signs of tapirs were found according with the behavioral habits of this species more frequently in wetter habitats in hunted sites. Also it was found to under-use dry forest, which can be considered as sub-optimal habitat for this species. Tapirs mainly browse vegetative parts of woody plants and consume grasses and fruits (Terwilliger 1978). It is associated with wetter habitats and with water bodies such as rivers or ponds where it spends a great part of the day (Fragoso 1991; Naranjo 2002). Normally tapir are found in very isolated places where they hide from human presence, since they are favorite prey for many human groups in Mexico, and Central and South America (Emmons and Feer 1990; Naranjo 2002). However, I found its signs to be pretty common in secondary-forest, and the same results was obtained in three different studies, one in Belize (Fragoso 1991) and two in Costa Rica (Williams 1984; Naranjo 1995), where tapirs used the perturbed forest and lowland forest. However, in another study in the Lacandon Forest in Mexico, tapir rarely use this kind of forest (Naranjo 2002).

The Calakmul results can be explained partially by the fact that tapir is not a favorite prey for the hunters in this region. During several interviews and informal conversations with residents in the region for four years, I found only one person who killed a tapir, and it happened because the tapir in question was causing damage to his crops. Escamilla et al. (2000) in a hunting assessment on three villages in the same area never documented a tapir harvested during their fieldwork. Probably tapir can find many favored plant species in the secondary forest but normally is pushed to more isolated habitats by hunting pressure, in Calakmul, where no high hunting pressure existed for tapir, it was found frequently in secondary-forest.

In contrast to collared peccary, which was the most generalist species, white-lipped peccary (WLP) showed the biggest degree of habitat selection of all the species. WLP sign was never found in secondary forest in either hunted and non-hunted sites.

Signs of this species also were never sighted in the low-dry forest in the CBR. WLP preferred the medium forest in the CBR and the low-flooded forest in the hunted sites. These differences can be associated with the behavioral habits of this species in avoiding all kinds of human perturbation. Since the human activities in the *ejidos* occur mainly in the medium forest (timber extraction, *chicle*, seed, palms and honey collection are activities that are conducted almost entirely in medium forest) WLP probably sought out better coverage in the low-flooded forest that contains abundant understory.

Another behavioral trait that can explain WLP preference for low-flooded forest is the fact that they show high preference for water bodies where they wallow and forage. This behavior may confine this species to live in the vicinity of wetter habitats where they can find ponds (March 1993; Fragoso 1994). WLP eat mostly fruits and nuts, and it is believed they travel long distances to find fruit patches in the forest. There are evidences that WLP move in a different scale than other ungulates as was showed for Fragoso (1999) in the northern Amazonian forest. This author based in the diet, size of the animals and ability to move state that the WLP move in different scale than the smaller collared peccary, and consequently take advantage of food distributed in patches within the forest. The results found here are concordant with what this author found and the fact that WLP was found only in certain forest types and collared peccary was the most generalist of all the ungulate species shows that WLP are highly selected and move between patches of preferred forest types and that collared peccary stay and survive in all the different forest types.

The ecological and behavioral characteristics of WLP found in the literature were concordant with what was found here where WLP never were found in the vicinity of villages and just a few observations were made in low-dry forest, where probably they entered traveling through the area. The majority of the signs were found in medium-forest, where fruit production is greater (Ucan et al. 2000; SEMARNAP 2000), and in the low-flooded forest where small ponds store the only water available for the Calakmul region during the dry season. Differences between hunted and non-hunted sites for this species can be a signal of human perturbation in hunted sites, however more studies are needed to corroborate this assumption.

This chapter presented general findings regarding the pattern of forest types use in hunted and non-hunted areas for the ungulate species. In general for all the ungulate species the low flooded forest was the most important forest type in hunted sites, while in the non-hunted site it was the medium forest. What the differences between forest type use in hunted and non-hunted areas mean for each individual species is to be determined in the future when individual studies focus on habitat use and hunting pressure.

At this point I must emphasize that the analyses presented above for all the ungulate species must be considered as a very general approach in estimating which forest types are preferred for the different species. However, there are different techniques to obtain more precise results of resource preferences of an animal species, like the one developed by Johnson (1980) that includes an analysis of ranks based in the amount of usage and availability of the resources or habitats. In order to use this technique we need supplementary information on the biology of each species like home range size, and a previous knowledge of habitat preference. This information is used to determine in a more objective way what we are considering as available and to exclude some habitat that we previously know is not used at all by the species in study. I believe the data gathered in this study provide preliminary results for a natural zone with special characteristics (forest types, weather water availability etc.) where no previous data had been obtained for the forest types preferences from the ungulate species. Therefore, this study can be considered as a first step in characterizing general habitat preferences in a very general way for the Calakmul region and can be considered as a basis to developed further analysis for the individual specie that include more specific information, as the technique developed by Johnson (1980).

Finally, a clear understanding of the relationship between forest use and human impact on the ungulate species in Calakmul region is necessary for the elaboration of forest and wildlife conservation strategies in Calakmul Biosphere Reserve and the communities living in the periphery.

CHAPTER 5
CONCLUSIONS

Calakmul region has a mosaic of protected and communal forests. Conservation of ungulates requires management of both types of lands in order to successfully protect all the species. The protection of the Calakmul Biosphere Reserve (CBR) alone may not guarantee that healthy populations of ungulates will be sustained in the future in the area.

The ungulate community (as a whole) within the region has similar relative abundances in hunted and non-hunted areas. However, the relative abundance of each species varies between the sites. According to my results and past studies in similar environments, some ungulates can sustain some degree of hunting pressure but management strategies need to pay attention to the individual response of each species to this activity.

White-lipped peccary (WLP) seems to be the most vulnerable ungulate species to hunting and other human perturbations in the Calakmul region. Analyses of relative abundance and direct observation of group size confirm that WLP do better in zones without hunters or any kind of human disturbance. Considering larger group size as a signal of healthy populations, it can be concluded that the WLP population is in better status in the CBR than in the hunted areas (*ejidos*).

Tapir occurred throughout the Calakmul region in both hunted and non-hunted areas. It was found more abundant in hunted areas than in the CBR. The main explanation for this result is the fact that this species is not a favorite prey for hunters in the region, because as was already showed for other places this species cannot sustain a high hunting pressure. Fragoso (1991) found a lower relative abundance of this species in a hunted site than in a protected one in Belize. Naranjo (2002) found similar results in the Lacandon Forest in Mexico. Tapirs also are considered a highly susceptible species to the hunting effect due to their low population growth rate where females bear a single young every 2 years on average (Emmons and Feer 1990; Bodmer et al. 1997b).

In this study the fact that tapirs are not a favorite prey for the hunters and the hypothesis of better habitat in the *ejidos* due to the more humid gradient present in the region can be the responsible for the higher relative abundance of this species in the hunted sites. It seems like tapir needs the more humid communal lands in Calakmul in order to sustain healthy populations. Overall habitat conditions probably are better habitat in communal lands than in the more xeric core area of CBR. Combinations of management strategies between the CBR and the communities are necessary in order to assure the protection of this species which is listed as endangered in Mexico and on the Appendix I in CITES (SEMARNAP 2000; IUCN 2000).

White-tailed deer was found with a higher abundance in hunted sites than in CBR. Habitat perturbation seems to favor this species with increased abundance in fragmented habitats. This relationship has been documented throughout this species' geographic range (Méndez 1984). Also this species persisted in highly hunted sites. White-tailed deer are very important for subsistence hunters and is the only ungulate species that benefits from the human perturbation. With a management plan white-tailed deer can become a very important source of animal protein for areas that have been already cleared and where other ungulates species are rare or absent.

Collared peccary is one of the most preferred species for subsistence hunters and is very easily hunted with dogs. Consequently, a higher relative abundance was found in CBR than for *ejidos* for this species. Considering this species is a generalist and can live in a wide array of habitats (Leopold 1959; Peres 1996; Sowls 1997), I can surmise that the reduction in relative abundance in hunted sites indicates that collared peccary is being affected by the hunting pressure in Calakmul region. However, the fact that the differences in relative abundance between hunted sites and non-hunted area was not so drastic, demonstrates that collared peccary has a high resistance to hunting pressure (Bodmer et al.1997a; Fragoso 2000; Naranjo 2002), and is ideally suited for experimental sustainable management plans.

Brocket deer are a common species in Calakmul in both hunted and hunted zones. Calakmul region is important for brocket deer because the two species are sympatric here. Calakmul represents a research challenge to understand how these species divided the habitat and how they are affected by hunting pressure. I was not able to distinguish between the two species signs, therefore, I could not estimate which species may be more affected by human perturbation. Overall brocket deer showed a high resilience to human impact, even though they are a highly prized species as well (Reyna-Hurtado et al. 1999; Weber 2000). Brocket deer can be another suitable species for an experimental sustainable management in Calakmul. They are also an interesting species in Calakmul because they (or at least one of the two species) seem to be adapted to the low-dry forest (pretty common forest type in Calakmul) and may have special ecological characteristics that allow them to survive and flourish in this kind of forest, which seems to be avoided by other ungulates species.

As a result of forest use analysis of the ungulates species in Calakmul, low-flooded forest are identified as a very important forest type, with more sign frequency than expected, especially in hunted areas. This forest type probably is serving as a refuge from human disturbance because is not the most visited for hunters in the Calakmul region. Medium-forest, which is the most abundant forest type in Calakmul is important to all the species and is commonly used by humans as well. Low-dry forests are very important for brocket deer that seem to be the only ungulate to use this habitat in a permanent way. White-tailed deer and tapir take advantage of secondary-forest and, while use of disturbed forest is well known for white-tailed deer, it is a surprising result for tapir, which have been reported to use this kind of forest in Belize and Costa Rica (Williams 1984; Fragoso 1991; Naranjo 1995), but it was an unknown fact for the Calakmul region before this study. Apparently hunters in this region do not prefer harvesting tapir, thus this species may be able to co-exist with humans in the *ejidos*.

Calakmul region represents a challenge for conservation and future research of ungulate species. Attention is needed to be paid to white-lipped peccary and tapirs. Collared peccary, brocket deer and white-tailed deer are suitable species for sustainable management plans on the basis of adaptative management discipline (Robinson and Redford 1991; Caughley and Sinclair 1994).

Conservation of ungulates, as well as other species and their habitats in Calakmul will have to involve the human communities present in the area. There is still time to set up some management strategies that may help alleviate the human impact. Without the incorporation of communal forest in the conservation plan and without the combined effort of CBR authorities, Calakmul municipality authorities, scientific researchers and inhabitants of the *ejidos*, the natural conditions of the area will be degraded more than in the present, directly affecting the wildlife populations and the human communities of the area.

If we fail to conserve Calakmul, Mexico and the world will lose one of the last remaining and interesting tropical forests in Meso-America, where herds of white-lipped peccary roam among the forest searching for water bodies and fruit patches, and where jaguars and tapirs walk among old Mayan temples.

Calakmul is a reminder that humans and nature have co-existed in the past and that our responsibility is to assure its maintenance for the future generations.

APPENDIX A
MAPS

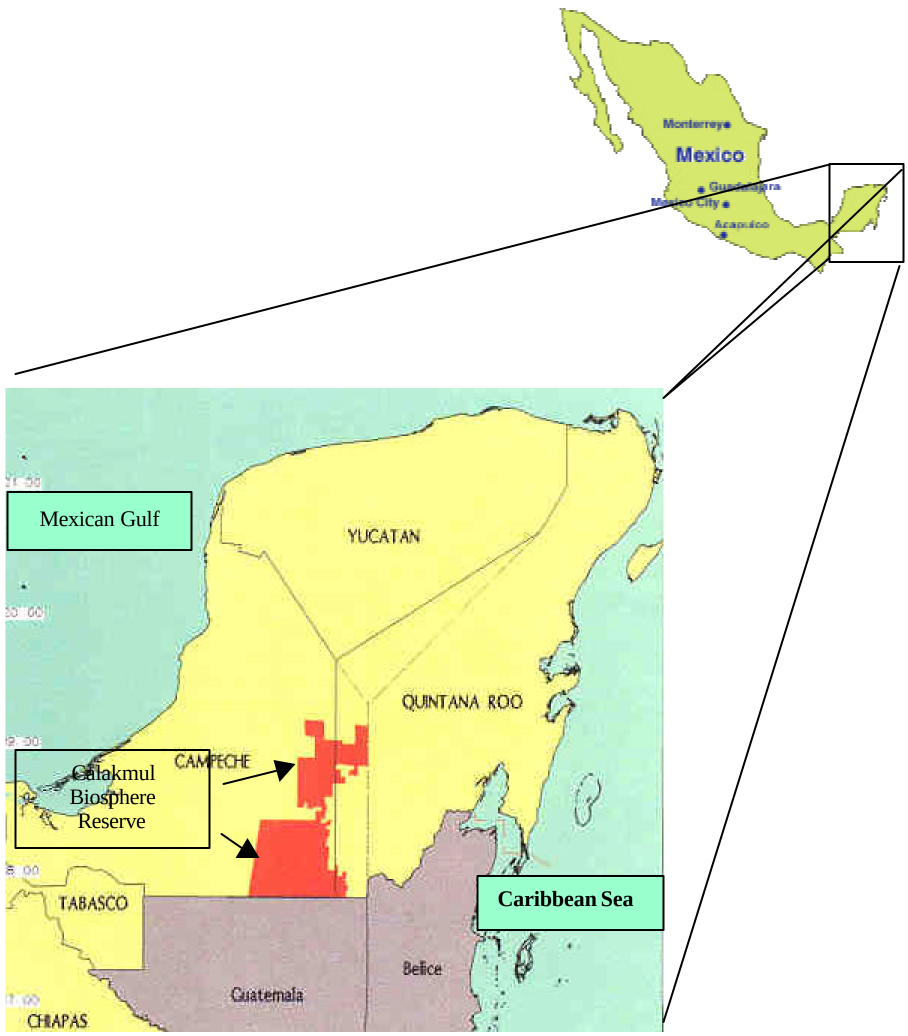

Figure A-1. Map of Calakmul Region, Campeche, México

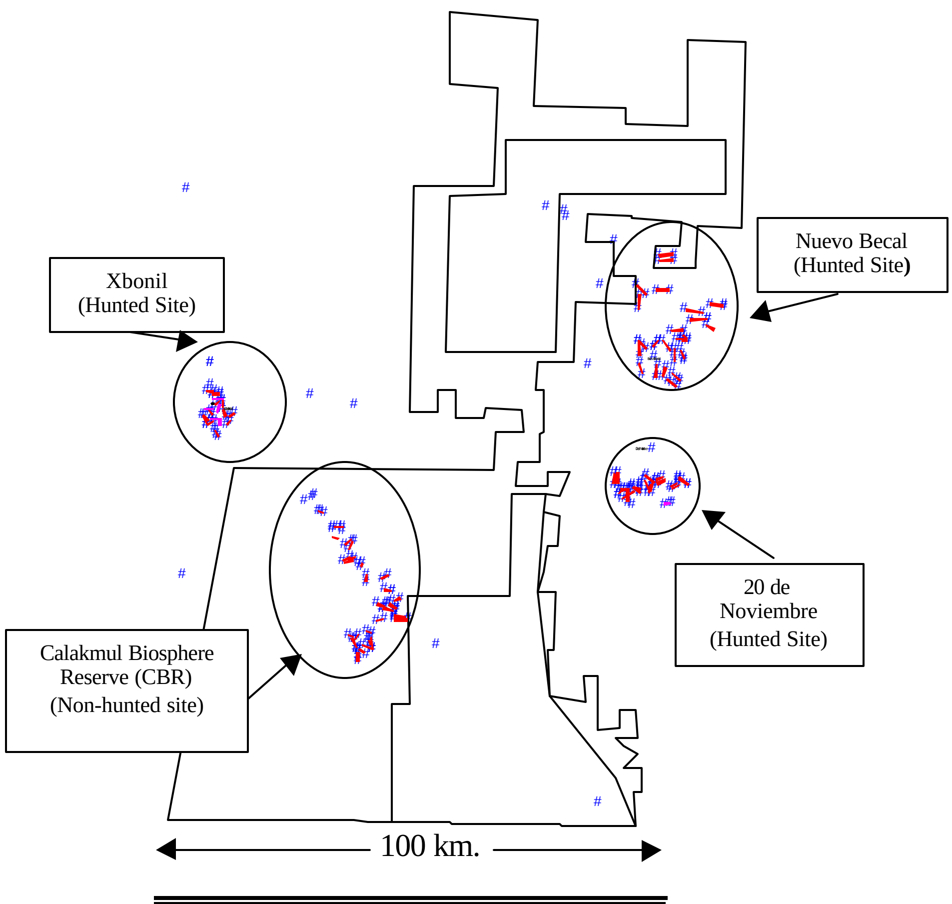

Figure A-2. Map of Study Sites and Transects Location

APPENDIX B
QUESTIONNAIRE**.**

Proyecto: Densidad poblacional y tamaño del grupo del pecarí de labios blancos (*Tayassu pecari*) en la Región de Calakmul

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CUESTIONARIO SOBRE CACERÍA DE SUBSISTENCIA

*(*Este cuestionario no es obligatorio, es confidencial ydurará de 20 a 30 minutos*)*

Ejido: ________________________ Entrevistó:___________________

Parte 1. Datos personales**.**

Nombre:		
Sexo:	Edad:	
Estado civil:	No. de hijos:	
Ocupación:	Cuántos viven en su casa?	
Lugar de origen:	Tiempo de vivir en el ejido:	
Caza (aunque sea ocasionalmente)?	Si	No

Parte 2. Datos sobre el pecarí de labios blancos.

2.1 Ha visto manadas de PLB en el ejido		Si		No
Cuántas veces?	Grupo 1	Grupo 2	Grupo 3	Grupo 4
Cuándo?				
Dónde vio ese grupo?				
Cuántos iban en el grupo?				
Cuántos juveniles o crias?				
Qué estaban haciendo?				

Parte 2.2 Datos sobre cacería del pecarí labios blancos.

2.2 Ha cazado PLB en el ejido?		Si		No
Cuántas veces?	Grupo 1	Grupo 2	Grupo 3	Grupo 4
Dónde?				
Cuándo?				
Como encontró el grupo?				
Cuántos iban en el grupo?				
Cuántos juveniles o crías?				

Cuántos cazó?				

Parte 3. Datos sobre cacería.

3.1 Lugares

Caza dentro del ejido	Si	No (pase a la parte 3.7)
Lugar a donde va mas seguido a cazar:		
A cuántos km queda ese lugar de su casa?:		
En qué se va a ese lugar		Tiempo en llegar:
Va solo o acompañado?		Cuántos van?

3.2 Frecuencia

Hace salidas especiales para cazar o solo cuándo va a la milpa?						
Frecuencia:	Diario	Semanal	Quincenal	Mensual	Trimestral	Semestral
Cuánto dura una salida a cazar?			1 día	2 días	Más (especifique)	
Época preferida para cazar:		Secas		Lluvias		

3.3 Metodos.

Que metodo utiliza:	Perros: Cuantos:	Arreadas: # de personas:	Espera: Dónde:
Búsqueda:	Lampareo:	Otros:	

Caza con escopeta o rifle:	Calibre:
Utiliza trampas o cebos?:	

3.4 Habitat

En donde caza mas frecuentemente?:	Montaña alta	Montaña baja	Aguadas
Milpa	Otros		

3.5 Especies

Cuál y cuántos de los siguientes animales ha cazado en el último mes:				
Venado CB.	Cabro rojo	Cabro bayo	P. de monte	Jabalí
Tapir	Tepescuintle	Armadillo	Tejon	Serete
Pavo	Hocofaisán	Tinamu	Chachalaca	Monos
Otros:				

3.6 Uso del animal.

Qué hace con la carne?	Vender	Repartir	Consumo familiar	Otro:
Utiliza la piel?	No	Si, como?		
Usa las astas, colmillos, plumas u otros productos de los animales que caza				No
Si, como?:				

3.7 Reservas.

Existe lugares de reserva de fauna en el ejido	No	Si
Cuáles?:		
Esta de acuerdo en la creación de lugares de reserva de fauna dentro del ejido?		
Si	No, por que?	

Gracias por su tiempo e información!!

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BIOGRAPHICAL SKETCH

Rafael Reyna was born in a small town in Michoacan State in Central Mexico. He was the seventh of an eight member family. Two things accounted for his love of nature: his frequent travels in company of his father and brothers to the forest surrounding the town, and the animal book collection his father had in his private office.

He decided to study biology at the State University (Universidad Michoana de San Nicólas de Hidalgo). During and after school he spent six years of professional experience in the State Zoological Park (Parque Zoológico Benito Juárez) and three years in a fieldwork study on the Calakmul Biosphere Reserve in Campeche State in Southern Mexico, where he fell in love with the tropical forest.

He was married in 1998 and in 2000 he went to the University of Florida to pursue a master's degree in wildlife ecology and conservation. His plans for the future are to remain at the University of Florida to pursue a PhD in wildlife ecology and conservation and to conduct deeper research on peccaries in the wild. Among his very personal plans, he is planning to increase his family with a new member in the non-immediate future.