

## Research Article

# Local perceptions of wildlife use in Los Petenes Biosphere Reserve, Mexico: Maya subsistence hunting in a conservation conflict context

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### Abstract

Conservation conflicts can arise in biosphere reserves when local people face restrictions on resource use and access, mainly in terms of subsistence. We studied the potential conservation conflict with subsistence hunting in two Maya communities (Los Petenes and El Remate) located in the zone of influence of Los Petenes Biosphere Reserve, Mexico. Perceptions, interests and expectations of stakeholders regarding subsistence hunting in the reserve were recorded through semi-structured and in-depth interviews of peasant-hunters and reserve authorities, and participant observation was carried out in both communities. A total of 66 peasant-hunters were identified in Los Petenes (62%) and El Remate (38%). Overall, peasant-hunters acknowledged hunting for family subsistence and expressed the conviction to continue hunting in the region. They mentioned their enthusiasm for hunting, mainly individually and aimed at obtaining white-tailed deer (*Odocoileus virginianus*) and perceived a recent reduction in potential prey locally. Although the law in Mexico does not prohibit subsistence hunting, external authorities stated that they have announced a generalized ban on hunting based on the precautionary principle to simplify enforcement both inside and outside the reserve. The *de facto* restriction on wildlife use, even for subsistence purposes, which was mentioned by external actors, conflicted with the local need and expectation of the contemporary Maya hunters to continue subsistence hunting in the region. Our study confirms the existence of a conservation conflict associated with this traditional practice in the reserve and provides necessary information for managing such conflict.

**Keywords:** Wildlife management, protected areas, stakeholder acknowledgement, Yucatan, Mexico.

### Resumen

En reservas de la biósfera, los conflictos de conservación pueden emerger cuando las poblaciones locales enfrentan restricciones de uso y acceso a sus recursos, principalmente de subsistencia. Para explorar esto, estudiamos el conflicto de conservación potencialmente asociado a la cacería de subsistencia en dos comunidades mayas (Los Petenes y El Remate) ubicadas en la zona de influencia de la Reserva de la Biósfera Los Petenes, México. Las percepciones y expectativas de los actores locales sobre la cacería de subsistencia, fueron registradas a través de entrevistas semi-estructuradas y a profundidad aplicadas a campesinos-cazadores y autoridades de la reserva, realizando observación participante en cada comunidad. Un total de 66 campesinos-cazadores fueron reconocidos en Los Petenes (62%) y en El Remate (38%). Ellos expresaron su gusto por la cacería, principalmente individual y orientada a la obtención de venado cola blanca (*Odocoileus virginianus*), percibiendo una disminución reciente de presas potenciales a nivel local. A pesar de que la cacería de subsistencia no está prohibida por ley en México, las autoridades externas han difundido, con base en el principio precautorio, que la cacería en general está prohibida para facilitar su control dentro y fuera del área protegida. Esta restricción *de facto* sobre el uso de fauna silvestre, aún con fines de subsistencia, contrasta con la necesidad y expectativa del cazador maya contemporáneo de continuar practicando la cacería de subsistencia regionalmente. Nuestro estudio confirma el conflicto de conservación asociado a esta práctica tradicional en el ámbito de la reserva y aporta información necesaria para manejar tal conflicto.

**Palabras clave:** Manejo de fauna silvestre, áreas protegidas, reconocimiento de actores locales, Yucatán, México.

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## Introduction

Although protected natural areas in their various forms represent a global strategy for combating the loss of biodiversity [1, 2, 3], an overemphasis on biocentric perspectives can lead to negative effects on human populations [4, 5]. Within protected areas, limitations on resource use and the exclusion of local populations from conservation planning may contribute to the existence of “conservation conflicts” [6]. Such conflicts arise when two or more parties hold opposing perceptions and perspectives of the use and conservation of natural resources [7]. The appropriate management of these conflicts is currently one of the most critical challenges to conservation, in order to reduce negative impacts on both biodiversity and human sustenance and wellbeing [6].

In contrast with other protected areas, biosphere reserves allow local populations to use natural resources, thereby reducing potential conservation conflicts. However, when biosphere reserves are established they inevitably require the local population to make adjustments, in their use and access to natural resources (e.g., excluding protected species, limiting the frequency and intensity of extractive practices) which are related to zoning of the protected area (e.g., core and buffer zones). In the absence of appropriate regulation, these social adjustments may cause negative impacts not only on biodiversity (e.g., through the overexploitation of species at risk), but also on local populations (e.g., through emergent conflicts linked to traditional subsistence practices) who depend on wildlife species for survival [4].

In the northwest Yucatan Peninsula, the establishment and operation of Los Petenes Biosphere Reserve (LPBR) in recent years has forced the surrounding Maya populations to adjust their traditional forms of natural resource use (e.g., wild fauna obtained through traditional hunting methods) so as not to oppose the management strategies of the reserve. For instance, there is evidence that Maya hunters in the region have been limiting their subsistence hunting activity to certain periods of the year due to the fear of being caught and punished by the external authorities associated with LPBR [8]. The challenge of incorporating the needs of the stakeholders into the management strategies of this region, both inside and outside the protected area, is vital to improving effective conservation of the reserve, as is the case for many protected areas around the world [2].

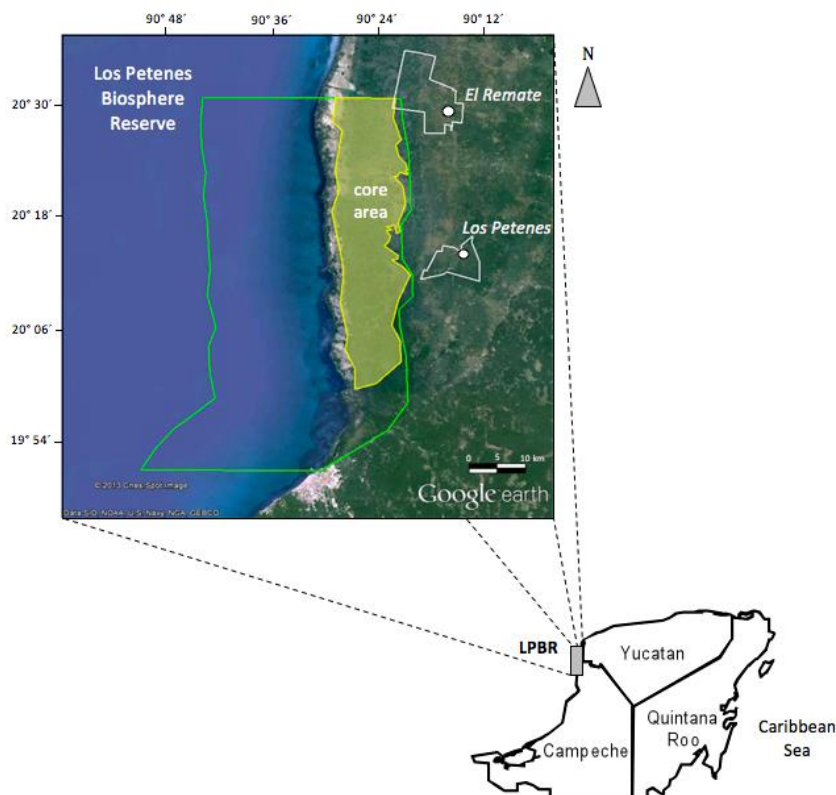
In this study, we analyse the social use of wildlife in the context of the management of LPBR in the perceptions of contemporary Maya peasant-hunters. We expected to find a conservation conflict associated with subsistence hunting within the context of reserve management. We assumed that the establishment of LPBR has imposed restrictions on wildlife use and access to rural people,

potentially incompatible with the perceptions and needs of Maya peasant-hunters who practice traditional subsistence hunting in the region [8, 9]. Subsistence hunting is not prohibited by law in Mexico [10], with the exception of specific zones (e.g., core areas) of protected areas [i.e., LPBR; [11]]. This type of hunting is an extremely important traditional practice for the rural Maya population of the Yucatan Peninsula [8, 12-15] and is associated with the multiple resource use that underlies Maya culture [16].

We also argue that information on expectations and regulation issues regarding wildlife use from the stakeholder's perspective is crucial for effectively managing this conservation conflict in the protected area. Our assessment provides valuable information for decision-making in LPBR and other protected areas of Mesoamerica, where natural resources management and conservation involve traditional practices for subsistence of local populations.

## Methods

The study was carried out in the zone of influence of LPBR (20°31'– 19°49' N, 90°45'–90°20' W), located on the northwest coast of the Yucatan Peninsula (Fig. 1). The region has a warm and sub-humid climate, with a mean monthly temperature of 26°C and mean annual precipitation of 819 mm [17]. Rains are seasonal with a dry season from December-May (mean monthly precipitation = 13.2 mm) and a rainy season from June-November (mean monthly precipitation = 149 mm) [18].



**Fig. 1.** Location of Los Petenes Biosphere Reserve (LPBR) in the northwest of Yucatan Peninsula. The illustration shows the polygons denoting the general borders of LPBR (green line) and its core zone (yellow line). Towards the east of the zone of influence of LPBR, the two study localities are shown (white dots; El Remate and Los Petenes) with their respective communal boundaries (white line). Source: LPBR Management Program [7] and official information on the study communities

Established in 1999, LPBR is a federal protected area spanning 282,857 ha (64% marine and 36% terrestrial), which includes an internationally relevant coastal wetland (RAMSAR site) on the Yucatan Peninsula [11]. There are no human settlements in the terrestrial area of LPBR [19]. Regional vegetation includes naturally formed forested mounds, locally known as *petenes*. These *petenes* (sub-deciduous forest and mangroves) are naturally developed on slightly elevated ground and escape the flooding during the rainy season, in a matrix of natural grassland (e.g., *Typha domingensis*, *Cladium jamaicense*) and mangroves (e.g., *Conocarpus erectus*, *Rhizophora mangle*) [11, 20]. There are also secondary vegetation patches (*hubches*), xerophytic bush, seasonally flooded grasslands and agricultural fields [21]. Terrestrial vertebrates in the region include 66% birds, 17% mammals, and 17% amphibians and reptiles [17]. The most important traditional hunting species are white-tailed deer (*Odocoileus virginianus*), collared peccary (*Pecari tajacu*), paca (*Cuniculus paca*), ocellated turkey (*Agriocharis ocellata*) and iguana (*Ctenosaura similis*) [14, 22].

In accordance with the LPBR Conservation and Management Program (hereafter Management Program [11]), a total of 19 rural communities are located in the terrestrial zone of influence of the reserve. Maya people of these communities maintain a close socio-environmental interaction with the reserve, engaging in seasonal agriculture, subsistence hunting, apiculture, charcoal production, horticulture and fishing. Several of these communities took part in formulating the Management Program of the reserve [23].

### *Study communities*

Two Maya communities in the terrestrial zone of influence of LPBR were selected for this study: Los Petenes and El Remate (community references used by León and Montiel [14] and Méndez-Cabrera and Montiel [22], respectively). Both communities are based on the *ejido* landholding system, under which members of the community or *ejido* hold the rights to use the land, governed by a community committee (*ejido* assembly), which makes decisions on the collective and individual use of communal lands [24]. Our previous work experience with these communities (25) promoted the trust and acceptance by the local population necessary for the fieldwork.

Los Petenes is a Maya community adjacent to the central part of LPBR (Fig. 1). In late 2010, it had a population of 885 inhabitants (53% men and 47% women) grouped into 197 families [26]. Inhabitants of Los Petenes are bilingual in Maya and Spanish, with Maya as their native language. Heads of the households engage in seasonal agriculture, apiculture, logging, charcoal production and subsistence hunting [8, 27]. El Remate is another Maya community adjacent to LPBR, but on its northeast side (Fig. 1). Towards the end of the same year, it had a population of 1,006 inhabitants (51% men and 49% women), grouped into 261 families [26]. In addition to the activities reported for Los Petenes, in El Remate the heads of households also engage in coastal fishing (travelling directly to another community located 30 km away), *huano* palm extraction, handcraft production and wage work (usually outside the community) [22].

Previous studies on the social use of wildlife in the study communities [8, 9, 25, 27] have found that subsistence hunting practiced individually or in *batida* (a group of at least 12 hunters) is common locally for hunting at least 15 species of wild vertebrates (mainly white-tailed deer, peccary, paca and ocellated turkey). This traditional practice involves complex knowledge systems passed down from generation to generation [14].

### *Ethnographic information*

At the beginning of the study, we made eight short visits (1-2 days per visit) to each community to interact with the local population and identify key actors (e.g., local authorities, peasant-hunters). This reinforced local acceptance and allowed us to calibrate the ethnographic instruments applied during fieldwork.

After the short visits, two alternating stays (one month each) were made per community in September-November 2012 and April 2013 to conduct semi-structured and in depth interviews (both following the methodology proposed by Bryman [28]), with all peasant-hunters, experienced and non-experienced, identified through the snowball sampling method [28], and subsequently confirmed as such by the local population. Informed consent was obtained from all subjects.

The semi-structured interviews were designed to record the perceptions, interests and expectations of peasant-hunters regarding the local use of wildlife and their relationship with LPBR. We tried to identify the personal expectations and beliefs of each interviewee regarding subsistence hunting and regulations. In some cases, mainly in response to the willingness of hunters' wives, we also interviewed the wives for further local perceptions of subsistence hunting.

During the community work, participant observation (following Jorgensen [29] and Quinn-Patton [30]) was carried out by M. Oliva in each community to identify everyday aspects of subsistence hunting and the intra-family relationships of peasant-hunters, in order to contextualise the data obtained in the interviews. At the end of the study, we held a participative workshop in each community to obtain collective feedback (e.g., motivations and long-term expectations about subsistence hunting, feasibility of local productive alternatives) on the data obtained during the community work.

Another group of semi-structured interviews were carried out with the local authorities (*ejidal* and municipal heads) and authorities external to the community (LPBR Director and other federal authorities with an influence on the management of wildlife in the region) to learn about their perceptions of subsistence hunting in relation to managing and conserving the protected area and its zone of influence. In these interviews we recorded the interviewees' opinions of restrictions on subsistence hunting, hunting permits and institutional links with stakeholders for managing fauna resources.

### *Data analysis*

Following Creswell [31], the data recorded in the semi-structured interviews were analysed through the content analysis technique by grouping answers into five categories: 1) perceptions on hunting *per se* (e.g., enthusiasm for the activity, preferred prey, hunting modality, seasonality), 2) perceptions of variation in the abundance and availability of potential prey, 3) expectations of continuing to hunt as an intergenerational practice (e.g., perceptions, desire and teaching by fathers for their sons to become hunters), 4) perceptions of hunting regulations (e.g., local controls and community organisation), and 5) beliefs related to hunting. In accordance with Taylor and Bogdan [32], these data categories were analysed for patterns and interpreted with reference to the field notes from participant observation carried out by M. Oliva in each community.

The ethnographic information of the study communities was used to determine whether peasant-hunters' perception of subsistence hunting might be influenced by the existence of different



income-producing practices such as coastal fishing and extraction of *huano* palm. Homogeneity tests [33] were carried out to perform community comparisons between the answers obtained in the interviews (e.g., preferred hunting prey, knowledge of hunting regulations). In those cases where  $\geq 20\%$  of the expected frequencies for the analysis categories had values  $\leq 5$  (e.g., enthusiasm for hunting, perceptions on the abundance of potential prey), tests for the difference between two population proportions were used instead [34]. A significance level of  $\alpha = 0.05$  was used for all analyses.

## Results

A total of 66 peasant-hunters identified by the local population were interviewed in Los Petenes (62%) and El Remate (38%). Interviewees from the two communities had a mean age of 45 years. The majority of them ( $> 80\%$ ) were married, with at least three dependants, and were landowners (*ejido* members) and members of the local *ejido* assembly.

In addition to traditional hunting, interviewees ( $> 88\%$ ) reported agriculture/fishing (El Remate) or agriculture/construction work (Los Petenes) as their principal productive activities. In the majority of cases, peasant-hunters acknowledged the need to engage in at least three productive activities for the family subsistence.

### *Perceptions on subsistence hunting*

*“When I’m in the bush I feel... like I’m from the bush. I feel good. Sometimes I say to my wife, ‘I don’t know what’s going on with me,’ I say, ‘the bush is calling,’ ‘I feel like going’. And so off I go. People... well, I like it”* (peasant-hunter, 39 years old).

In both communities ( $\chi^2 = 0.02$ ;  $P > 0.05$ ), the majority of interviewees expressed enthusiasm for hunting, mainly individually (Fig. 2a), for white-tailed deer. They did not have a preference for a hunting season (especially in El Remate). Opinion was divided among peasant-hunters (ca. 50%;  $\chi^2 = 0.14$ ;  $P > 0.05$ ) about encouragement by their families to practice hunting. In the majority of cases, interviewees perceived a reduction in potential prey (compared to the previous decade) in the vicinity of their community (Table 1).



**Fig. 2. Images of contemporaneous subsistence hunting in LPBR: (a) Peasant-hunter during an individual hunting trip, approaching a *peten* in a typical hunting landscape of the region; (b) Peasant-hunter wrapping a small prey in palm leaves and plastic to conceal it and transport it back to the community; (c) View of the prey wrapped and ready for transport by peasant-hunter at the end of his hunting activity; (d) “Deer stone”, the most precious talisman for hunters in the region, due to the quantity and type of prey which provides with.**

The opinions of interviewees about the potential for their sons (minors) to hunt differed between the communities ( $\chi^2 = 10.7$ ;  $P < 0.05$ ). Whilst the majority of interviewees in Los Petenes (51%) assumed that their sons would not want to become hunters, this was not the majority opinion in El Remate (16% of cases). In El Remate, 44% of interviewees assumed that their sons would want to be hunters, and the rest stated that were unaware of their sons' expectations in this regard (40% of cases). In contrast to this finding, 44-51% of interviewees in both communities hope that their sons will become hunters ( $\chi^2 = 0.3$ ;  $P > 0.05$ ), and these interviewees are teaching them about traditional hunting activities (Table 1).

### *Local regulations*

Acknowledgement of regulations on wildlife use in the reserve differed between the communities ( $\chi^2 = 16$ ;  $P < 0.05$ ). However, at least 66% of interviewees mentioned being familiar with these regulations in both communities (Table 1). Based on participant observation, we found that the populations of both communities believed hunting to be prohibited both inside and outside the reserve, including on its neighbouring communal lands. Nevertheless, both the interviewees (and their wives) commonly recognised the need to hunt in order to obtain food, despite the supposed ban on subsistence hunting in the region.

*"...to be honest, we know very well that it is against the law, but... there are times when I think that the authorities don't understand. They're right, they have a right to conserve the animals, but sometimes they don't understand that it's what our family lives off, do you understand? And even though [you] know that it's against the law, [you] have to go out and look for something for your children to eat,"* (hunter's wife, 38 years old).

The existence of local controls on hunting was acknowledged by the majority of interviewees (51%) in Los Petenes, but only by a minority (12%) in El Remate ( $\chi^2 = 10.3$ ;  $P < 0.05$ ) (Table 1).

During the community work, we found that the presence of external authorities influences certain behaviours of peasant-hunters, making their hunting activities evasive (e.g., avoiding transporting the whole prey so as not to get caught in the act by the authorities) faced with the generalised idea that they are engaging in an illegal practice (Fig. 2b and 2c).

Regarding the restrictions on the wildlife use established by the reserve authorities, the majority of peasant-hunters in El Remate (52%) expressed an interest in obtaining information on external regulations, productive alternatives, and actions to monitor wildlife. In Los Petenes, this type of information was only of interest to the minority (15%) of interviewees. In both communities, at least 56% of interviewees believed that they could organise themselves in order to regulate hunting practices at a local level ( $\chi^2 = 0.04$ ;  $P > 0.05$ ) (Table 1).

During participant observation, we did not find evidence of a local regulation system for the use of wildlife by the group of peasant-hunters identified in each community. On the contrary, it was evident that stakeholders expect external governmental alternatives in order to regulate the wildlife use in the study communities.

*"The Government truly wants to look after [fauna resources], (...) but then what are we supposed to live on? If they give us an option for people to work (...) people will gradually stop going hunting. But*

*there has to be something in exchange. The Government has to do something to change that, because people can't give up something just for the sake of it,"* (peasant-hunter, 38 years old).

### *Hunting beliefs*

In El Remate and Los Petenes, the majority of interviewees acknowledged that they believe in five to seven hunting talismans ( $\chi^2 = 1.6$ ;  $P > 0.05$ ) or superstitions ( $Z = 1.71$ ;  $P > 0.05$ ) (Table 1). The existence of hunting talismans (Fig. 2d) and a "*lord of the wild*" (spiritual owner who protects wild animals) was acknowledged by peasant-hunters in both communities. They stated that the talismans favour a successful hunt for those who possess them.

*"I also once had (a talisman). Wow! I killed so many deer! I had one once. (...) and then I threw it away (because) well, lots of deer chase me, they chase me. It's true, I'm telling you, they chase me, when I go out, listen, up to 100 deer on a single plain"* (peasant-hunter, 60 years old).

When the number of permitted prey for a talisman is exceeded (30-100 prey depending on the type of talisman), the interviewees mentioned that the hunter can be punished by the *lord of the wild* (e.g., inexplicable reduction in hunting effectiveness) or be faced with unusual behaviour from potential prey (confrontation or threatening by the animal), which often leads the person who possesses the talisman to discard it.

### *Community workshops*

In addition to the interviews, participants in the workshops held in Los Petenes (n = 21 individuals) and El Remate (n = 26 individuals), indicated that local families would be negatively affected by a lack of animal protein in their diet if subsistence hunting was permanently banned or if traditional hunting species (e.g., deer, peccary, ocellated turkey) became locally extinct. Faced with this, the participants in both workshops envisioned alternatives that included new hunting areas (farther away from the community), and the adoption of official proposals for wildlife management (e.g., Wildlife Management Units or *UMA* in Spanish [10]).

During the workshops, it was apparent that the participants were willing to learn about and accept possible forms of regulation on wildlife use in their community. They acknowledged that possible regulations on subsistence hunting could bring advantages not just for the people (and families) that benefit from this activity, but also to conserve the resource being exploited, thereby promoting: 1) the recovery of animal populations, 2) the recovery of forest habitats where hunting is practiced, and 3) access to and availability of wild meat for local consumption.

### *Wildlife management in LPBR*

The federal authorities stated that, based on the lack of technical information regarding the distribution and abundance of regional wildlife, together with the lack of economic, technical and human resources for managing the reserve, they currently face significant obstacles to implementing the LPBR Management Program. They also mentioned that, although the Management Program acknowledges and permits subsistence hunting of unprotected species even within the reserve (buffer zone), they have had to resort to the precautionary principle in order to facilitate control of the fauna resources inside and outside the protected area. In invoking this principle, or assuming *a priori* (without empirical data) that wildlife populations are being severely affected by subsistence hunting in the region, the authorities stated that they had imposed a *de*



*facto* ban on hunting in general (by any method and for any purpose), mainly in the communities adjacent to the reserve.

Table 1. Perceptions, interests and expectations of peasant-hunters interviewed regarding subsistence hunting and their relationship with LPBR.

Local issues and features of subsistence hunting	Answers/mentions	Community		$\chi^2$	Z	P																																																																																																																																										
		El Remate (%)	Los Petenes (%)																																																																																																																																													
Are you enthusiastic about hunting?	Yes	84	85		0.02	0.85																																																																																																																																										
	No	16	15				Preferred hunting modality	Individual	76	59	2.6		0.10	Group hunting	20	29	No answer	4	12	Preferred hunting prey	White-tailed deer	72	54	2.2		0.14	Others	28	46	Preferred hunting season	Rainy season	24	15	4.3		0.12	Dry season	36	59	No answer	40	27	Does your family support or motivate you to hunt?	Yes	44	49	0.14		0.71	No	56	51	Do you perceive a reduction on potential prey?	Yes	88	85	0.09		0.76	No	12	15	Do you think your sons would want to become hunters?	Yes	44	29	10.7		0.001	No	16	51	No answer	40	20	Do you expect your sons (current or future) to become hunters?	Yes	44	51	0.3		0.57	No	28	37	No answer	28	12	Do you teach your sons to hunt?	Yes	40	42	0.3		0.57	No	60	58	Are you familiar with reserve regulations on wildlife use?	Yes	84	66	16		0.00006	No	16	34	In your community, are there local controls on hunting?	Yes	12	51	10.3		0.001	No	88	49	Do you think hunters would organize themselves locally to regulate hunting practice?	Yes	56	59	0.04		0.84	No	44	41	Are you aware of the existence of at least one hunting talisman?	Yes	92	80	1.6		0.21	No	8	20	Are you aware of the existence of a <i>lord of the wild</i> ?	Yes	92	56		1.71
Preferred hunting modality	Individual	76	59	2.6		0.10																																																																																																																																										
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Preferred hunting season	Rainy season	24	15	4.3		0.12																																																																																																																																										
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	No answer	40	27				Does your family support or motivate you to hunt?	Yes	44	49	0.14		0.71	No	56	51	Do you perceive a reduction on potential prey?	Yes	88	85	0.09		0.76	No	12	15	Do you think your sons would want to become hunters?	Yes	44	29	10.7		0.001	No	16	51	No answer	40	20	Do you expect your sons (current or future) to become hunters?	Yes	44	51	0.3		0.57	No	28	37	No answer	28	12	Do you teach your sons to hunt?	Yes	40	42	0.3		0.57	No	60	58	Are you familiar with reserve regulations on wildlife use?	Yes	84	66	16		0.00006	No	16	34	In your community, are there local controls on hunting?	Yes	12	51	10.3		0.001	No	88	49	Do you think hunters would organize themselves locally to regulate hunting practice?	Yes	56	59	0.04		0.84	No	44	41	Are you aware of the existence of at least one hunting talisman?	Yes	92	80	1.6		0.21	No	8	20	Are you aware of the existence of a <i>lord of the wild</i> ?	Yes	92	56		1.71	0.92	No	8	44																																
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## Discussion

Our results confirm the existence of a conservation conflict associated with subsistence hunting in LPBR. This conflict mainly stems from the incompatibility between 1) the need acknowledged by contemporary Maya hunters to continue using wildlife for subsistence (inside and outside the reserve) and 2) the restrictions (based on the precautionary principle) resulting from a highly limited implementation of the reserve Management Program. Until now, these management limitations have been based on 1) a lack of information regarding the conservation status of exploited species, and 2) an incipient mutual acknowledgement between actors (local and external) regarding perceptions and expectations about the use and management of wildlife in the region. This study provides fundamental information for overcoming this second management limitation [7] and strengthens the scientific bases for managing the conservation conflict associated with the social use of wildlife in this important Maya-occupied area of the Yucatan Peninsula.

The conviction of peasant-hunters not just to continue hunting, but to do so along with other traditional productive activities (i.e., seasonal agriculture), reflects the multiple resource use strategy which has characterised Yucatan's Maya culture and is still in effect today [16]. This conviction of continuing to practice hunting in both study communities demands the consideration of alternatives for managing fauna resources. A strategy which balances conservation and development objectives [35] would be the most feasible management option in the reserve, thereby permitting the use of wildlife under regulatory guidelines (e.g., permitting subsistence hunting in the buffer zone of the reserve [11]), as established in the LPBR Management Program.

Recent studies on Maya hunting have documented various sociocultural aspects of this traditional practice, including its methods, seasonality, purpose and the animal species exploited in Yucatan's Maya communities [e.g., 8, 13, 14, 22]. Nevertheless, the perceptions and perspectives of contemporary Maya hunters regarding hunting regulations (local and external) on their activity have scarcely been explored to date, especially in the context of an important federal reserve (in ecological and sociocultural terms) such as Los Petenes [8].

Although there is no evidence for the existence of self-regulation mechanisms on the wildlife use in the study communities, it is important to highlight the concerns of the peasant-hunters with respect to the development of regulatory alternatives that allow them to satisfy their local needs while conserving natural resources. The feasibility of establishing levels of subsistence hunting that conserve biodiversity [36] and the possibility of the community participating in (unofficial) hunting regulations underscore the need to empower communities for such purposes [15, 37].

The role that Maya beliefs on hunting (talismans and superstitions) may have in regulating the activity turns out to be controversial [see 13, 38, 39]. These talismans and superstitions can motivate hunters to seek out (and eventually obtain) increasing numbers of prey (e.g., as many as 100 prey if they have the *deer stone* [8]), given the power or permission to hunt provided by such a talisman. Hunting talismans and superstitions therefore do not appear to be operating as regulatory factors to reduce hunting in the study communities.

Local willingness to participate in the management of resources depends on acknowledgement of the problem by stakeholders. Such acknowledgement is built upon 1) the perceived reduction in potential prey, 2) the expectation of continuing the activity, and 3) the need to comply with regulatory guidelines established by the reserve authorities. The above, together with their

willingness to receive information from the external authorities, can be capitalised on as a willingness to manage the conflict, thereby permitting and motivating the design of co-management strategies which are in line with local perspectives and can be applied in a participatory manner [15, 35]. However, this option is threatened by the marked dependence on government support evident in the study communities, which discourages greater local involvement in the management and regulation of natural resources in the region.

In order to capitalise on the local willingness for conflict management, there must also be support from the external authorities, who must permit a genuine involvement of stakeholders in the decision-making process and the implementation of management actions through transparent processes [40]. Both the local and the reserve authorities indicated that communication between the two parties mainly occurs through official programs that support the development of productive activities (e.g., agriculture, handcraft production) in the region. This demonstrates the need to strengthen the lines of communication which must exist between the parties involved in management, in order to achieve adequate information transfer on the parameters established in the official management instrument and the exploitation contemplated by this instrument [41-43].

The belief of peasant-hunters that subsistence hunting is a prohibited activity, regardless of the area where it is practiced, underscores communication deficiencies on the part of the external authorities, given that subsistence hunting is not prohibited by law in Mexico [10] except, as is the case in other protected areas, in the core zone of LPBR [11]. The contradiction between local interests (i.e., the practice of subsistence hunting) and the management actions carried out by the external authorities (i.e., penalties for subsistence hunting) is exacerbated when we acknowledge the historical background of the use (spatially unrestricted) of natural resources in the region prior to the establishment of the reserve. Nevertheless, it appears that the conflict arises from deficiencies in communication and liaison mechanisms between the two parties, rather than a strict contradiction of their interests. These deficiencies, which hinder the appropriate implementation of the official management guidelines, stem from a lack of economic and human resources, which are widely regarded to severely limiting the application of regulations in reserves and co-management in local communities under the influence of protected tropical areas [35, 44].

Ignorance of the impact of subsistence hunting on the wildlife species of the region has brought about unfounded limitations or bans on traditional Maya hunting [9]. This is not only an obstacle to general management, but also reduces the possibility of implementing better management actions in LPBR. The perceived decrease in potential prey inside and outside the reserve by Maya peasant-hunters highlights the pressing need to carry out demographic studies to determine the conservation status of traditional hunting species in this and other Maya regions of Yucatan [8, 14]. The resulting estimates of sustainable exploitation rates [45] would allow guidelines and recommendations to be drawn up for appropriate regional management of fauna resources [9]. Obtaining quantitative data on the conservation status of wild animal species traditionally used would prevent a significant social impact from being produced due to the application of the precautionary principle, which becomes more complex in contexts of subsistence use of natural resources with a high sociocultural value, as is the case of wildlife in LPBR [8].

In conclusion, the deep sociocultural roots and subsistence nature of hunting make management of the conservation conflict more complex. It is therefore essential to recognise local perceptions and perspectives on the resource and its regulation [6, 7]. It is equally important to strengthen the mutual acknowledgement of the interests and needs of local and external actors [6] in order to

reconcile, on the one hand, the social interest and need to carry out subsistence practices and, on the other hand, the interest in conserving the fauna resources inside and outside the reserve. In practice, the reconciliation of these interests would achieve the dual objective of conserving and developing biosphere reserves [46], and improve conservation conflict management in this important Mesoamerican region.

## Implications for Conservation

Appropriate management of conservation conflicts is critical to reducing negative impacts on biodiversity and human wellbeing [6], mainly in the context of biosphere reserves, where the use of natural resources by local populations is permitted (according to the zoning of the protected area) [46]. Management limitations, such as those observed in LPBR, could lead to negative impacts not only on biodiversity, but also on local populations who depend on wildlife species for subsistence. Our study not only provides relevant information for managing an important Mesoamerican reserve, but also highlights the importance of incorporating the needs of neighboring populations into the management strategies of the protected area in order to improve the effectiveness of conservation in LPBR and many other protected areas around the world [2].

As proposed by Young et al. [7] and Redpath et al. [6], the study and management of the conservation conflict associated with subsistence hunting in LPBR should primarily focus on the social context of the activity and take the perceptions, interests and needs of stakeholders into account. This socio-environmental approach has important implications for conservation planning in LPBR and in other Mesoamerican protected areas with similar problems with the social use of natural resources.

Our results provide fundamental information for the mutual acknowledgement required between actors (local and external) to adequately manage the conflict associated with subsistence hunting in LPBR. The conflict consists in the *de facto* restriction on wildlife use, even for subsistence purposes, which was mentioned by external actors contrasted with the local need and expectation of contemporary Maya hunters to continue practising subsistence hunting in the region. We identified the role of each part (local and external actors) in this conservation conflict, and detected potential to conciliate between them in order to manage the conflict.

Despite the lack of transparency in communication from the reserve authorities, stakeholders are willing to participate in conservation initiatives for the protected area. This collective attitude represents an important social aspect to manage and overcome the conflict associated with subsistence hunting in LPBR and its zone of influence. Acknowledgment of local interests and the needs and expectations of stakeholders is critical for adequately managing and solve this type of conflict, commonly expected in many rural areas of Mesoamerica where conservation actions are implemented.

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