El Colegio de la Frontera Sur

Aprovechamiento integral de la fauna silvestre en Montecillo Santa Cruz, Oaxaca, México a través del co-manejo

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Por

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Aprovechamiento integral de la fauna silvestre en Montecillo Santa Cruz, Oaxaca, México a través del co-manejo

para obtener el grado de **Maestra en Ciencias en Recursos Naturales y Desarrollo Rural**

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Resumen

En comunidades rurales la fauna silvestre es una alternativa para cubrir las necesidades básicas; en ocasiones, es la principal fuente de abastecimiento para las personas. Los pobladores de Montecillo Santa Cruz, Oaxaca, México, aprovechan en su mayoría especies acuícolas durante la época lluviosa y vertebrados terrestres en época seca principalmente para el autoconsumo y comercio; sin embargo, la pérdida de hábitat, la expansión de las actividades agropecuarias y la cacería de subsistencia han afectado negativamente a las poblaciones de vertebrados terrestres que aprovechan, generando problemas económicos y ambientales en la comunidad. El objetivo del presente estudio consistió en aplicar el enfoque del co-manejo, con la finalidad de proponer alternativas de aprovechamiento integral para contribuir al fortalecimiento de los medios de subsistencia de los pobladores y favorecer a la conservación de la fauna silvestre local y su hábitat. Se realizaron cinco salidas de campo de enero a junio de 2019, la caracterización ambiental del territorio comunitario se realizó con un etnomapa mediante el método de Diagnóstico Rural Participativo para que los pobladores identificaran a los vertebrados terrestres y las zonas más importantes de la comunidad, así como los lugares en donde las capturan. Se aplicaron 40 entrevistas semiestructuradas para obtener el índice de importancia relativa (IRE) de las especies de fauna utilizadas. Se identificaron cinco zonas hídricas y tres terrestres donde se aprovechan 61 especies de fauna silvestre, las principales categorías de uso fueron el alimentario y el comercio (venta). La iguana negra (*Ctenosaura pectinata*) fue la especie con el IRE de uso alimentario más alto (0.97). Para que los pobladores puedan conservar y generar ingresos económicos por medio de la fauna, se propuso la creación de una UMA a través del modelo de co-manejo para aprovechar de forma integral a dos especies de iguanas (*Ctenosaura pectinata* e *Iguana iguana*).

Palabras clave: Istmo de Tehuantepec, Manejo, Conservación, Etnomapa, UMA.

Capítulo 1. Introducción

La fauna silvestre forma parte de dos sistemas que están ligados e interactúan entre sí, los sistemas ecológicos que involucran las estaciones del año, cambio climático y fenómenos naturales e influyen en la cultura, relaciones de poder y actividades económicas; y los sistemas sociales que son las actividades de carácter político, sociocultural y económico que alteran el ambiente (agricultura, deforestación, pesca) (Salas-Zapata et al. 2012). Actualmente las comunidades dependen de la fauna silvestre para abastecer parte de sus necesidades básicas (Retana 2010); no obstante, la degradación ecológica aunada a la situación de pobreza que presentan, pueden afectar negativamente a las poblaciones de vertebrados terrestres que aprovechan al aumentar su autoconsumo o venta, de tal forma la defaunación puede provocar altos costos ambientales, económicos y sociales (Carabias y Provencio 1993; Pérez-Gil et al. 1995; Vargas 2001).

Ante dicha situación, se han desarrollado modelos como el co-manejo, el cual se centra en implementar prácticas de aprovechamiento integral de los recursos naturales de un territorio a través del consenso comunitario de las problemáticas sociales, económicas y ambientales (Villalba 2001), que junto con el conocimiento local y científico tienen el propósito de recuperar y conservar la biodiversidad (Ariza et al. 2017). A partir del co-manejo, las actividades antropogénicas (sistema social) no deben afectar los ecosistemas (sistema ecológico), el manejo de los recursos naturales se adecúa a las condiciones ambientales, aspectos políticos y culturales de las personas, ya que las actividades pueden estar sujetos a tradiciones o programas institucionales (Borrini-Feyerabend et al. 2001; Salas-Zapata et al. 2012).

El co-manejo también llamado manejo participativo, puede realizarse a diferentes escalas: en áreas específicas, áreas naturales protegidas (ANP) y Unidades de Manejo para la Conservación de la Vida Silvestre (UMA) (Ortega et al. 2014), ya sea para un conjunto de recursos (flora o fauna) o uno en específico. La Secretaría del Medio Ambiente y Recursos Naturales (SEMARNAT) creó las ANP y las UMAs para integrar la conservación de la biodiversidad y manejo de fauna silvestre con las necesidades de

producción y desarrollo socioeconómico comunitario por medio de la diversificación de prácticas no convencionales (CONABIO 2013).

Las tomas de decisiones a nivel comunitario basadas en conocimientos locales se van perdiendo y las actividades que practican los pobladores en su territorio ya no son consensuadas con el resto de la comunidad. El co-manejo necesita de la participación de dos o más actores sociales (*e. g*. campesinos, pescadores, investigadores, organizaciones sociales, autoridades ambientales) para aprovechar cierto recurso y mejorar las condiciones socioeconómicas, mediante la definición y distribución de funciones, así como los derechos y beneficios en torno al manejo (Borrini-Feyerabend 1996; Borrini-Feyerabend et al. 2000; Borrini-Feyerabend et al*.* 2001; Carlsson y Berkes 2005). Mediante el co-manejo, el aprovechamiento debe ser integral, es decir, realizar un uso diversificado mediante actividades productivas no convencionales, las cuales se enfocan en la producción de varios bienes y servicios en un mismo terreno, integrando factores ambientales, sociales y económicos en un proceso participativo de evaluación, planificación y manejo de los recursos disponibles (Ojasti 2000; Toledo et al*.* 2008; Retana 2010).

El aprovechamiento integral de la fauna silvestre en los territorios indígenas de México bajo el enfoque de co-manejo es fundamental, ya que el 50% de los recursos naturales se localizan en territorios indígenas y campesinos, entre el 70% y 80% de los bosques y selvas del país son manejadas por este sector y casi el 60% de las áreas recomendadas para su conservación en la región sur y sureste están en terrenos comunales (Toledo et al*.* 2002; Sarukhán et al. 2009). Por ende, el consenso y la participación comunitaria son fundamentales para planificar el ordenamiento de las actividades antropogénicas y las alternativas de aprovechamiento integral, así se podrán fortalecer las opciones de desarrollo comunitario a través del uso sustentable de la diversidad biológica presente en los territorios (Pearce y Moran 1994; Toledo 2000; Borrini-Feyerabend et al*.* 2001; Salas-Zapata et al*.* 2012).

En la comunidad indígena zapoteca Montecillo Santa Cruz, los pobladores practican la pesca debido a que están asentados alrededor de la Laguna Inferior que conecta con el Golfo de Tehuantepec (Vargas, 2001). La Laguna Inferior está conectada por medio de una barra de arena al Golfo de Tehuantepec, la barra se cierra y abre

cíclicamente por eventos naturales (nivel del mar, huracanes, nortes) que cambian su longitud. Tal proceso afecta las actividades socioeconómicas de los pescadores, cuando la barra se cierra, se inhibe el movimiento de peces y nutrientes del Golfo de Tehuantepec a la Laguna Inferior, ocasionando la disminución de las poblaciones de peces y camarones. Con base a lo anterior, los pobladores recurren en mayor medida a la cacería de subsistencia y a realizar actividades agropecuarias (agricultura y ganadería), lo que provoca que disminuyan las poblaciones en algunos vertebrados terrestres (Lorenzo et al. 2017).

Bajo el contexto anterior, el objetivo del presente estudio fue determinar alternativas de aprovechamiento integral en la comunidad de Montecillo Santa Cruz, Oaxaca, México, aplicando el enfoque de co-manejo para contribuir al fortalecimiento de los medios de subsistencia de la población local y favorecer a la conservación de la fauna silvestre y su hábitat. Para cumplir con el objetivo se implementó el método de diagnóstico rural participativo para obtener un consenso de las problemáticas y alterativas para la fauna silvestre a partir de los pobladores. Con el método se realizaron tres talleres comunitarios con la participación de 47 personas, se elaboró un etnomapa para que los pobladores pudieran ubicar espacialmente sus recursos naturales y las actividades antropogénicas que conocen y efectúan en su territorio.

Para poder brindar alternativas de aprovechamiento integral de la fauna silvestre primero se aplicaron 40 entrevistas semiestructuradas para conocer como usan a las especies, también se obtuvieron categorías de análisis como los motivos por los que usan a la fauna, factores antropogénicos, sociales y ambientales que afectan a la fauna y a los pobladores, métodos de captura, alternativas legales para aprovechar a la fauna, entre otras. Con el consenso y alternativas establecidas por parte de los pobladores, se podrán generar más opciones para obtener ingresos económicos de forma equitativa.

Debido al poco tiempo que se tuvo para realizar el trabajo de campo, se sugiere realizar estudios poblacionales de las especies con mayor importancia para los pobladores de Montecillo Santa Cruz, esto permitirá corroborar la información brindada por las personas. El estudio se realizó durante la época de nortes y de secas, se recomienda ampliar el trabajo de campo para poder incluir información y evidencia relevante de la temporada de lluvias en la comunidad.

Capítulo 2. Artículo enviado a la revista Journal of Ethnobiology (F. I. 1.195)

INTEGRAL USE OF WILDLIFE IN MONTECILLO SANTA CRUZ, OAXACA, MEXICO THROUGH CO-MANAGEMENT

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Abstract The local inhabitants of Montecillo Santa Cruz, Oaxaca use aquatic and terrestrial species, mainly for home consumption and trade. However, habitat loss, the expansion of farming activities, and subsistence hunting have all negatively affected the populations of terrestrial vertebrates exploited, leading to economic and environmental issues in the community. The present study applied a co-management approach aiming to propose integral development alternatives to contribute to strengthen the livelihood of local inhabitants and conserve terrestrial vertebrates and their habitat. The community was visited five times from January to June 2019. The Participatory Rural Appraisal method was used to conduct an environmental characterization of the territory with an ethnomap; the persons interviewed identified the most important terrestrial vertebrates and the common sites of capture, with forty semi-structured interviews applied to estimate the relative importance index (RII) for the uses of wildlife. A total of 59 species are exploited; the main use categories were food and trade (sale). The black iguana (*Ctenosaura pectinata*) was the species with the highest RII of use as food (0.97). For local inhabitants to conserve and earn an income from wildlife, we proposed the creation of a Management Unit for Wildlife Conservation (UMA, for its name in Spanish) through a co-management model to achieve an integral use of iguana species (*Ctenosaura pectinata* and *Iguana iguana*).

Key words: Isthmus of Tehuantepec, Management, Conservation, Ethnomap, UMA.

Introduction

Today, a number of indigenous communities inhabiting southeastern Mexico depend on wildlife as a major resource to meet part of their basic needs (Retana 2010). However, the ecological degradation associated with greater poverty in rural communities adversely affects the wildlife populations exploited, a process named defaunation that involves high environmental, economic, and social costs (Carabias y Provencio 1993; Pérez-Gil et al. 1995; Vargas 2001). This issue has led to the development of models such as co-management, which focuses on implementing practices intended for the integrated use of natural resources in a territory through the consensus and participation of the local inhabitants (Villalba 2001), aiming to recover and preserve biodiversity as a natural heritage (Ariza et al. 2017).

Co-management, also called participatory management, can be implemented at various scales: in specific areas, protected natural areas (ANP, for its acronym in Spanish) and Management Units for Wildlife Conservation (UMA, for its acronym in Spanish) (Ortega et al. 2014), either for a set of resources (flora or fauna), or for a single particular resource. Co-management can be applied in Mexico, since the Secretary of the Environment and Natural Resources (SEMARNAT) uses ANP and UMA schemes, which incorporate biodiversity conservation and wildlife management into the production needs and socioeconomic development of local communities through the diversification of non-conventional practices (CONABIO 2013).

Co-management demands a dialog between two or more social stakeholders (e.g., farmers, fishermen, researchers, social organizations, environmental authorities) to exploit a natural resource and improve the socioeconomic conditions through the definition and assignment of roles and functions, as well as the rights and benefits related to resource management (Borrini-Feyerabend 1996; Borrini-Feyerabend et al. 2000; Borrini-Feyerabend et al. 2001; Carlsson y

Berkes 2005). Co-management implies integral use, i.e., diversified use through non-conventional productive activities focused on the production of several goods and services within the same area, thus integrating environmental, social, and economic factors in a participatory process including the assessment, planning, and management of available resources (Ojasti 2000; Toledo et al. 2008; Retana 2010).

The integral use of wildlife in indigenous territories of Mexico under a co-management approach is key, as 50% of all natural resources are located in indigenous and rural areas. In Mexico, between 70% and 80% of temperate and tropical forests are managed by indigenous communities, and nearly 60% of the areas recommended for conservation in the south and southeast of Mexico are located in communal land (Toledo et al. 2002; Sarukhán et al. 2009). Thus, the consensus and participation of local communities are essential to identify environmental and economic issues in their territories, manage anthropogenic activities, and develop integral development approaches.

This will allow the strengthening of community development options while transitioning to the sustainable use of local biodiversity (Pearce and Moran 1994; Toledo et al. 2000; Borrini-Feyerabend et al. 2001; Salas-Zapata et al. 2012). In this context, this study aims to propose integral development alternatives in a Zapotec community inhabiting the Isthmus of Tehuantepec, Oaxaca, by applying the co-management approach, in order to contribute to the strengthening of the livelihood of local inhabitants while conserving the local wildlife.

Methods

Study area

This work was conducted on the Zapotec community of Montecillo Santa Cruz (MSC), located in the Isthmus of Tehuantepec, Oaxaca, Mexico (Fig. 1), between coordinates 16º21´57.6´´ and 94º35´09.6´´ W, at an altitude of 24 meters above sea level (Lorenzo et al. 2000). The main economic activity of the local inhabitants is fishing in Laguna Inferior (LI); however, agriculture has increased in recent decades, with sorghum cultivated for sale or use as forage for livestock, and maize and watermelon for home consumption (Vargas 2001; Lorenzo et al. 2006, 2017; Rioja-Paradela et al. 2012; Sántiz et al. 2012). Livestock production is extensive, and grasslands have been altered by induced burning to promote the growth of pasture for cattle raising (Lorenzo et al. 2000, 2008; Vargas 2001).

There are five types of vegetation in MSC: a) tropical deciduous forest (TDF); b) thorny forest (TF) including shrub patches with species such as *Acacia farnesiana*, *Casearia* sp. and *Aristida* sp. (INEGI 1985a, 1985b; Rzedowski 2006; Farías y Fuller 2009); c) grassland, located in open flat areas with scattered trees such as *morro* (*Crescentia alata*); d) *nanchal*, in semi-open areas dominated by *nanche* (*Byrsonima crassifolia*); and e) riparian vegetation (RV), consisting of small patches of dense vegetation growing in riverbanks, including deciduous trees such as *Gliricidia sepium* and *Celtis iguanaea* (Pérez-García et al. 2001; Farías et al. 2006; Sántiz 2006).

Forty nine species of herpetofauna have been recorded around LI (10 amphibians and 39 reptiles, including the endemic black iguana, *Ctenosaura oaxacana*) (Vargas 2001; Rioja-Paradela et al. 2012). A total of 130 bird species (Henestroza 2009) and 59 species of terrestrial mammals (López et al. 2009) have been reported in the area of Juchitán de Zaragoza. Mammals include the Tehuantepec hare (*Lepus flavigularis*), an endemic species endangered of extinction because of the conversión of its habitat to farming land, unregulated hunting, and predation by feral dogs (*Canis lupus familiaris*) (Vargas 2001; Lorenzo et al. 2000, 2005, 2017; Sántiz 2006; Rioja et al.

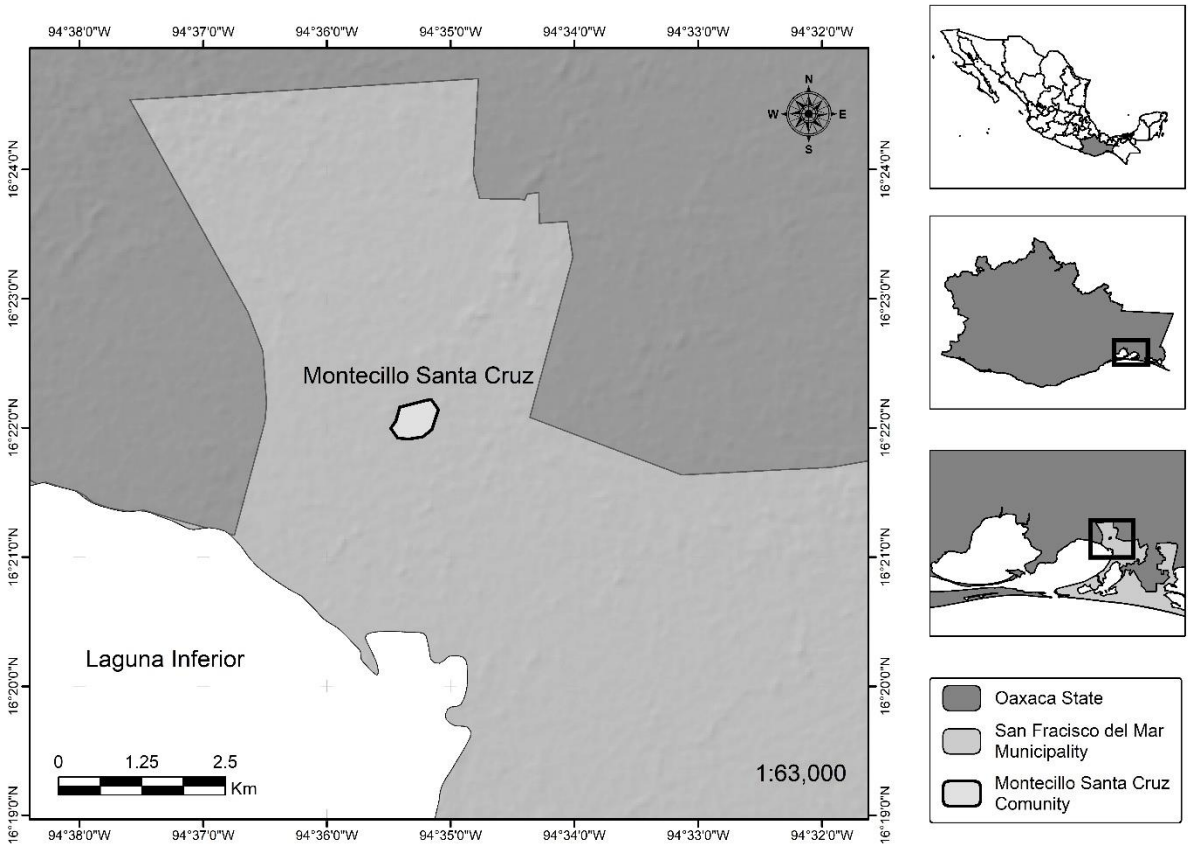

Figure 1. Location of Montecillo Santa Cruz, Oaxaca, Mexico. (Drawn by Ivan Briseño-Hernández with the Software QGIS version 3.10).

2008; López et al. 2009; Carrillo-Reyes et al. 2012). These factors may be replicated for other species subjected to heavy hunting for home consumption or sale in regional markets in MSC, such as iguanas (*Ctenosaura pectinata* and *Iguana iguana*), armadillo (*Dasypus novemcinctus*), and white-tailed deer (*Odocoileus virginianus*) (Vargas 2001; Rioja-Paradela et al. 2012).

Field work

Five field trips to MSC, Oaxaca, were conducted from January to June 2019, including a total stay of 50 days. The Participatory Rural Appraisal method (Bustos et al. 2003) was used from

three workshops with local inhabitants, including women and men between 30 and 60 years old. The environmental characterization of the territory included the spatial location of ecological (water bodies, vegetation, fauna), economic (livestock raising, agriculture, hunting), and anthropic (roads, locations) components that influence the structure and dynamics of the territory (Salinas 2005; Lara-Ponce et al. 2012).

The spatial distribution of these components was confirmed by walking 38 transects accompanied by three local guides who were familiar with the aquatic areas (fresh and saltwater), the inner land, and areas adjacent to MSC. The water bodies, roads and fringes were geo-referenced and photographed to define reference points across the territory (Salinas 2005; Lara-Ponce et al. 2012).

To estimate the use value of wildlife, semi-structured interviews were conducted with 20 women and 20 men using the information saturation method (Morse 1995). The species ranking technique (Martin 1995) identified the top 10 animal species most intensively used in the past 10 years. We estimated the relative frequency (RF) and the relative importance index (RII) (Cox 1985; Martinez et al. 2011) of the uses reported for all species (food, trade, pet, medicine) with the formula:

$$RII = \frac{\mathrm{nC}}{\mathrm{N}}$$

Where:

RII= Relative Importance Index

nC= number of interviewees who mentioned a species subject to use.

N = total number of persons interviewed.

In order to establish alternatives for the integral use of the wildlife, a consensus was performed about the issues that affect to reach solutions and alternatives (Bustos et al. 2003). Two workshops were held, one with fourteen people which identified issues in terrestrial areas (culture and conserved areas), water bodies and wildlife. The second was conformed by seventeen people, they identified the causes of problems in each zone and effects in the territory, providing alternatives to get solutions for zones and fauna damaged. In this events participe farmers, fhishermen, hunters, sellers, housewives and the municipal agent; the information used it is supported by semi-estructured interviews.

Results

Environmental characterization of the territory

The environmental components (hydrics and terrestrial) that are deemed essential for the development and management of natural resources from the perspective of MSC inhabitants were projected in the ethnomap. The species of terrestrial vertebrates mentioned as most important for villagers were located in each habitat type (Fig. 2).

Hydric Environmental Components

The water component comprises freshwater and saline water bodies: two lagoons, 11 estuaries, one river, two streams, and two beaches. The elements with the greatest influence on socio-economic activities in MSC are:

Lagoons. LI is the largest fishing area, the local inhabitants call it "Dead Sea" because its size resembles the sea; fishers are guided by tropical storms in the rainy season, as well as by the

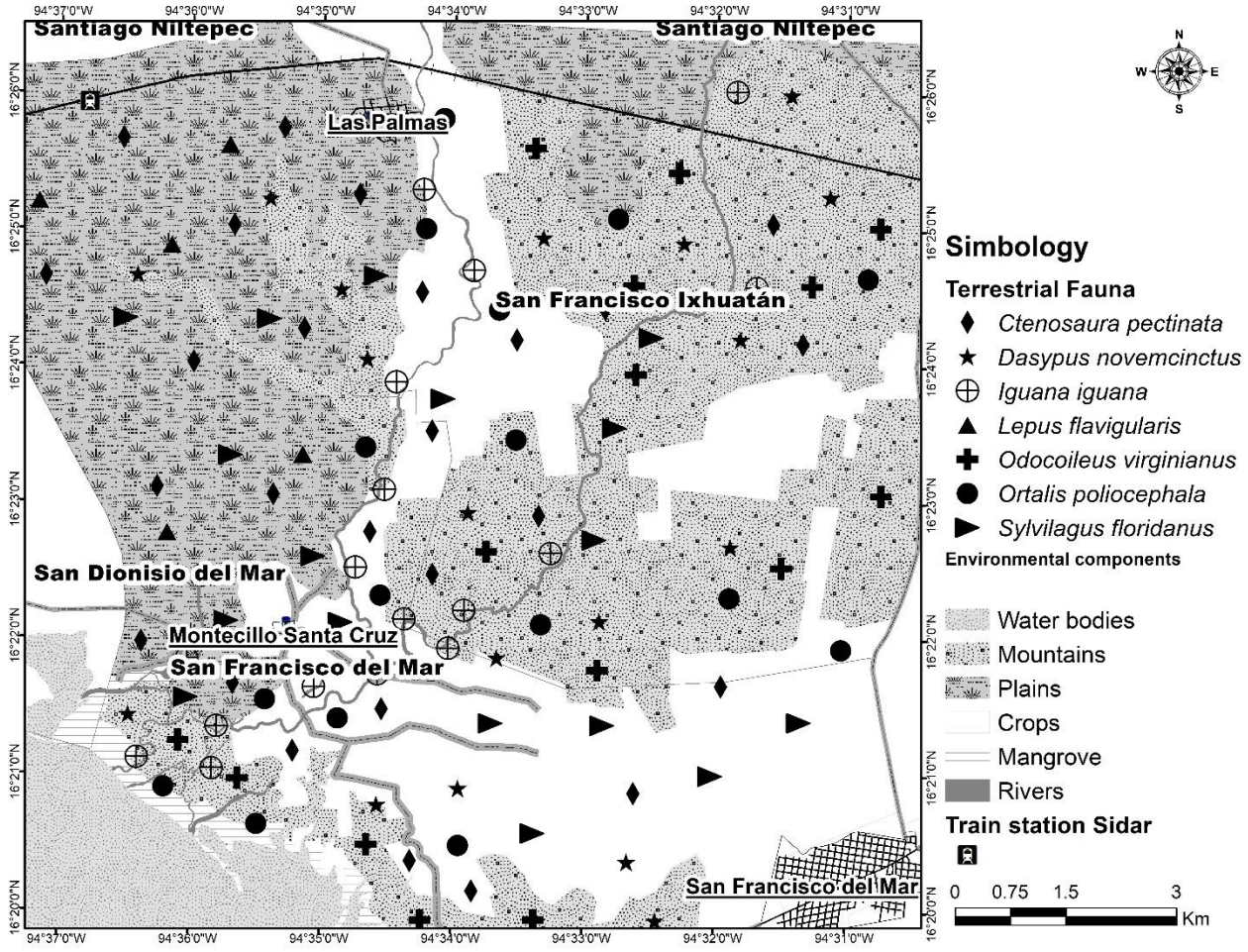

Figure 2. Ethnomap of the environmental components and distribution of terrestrial vertebrates and their hunting zones in Montecillo Santa Cruz, Oaxaca, Mexico. Drawn by Ríos-Quiroz (2019) with the Software QGIS version 3.4.

velocity of wind from the north and the phases of the moon. The number and size of fish captured depend on the effect of weather events.

Estuaries. Estuaries are important for catching shrimp and fish of the genus *Oreochromis* spp. (tilapia) and the family Gerreidae (black mojarra). Estuary waters become seasonally stagnant when connectivity with LI is lost in the dry season, undergo eutrophication for lack of circulation, and ultimately dry up completely. Estuaries that do not dry up are exploited by fishers, who catch

organisms unable to survive for lack of water; when estuaries dry up, villagers also extract salt from them. Estuaries are a water source for terrestrial vertebrates and livestock, mainly during the dry season.

River. The Niltepec river overflows along the MSC territory in the rainy season. During the dry season, some areas of the river dry up completely. The desiccation at the mouth of the river to LI affects fishers, who are unable to travel by boat to the lagoon and are forced to leave their boats at the shore of the lagoon and walk to the village every day through the river channel.

Beaches. Villagers mention two beaches connected by an estuary where they catch shrimp and extract salt. The so-called beaches in reality are systems called *blanquizales*, very shallow water bodies located in plains, with highly saline waters, flooded during the rainy season; these are ideal for salt extraction during the dry season.

Terrestrial Environmental Components

Three terrestrial components were recognized as zones: mountain (TDF, TF, and RV), plain (grassland, *nanchal*, and thorny shrubland), and farmland (crops) (Fig. 2). These components and the most important vegetation types in each, according to local inhabitants, are:

Mountains. MSC has small patches of remnant TDF, TF, and RV due to deforestation, and are mentioned by villagers as the mountain area. These patches are important for hunting white-tailed deer (*O. virginianus*), iguana (*C. pectinata* and *I. iguana*), *chachalaca* (*Ortalis poliocephala*), and armadillo (*D. novemcinctus*). Deforestation in MSC has displaced species such as *O. virginianus* and *I. iguana;* many hunters catch them in the mountain forest remnants of San Francisco Ixhuatan, approximately 5 km from MSC. Iguanas are the animals more heavily affected by hunting in TDF and RV, mainly *I. iguana*, since *C. pectinata* inhabits drier rocky areas such as

plains; females are more exposed to hunters during the breeding season because they seek damp sandy soils adjacent to water bodies to lay eggs.

MSC inhabitants do not enter TDF, TF, and RV in the rainy season because vegetation is denser and hunting becomes more difficult. For its part, TF is a hard-to-access area even in the dry season, as it mainly consists of thorny trees dominated by the legume *Prosopis juliflora* (*mesquite*) and the cactus *Pereskia lychnidiflora*; therefore, hunters go only to *puestear* (wait hidden in a site for an animal to hunt) a deer once they have identified its prints.

Llanerías (plains). Plains are located in areas prone to periodic flooding adjacent to mangrove forests and agriculture areas; induced pastures for cattle raising have expanded and are maintained by regular fires. This practice has affected the wild populations of *L. flavigularis* and *Sylvilagus floridanus*, which are unable to flee the fire and cannot survive in burned areas; halophytic grasslands (vegetation originally dominated by grasses) have also declined. Plains are important for *D. novemcinctus, O. poliocephala, Didelphis marsupialis* and other species to get food; there are also carnivorous predators like *Urocyon cinereoargenteus* and *Canis latrans.* Within plains, *nanchal* prospers in semi-open flat areas; *nanche* (*B. crassifolia*) is important for *C. pectinata* and *I. iguana* because iguanas use it as food source and shelter.

Mangrove forest. Although not mentioned by villagers, mangrove forests are important for the local fauna (fish, amphibians, reptiles, birds, and mammals), as well as for the maintenance of water systems (estuaries, *blanquizales*, mouth of the Niltepec river and LI banks). In the region, the red mangrove (*Rhizophora mangle*) is used by fishers to manufacture traps known as *ramas* (branches) to capture fish in LI; to manufacture them, mangrove branches are collected until a very large branch is obtained that is dragged from a boat to a given point in the lagoon to attract fish

that use it as shelter. Mangroves are an important habitat for several species of mollusks and crustaceans such as shrimp.

Agricultural areas. Since MSC was founded in 1941, agriculture and livestock-raising practices have been on the rise. Initially, the only cultivated areas were *chahuites*, characterized by wet fertile soils adjacent to water bodies. Farmers and ranchers started growing sorghum between years 2005 and 2008, when maize prices dropped along with harvest losses from little rainfall; sorghum is more drought-resistant and profitable. Livestock raising increased when sorghum became an option as forage for cattle.

Use of Wildlife

The use of 59 species of wildlife was recorded (Appendix 1). Of the seven species of reptiles mentioned above, the black iguana (*C. pectinata*) has the highest demand, mentioned in 97.5% interviews, followed by the green iguana (*I. iguana*) with 57.5%. This preference is due to the unique taste of the meat of each species; local inhabitants claim they consume less of the green iguana for its sweet taste, maybe associated to its herbivorous feeding habits, while the black iguana consumes both animal and plant protein, so its taste is more appealing. For both species, 17.5% of interviewees reported hunting them for sale.

After reptiles, aquatic animals are the fauna in highest demand for home consumption and trade. Of the 26 species mentioned, six were the most important; shrimp (*Farfantepenaeus californiensis* and *Litopenaeus vannamei*) is the most important resource, used by 85% of interviewees for home consumption and by 30% for sale; the blue crab (*Callinectes* spp.) ranks second, used as food by 77.5% of inhabitants and for sale by 17.5%; the white mojarra (*Eugerres mexicanus*) is a species reported to be used as food (67.5%) and for sale (15%.) Other species

commonly used as food were the *lisa* (flathead grey mullet, *Mugil cephalus*) with 67.5%, and the snook (*Centropomus robalito*) with 52.5%.

Mammals (14 species) and birds (12 species) are hunted mainly for use as food, especially when aquatic species become scarce in the dry season. The mammals most commonly used for home consumption are the white-tailed deer, *O. virginianus* (72.5%); the armadillo, *D. novemcinctus* (67.5%), and the cottontail rabbit, *S. floridanus* (60%); in the case of birds, the *chachalaca, O. poliocephala* (67.5%) and the white-winged dove, *Z. asiatica* (60%) are the species most consumed.

Table 1 summarizes the relative frequency (RF) and relative importance index (RII) of those species that attained a relative use above 0.5, i.e., species used for a particular purpose by more than 50% of interviewees. The uses as food and for sale are the most commonly use modalities practiced in MSC relative to other uses (pets, medicine).

Table 1. Relative frequency (RF) and relative importance index (RII) for food (F) and sale (S) of species of wild fauna (aquatic and terrestrial) most commonly used in Montecillo Santa Cruz, Oaxaca, Mexico.

Aquatic species	**RF**	**RII F**	**S**	**Terrestrial Species**	**RF**	**RII F**	**S**
Shrimp *Farfantepenaeus californiensis* and *Litopenaeus vannamei*	90	0.85	0.3	Black Iguana *Ctnosaura pectinata*	97.5	0.97	0.17
Blue crab *Callinectes* spp.	70	0.77	0.17	Green Iguana *Iguana iguana*	60	0.57	0.17
White mojarra	67.5	0.67	0.15	White-winged dove *Zenaida asiatica*	62.5	0.6	0.1

Eugerres mexicanus							
Flathead grey mullet *Mugil cephalus*	62.5	0.67	0.15	Chachalaca *Ortalis poliocephala*	65	0.67	0.1
Snook *Centropomus robalito*	50	0.52	0.12	Cottontail rabbit *Silvilagus floridanus*	62.5	0.6	0.1
				White-tailed deer *Ordocoileus virginianus*	50	0.72	0.12
				Armadillo *Dasypus novemcinctus*	62.5	0.67	0.1

Sixty-five percent of interviewees purchase animals for consumption in MSC, 25% of them hunt the animals consumed and 10% either purchase or hunt them, depending on the species. The number of individuals of terrestrial species consumed in 2018, according to the 40 persons interviewed, were 432 black iguanas (*C. pectinata*), 374 armadillos (*D. novemcinctus*), 237 green iguanas (*I. iguana*), 74 cottontail rabbits (*S. floridanus*), 35 raccoons (*Procyon lotor*), 35 *chachalacas* (*O. poliocephala*), and 20 white-tailed deers (*O. virginianus*).

Hunting is carried out mainly with dogs and firearms. Dogs are used primarily to capture iguanas (*C. pectinata* and *I. iguana*) and armadillos (*D. novemcinctus)*, and hunters take dogs to *arriadas* (a sort of collective hunting) to hunt white-tailed deer (*O. virginianus*); this practice is disappearing as it requires the coordinated teamwork of up to 15 hunters. Seventy percent of hunters prefer to hunt *C. pectinata, I. iguana,* and *P. lotor* on the banks of water bodies (river,

estuaries, and LI); 35% of hunters capture *O. virginianus*, *D. novemcinctus*, and *O. poliocephala* in the mountain, while *S. floridanus* is captured in the plains.

Sixty percent of interviewees mentioned that the dry season is the best time for hunting, as fauna is easier to locate because animals search for food and water, 20% mentioned that the rainy season is better because tracks can be easily identified; however, hunting becomes difficult as vegetation grows denser. Hunting is an important practice in MSC; 50% of interviewees have relatives who hunt, and 20% would like that their children learn to hunt; however, 80% would prefer that their children learn a profession rather than hunting, and 27.5% mentioned that their children already perform a hunting-related activity.

Farmers and peasants hunt to consume animals and because these cause damage to crops. Eighty percent of interviewees consider that some species are pests, causing damages to crops and households; 40% mentioned birds as pests (white-winged dove, *Z. asiatica*; parakeets, psittacidae; and *zanate, Quiscalus mexicanus*) as they feed on sorghum seeds. As regards species feeding on maize, 20% mentioned *P. lotor* and 20% to rodents; 10% considered *C. latrans* and the genus *Didelphis* as pests for feeding on melon, watermelon, and pumpkin; 7.5% considered bats as pests for transmitting *derriengue* (cattle rabies) to livestock, and 12% kill snakes for being dangerous to man. Forty-five percent of interviewees control wildlife through hunting, while 32.5% scares birds with fireworks, and 15% use poison. It worth stressing that 20% of interviewees indicated not having suffered damage caused by wildlife.

Interviewees claim a negative impact to terrestrial vertebrates. The majority (82.5%) mentioned a decrease in wildlife hunting for a couple of reasons: on the one hand, the lack of job opportunities force inhabitants to hunt animals for sale; on the other, deforestation has affected the abundance of wildlife by reducing their habitats. Seventy-two point five percent perceived changes

in the size of individual animals, an observation attributed to the fact that only adults were hunted in the past, while today all age groups (adults, juveniles and young) are hunted. Twenty-seven point five percent perceived no changes in the size of animals as they only hunt adults on a seasonal basis, thus contributing to preserve wildlife populations in the area.

The decline in populations of terrestrial vertebrates coincides with the increase in agricultural areas. Thirty-two point five percent of interviewees aged 50 years or older claimed a decline in the abundance of wild fauna since 10 years ago, while 45% of 20-40 years old interviewees perceived changes in the fauna since 5 years ago; this differential perception may be due to the fact that older people have witnessed the expansion of agricultural areas and encountered more wild animals historically in the previous years.

Due to the high demand for wildlife in MSC, 95% of interviewees are interested in participating in any project to breed or conserve wildlife species: 65% are interested in breeding *C. pectinata*, 22.5% would like to culture tilapia (*Oreochromis* spp.), 20% prefer raising *I. iguana* and 17.50% *S. floridanus*; the rest of interviewees are interested in rearing parrots, *O. virginianus*, *D. novemcinctus* and backyard animals (chickens and sheep).

Alternatives for Integral Wildlife Management

Aquatic species are important in LI, as the decline of aquatic populations has caused problems for MSC fishers, forcing them to hunt terrestrial vertebrates most often to earn an income from sale or partially meet the family diet. For the above reasons, an alternative proposed in this work, aiming to achieve an integral use of terrestrial vertebrates and their habitat, was the creation of a Management Unit for Wildlife Conservation (UMA), mainly for iguanas *C. pectinata* and *I.*

iguana, both being wildlife species that are important to the household economy in MSC and the local ecosystems.

The proposal was based on the RII for *C. pectinata* (0.97) and *I. iguana* (0.57); besides, it focuses on conservation and use due to the RII for use as food, being highest for *C. pectinata* (0.97). The UMA will be subjected to intensive management (ranching type), i.e., wildlife specimens will be kept in captivity and bred under a ranching approach, consisting in catching free-living pregnant females to lay eggs in captivity, followed by rehabilitation and release, so no individuals are removed from the wild.

UMAs include two management categories, where intensive management is the preferred option when local inhabitants will use multiple individuals per year and management is controlled, and individuals or populations are kept in captivity or confinement within usually enclosed facilities. Examples of intensive UMAs are tree nurseries and hatcheries to raise pets, breeding stock, or bushmeat for sale. For its part, extensive management does not restrain the movements of free-living fauna; also, there is no certainty about the number of individuals living in the premises, and density is estimated only through sampling; individuals feed and shelter under natural conditions. An UMA under extensive management allow sport or subsistence hunting, as well as ecotourism activities. The UMA can be used for extraction (collection, capture or hunting of specimens), non-extractive uses (no removal of specimens), or a combination of both.

To create the UMA, a meeting was held in the municipality of San Francisco del Mar with the participation of government authorities, officers of Ecology and Public Works, the chairman of the UMAs National Council and PIMVS A. C. (premises or facilities that manage wildlife under confined conditions) and local inhabitants interested in the management of iguanas. An agreement was reached about the donation of materials for the hatchery, and of monetary resources to

elaborate documents involving an economic cost. A Management Plan was drafted for both species with a focus on integral use of these iguana species: home consumption, sale as pets to businesses or persons, sale for meat consumption in MSC and the surrounding communities, sale as breeding stock to open more hatcheries or for sale to other UMAs, reintroduction of specimens to areas previously populated for conservation purposes and protection of free-living species, and environmental education. Additional uses include the skin to manufacture purses, wallets, and belts, and ornamental (taxidermy specimens) for sale. The use of iguanas will be diversified and integral to achieve conservation and economic benefits through the UMA.

The activities for the use of terrestrial vertebrate species with high importance figures in terms of RF and RII (Table 1) and the areas with management potential according to the local inhabitants are shown in Table 2.

Table 2. Integral use activities for species of terrestrial fauna with high relative frequency and importance index figures in Montecillo Santa Cruz, Oaxaca, México.

Species	**[a] Conservation status**	**Alternatives**	**[b] Integral Use Activities**	**[c] Areas with management potential**
Black Iguana *Ctnosaura pectinata*	A	Intensive UMA	HC, SP, SM, SBS, FP, J	TDF, RV, BWB
Green iguana *Iguana iguana*	Pr	Intensive UMA	HC, SP, SM, SBS, FP, J	TDF, RV, BWB
White-winged dove *Zenaida asiatica*		Extensive UMA	HC, J, SM, HPC,	C

Chachalaca *Ortalis poliocephala*	Extensive UMA	HC, J, SM, HAP	TDF, VR
Cottontail rabbit *Sylvilagus floridanus*	Intensive UMA	HC, SM, O	P
White-tailed deer *Odocoileus virginianus*	Extensive UMA	HC, FP, HAP, O, SHt	TDF, TF
Armadillo *Dasypus novemcinctus*	Extensive UMA	HC, FP, SM, HAP, O	TDF, RV

[a] Conservation status (according to the Mexican Official Standard NOM-059-SEMARNAT-2010): A (threatened), Pr (Special Protection).

[b] Integral Use Activities: HC = home consumption, SP = sale as pets, SM = sale for meat, SBS = sale for breeding stock, FP = fur/skin production, J = jewelry, HPC = hunt for pest control in crops, HAP = handcrafts from animal parts, O = ornamental, SHt = sport hunting.

[c] Areas with management potential: RV: riparian vegetation, TDF: tropical deciduous forest, TF: thorny forest, BWB: banks along water bodies (rivers, creeks, estuaries), C: crops; and P: plains.

Discussion

In MSC, aquatic species are important for home consumption and local trade, so that the declining populations aggravate the economic condition of fishers (Cervantes-Hernández et al. 2012). This has led to a more intense use of terrestrial vertebrates as an alternative to earn an income or for home consumption.

Uses of terrestrial vertebrates

A study conducted in MSC 18 years ago on the valuation of terrestrial vertebrates by Huaves and Zapotec inhabitants revealed hunting for home consumption, where the species most commonly hunted being iguanas (*C. pectinata* and *I. iguana*), armadillo (*D. novemcinctus*), cottontail rabbit (*S, floridanus*), white-winged dove (*Z. asiatica*), white-tailed deer (*O. virginianus*), and *chachalaca* (*O. poliocephala*) (Vargas 2001). These currently remain as the most important species for local inhabitants, and the preference for certain species over the years is likely related to the benefits they provide. The use of terrestrial vertebrates by some Mesoamerican cultures is linked to the selective use of species of nutritional, economic, ornamental, traditional, or religious value, or that are suitable for use as a pet, medicine, or exchange commodity (Rodas-Trejo et al. 2014; Buenrostro et al. 2016).

This study detected the use of 33 terrestrial vertebrates in MSC, with mammals as the group with the highest number of species used (14), followed by birds (12) and reptiles (seven). For comparison with other studies, inhabitants of the Zoque Tropical Forest use 13 species of mammals, four species of birds and one reptile (Lira-Torres et al. 2014), while inhabitants of the Lagoons of Chacahua National Park (LCNP) use 14 species of mammals, eight of birds, and eight of reptiles (Buenrostro et al. 2016). In the three studies, mammals and birds are the vertebrates most commonly used, given their diverse uses (González-Bocanegra et al. 2011; Ortega del Valle et al. 2012; Buenrostro et al. 2016); this finding is consistent with other studies conducted in Mexico (Puc-Gil and Retana-Guiascón 2012; Cortés-Gregorio et al. 2013; Rodas-Trejo et al. 2014; Tejeda-Cruz et al. 2014).

The mammal species with the highest demand in MSC were white-tailed deer (*O. virginianus),* armadillo (*D. novemcinctus*) and cottontail rabbit (*S. floridanus*); this is consistent with the study conducted in the LCNP, where villagers used mainly armadillo (*D. novemcinctus*),

rabbit, collared peccary (*Pecari tajacu*) and white-tailed deer (*O. virginianus*) (Buenrostro et al. 2016); in Zoque Forest the only shared preference regards armadillo (*D. novemcinctus*), in addition to other species locally available such as paca (*Cuniculus paca*), collared peccary (*P. tajacu*), badger (*Nasua narica*), and Central American red brocket (*Mazama temama*) (Lira-Torres et al. 2014). The preference toward certain species may be related to the location of the study areas. MSC and LCNP are communities located in the coast of Oaxaca, whereas the Zoque Forest is located to the north of the state; these areas have different vegetation types and, consequently, the local inhabitants have access to different mammal species.

As noted in previous studies, armadillo is the mammal species most commonly hunted for home consumption, given its appealing taste (Pérez y Ojasti, 1996). It is hunted frequently in MSC because no firearms are needed to capture him; thus, access to iguana bushmeat is easier, and often times dogs catch it inside its burrow. LCNP inhabitants capture iguanas, armadillos, and raccoons assisted by dogs (Buenrostro et al. 2016). Only a few works describe the use of dogs as support in hunting; however, it is a common practice in the coast of Oaxaca. The use of dogs has also been documented in the Zoque region of Oaxaca (Lira-Torres et al. 2014) and in the Lacandon tropical forest of Chiapas (Tejeda-Cruz et al. 2014), in relation to the hunting of minor species such as armadillo and iguanas.

Wildlife is a resource used in a variety of ways and to different degrees, depending on habitat conditions and local needs (Escamilla et al. 2000; Naranjo et al. 2004). In MSC, the meat of *S. floridanus* and *O. virginianus* for consumption is usually purchased, because these species can be captured with firearms only. Local inhabitants report a decline in the populations of these species; however, a study revealed that rabbit populations decreased only between years 2001 and 2005, followed by stable numbers despite pasture burning and predation by feral dogs and wild

predators (Lorenzo et al. 2017). Separately, deer is increasingly harder to find due to deforestation and expansion of agriculture in MSC. A study conducted in the coast of Oaxaca reports that in spite of hunting, habitat fragmentation, increasing agricultural practices, and growth of urban areas, *O. virginianus* has managed to subsist, and suggests the implementation of conservation, management and sustainable use to conserve this as a free-living species (Buenrostro-Silva y García-Grajales 2018).

In MSC, birds are hunted for home consumption and sale, except for parrots and other species that are hunted for being considered crop pests. When birds are caught for consumption, hunters use a rubber strip or a firearm; for sales or population control purposes, fishing nets are used around crops to capture flocks. In addition, fireworks are used to scare pest birds, but inhabitants claim that this practice ceases to be effective once birds get used to the noise. The number of birds that are captured is hard to estimate, as more than one individual is captured to meet the home consumption needs, given their small size; hence, most villagers cannot recall the total number of individuals captured (Buenrostro et al. 2016). This is evidenced by the lack of information on bird catches in previous studies. In the LCNP, only the capture of 40 pigeons was recorded in three communities between the years 2011 and 2012, and in MSC only 34 chachalacas (*O. poliocephala*) were recorded for 2018 (Buenrostro et al. 2016).

In various Neotropical regions, the vertebrate classes providing the largest amount of products and byproducts are mammals and birds (Montiel et al. 2000); however, it does not mean these are the fauna most in demand. In the present study, iguanas (*C. pectinata* and *I. iguana)* were the species with the highest demand by local inhabitants, being a major component in the diet of communities in the region: villagers use the meat and eggs, and fishers sell them to increase their household income (Camacho 2001). A total catch of 172 iguanas was reported for LCNP; the

analysis of preferences by species revealed that 110 and 62 individuals corresponded to the black and green iguana, respectively, iguanas were the species with the highest specific use figures (1) in the food category (Buenrostro et al. 2016), in MSC; *C. pectinata* obtained the highest RII (0.97) as food, while *I. iguana* obtained an RII of 0.57 in the same use category.

In this study, the black iguana was the species in greatest demand, given its value for Zapotec households as a food source. In LCNP, villagers prefer the black iguana based on meat taste, similar to other regions of Oaxaca such as Los Chimalapas (Lira-Torres et al. 2014) and MSC. Iguana consumption on the coast of Guerrero and Oaxaca is very high; however, the amount of bushmeat extracted annually is unknown. In MSC, iguanas are caught through subsistence hunting; bushmeat consumption is strongly rooted in villagers, and may make up to 70% of annual animal protein intake (Toledo et al. 2008). It is clear that wildlife use by rural communities is rooted in traditions and usage patterns established according to the ethnic and geographical origin of each community (Guerra et al. 2010).

Catches for home consumption and sale as food are the main exploitation modalities of terrestrial vertebrates in tropical America (Pérez y Ojasti 1996). In MSC, the capture of terrestrial vertebrates depends on environmental, social, and economic factors. In the past decade, local inhabitants hunted to meet their economic needs due to the decline of fisheries in LI, especially during the dry season. As a result, hunting has become an option to earn an income that previously came from fishing, threatening species such as iguanas (*C. pectinata* and *I. iguana*), white-tailed deer (*O. virginianus*), armadillo (*D. novemcinctus*), cottontail rabbit (*S. floridanus*), white-winged dove (*Z. asiatica*) and *chachalaca* (*O. poliocephala*).

Co-management for the integral use of species

In MSC, weather affects the activities carried out in the territory (agriculture, livestock raising, and fisheries); droughts are becoming more intense and rains start later each year with a trend to lower precipitation levels. However, villagers have been able to subsist by replacing one activity by another when the former is affected. The diversification of economic activities is key because ecosystems are dynamic systems; this strategy allows villagers to persist even under the most difficult and unforeseen circumstances for the household economy (Robles 2005).

Iguanas were the species subjected to the strongest pressure by hunting as a result of poor fishing catches in LI during drought, coupled with the high demand of iguana bushmeat and eggs by villagers; other species also hunted are *D. novemcinctus*, *O. virginianus*, and *O. poliocephala*. Villagers should change their use practices to broaden the range of benefits through proper wildlife species management. The breeding of terrestrial vertebrates in captivity supports activities such as wildlife trade for different purposes (pets, meat consumption, broodstock, furs and skins, jewelry, handicrafts using parts of animals, and ornaments); otherwise, wildlife populations will continue declining and will be insufficient to meet the dietary and economic needs of local inhabitants. Based on the above, the co-management model can be implemented in order to define and warrant a fair strategy to distribute roles, rights and responsibilities on the use of terrestrial wildlife across local villagers (Borrini-Feyerabend et al. 2001).

As MSC is a community constantly facing changes in its territory in the rainy and dry seasons, co-management may be adaptive, i.e., the management of natural resources should adapt to the environmental conditions and the political and cultural aspects of the local inhabitants, as the activities may be based on traditions or institutional programs; in addition, anthropogenic activities (social system) should not affect ecosystems (ecological system) (Borrini-Feyerabend et al. 2001; Salas-Zapata et al. 2012). Based on the key findings of the study, villagers were made

aware about the need to implement a proper wildlife management scheme for those species that are important for the household economy and diet and with perceived declining populations.

One of the proposals put forward by villagers was the establishment of nurseries for some wildlife species such as iguanas. They chose to design an alternative focused on the conservation and integral use of *C. pectinata* and *I. iguana* by implementing the co-management model to create an intensive UMA. UMA is a scheme that can be adapted to the needs of wildlife species and the people, where progress can be monitored. Should an issue arise, the UMA can be adapted to the new conditions, as required, to continue providing economic and environmental benefits (Borrini-Feyerabend et al. 2001).

In MSC, the co-management model was applied thanks to many factors, incluided social actors (Ariza et al. 2017) such as fishermen, farmers, local authorities, a civil association, among others through the workshops; the co-management besides being done in ANP can be implemented as scheme (Borrini-Feyerabend et al. 2001) such as UMA, which allow the community participation in natural resources administration (SEMARNAT 2000), in MSC the administration was based on the lizard co-management, agreements were made to preserve its habitat, to protection and integral use to reverse the issues generated by consumption and sale.

UMA will allow managing and using several wildlife species in different ways, also allow the organization among the interesred people to get a fair and equal distribution of benfits derived from the resource management. (Borrini-Feyerabend et al. 2000; Borrini-Feyerabend et al. 2001; Carlsson y Berkes 2005). In MSC, management and integral use was proposed for the seven most used terrestrial vertebrates (iguana negra, *C. pectinata*; iguana verde, *I. iguana*; paloma de alas blancas, *Z. asiática*; chachalaca, *O. poliocephala*; conejo castellano, *S. floridanus*; venado cola blanca, *O. virginianus* y armadillo, *D. novemcinctus);* however, other species of the 33 terrestrial

vertebrates reported may also be managed and used. MSC inhabitants will use iguanas for sale of meat and as pets, for home consumption, repopulation, and environmental education; other potential uses of these species include research, reintroduction, recovery, and display (SEMARNAT 2000).

Few studies have been conducted on co-management in Latin America, and those available focus mainly on fisheries (Zepeda-Domínguez et al. 2013); however, there are factors that help the model to be viable through UMA. It has legal framework, it can receive financing programs from government; enviromental, social and culture problems are considered, it is regulated by government institutions such as SEMARNAT that helps to the state keeps participation in natural resources administration (Borrini-Feterabend et l. 2001; Carlsson y Berkes 2005) and the handling con be perfomed by local inhabitants and train nearby communities interested to use the same resource.

The UMAs are a feasible tool for the application of this model and bring integral use alternatives to generate income while contributing to wildlife conservation. UMAs are an innovative approach for the utilization of wildlife in México, with cases that demonstrate their viability. UMAs are based on the assumption that legalizing wildlife use will facilitate a controlled and regulated use, in addition to increase the market value of wildlife; this enhances sustainable practices at the local level (Servín et al. 2018). The implementation of an UMA facilitates the management and regulation of terrestrial vertebrate species in high demand by MSC inhabitants. In Oaxaca, there are currently 92 premises and facilities that either manage or use wild mammals. The species with the highest number of approved management units under intensive and extensive schemes is *O. virginianus,* in 78% of all facilities (Masés-García et al. 2016).

The creation of an UMA facilitates management based on a consistent regulation between local and federal laws; the UMA for iguanas will comply with federal regulations as well as with local standards and values (Bray et al. 2005). Co-management based in integral use can improve the living standard of local inhabitants, contributing to the fair and equitable sharing of benefits derived from conservation. These alternatives will lead to the recovery of disturbed social ecosystems as a result of the proper management of wildlife resources such as terrestrial vertebrates (Zepeda-Domínguez et al. 2013).

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References Cited

Ariza, P., N. Cuvi, and J. Cabezas. 2017. El co-manejo adaptativo como estrategia de adaptación ante el cambio climático Lecciones aprendidas de su aplicación en seis sitios clave para la conservación de la diversidad ecosistémica del Ecuador. *Propuestas Andinas* 15:1-12.

Borrini-Feyerabend, G. 1996. *Collaborative Management of Protected Areas: Tailoring the Approach to the Context*. IUCN Social Policy Group, Gland-Switzerland. Available at: http://www.iucn.org/themes/spg/Files/tailor.html.

Borrini-Feyerabend, G., M. T. Farvar, V. Solis, and H. Govan. 2001. *Manejo Conjunto de los Recursos Naturales - Organizarse, Negociar y Aprender en la Acción*. GTZ y UICN, Kasparek Verlag, Heidelberg, Alemania.

Bray, D., L. Merino, and D. Barry. 2005. Community managed in the strong sense of the phrase: The community forest enterprises of México. In *The Community Forests of México.*

Managing for Sustainable Landscapes, edited by D. Bray, L. Merino, and D. Barry, pp. 3–26. University of Texas Press. eBook Collection (EBSCOhost), Texas.

Buenrostro, A., M. Rodríguez, and J. García. 2016. Uso y conocimiento tradicional de la fauna silvestre por habitantes del Parque Nacional Lagunas de Chacahua, Oaxaca, México. *Quehacer Científico en Chiapas* 11: 84–94.

Buenrostro-Silva, A., and J. García-Grajales. 2018. Venado cola blanca en la costa de Oaxaca. In *Venado cola blanca en Oaxaca: potencial, conservación, manejo y monitoreo*, edited by S. Mandujano, pp. 73-82. Instituto de Ecología, A. C., Comisión Nacional para el Conocimiento de la Biodiversidad, Xalapa, Veracruz, México.

Bustos, D. E., J. A. Espinosa, and C. A. Tapia. 2003. *Diagnóstico participativo en comunidades rurales del semiárido de Querétaro y Guanajuato*. SAGARPA, INIFAP, Campo Experimental Querétaro, Querétaro, México.

Camacho, S. 2001. *Armadillo, Tepezcuintle, Tortuga y Roedor, Elementos de la Gastronomía Maya Lacandona*. CONACULTA, México, D. F.

Carabias, J., and E. Provencio. 1993. Hacia un modelo de desarrollo agrícola sustentable. *In: Alternativas para el campo mexicano. Tomo II*, edited J. Calva, pp. 44–59. Friedrich Ebert Stiftung UNAM, México.

Carlsson, L., and F. Berkes. 2005. Co-management: concepts and methodological implications. *Journal of Environmental Management* 75: 65–76. Doi: 10.1016/j.jenvman.2004.11.008.

Carrillo-Reyes, A., C. Lorenzo, T. Rioja-Paradela, E. Naranjo, and M. Pando. 2012. Uso de hábitat de la liebre en peligro de extinción, *Lepus flavigularis*: implicaciones para su conservación. *THERYA* 3: 113–125. Doi: 10.12933/therya-12-63.

Centro Regional de Investigación Pesquera de Salina Cruz, Oaxaca. 1996. Fauna de acompañamiento del camarón: Evaluación durante el 2do ciclo de muestreo de camarón y D. T. E. en el Golfo de Tehuantepec, Julio-Agosto 1993. In *Boletín del Centro Regional Pesquera, Salina Cruz, Oaxaca*, edited by R. Rojas-Crisóstomo, and H. Ramírez-García, pp. 9-13. Secretaria de Medio Ambiente, Recursos Naturales y Pesca-Instituto Nacional de Pesca Salina Cruz, Oaxaca.

Cervantes-Hernández, P., M. Gallardo-Berumen, and S. Serrano-Guzmán. 2012. Explotación y distribución de la captura artesanal de camarón en el Sistema Lagunar Huave, Oaxaca, México. *Revista Ciencias Marinas y Costeras* 4: 67–81. DOI: https://doi.org/10.15359/revmar.4.4.

Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO) 2013. Los anfibios. In *La Biodiversidad en Chiapas: Estudio de Estado*, edited by L. A. Muñoz, N. López, A. Hórvath and R. Luna, pp. 351–358. CONABIO/Gobierno del Estado de Chiapas, México.

Cortés-Gregorio, I., E. Pascual-Ramos, S. M. Medina-Torres, E. A. Sandoval-Forero, E. Lara-Ponce, H.H. Piña-Ruíz, R. Martínez-Ruíz, and G. E. Rojo-Martínez. 2013. Etnozoología del pueblo mayo-yoreme en el norte de Sinaloa: Uso de vertebrados silvestres. *Agricultura, Sociedad y Desarrollo* 10: 335–358.

Cox, W. G. 1985. *Laboratory Manual of General Ecology,* 1ª edition. WMC. Brown Company, EUA.

Del Moral-Flores, L. F., V. Anislado-Tolentino, E. Martínez-Ramírez, G. Pérez-Ponce de León, E. Ramírez-Antonio, and G. Gonzales-Medina. 2016. Ictiofauna marina de Oaxaca, México: listado sistemático y afinidades zoogeográficas. Acta Universitaria *27*: 3-25. Doi: 10.15174/au.2016.1069.

Escamilla, A., M. Sanvicente, M. Sosa, and C. Galindo-Leal. 2000. Habitat Mosaic, Wildlife Availability, and Hunting in the Tropical Forest of Calakmul, Mexico. *Conservation Biology* 14:1592–1601. Doi: 10.1111/j.1523-1739.2000.99069.x.

Farías, V., T. K. Fuller, F. A. Cervantes, and C. Lorenzo. 2006. Home range and social behavior of the endangered Tehuantepec jackrabbit (*Lepus flavigularis*) in Oaxaca, Mexico. *Journal of Mammalogy* 87(4): 748-756.

Farías, V., and T. K. Fuller. 2009. Native vegetation structure and persistence of endangered Tehuantepec jackrabbits in a neotropical savanna in Oaxaca, México. *Biodiversity and Conservation* 18: 1963–1978. Doi: 10.1007/s10531-008-9567-1.

González, P., M. Briones-Salas, and A. Alfaro. (2004) Integración del conocimiento faunístico del estado. In *Biodiversidad de Oaxaca*, edited by A. García-Mendoza, M. Ordóñez, and M. Briones-Salas, pp. 449-466. Instituto de Biología, México, D.F.

González-Bocanegra, K., E. I. Romero-Berny, M. C. Escobar-Ocampo, and Y. García-Del Valle. 2011. Aprovechamiento de fauna silvestre por comunidades rurales en los humedales de Catazajá- La Libertad, Chiapas, México. *Ra Ximhai* 7: 219–230. Doi: 10.35197/rx.07.02.2011.06.kg.

Guerra, M., S. Gallina, and E. Naranjo. 2010. *Uso y Manejo de la Fauna Silvestre en el Norte de Mesoamérica*. Secretaria de Educación, Gobierno del Estado de Veracruz, Xalapa.

Henestroza, R. 2009. Centrales eólicas en el Istmo de Tehuantepec; su impacto ambiental y socioeconómico. *Elementos: Ciencia y cultura* 16: 39–44.

Instituto Nacional de Estadística, Geografía e Informática (INEGI) 1985$_a$. *Carta Uso del Suelo y Vegetación, 1:250 000. Unión Hidalgo. E15C74 Oaxaca. Dirección General de Geografía del Territorio Nacional.* Instituto Nacional de Estadística, Geografía e Informática.

Instituto Nacional de Estadística, Geografía e Informática (INEGI) 1985$_b$. *Carta Uso del Suelo y Vegetación. 1:250 000. Juchitán El 510 D15- 1. Oaxaca. Dirección General de Geografía del Territorio Nacional. Instituto*. Nacional de Estadística, Geografía e Informática.

Lara Ponce, E., L. Caso-Barrera, M. Aliphat, B. Ramírez, A. Gil, and G. Garcíar. 2012. Etnomapa: Uso De Los Recursos Naturales por los Mayas Itzaes de San José y San Andrés del Petén, Guatemala. *Universidad y Ciencia* 28: 97–117.

Lira-Torres, I., M. Briones-Salas, F. R. Gómez de Anda, D. Ojeda-Ramírez, and A. Pelaéz Acero. 2014. Uso y aprovechamiento de la fauna silvestre en la Selva Zoque, México. *Acta Zoológica Mexicana* 30: 74–90.

López, J. A., C. Lorenzo, F. Barragán, and J. Bolaños. 2009. Mamíferos terrestres de la zona lagunar del Istmo de Tehuantepec, Oaxaca, México. *Revista Mexicana de Biodiversidad* 80: 491–505.

Lorenzo, C., E. C. Sántiz, J. E. Bolaños-Citalán, and D. Navarrete-Gutiérrez. 2017. Influences of long-term changes in land cover on mammal populations: an example from México. *Oryx* 53: 1–8. Doi: 10.1017/S0030605317000485.

Lorenzo, C., F. Cervantes, F. Barragán, and J. Vargas. 2006. New records of the endangered Tehuantepec jackrabbit (*Lepus flavigularis*) from Oaxaca, Mexico. *The Southwestern Naturalist* 51: 116-119. DOI: 10.1894/0038-4909(2006)51[116:NROTET]2.0.CO;2.

Lorenzo, C., J. E. Bolaños, E. C. Sántiz, and F. Cervantes. 2005. Distribución y densidad de zorrillos en el Istmo de Tehuantepec, Oaxaca, México. In *Contribuciones Mastozoológicas en Homenaje a Bernardo Villa*, edited by V. Sánchez, and R. Medellín, pp. 317–324. Instituto de Biología, UNAM; Instituto de Ecología, UNAM; CONABIO, México.

Lorenzo, C., O. Retana-Guiascón, F. Cervantes, J. Vargas, and G. Portales. 2000. *Status Survey of the Critically Endangered Lepus flavigularis.* Final report to Chicago Zoological Society. El Colegio de la Frontera Sur, San Cristóbal de Las Casas, Chiapas, México.

Lorenzo, C., T. Rioja, A. Carrillo, and F. Cervantes. 2008. Population Fluctuations of *Lepus flavigularis* (Lagomorpha: Leporidae) at Tehuantepec Isthmus, Oaxaca, México. *Acta Zoológica Mexicana* 24: 207–220.

Martin, G. J. 1995. *Ethnobotany. A methods manual*. Edited by M. Walters. People and plants conservation series, WWF, United Nations Educational, Scientific and Cultural Organization (UNESCO) and the Royal Botanic Gardens, Kew, Londo, UK.

Martínez, C. M. M., B. M. Suarez, I. M. González, and L- J. Calderón. 2011. Estudio etnozoológico en la Red de Reservas Naturales de la Cocha, Corregimiento del Encano, Departamento de Nariño, Colombia. In. *Etnozoología, Un enfoque binacional México-Colombia, e*dited by R. Monroy, F. A. García, M. J. Pino, and O. R. Monroy, pp. 75-129. Universidad Autónoma del Estado de Morelos, México.

Masés-García, C., M. Briones-Salas, and J. Sosa-Escalante. 2016. Análisis del manejo y aprovechamiento legal de los mamíferos silvestres de Oaxaca, México. *Revista Mexicana de Biodiversidad* 87: 497–507. Doi: 10.1016/j.rmb.2016.02.001.

Montiel, S., L. M. Arias, and F. Dickinson. 2000. La cacería tradicional en el norte de Yucatán: una práctica comunitaria. *Revista de Geografía Agricola* 29: 43–52.

Morse, J. 1995. The significance of saturation. *Qualitative Health Research* 5: 147–149.

Naranjo, E., M. M. Guerra, R. E. Bodmer, and J. E. Bolaños. 2004. Subsistence hunting by three ethnic groups of lacandon forest, México. *Journal of Ethnobiology* 24: 233–253.

Núñez-Orozco, A. L., Labastida-Che, A., and J. A. Oviedo-Piamonte. 2013. Composición y abundancia de la ictiofauna en la franja sublitoral del Golfo de Tehuantepec, Oaxaca/Chiapas, México. *Ciencia Pesquera* 21:29-40.

Ojasti, J. 2000. *Manejo de Fauna Silvestre Neotropical*. SI/MAB Series # 5. Smithsonian Institution/MAB Biodiversity Program. Edited by F. Dallmeier. Washington, D.C.

Ortega del Valle, D., L T. Carranza, and J. Martínez. 2012. *Una mirada desde el corazón de la Jicara de Oro (Experiencias de conservación en la Selva Zoque de los Chimalapas)*. WWF-México/USAID. México, D.F.

Ortega, J., J. Villareal, S. Mandujano, S. Gallina, M. Weber, F. Clementes, and R. Valdez. 2014. Retos y estrategias de conservación y aprovechamiento de la fauna en México, In *Ecología y manejo de fauna silvestre en México,* edited by R.Valdez, and J. Ortega, pp. 523–542. Biblioteca Básica de Agricultura, Guadalajara, Jalisco, México.

Pearce, D. and D. Moran. 1994. *The Economic Value of Biodiversity*. IUCN – The World Conservation Union, London.

Pérez, E., and J. Ojasti. 1996. La utilización de la fauna silvestre en la América tropical y recomendaciones para su manejo sustentable en las sabanas. *Ecotrócpicos* 9: 71–82.

Pérez-García, E., J. Meave, and C. Gallardo. 2001. Vegetación y flora de la región de Nizanda, Istmo de Tehuantepec, Oaxaca, México. *Acta Botanica Mexicana* 56: 19–88.

Pérez-Gil, R., F. Jaramillo, A. Muñiz, and M. Torres. 1995 *Importancia económica de los vertebrados silvestres de México. PG-7 Consultores, S. C.* CONABIO, México.

Puc-Gil, R. and O. Retana-Guiascón. 2012. Uso de la fauna silvestre en la comunidad maya Villa de Guadalupe, Campeche, México. *Etnobiología* 9: 3–9.

Retana, O. G. 2010. Uso de la Vida Silvestre y Alternativas de Manejo Integral en Comunidades Rurales del Norte de Campeche. Centro de Estudios de Desarrollo Sustentable y

Aprovechamiento de la Vida Silvestre (CEDESU). Informe final Fomix-2007. Proyecto CAMP-2007-C01-71355. Campeche, México.

Rioja, T., C. Lorenzo, E. Naranjo, L. Scott y A. Carrillo. 2008. Polygynous mating behavior in the endangered Tehuantepec Jackrabbit (*Lepus flavigularis*). *Western North American Naturalist* 68: 343-349.

Rioja-Paradela, T., A. Carrilo-Reyes, G. Catañeda-Gaytán, E. Espinoza-Medinilla, and S. López-Mendoza. 2012. Anfibios y reptiles del Istmo de Tehuantepec: distribución, uso de hábitat, riqueza y diversidad. Informe Técnico. PROMEP/103.5/10/4979. México.

Rivera, R., A. Santos, D. Alavez, E. Martinez, E. Cruz, F. Palma, P. S. Vasques, R. Contreras, and R. Ramirez. 2011. *Programa de ordenamiento ecológico regional del territorio del estado de Oaxaca*. Universidad Autónoma Benito Juárez de Oaxaca/Secretaria de Medio Ambiente y Recursos Naturales, Oaxaca.

Robles, R. 2005. *Apropiación de recursos naturales y relaciones sociales en la Reserva de la Biosfera Ría Celestún.* CINVESTAV, *Yucatán*.

Rodas-Trejo, J., P. Ocampo-González, and P. R. Coutiño-Hernández. 2014. Uso de los mamíferos silvestres en el municipio de Copainalá, región Zoque, Chiapas; México. *Quehacer Científico en Chiapas* 9: 3–9.

Rzedowski, J. 2006. *Vegetación de México*. 1ra Edición. Edited by Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO) Limusa, México.

Salas-Zapata, W., L. Ríos-Osorio, and J. Del Castillo. 2012. Marco conceptual para entender la sustentabilidad de los sistemas socioecológicos. *Ecologia Austral* 22: 74–79.

Salinas, A. L. 2005. Mapeo y análisis participativo de los recursos naturales en siete comunidades de la subcuenca del río Jucuapa Matagalpa-Nicaragua. Tesis de Licenciatura. Departamento de manejo de cuencas. Universidad Nacional Agraria. Nicaragua.

Sántiz, E. C. 2006. Selección de hábitat y densidad de la liebre del Istmo *Lepus flavigularis* (Wagner 1844) en Oaxaca, México. Instituto de Ecología. Tesis de Maestría. Departamento de Conservación de la Biodiversidad. Instituto de Ecología, México.

Sántiz, E. C., A. González-Romero, C. Lorenzo, S. Gallina-Tessaro, and F. A. Cervantes. 2012. Uso y selección de asociaciones vegetales por la liebre de Tehuantepec (*Lepus flavigularis*) en Oaxaca, México. *Therya* 3:127-136. DOI: 10.12933/therya-12-70.

Sarukhán, J., P. Koleff, J. Carabias, J. Soberón, R. Dirzo, J. Llorente-Bousquets, G. Halffter, R. González, I. March, A. Mohar, S. Anta, and J. de la Maza. 2009. *Capital natural de México. Síntesis: conocimiento actual, evaluación y perspectivas de sustentabilidad.* CONABIO. México.

Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT). 2000. Escala 1:250000. Inventario Nacional Forestal. Mapa temático.

Servín, J., D. E. Carreón-González, F. Castro-Campos, A. Huerta, and M. Garza. 2018. *Las Unidades de Manejo para la Conservación de la Vida Silvestre (UMA) en el Noroeste de México:* 1ra edition. Edited by D. P. Orea, E. C. Jarillo, F. Mendoza, J. A. Arévalo, J. A. Granados, J. E. Miranda, P. Castilla, and R. Espinosa. Universidad Autónoma Metropolitana, México.

Tejeda-Cruz, C., E. J. Naranjo-Piñera, L. M. Medina-Sanson, and F. Guevara-Hernández. 2014. Cacería de subsistencia en comunidades rurales de la selva Lacandona, Chiapas, México. *Quehacer Científico en Chiapas* 9: 59–73.

Toledo, V., J. Carabias, C. Mapes, and C. Toledo. 2000 *Ecología y autosuficiencia alimentaria: Hacia una opción basada en la diversidad biológica, ecológica y cultural de México*. 6a

edición. Siglo XXI de España Editores, México.
Toledo, V., N. Barrera-Bassols, E. García-Frapolli, and P. Alarcón-Chaires. 2008. Uso Múltiple y Biodiversidad entre los Mayas Yucatecos. *Interciencia* 33:345–362. Disponible en: https://www.redalyc.org/articulo.oa?id=339/33933505. Consultado: 10 de Diciembre de 2019.
Toledo, V., P. Alarcón-Chaires, P. Moguel, M. Olivo, A. Cabrera, E. Leyequien, and A. Rodríguez-Aldabe. 2002. Biodiversidad y Pueblos Indios en México y Centroamérica. *Biodiversitas* 7:2- 16.
Vargas, Z. F. 2001. Valoración de los vertebrados terrestres por Huaves y Zapotecas del Istmo de Tehuantepec, Oaxaca, México. Tesis de Maestría. Maestría en Ciencias en Recursos Naturales y Desarrollo Rural. El Colegio de la Frontera Sur. México.
Villalba, A. 2001. Esfuerzo conjunto para la elaboración y aplicación del Programa de Manejo para la conservación de los humedales costeros de Bahía Santa María, Sinaloa. Agencia estadounidense para la Oficina del Desarrollo Internacional de Ambiente y Oficina de Recursos Natural para Crecimiento Económico, Agricultura y Comercio bajo los términos del Acuerdo Cooperativo #PCE-A-00-95-0030-05. Guaymas, Sonora, México.
Zepeda-Domínguez, J. A., D. Lluch-Belda, G. Ponce Díaz, F. Arreguín-Sánchez, S. Lluch-Cota, S. Salas-Márquez, A. Espinoza-Tenorio. 2013. Rumbo a un co-manejo pleno y efectivo de los recursos pesqueros en México: Fortalezas y debilidades del proceso. In *Opciones de Gestión para Recursos Naturales en Baja California Sur*, edited by L. Palos, V. Hernández, and G. Áviles, pp. 117–144. Universidad Autónoma de Baja California Sur, Baja California Sur, México.

Appendix 1. Uses of aquatic and terrestrial wildlife by the local inhabitants of Montecillo Santa Cruz, Oaxaca, Mexico. Italic common names are local names.

Class/Family	**Species**	**Common Name**	**[a]NOM-059**	**Uses**
Gastropoda				
Muricidae	*Hexaplex* sp.	Abalone or snail		F, S, ME
Malacostraca				
Portunidae	*Callinectes* spp.	Blue crab		F, S
Penaeidae	*Farfantepenaeus californiensis*	Brown shrimp		F, S
	Litopenaeus vannamei	White shrimp		F, S
Actinopterygii				
Cichlidae	*Oreochromis* spp.	Tilapia		F, S
Anablepidae	*Anableps dovii*	Four-eyed fish		ME
Chondrichthyes				
Dasyatidae	*Dasyatis longa*	Longtail stingray		F
Ophichthidae	*Ophichthus zophochir*	Anguilla		F
Clupeidae	*Opisthonema* spp.	Water sardine		F, S
Chanidae	*Chanos chanos*	*Sabalote*, Milkfish		F, S
Ariidae	*Occidentarius platypogon*	*Tacazonte*, combinate sea-catfish		F, S
	Sciades spp.	Catfish		F, S
Batrachoididae	*Batrachoides waltersi*	Toadfish		F,S
Mugilidae	*Mugil cephalus*	Flathead grey mullet		F, S
	Mugil curema	Silver mullet		F
Centropomidae	*Centropomus robalito*	Snook		F, S
Carangidae	*Hemicaranx zelotes*	*Pelona*, blackfin jack		F

Gerreidae	*Eugerres mexicanus*	White mojarra		F, S
	Diapterus peruvianus	White or yellow-finned mojarra		F, S
Lutjanidae	*Lutjanus* spp.	Snapper		F, S
	Lutjanus colorado	Red snapper		F, S
Haemulidae	*Pomadasys* spp.	Grunt		F, S
Sciaenidae	*Elattarchus archidium*	Bluestreak drum		F
Eleotridae	*Dormitator latifrons*	*Popoyote*, Pacific fat sleeper		F, S
Ephippidae	*Chaetodipterus zonatus*	*Zapatera*, Pacific spadefish		F, S
Achiridae	*Achirus zebrinus*	Sole		F, S
Reptiles				
Iguanidae	*Ctenosaura oaxacana*	Oaxacan spiny-tailed iguana	T	F
	Ctnosaura pectinata	Black iguana	T	F, S
	Iguana iguana	Green iguana	SP	F, S
Scincidae	*Marisora brachypoda*	Campeche		M
Elapidae	*Micrurus browni*	*Coralillo*, Brown's coral snake	SP	PD
Viperidae	*Agkistrodon bilineatus*	Cantil	SP	PD, M
	Crotalus simus	Rattlesnake		ME
Birds				
Anatidae	*Cairina moschata*	Muscovy duck	DE	F, S
	Dendrocygna autumnalis	*Pichichi*, Black-bellied whistling duck		F
Columbidae	*Columbina inca*	Mexican dove		F
	Zenaida asiatica	White-winged dove		F, S
Falconidae	*Herpetotheres cachinnans*	Laughing falcon		PD
Gracidae	*Ortalis poliocephala*	Chachalaca		F, S

Odontophoridae	*Cyrtonyx sp.*	Quail		F
Corvidae	*Calocitta formosa*	White-throated magpie-jay		F
Icteridae	*Quiscalus mexicanus*	*Zanate*, great-tailed grackle		PD
Mimidae	*Mimus gilvus*	*Cenzontle*, tropical mockingbird		Pt
Psittacidae	*Amazona albifrons*	White-fronted parrot	SP	Pt
	Eupsittula canicularis	Orange-fronted parakeet	SP	Pt
Mammals				
Cervidae	*Odocoileus virginianus*	White-tailed deer		F, S, ME, O, FS
Tayassuidae	*Pecari tajacu*	Collared peccary		Pt
Canidae	*Canis latrans*	Coyote		PD
	Urocyon cinereoargenteus	Gray fox		F, Pt
Mephitidae	*Conepatus* sp.	Skunk		ME
Procyonidae	*Nasua narica*	Badger	T	PD
	Procyon lotor	Raccoon		F, S, PD, Pt
Didelphidae	*Didelphis marsupialis*	*Tlacuache*, opossum		F, PD, ME
	Didelphis virginiana	Northern opossum		F, PD, ME
Leporidae	*Sylvilagus floridanus*	Cottontail rabbit		F, S
	Lepus flavigularis	Tehuantepec jackrabbit	DE	F
Sciuridae	*Sciurus* sp.	Squirrel		F, S, PD
Dasypodidae	*Dasypus novemcinctus*	Armadillo		F, S

Myrmecophagidae	*Tamandua mexicana*	Anteater	DE	Pt

[a] Conservation status (according to the Mexican Official Standard NOM-059-SEMARNAT-2010): T (Threatened), SP (Special Protection) and DE (Danger of Extinction).

[b] Uses of wildlife: F= Food, S= Sale, ME = Medicine, M = mythical, PD = prevent damage, O = Ornamental, FS = Fur/skin, Pt = Pet.

Source: Buenrostro et al. 2016; Del Moral-Flores et al. 2016; Núñez-Orozco et al. 2013; Rodas-Trejo et al. 2014, and Centro Regional de Investigación Pesquera de Salina Cruz, Oaxaca 1996.

Capítulo 3. Conclusiones

Diversas investigaciones etnozoológicas describen el uso de las especies; pero muy pocas implementan métodos participativos que ayuden a identificar las problemáticas internas y externas de una comunidad. Actualmente MSC se encuentra en un periodo de transición debido a que los pobladores están tomando conciencia sobre la conservación y manejo adecuado de la fauna silvestre, es una comunidad en la que se puede aplicar el modelo de co-manejo, ya que los pobladores tienen interés en realizar el manejo y aprovechamiento adecuado de las especies terrestres y acuáticas, pero debido al desconocimiento no han podido desarrollar un sistema sustentable.

La participación comunitaria permitió que durante el consenso de problemáticas y alternativas para el aprovechamiento integral de las especies se pudieran reunir tanto jóvenes como adultos, lo anterior ayudo a reconocer las necesidades de los pobladores desde las perspectivas de diferentes edades, tales como la falta de opciones de empleo que tienen los jóvenes en la comunidad, lo cual los obliga a migrar a las zonas urbanas de la región. Cuando se implementa adecuadamente el modelo de co-manejo en un territorio se pueden desarrollar diversas actividades económicas compatibles con el medio ambiente, esto permite a los pobladores tener más opciones para generar ingresos económicos en su comunidad a través del manejo adecuado de los recursos naturales.

Las alternativas que se generaron a partir del consenso y el diálogo de saberes (locales y académicos) durante el estudio en MSC, permitió proponer el aprovechamiento integral de las iguanas a través de la creación de una UMA intensiva (tipo *ranching*). La iguana negra fue la especie con mayor importancia de valor de uso alimentario, por lo tanto, la implementación de la UMA de iguanas les permitirá abastecer sus necesidades alimenticias, obtener ganancias monetarias y a conservar a las especies a través de la reproducción en cautiverio.

El estudio permitió aplicar el modelo de co-manejo para el aprovechamiento integral de las especies, lo anterior se evidencio en los siguientes puntos a tratar: hubo una participación comunitaria (hombres y mujeres) y gubernamental (autoridades municipales y locales); las juntas que se realizaron ayudaron a que surgiera una organización principalmente en torno al aprovechamiento legal de las iguanas, la decisión

de crear una UMA por parte de los pobladores fue a partir de las necesidades que tienen para consumir y vender a las iguanas no solo en Montecillo Santa Cruz sino también en la región; las UMA en México son un esquema que permite a los pobladores tener poder sobre el recurso que quieren aprovechar sin dejar de tomar en cuenta las leyes federales, además permite la participación de hombres y mujeres, administrar, repartir responsabilidades y garantizar beneficios a partir de un manejo adecuado de los recursos.

La participación comunitaria ayudo a difundir el aprovechamiento integral de las iguanas mediante los talleres que se realizaron, además los pobladores obtuvieron información de cómo aprovechar a los vertebrados terrestres conforme a las leyes (Ley General del Equilibrio Ecológico y la Protección al Ambiente, Norma Oficial Mexicana e instituciones gubernamentales), así como protegerla y conservarla. Las alternativas para el aprovechamiento integral se basaron en obtener una diversificación de productos derivados de la iguana negra e iguana verde, de esta forma se podrán desarrollar más opciones para que los pobladores obtengan beneficios económicos. En MSC se pueden realizar actividades de manera autónoma bajo las leyes gubernamentales a través de proyectos económicamente redituables como la UMA. Al proponerle a los pobladores realizar actividades que no sean convencionales, pueden dejar de realizar ciertas prácticas como la cacería con fines de comercio, la ganadería y la agricultura.

Con base en lo anterior, el enfoque de co-manejo basado en el aprovechamiento integral podrá mejorar la calidad de vida de los pobladores de MSC. La distribución justa y equitativa de los beneficios derivados de la conservación y las alternativas permitirán la recuperación de los socioecosistemas perturbados a partir del manejo adecuado de recursos como las iguanas.

Literatura citada

Ariza P, Cuvi N, Cabezas J. 2017. El co-manejo adaptativo como estrategia de adaptación ante el cambio climático. Lecciones aprendidas de su aplicación en seis sitios clave para la conservación de la diversidad ecosistémica del Ecuador. Propuestas Andin. 15:1–7.

Borrini-Feyerabend G. 1996. Collaborative Management of Protected Areas: Tailoring the Approach to the Context, IUCN. Gland (Switzerland): UICN Social Policy Group. 59 p.

Borrini-Feyerabend G, Farvar MT, Nguinguiri J, Ndangang V. 2000. Co-management of Natural Resources: Organizing Negotiation and Learning. Kasparek, editor. Heidelberg (Germany).

Borrini-Feyerabend G, Taghi Farvar M, Solis V, Govan H. 2001. Manejo Conjunto de los Recursos Naturales - Organizarse, Negociar y Aprender en la Acción. GTZ y UICN. Kasparek V, editor. Heidelberg, Alemania. 113 p.

Carabias J, Provencio E. 1993. Hacia un modelo de desarrollo agrícola sustentable. In: Calva J, editor. Alternativas para el campo mexicano. Tomo II. México.: Friedrich Ebert Stiftung. UNAM. p. 44–59.

Carlsson L, Berkes F. 2005. Co-management: concepts and methodological implications. J. Environ. Manage. 75(1):65–76.

Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO). 2013. Los anfibios. In: Muñoz LA, López N, Hórvath A, Luna R, editors. La Biodiversidad en Chiapas: Estudio de Estado. 1a ed. México: Comisión Nacional para el Conocimiento y Uso de la Biodiversidad/Gobierno del Estado de Chiapas. p. 351–358.

Ojasti J. 2000. Manejo de Fauna Silvestre Neotropical. Dallmeier F, editor. Washington, D.C. 304 p.

Ortega J, Villareal J, Mandujano S, Gallina S, Weber M, Clemente F, Valdez Raul. 2014. Retos y estrategias de conservación y aprovechamiento de la fauna en México. In: Valdez Raúl, Ortega J, editors. Ecología y manejo de fauna silvestre en México. 1a ed. Guadalajara, Jalisco, México: Biblioteca Básica de Agricultura. p. 523–542.

Pearce D, Moran D. 1994. The Economic Value of Biodiversity. USA: IUCN – The World Conservation Union, Earthscan. 167 p.

Pérez-Gil R, Jaramillo F, Muñiz A, M. T. 1995. Importancia económica de los vertebrados silvestres de México. PG-7 Consultores, S. C. CONABIO. México. 170 p.

Retana O. 2010. Uso de la Vida Silvestre y Alternativas de Manejo Integral en Comunidades Rurales del Norte de Campeche. Centro de Estudios de Desarrollo Sustentable y Aprovechamiento de la Vida Silvestre (CEDESU). Informe final Fomix-2007. Proyecto CAMP-2007-C01-71355. Campeche, México. 93 p.

Salas-Zapata WA, Ríos-Osorio LA, Castillo JÁ Del. 2012. Marco conceptual para entender la sustentabilidad de los sistemas socioecológicos. Ecol. Austral 22:74–79.

Sarukhán J, Koleff P, Carabias J, Soberón J, Dirzo R, Llorente-Bousquets J, Halffter G, González R, March I, Mohar A, et al. 2009. Capital natural de México. Síntesis: conocimiento actual, evaluación y perspectivas de sustentabilidad. México: Comisión Nacional para el Conocimiento y Uso de la Biodiversidad. 104 p.

Toledo V. 2000. Ecología y autosuficiencia alimentaria: Hacia una opción basada en la diversidad biológica, ecológica y cultural de méxico. 6a ed. México: Siglo XXI de

España Editores. 118 p.
Toledo V, Alarcón-Chaires P, Moguel P, Olivo M, Cabrera A, Leyequien E, Rodríguez-Aldabe A. 2002. Biodiversidad y Pueblos Indios en México y Centroamérica. Biodiversitas 7(43):1–16.
Toledo V, Barrera N, García E, Alarcón P. 2008. Uso Múltiple y Biodiversidad entre los Mayas Yucatecos. Interciencia 33 (5):345–362.
Vargas Z. 2001. Valoración de los vertebrados terrestres por Huaves y Zapotecas del Istmo de Tehuantepec, Oaxaca, México. [Tesis de Maestría] El Colegio de la Frontera Sur. 170 p.
Villalba, A. 2001. Esfuerzo conjunto para la elaboración y aplicación del Programa de Manejo para la conservación de los humedales costeros de Bahía Santa María, Sinaloa. Agencia estadounidense para la Oficina del Desarrollo Internacional de Ambiente y Oficina de Recursos Natural para Crecimiento Económico, Agricultura y Comercio bajo los términos del Acuerdo Cooperativo #PCE-A-00-95-0030-05. Guaymas, Sonora, Mexico.