Research Article

Conservation status of the white-lipped peccary (*Tayassu pecari*) outside the Calakmul Biosphere Reserve in Campeche, Mexico: a synthesis

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Abstract
The white-lipped peccary is a social ungulate that forms the largest groups documented for any other ungulate species living in tropical forests. White-lipped peccaries have become increasingly rare in Mexico and Central America in the last 50 years. Here I suggest some management actions for conservation of this endangered species in the Calakmul region based on a synthesis of ecological and social data coming mainly from a two-years' field study conducted in the Calakmul Biosphere Reserve (CBR) and three human communities (*ejidos*) that surround it in Southeastern Mexico. Group size and breeding season were recorded in the CBR and in four adjacent hunted sites. Home range, habitat use, and population density were estimated only for the CBR, and hunting patterns were recorded for the three adjacent villages. Home range was among the largest reported anywhere for this species. White-lipped peccary groups were larger in the CBR than in the hunted areas, but groups were generally smaller than those reported in other forests. These smaller group sizes signal a conservation concern for this species in the Calakmul region. Hunting occurs mainly in the dry season when the breeding season is at the peak and peccary groups are visiting water bodies where they are more easily hunted. To conserve the white-lipped peccary in the Calakmul region we need to reduce hunting pressure and preserve large forested areas outside the CBR.

Key words: White-lipped peccary, Calakmul Biosphere Reserve, conservation, population density

Resumen
El pecarí labios blancos o senso es un ungulado social que forma los grupos más grandes de todos los ungulados que viven en bosques tropicales densos. Esta especie ha desaparecido de grandes áreas de Centroamérica y México debido a la cacería y desaparición del hábitat en los últimos 50 años. Aquí presento sugerencias de manejo para la conservación de este ungulado tropical en peligro de extinción en la región de Calakmul en base a una síntesis de información ecológica y de comunidades humanas obtenidas principalmente en la Reserva de la Biosfera de Calakmul y en tres ejidos aledaños. Anteriormente en 2005 y 2006, estudié patrones de movimientos, ámbito-hogareño, tamaños de grupo, densidad y temporadas de reproducción y cacería de esta especie en la Reserva de la Biosfera de Calakmul, un bosque tropical semi-seco del sur de México. Capturamos y seguimos individuos de cuatro grupos de pecaríes por diversos periodos durante 2005 y 2006. Los ámbitos hogareños fueron de los más grandes reportados en la literatura y los tamaños de grupo de los más pequeños. Los grupos fueron más grandes en la zona protegida que en las zonas con cacería. La cacería legal y de subsistencia de esta especie se realiza en la época de secas que coincide también con la época de reproducción cuando esta especie visita los cuerpos de agua regularmente y es altamente vulnerable. La conservación del pecarí labios blancos requiere la preservación de grandes extensiones de bosque tanto en el área protegida como en los ejidos y la reducción y control de la cacería de subsistencia y deportiva.

Palabras clave: Pecarí labios blancos, Reserva de la Biosfera de Calakmul, conservación, densidad de población.

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Introduction

The white-lipped peccary (*Tayassu pecari*, Link 1795, Order: Artiodactyla, Fam: Tayassuidae; Fig. 1) is one of the three recognized living species of peccaries [1]. White-lipped peccary distribution once ranged from Veracruz (Mexico) to northern Argentina. However, the range of this species has been reduced in several regions due to overhunting and forest fragmentation. The species is on CITES Appendix II, but its status is poorly known. The IUCN Red-List (2007, www.iucnredlist.org) classified it as Lower Risk/Least Concern due to the wide range of the species. It was determined recently [2] that the species has been extirpated in 80% of the historical range in Mexico. More than 50 years ago, Leopold [3] pointed out the reduction in numbers and range of this species in Mexico due to habitat loss and excessive hunting [3, 4]. So true were his predictions that in Mexico white-lipped peccaries have disappeared from Veracruz, Tabasco, and Yucatan states, and isolated populations remain in Oaxaca and Quintana Roo, with the only stable populations in Chiapas and Campeche [2-5].

Despite this reduction of the range, until 2008 the species has not been classified in the national list of endangered species (NOM-Norma Oficial Mexicana de Especies en Peligro) issued by the Environmental Ministry of the Mexican Government (SEMARNAT), and sport hunting is still allowed in Campeche and Quintana Roo states under the official scheme of Conservation and Management Units (UMA for its Spanish initials). The current situation is even worse when we consider that subsistence hunting [5-8], and forest fragmentation are affecting this species outside the protected areas without a conservation plan at any regional or national scale.

Fig. 1. Individual white-lipped peccary (*Tayassu pecari*) and a group showing some individuals radio-marked. Photo: Rafael Reyna-Hurtado

The white-lipped peccary is an unusual social ungulate that lives in closed habitats while forming large and cohesive groups, generally from 10 to 300 individuals, but there are historic reports of groups larger than one thousand animals [9]. Usually the white-lipped peccary travels long distances in non-predictable movements, but evidence of seasonal movements have been found for some places; however these movements are inside large home ranges [10, 11]. In other areas its presence is episodic and unpredictable [12]. The white-lipped peccary likes to wallow in muddy soils around water ponds and rivers, especially during the dry season. Peccaries are mainly frugivorous and can eat hard nuts not consumed by other species, e.g., *Buriti* palm (*Mauritia flexuosa*; [13]). White-lipped peccaries are prey to great cats like the puma (*Puma concolor*), and jaguar (*Panthera onca*). This species shows little tolerance for humans and avoids or disappears quickly from highly populated areas when the habitat changes dramatically [1, 3, 6, 14).

Here I present a synthesis of ecological data on the white-lipped peccary and human social data obtained in the Calakmul Biosphere Reserve (CBR hereafter) and three adjacent communal lands (*ejidos* hereafter), from two major studies I conducted in 2001 [7], and from 2004 to 2006 [15]. I integrated recently published data from home range, habitat use [16], relative abundance [6], ecological density, group size, reproduction season, and hunting pressure [17], aiming to suggest some management strategies for the conservation of this highly endangered species of Mexican wildlife.

Study Area

The Great Calakmul Region. This study was conducted in the Calakmul municipality in the Mexican state of Campeche (Fig. 2). This municipality includes the CBR, the largest protected tropical forest in Mexico, with 7,238 km^2 that was decreed as a protected area in 1989. The CBR is part of the Great Calakmul Region [18] that includes the Maya Biosphere Reserve in Guatemala and the Rio Bravo-Dos-Milpas conservation area in Belize, which together form one of the largest tropical forests in Mesoamerica, covering more than 20,000 km^2. The CBR is divided into two core areas (Southern and Northern) with mitigation areas around them.

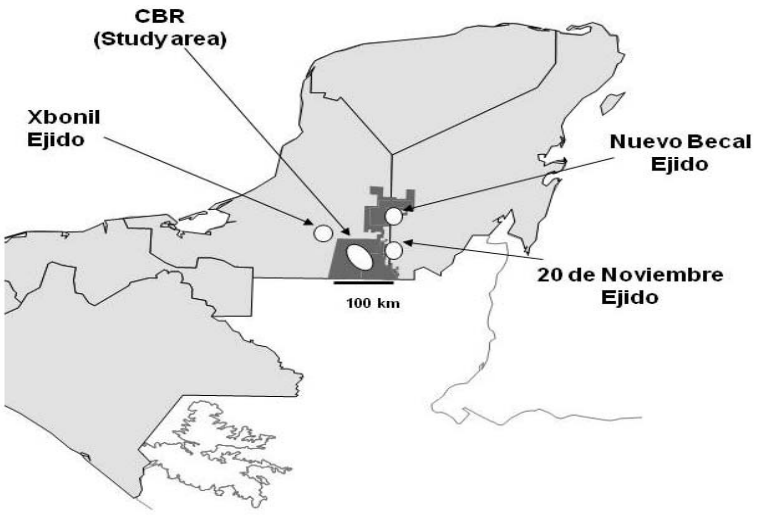

Figure 2. Localization of the Calakmul Biosphere Reserve (in dark gray) a study areas (white oval) in Mexico (light gray).

According to Köppen (modified by Garcia [19]), the Calakmul climate is warm and sub-humid (Aw), with a mean annual temperature of 24.6^{o} C. There is seasonal rainfall, mainly in summer and early fall, with an annual average of 1,076.2 mm. The water in the area is obtained through precipitation since there is no a permanent river system. Most of the rainfall percolates through the limestone, but some drains superficially and stores in ponds. These ponds constitute the only source of water for wildlife through the dry season. There are four major forest associations [20], the Medium Sub-Perennial Forest (Medium), the Low-Flooded Forest (Flooded), which gets seasonally inundated after two to three months of heavy rains, and the Medium and Low Semi-Deciduous Forests, which both can be classified as dry forest (Dry).

Despite the presence of some jaguar hunters, gum tappers, and archeological looters, this region has remained almost undisturbed since the Mayans abandoned it 1,100 years ago. In the 1970s when the Mexican government encouraged the colonization of the "last frontier" in Mexico, the tropical forests of the humid and semi-humid tropics, such as Calakmul and other parts of Mexico, received a large influx of people from Mexico's central and southern states. This colonization process brought environmental changes to the region, and a municipality that presently includes 114 human settlements (*ejidos*) and an estimated population of 35,000 persons [21]. 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 [6, 8, 22-24]. The three *ejidos* where I conducted studies on this species where: Nuevo Becal, Xbonil, and 20 de Noviembre (see details [6, 17]). These *ejidos* have some of the largest communal forests, and are located adjacent to the CBR in the Northeast, East, and West, respectively, representing the microclimate and habitat variation of the area that surrounds the CBR.

Ejido Nuevo Becal. This community is formed by approximately 350 inhabitants of "mestizo" origin from Campeche, Tabasco and Veracruz status. The *ejido* was created in 1970 and encompasses 520 km^2 of mainly forested area. This community is located at the northeast of the CBR and is running a community sport hunting enterprise under the UMA scheme in its lands (see details in [24]).

20 de Noviembre. This *ejido* is located to the east of the south core area of the CBR, and includes 343 inhabitants of Maya origin. The land is 280 km^2 in extension. The *ejido* was also created in the early 1970s and has been mainly forested. .

Xbonil. This *ejido* is located to the Northwest of the CBR southern area. It consists of approximately 618 inhabitants of "mestizo" origin, mainly from Michoacán, Tabasco, Veracruz, and Chiapas states. The area is 400 km^2 of mainly forested land. Xbonil also has a UMA with sport-hunting purpose [22].

Methods and background information

White-lipped peccary capture, radio-telemetry, home range and habitat use

With the assistance of two persons, a total of 17 white-lipped peccaries from four groups were captured during the 2005 dry season and fitted with radio transmitters (Telonics, Inc.). Details may be seen in [16]. Groups were monitored using the homing method [25] that consisted of locating the groups from the only existing high points, the two Mayan temples of the Calakmul archeological city, and then walking towards the group. Using the homing method I collected 70% of the home range fixes as GPS points, while the other 30% were obtained through radio-telemetry triangulation from temporal points, and in some rare occasions from the highest points (Mayan temples and hills) [16]. Home range sizes were estimated for each group by the fixed-kernel, adaptive-kernel, and minimum-convex-polygon (MCP) methods [26]. Details may be seen in [16]. The four groups were monitored for different periods of time during the 18

months that encompassed the study time. The groups were identified as the Red, Blue, Green, and Yellow groups.

To estimate habitat preferences for each group, I recorded the forest type where the group was observed, and thereafter at 15-minute intervals while in contact with the group. I never attempted to estimate forest type based on the radio-telemetry locations; all forest type use data was obtained by direct observations of the four groups. I used compositional analysis [27] as the main method for contrasting the use of habitat types by white-lipped peccary groups vs. habitat availability (see details in [16]).

During the 18 months of the study I encountered the groups on 203 days. I maintained contact with the groups from 10 to 17 months (see details in [16]). In accordance with Seaman and Powell [28] and Seaman et al. [29], I considered the 95% fixed-kernel estimates to best represent the home range of the groups for their respective periods of time (Fig. 3). With 95% fixed-kernel, the Blue group had the largest home range (97.5 km^2) followed by the Green group (82.4 km^2). Groups shared the same space almost completely during the dry season of 2005 with a 91.7% degree of overlap for the four groups combined (Fig. 4). During the rainy season of 2005, the Blue, Green and Yellow groups traveled to different areas to the north whereas the Red group stayed in the dry-season area (Fig. 5). The degree of overlap dropped to 34.5% for the rainy season of 2005 for all the groups (see details in [16]).

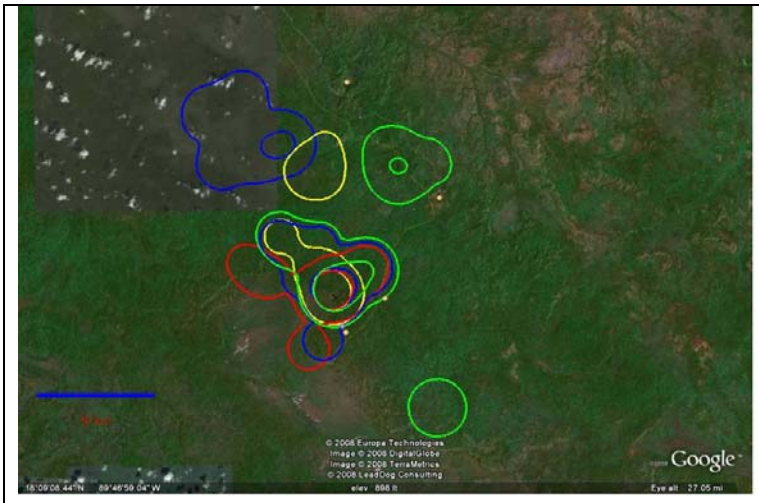

Fig. 3. All-seasons fixed kernel (95% home range represented by the total area of each color, and 50 % by the circles inside, respectively) home ranges for the four groups of white-lipped peccary in the Calakmul Biosphere Reserve, Campeche, Mexico (taken from [16]).

Fig. 4. Fixed kernel home range estimation for the dry season of 2005 for the four groups of white-lipped peccary in the Calakmul Biosphere Reserve, Campeche, Mexico (taken from [16]).

Compositional analysis for Johnson's [30] third-order selection (MCP home ranges vs. group localizations) showed that inside their home ranges all groups significantly preferred ponds and medium forest and avoided the dry forest. I performed an additional analysis taking away observations in ponds; the results consistently showed that all white-lipped peccary groups significantly preferred medium forest and avoided dry forest. Flooded forest was also very important for the four groups and for the Green group was ranked even above medium forest and just below ponds (see details in [16]).

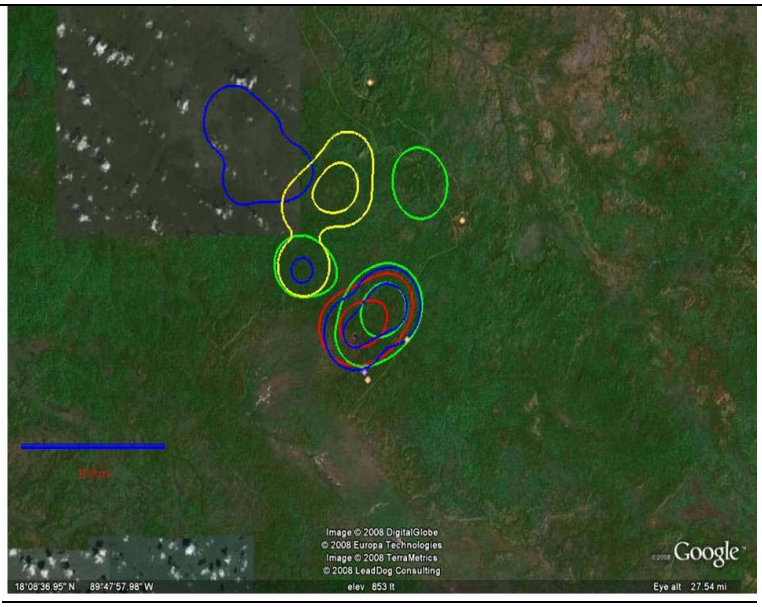

Fig. 5. Fixed-kernel home range estimation for the rainy season of 2005 for the four groups of white-lipped peccaries in the Calakmul Biosphere Reserve, Campeche, Mexico (taken from [16]).

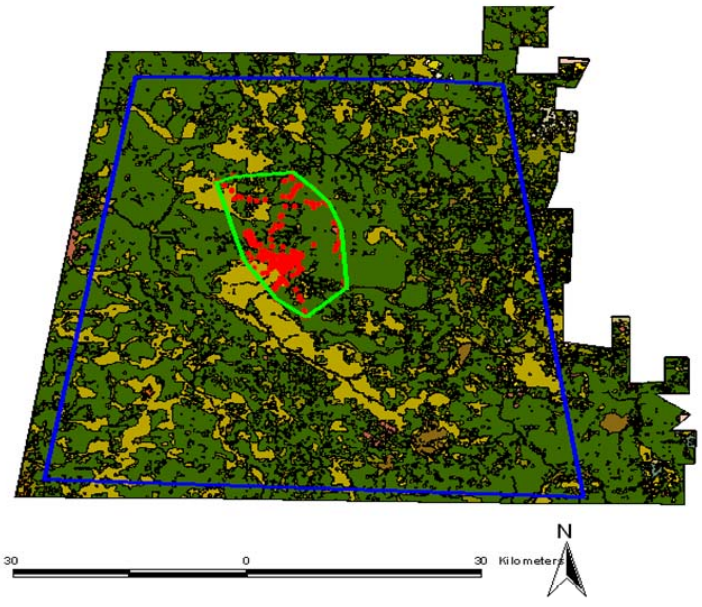

Fig. 6. Area used and shared by four groups where density was estimated (encircled by light green line) and area where density was extrapolated (encircled by the blue line) of white-lipped peccaries in the southern area of the Calakmul Biosphere Reserve, Campeche, Mexico (taken from [17]).

Group sizes, breeding season and hunting patterns

Group sizes and breeding season of white-lipped peccaries were recorded during field surveys at five sites. Three sites were the *ejidos* of Nuevo Becal, 20 de Noviembre, and Xbonil, where subsistence hunting, as well as selective logging and extraction of forest products (palm leaf, honey, mahogany seed, etc.), are common activities. The fourth site (Calakmul-limit) encompasses some ponds located in the border between the southern core of the CBR and an *ejido* in which hunting occurred. The last site was the southern core area of the CBR (with approximately 3,500 km^2). This site was at least 40 km south of the nearest human population center and no hunting occurred there due to the natural isolation of the area and to law enforcement along the only road existing in the area (see details of data collection in [17]).

Data about subsistence and sport hunting events in the three *ejidos* were collected mainly with the help of field assistants who lived there during 2005-2006, and by systematic talks with subsistence hunters who were visited every month for the whole period by one student involved in this research (Sadao Pérez Cortez). In addition, for the sport hunting I consulted the people in charge of the program (SEMARNAT, Campeche-office, Mexico) to obtain the dates when it is legal to hunt white-lipped peccaries under the UMA guideline. I focused on the season when white-lipped peccary hunting took place. I also included estimates of hunting pressure on the three *ejidos*, estimates which were obtained in 2001 as part of a study that included interviews of 30 local villagers in each *ejido* to estimate hunting pressure and other social characteristics of the community [6].

The sizes of 24 white-lipped peccary groups were recorded at the four sites from 2001 to 2007. Ten observations were obtained from *ejidos*, nine from the CBR and five from Calakmul-limit. Considering Calakmul-limit as a hunted site, groups were larger in the non-hunted areas (Median=25, SE=1.84 n=9), than in the hunted areas (Median=16, SE=1.84, n=15) and the difference was significant (*Mann-Whitney* test $p=0.02$, $n=24$). Details may be seen in [17].

From 2001 to 2007, I recorded 19 birth events in at least 17 different groups from all the study sites except from one of the *ejidos* (20 de Noviembre). In 18 cases the birth events took place in a period between late December and May with the peak of the breeding season being in January–February; the single exception was a group with newborns sighted in October. On five occasions I observed that females had given birth to twins (see details in [17]).

I recorded 21 hunting events during the study period. These events were performed by subsistence hunters (19) in the three *ejidos* and sport hunters (2) in one *ejido* where legal hunts of this species are allowed through the UMA system. All the hunting events but three took places in the dry season, from late December to mid-May. The exceptions were two hunting events recorded on November 2002 and October 2004 in the Nuevo Becal *ejido* and one from an undetermined season. The legal time to hunt this species is always from early April to mid-May (Dirección General de Vida Silvestre, Campeche, pers. comm.). Of these 21 events, 17 were successful and hunters took between 1 to 13 white-lipped peccaries per event. Sport and subsistence hunters did not discriminate in regard to females that were lactating or pregnant (pers. obs.). Details may be seen in [17]. Finally, I recorded that in a period of two months in 2005, subsistence hunters in combination with sport hunters harvested 27 white-lipped peccaries from a group of 29 individuals, leaving a single mother and her newborn [24]. This occurrence documented the almost complete elimination of a group in an *ejido.*

Ecological density

I estimated white-lipped peccary density for the CBR based on a minimum convex polygon constructed from location fixes obtained while searching the area several times every month (from the period of 2005-2006) while trying to make contact with the four radio-marked groups (named Red, Blue, Green and Yellow) during a 10-month period. I favored this estimate because from March to December 2005 I had continuous contact with the four groups and had

precise counts of their size. Additionally, during intense field work in these 10 months, I did not see any white-lipped peccary sign that could not be attributed to the four groups. Every time I encountered a white-lipped peccary sign I confirmed the identity of the group traveling there by using the radio-marked animals in each group. Group observations for more than 200 days confirmed the high fidelity of marked individuals to their respective groups (see details in [17]). Additionally, I estimated the number of individuals and groups existing in the southern area of the CBR by extrapolating these estimates to a larger polygon that included the study area and almost all the southern area of the CBR, with an exception of a 5 km buffer from the border with the *ejidos* (Fig. 6). This extrapolated area shares similar protection status and the habitat types have not changed dramatically [17].

The entire area where only the four radio-marked groups lived during a 10-month period of continuous radio contact was estimated to be 236.7 km^2 (Fig 6). The sizes of the four groups were 31, 25, 25, and 20 at the beginning of the radio-telemetry study for a total of 101 white-lipped peccaries. Therefore, the estimated density was 0.43 / km^2, or one white-lipped peccary/2.34 km^2. I used this density estimate to calculate white-lipped peccary density on the whole southern area of the Calakmul Biosphere Reserve. For the extrapolation exercise, I defined a larger area that encompassed almost all the southern area of the CBR except a buffer of 5 km between the reserve and the *ejidos*. This area selected comprised 3,509.41 km^2 and has the same status of legal protection, a similar level of isolation and, more importantly, similar proportions of forest types (see details in [17]). Therefore, assuming that white-lipped peccaries disperse equally over this area, I estimated 1,493 individuals on the whole southern area of Calakmul Biosphere Reserve. Considering that the mean size of the nine groups recorded in the CBR was 25.7 individuals per group, approximately 58 groups could exist on the total southern area of the Calakmul Biosphere Reserve [17].

Conservation analysis

Data on home range, habitat use, relative abundance, group size, hunting pattern, density, and range behavior were integrated and analyzed under the spatial and social perspectives of the CBR and the three *ejidos* around it. I did an exercise of extrapolating density and area-used data obtained in the CBR to the three *ejidos* to estimate a maximum potential number of individuals present if hunting did not have an effect. Then I divided this maximum number of individuals for the median of group size I found for the *ejidos* to estimate a potential maximum number of groups present in each *ejido* according to the forested area. Based on these numbers, and in actual hunting and forest use practices, I rated the *ejidos* (Appendix 1) and present some specific recommendations for conservation and better management of the species in the region.

Results

Current status of the species outside the Calakmul Biosphere Reserve

The situation of white-lipped peccary population outside the CBR is worrisome due to several facts indicating that the species is not doing well outside the protected area. For example, groups were bigger in the protected area than in the *ejidos,* where there is hunting pressure in all of them practiced by subsistence and sport hunters; the hunting season is mainly in the dry season when this species is highly vulnerable because groups are attached to the few remaining water sources. Combined subsistence and sport hunting harvest rates are probably larger than sustainable as the extermination of a group in a single season was demonstrated for one of the *ejidos*.

The large home range of groups as determined in the CBR indicates that this species needs large forested areas to sustain viable populations. It was also shown that the species often visits water bodies and that the preferred habitats were the medium semi-perennial forest and the

low-flooded forest while the dry forest was always avoided. These conditions can be found in the *ejidos* forest only partially, as these already have deforested areas, and the connectivity with the CBR is limited. The following analyses show the particular conditions of each *ejido* according to the potential number of individuals and groups that can be sustained.

Projections of population density

I extrapolate the density estimation obtained from the CBR into the forested area in the *ejidos*. Due to the lack of exact figures of actual deforestation rates in each *ejido,* I took a precautionary 20% of the total area to account for deforestation due to crop cultivation, urban areas, and cattle ranching in each. Within this new estimate of suitable areas, Nuevo Becal and Xbonil *ejidos* could potentially maintain a maximum population of between 170 to 180 individuals, while the 20 de Noviembre *ejido'*s population would not reach 100 individuals (Appendix 1). According to these estimates and considering a median group size of 20 in each group [17], there are potentially nine groups in Nuevo Becal, nine in Xbonil, and only five in 20 de Noviembre (Appendix 1). Finally, the *ejidos* were categorized for purposes of white-lipped peccary conservation according to size of the area, degree of hunting pressure, and connectivity with the CBR. The best was Xbonil, followed by Nuevo Becal and the worst was 20 de Noviembre *ejido,* which is the smallest of the three and has almost no connectivity with the reserve (Appendix 1).

Discussion

Among the main results, I found that in the Calakmul region group sizes never exceeded 35 individuals, and that they have one of the largest reported home ranges. White-lipped peccaries substantially increased their home ranges when the rainy season arrived in the CBR, suggesting that water availability plays an important role in determining movements of this species.

Habitat use of white-lipped peccaries showed that a forest having a high density of ponds with a combination of semi-perennial and low-flooded forests are the preferred habitats for this species. Water availability could be the factor most important for groups of white-lipped peccaries in any given site. In this study, water access was the driving force behind long movements, and this determined extension of home ranges during the dry season. Empirical observations showed also that white-lipped peccaries prefer areas where the two forest types are mixed and that they avoid large patches of single-forest types [16]. Therefore, preserving the mosaic of vegetation and existing water bodies is one of the very important actions for conservation of this species in the region.

If we compare white-lipped peccary populations in the CBR to populations in human-use areas where hunting pressure exists, this study presents evidence that the populations in the human-dominated areas are not doing well. When contrasting the size of groups in the CBR and in communal forests where hunting pressure exists, I found that groups were bigger in the CBR than in the hunted sites, which suggests that this species is being affected by human factors in the communal forests. Additionally, hunting activities (either subsistence or sport) were practiced in the dry season, which is also the breeding season for the species, when they are very vulnerable to hunting due to their behavior of visiting ponds. Hunting during the dry season is one of the main threats to the species in communal forests and can have disastrous consequences for the populations outside the CBR. Additionally, sport hunters are allowed to hunt this species during the last two months of the dry season (April-May), a time of potential maximum stress on white-lipped peccary groups. Along the same lines, hunting a large proportion of any group will have behavior consequences for the rest of the animals, making them vulnerable to high predation levels or limiting the ability to reach feeding/drinking areas, since only some of the animals may know the locations. The social behavior of the group must be respected and preserved in any management activity like sport or subsistence hunting.

Implications for conservation

According to these results, to conserve white-lipped peccary populations in the CBR and the communities around it we will need to preserve large areas of tropical forest.

To conserve white-lipped peccaries in northern Central America it will be necessary to preserve intact this piece of the Maya forest and the attributes that allow this species to survive in it. Conservation measures will likely include effective protection against hunting, no further road development to maintain the isolation of the area, maintaining the availability of ponds and/or other sources of water, and the maintenance of a landscape composed of interspersed medium and flooded forests. Among active conservation measures would be to insure that white-lipped peccary groups have access to water sources (it might even be worthwhile to strategically locate artificial water containers for the extremely dry years like 2005 and 2006). Also, conserving large intact patches of forest would maintain white-lipped peccary populations on human-dominated landscapes if hunting pressure can be controlled [17].

Very important components of the landscape are the communal forests (*ejidos*) because they represent an extension of the population living in the CBR and can serve as corridors between populations. According to the home range and density data obtained in this study, to sustain a population of at least 100 white-lipped peccaries we need at least an area of 236 km^2. In Calakmul region there are some *ejidos* which have more land than that, for example the three *ejidos* studied here. However, these forested areas are also hunting grounds for subsistence hunters, as well as extractive areas where timber and non-timber products are obtained. Activities such as agriculture, cattle ranching, and road-building also are threatening the continuity of these areas with the CBR. There are two main roads that bisect the CBR, one west-east which currently is being converted into a four-lane high-speed road, and one north-south which separated the east side of CBR from the surrounded *ejidos*, among them Nuevo Becal and 20 de Noviembre.

Conserving white-lipped peccaries in *ejidos* forests and assuring connection between the CBR and these forests must be a priority for a conservation plan. Peccary groups living in these areas can exchange genetic material with the population of the CBR, which will prevent the genetic isolation that can be detrimental for any population. Connection will also allow dispersal of individuals to new areas, and in addition will serve as part of corridors between the CBR and other areas where the population exists, like the Sian Ka'an Biosphere Reserve in Quintana Roo State and the Montes Azules Biosphere Reserve in Chiapas State.

For any conservation plan to be successful in such forests, it will have to be developed inside the communities with advice from outsiders, because rules applied by authorities in the city are usually ignored in the area, and there is no law enforcement in the region. Subsistence hunters, if willing, have many options to reduce the pressure on this species. One could be to agree to temporarily ban hunting of the species, at least during the dry season, to allow groups to have access to water during this vulnerable time of the year that is also the breeding time. Other measures that could be taken locally would be to decree a protected area to serve as a source of individuals for the hunting areas. For all these management/conservation actions, monitoring of success and impact will be essential, so residents need to work closely with NGOs, or with academic and governmental institutions that can provide training and capacity building on wildlife ecology and conservation issues.

White-lipped peccary groups in the Calakmul region inhabit a forest that lies in the northern extreme of the species' distribution and where conditions are sub-optimal for its survival. These conditions make this species vulnerable to hunting and other human-induced effects because of the low density and smaller group sizes occurring there. Additionally, the breeding season coincides with the time of the year when the peccaries become more vulnerable to hunting. It is a priority that the government institution in charge of sport hunting (Direccion General de Vida

Silvestre), as well as other NGOs and academic institutions involved, consider banning the sport hunting of this species until more sound biological information is obtained, or allowing hunting only during the rainy season. Additionally, a very important action is to limit the number of individuals harvested from a group. As a preventive measure, no hunter should take more than 10% of any given group. Considering that the median group size in the *ejidos* is 20 individuals, two peccaries must be the maximum number of animals a sport hunter may extract when hunting from a single group. Reducing the number of animals in a group can have ecological consequences for the rest of the group, since animals are more vulnerable to natural predation, or the common knowledge of feeding areas may be reduced if the hunter kills some of the alpha males that usually lead the groups.

The future disappearance of white-lipped peccary in communal forests could have significant consequences for the ecological processes of these forests and for the remnant white-lipped peccary population in the CBR. Conservation of white-lipped peccaries only within a few large and well-protected reserves, like the CBR, will not represent the best scenario for the conservation of this species in México.

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Appendix 1. Maximum estimated number of individuals and groups in the *Ejidos* and categorization of each, according to the size of the area, hunting pressure and connectivity with the CBR.

Study Sites	**Nuevo Becal Ejido**	**20 de Noviembre Ejido**	**Xbonil Ejido**	**CBR**
Area and connectivity parameters				
Total Area	520 km^2	280 km^2	500 km^2	3509 km^2
Total area minus a 20 % (to account for land transformed).	416 km^2	224 km^2	400 km^2	n/a
Connectivity with the CBR	Low	Inexistent	High	
Categorization	*Intermediate (2)*	*Low (1)*	*High (3)*	*Control*
White-lipped peccary population estimation				
Relative abundance of white-lipped peccary obtained in 2001 (# of traces per km walked)	0.05	0.02	0.20	0.22
Maximum population estimated based on extrapolated density found on the CBR	178 indiv.	96 indiv.	171 indiv.	1493 indiv.
Maximum number of groups of white-lipped peccary (considering a median of 20 indiv./group in the *ejidos* and 25 ind./group in the CBR)	9	5	9	58
Categorization	*Intermediate (2)*	*Low (1)*	*High (3)*	*Control*
Human population parameters and hunting pressure				
Total human population	350	343	618	--------
Proportion of hunters among adult men interviewed	93 %	62 %	70 %	--------
Average of people per household	6.33	5.45	4.44	--------
Average distances in each hunting trip	15.5 km	10 km	12.8 km	-------
Occurrence of hunting trips	Every 28 days (from 4 to 90 days)	Every 91 days (from 3 to 360 days)	Every 25 days (from 3 to 120 days)	-------
Categorization	*Low (1.5)*	*High (3)*	*Low (1.5)*	*Control*
Synthesis of the status of the species in each site in relationship with the CBR	**Intermediate (5.5)**	**Low (4)**	**High (7.5)**	**Control**