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Evaluation of the potential of the observation of Alouatta palliata for local conservation and development in fragments of rainforests: the case of the Isthmus of Tehuantepec, Mexico

Evaluación del potencial del avistamiento de Alouatta palliata para la conservación y el desarrollo local en fragmentos de la selva húmeda: el caso del Istmo de Tehuantepec, México

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Abstract

In order to develop a quantitative, georeferenced instrument for evaluating the factors that favor or impede the successful implementation of ecotourism activities based on the observation of *A. palliata* in fragments of rainforests, we devised a set of indicators that permit a multidimensional quantification of the potential, both natural and socioeconomic, of this activity. Based on a normative vision of ecotourism, these indicators (i) assess the natural conditions that determine the potential long-term conservation of this species, and (ii) provide indices for evaluating the social and professional potential of the populations that reside near fragments of the rainforest for developing ecotourism services capable of generating socially-balanced economic benefits. Based on fragments of rainforest with extant troops of *A. palliata* in the northern Isthmus of Tehuantepec, we demonstrate the applicability of the indices in decision-making founded upon transparent, multivariable criteria related to assigning economic and human resources to foment ecotourism in specific regions.

Keywords:
Alouatta palliata, ecotourism, potential, conservation, Mexico.

Resumen

Para proporcionar una evaluación cuantitativa y georreferenciada de los factores que favorecen u obstaculizan la implementación exitosa de actividades ecoturísticas basadas en el avistamiento de primates en específico *A. pallitata* en fragmentos de selva húmeda, se desarrolla un conjunto de indicadores que permite una cuantificación multidimensional de potencial natural y socioeconómico. Partiendo de una visión normativa de ecoturismo, dichos indicadores se centran, por un lado, en las condicionales naturales que determinan las posibilidades de la conservación de esta especie a largo plazo. Por otra parte, se presentan índices adicionales para evaluar el potencial social y profesional que tienen las poblaciones que viven acerca de fragmentos de selva con presencia de primates para desarrollar servicios ecoturísticos que generen beneficios económicos socialmente equilibrados. Con base en el ejemplo de fragmentos de selva que aún sostienen tropas de *A. palliata* en el norte del Istmo de Tehuantepec, se demuestra la aplicabilidad de los índices para tomar decisiones fundadas en criterios transparentes y multivariables al momento de una asignación de recursos económicos y humanos para fomentar el ecoturismo en regiones y zonas específicas.

Palabras clave:
Alouatta palliata, ecoturismo, potencial, conservación, México.

Introduction

A consensus exists which holds that it is convenient to perceive and define "ecotourism" as a normative concept related to sustainable nature-based tourism. Numerous authors and institutions understand ecotourism as tourist activities that are conceived to achieve the following goals (Guzmán *et al*., 2013): a) ensure the sustainable use of species and their habitats by promoting conservation (Lanier, 2014); b) foment the economic development and wellbeing of local populations (Magio *et al*., 2013); and c) promote environmental education (Yacob, 2007). In addition, several scholars highlight that ecotourism constitutes an alternative to mass tourism by fostering authentic, direct contact with natural or near-natural environments (Mayer *et al*., 2018). Other authors stress that ecotourism should also focus on sociocultural issues such as meaningful participation in decision-making (Guzmán *et al*., 2013), non-biased stakeholder representation (Brenner & San Germán 2012), and compatibility with local settings (Monterrubio *et al*., 2013).

Since the early 1990s, the Mexican government has sponsored various forms of nature-based tourism (but not necessarily "ecotourism" defined as a normative concept), especially in zones with abundant biodiversity but high levels of socioeconomic marginalization (SECTUR, 2017). Several public policies at the federal and state levels grant financial and logistical support to socially-organized groups to facilitate the construction of tourism infrastructure and the training of (future) service-providers (Pozo-Montuy *et al*., 2017), but numerous studies confirm that these measures often fail to achieve these goals due to multiple causes (see also Carabias *et al*., 2010; López-Hernández and Ixtacyu, 2018). Indeed, numerous projects in Mexico have failed to achieve the goals envisioned in public policies, especially when it comes to generating substantial economic benefits for local populations, promoting the sustainable use of natural resources, fomenting the active participation of residents, and offering environmental education (Brenner & Job, 2012; Guzmán *et al*., 2013; Monterrubio *et al*., 2013). Problems often arise because the institutions entrusted with implementing public policies fail to consider –at the same time and equally ranking– environmental and socioeconomic conditions that could favor, or hamper, attaining these objectives (Horwich and Lyon, 2006; Magio *et al*., 2013). Their analyses often do not systematically and simultaneously evaluate the natural potential and local socioeconomic conditions before granting economic support (Brenner, 2010). In other words, when it comes to evaluating the feasibility of implementing ecotourism, there is often a bias towards environmental issues (such as conditions of habitat or impacts of tourist activities on specific species) that tacitly disregards socioeconomic ones (e.g. social organization at the community level or formal usufruct rights) (De la Vega *et al*. 2016). Thus, though technical feasibility studies are usually done, they tend to be partial and biased, in part because their main function is to justify applications elaborated by social actors interested in developing ecotourism projects (SECTUR, 2017), or by consultants who depend for their income on obtaining authorization for their initiatives (Brenner & Bosch, 2015). These conditions mean that public support for ecotourism is rarely based on indicators that evaluate, simultaneously and accurately, environmental (focused on concrete species and their habitats) and socioeconomic factors that may favor or disfavor ecotourism projects (Valenzuela-Córdova *et al*., 2015).

This paper addresses these shortcomings by providing a more comprehensive approach to what "ecotourism" strives to procure or, in other words, to what the results of environmental conservation and local development should be based on sustainable nature-based tourism. Thus, the contribution of the paper is to develop a set of comprehensible, multidimensional, and quantifiable indicators that allow a non-biased, *ex ante* evaluation of the feasibility of implementing ecotourism in highly-fragmented tropical environments. Another contribution relates to techniques that allow professional georeferencing of identified potentials that makes it possible to geographically delimit the vocation of specific areas (Tapia-Silva, 2014) in order to promote ecotourism activities with genuine potential more accurately in spatial terms. This article uses the case of a hydrographic basin with howler monkey troops (*Alouatta palliata*) to develop a system of indicators for quantitatively evaluating and georeferencing the natural and socioeconomic potential of fragments of rainforest.

To the best of our knowledge, no studies using biological and socioeconomic indicators simultaneously to assess ecotourism potential based on the observation of *A. palliata* (and other species of monkeys) have been conducted in countries like Mexico; that is, i.e. newly-industrialized countries characterized by rapid urbanization and fast-paced industrial, agricultural, and tourism development in formerly sparsely populated areas. However, we recognize Serio-Silva 's *et al.*, (2013) and Serio-Silva's (2006) efforts to develop biological indicators (but not socioeconomic ones) to measure ecotourism potential related to the habitat –and threats to it– of *A. pigra* in the state of Chiapas (southeastern Mexico). We modified those indicators to adapt them for use with *A. palliata* mainly by changing aspects related to population.

The case study on which our work rests focused on defining the ecotourism potential for observation of *A. palliata* in extant fragments of rainforests in the northern reaches of the Isthmus of Tehuantepec (Veracruz state, southeastern Mexico). By "potential" we refer to a series of features of these fragments that can facilitate the medium- and long-term conservation of *A. palliata* while also promoting socioeconomic development in the human populations that border those areas. *A. palliata* is a potential tourist attraction but it is currently being threatened by deforestation and fragmentation of the forest cover due to the spread of agricultural activities and human settlements (Laborde, 2004). Under these conditions, our research goals were to: a) present a system of indicators to quantitatively evaluate the biological and socioeconomic potential for developing ecotourism activities in peripheral areas with no, or only rudimentary, tourism development (in our case, watching *A. palliata*); b) determine values (associated with each indicator) to quantify and classify key potentials for both the conservation of *A. palliata* and ecotourism development; c) develop a method for georeferencing these potentials, including the elaboration of maps; and d) elaborate comprehensible criteria to assign available resources more transparently, efficaciously, and efficiently. Our ultimate objective is to construct a set of indices that can be considered as both a result of, and a methodology for, obtaining these results. In the first step, a literature review and preliminary observations of *A. palliata* allowed us to identify crucial factors for achieving the goals stipulated in the normative concept of ecotourism. In addition, we highlight the need to consider both biological and socioeconomic issues when evaluating potentials for ecotourism. We then present our set of indicators and associated values. Finally, we discuss the usefulness of this system of indicators for improving transparency and effectiveness in implementing public policies. We also address ways to apply (slightly modified) indicators in other socioenvironmental settings.

Key factors for ecotourism

A thorough literature review carried out by the first author allowed us, to identify and classify several key factors related to the feasibility of long-term conservation of *A. palliata* and its habitat. We also identified socioeconomic conditions that favor or hamper successful ecotourism development. As to conservation-related factors, numerous authors (usually biologists or conservation experts publishing in journals related to their disciplines) stress three major areas of concern: a) basic conditions for long-term survival (availability of food resources, size of, and distance between, fragments, and population stability); b) severity of pressures generated by human activities (distance to settlements/bodies of water/roadways, presence of cattle-raising, logging, and extraction of flora); and c) environmental conditions that facilitate ecotourism (facility of establishing visual contact with *A. palliata*, and the time required to search for the species before achieving visual contact). Other authors (usually social scientists publishing in journals related to their disciplines) stress three factors that might benefit or impede successful ecotourism development: d) the conditions of local institutions (formal rights to usufruct natural resources, collaboration at the community level, access to important resources); e) professional competences (experiences in the service sector, genuine interest in developing ecotourism, contact with/knowledge of the natural environment); and f) external factors (perception of safety/security). We argue that when defining indicators it is imperative to consider equally factors and issues highlighted by biologists/conservation experts and social scientists. In the interests of clarity, we first address factors involved in conserving *A. palliata* and its habitat, and then go on to identify key socioeconomic aspects for successfully providing ecotourism services.

Key biological factors for conservation

The following factors (see also table 1) are important for conserving *A. palliata* in the study area. *Biological Factor (BF 1): the type of food-providing vegetation in the fragments* is important because this species' diet includes the tender leaves of macayo plants (*Andira galeottiana*), mature fig leaves (*Ficus benjamina*), tender magnolia fruits (*Xylopia frutescens*), mature mangoes (*Mangifera indica*), pink poui flowers (*Tabebuia rosea*), zapote fruit (*Manikara zapota*), and amate seeds (*Ficus insípida)*, depending on elevation and the tree species available. These food sources are found mainly in riverine zones and the remaining rainforest (Rodrigo *et al.*, 2013). Pozo-Montuy and Serio-Silva's study (2011) of the landscape composition of *A. palliata's* habitat underlines the importance of riverine zones along river or stream banks that provide water and the aforementioned sources year-round (Marshall *et al.*, 2014). Those authors affirm that a "second-best" ecological niche consists of the remaining areas of high evergreen forest that supply sufficient food even in the dry season (November-May) (Chapela *et al.*, 2012; Peh *et al.*, 2014). Third, they mention areas of young vegetation (*acahuales* in Spanish), though these are of much less importance because the food they provide is deficient, barely enough to permit survival (Pozo-Montuy and Serio-Silva, 2011). Moreover, elements of the matrix, such as 'fence lines' of live trees, provide some food, but direct contact with cattle and vehicles there represents a great risk for these monkeys, as observed by Pozo-Montuy *et al.* (2013) in southeastern Mexico and other countries, like Costa Rica (Jones *et al.*, 2021) and Peru (Aquino *et al.*, 2016). Grasslands are least appropriate as these areas do not provide any type of food apt for *A. palliata* (Arroyo-Rodríguez *et al.*, 2005).

The second key biological factor *(BF 2)* is the *adequate size of fragments* since this determines the pressure exerted on the natural resources that ensure the survival of *A. palliata*. Moreover, the size of fragments is crucial for the persistence and expansion of the species (Baddi *et al*., 2015). Bonilla-Sánchez *et al*. (2010) argue that areas of non-fragmented vegetation of 5 hectares or more are ideal because they can sustain more individuals of *A. palliata* and allow them to perform their basic functions: feeding, movement, rest, and reproduction. Larger extensions also enhance the conservation and expansion of the species and its habitat (Aquino *et al.,* 2018). However, the rainforest that remains in the study area has largely been reduced to fragments of just 1.1 to 5 hectares, a process that seriously affects *A. palliata* in the sense that while the monkeys generally survive in the medium term, they cannot adequately perform the aforementioned basic functions in areas with fewer than 5 hectares (Pozo-Montuy *et al*., 2017). Finally, fragments ranging in size from 0.06-1.0 hectares can sustain only very few individuals and are not suitable for medium- and long-term species conservation because competition for vital resources intensifies in small areas, considerably reducing the potential for long-term survival (Berovides, 2000).

The third significant biological factor *(BF 3)* is the *distance between fragments* since this relates to the monkeys' dependence on limited food species (mainly zapote fruit and amate seeds), which obliges them to move among different fragments (Onderdonk and Chapman, 2000). It is important to mention that *A. palliata* can only move about one kilometer while foraging for food because of the amount of energy expended, whether inside a fragment larger than 5 h, or between smaller ones (Oropeza and Rendón, 2012). A maximum displacement of 200 meters (between small, or within larger, fragments) is deemed ideal, while a range of 200-1000 m is viable for purposes of conservation, but less favorable for feeding due to the greater energy consumption entailed (Bonilla-Sanchez *et al*., 2010).

The factors described in the next section refer to population stability. Following Rodríguez-Matamoros *et al*. (2012), we adopt the term "vortices of extinction" and utilize this concept to evaluate the probability of troop survival as a function of the proportion of sexes and ages of individuals necessary to ensure long-term conservation of the species (Glander, 1980; Young, 1982; Rodríguez-Matamoros *et al*., 2012). In this context, *the proportion of adult females to each male (BF 4)* is relevant because male howler monkeys are primarily responsible for obtaining the resources necessary for troop survival, while females attend to procreation (Cano-Huertes *et al*., 2017). This influences the species' reproductive strategy which is called the "female-centered model of social evolution", where the ideal proportion is two or more females for each male (Glander, 1980). A second factor here is the *proportion of sub-adults to each adult female or male (BF 5).* If the sub-adults that reach sexual maturity at 42 months are male, they may present natal emigration; that is, abandoning the troop to try to form their own group due to the proportion of the sexes in their original one (Days *et al*., 2020). If the sub-adults that reach sexual maturity are females, in contrast, the reproductive proportion improves for the alpha male. This explains why the ideal proportion is two or more sub-adult females per troop (Rodríguez-Matamoros *et al*., 2012). Finally, the proportion of *infants per female adult (BF 6)* is significant in terms of ensuring the necessary conditions of reproduction. The ideal proportion occurs when females have two or more infants (Glander, 1980; Young, 1982).

BF 7 refers to the *distance to the nearest human settlement*. A distance below 1000 m is considered problematic due to the fragmentation of the species' habitat caused by agriculture, cattle-raising, and/or urban sprawl, all of which bring human settlements closer. Distances above 5000 m usually generate better conditions for *A. palliata* populations (Pozo-Montuy *et al.*, 2017). *BF 8* is related to the *distance to bodies of water*, a crucial resource for survival. Since around 60% of primate populations live in riverine zones, the availability of permanent bodies of water ensures their survival (Martínez and Veá, 2002). In light of this, and the fact that the maximum displacement of *A. palliata* is 1000 m, the ideal distance to bodies of water is 0-500 m, while distances above 1000 m are deemed problematic (Bonilla-Sanchez *et al.*, 2010). *BF 9* refers to the *distance to roadways*, due to mortality caused by traffic accidents that considerably impact *A. palliata* and other species. Statistics from the state of Tabasco (south of the study area), for example, 64.1% of the deaths of wild fauna that live near roadways are due to accidents caused by motor vehicles indicate that 61.4% of the wild fauna that live near roadways are killed in accidents caused by motor vehicles (Pozo-Montuy *et al.*, 2008). As a result, a distance below 500 meters between the habitat of *A. palliata* and communication routes constitutes a significant threat to these populations (Klippel *et al.*, 2015; Jasso-del Toro *et al.*, 2016). The ideal space would be above 1000 meters (Bonilla-Sanchez *et al.*, 2010).

BF 10 refers to the *presence of cattle* in sites with *A. palliata* troops since this activity and the movement of these large animals can trigger competition over territory and deterioration of the terrain that may severely damage the monkeys' habitat. The absence of cattle operations is favorable for the conservation of *A. palliata* (Estrada and Coate-Estrada, 1996). Another threat to this species' habitat is *BF 11*, *extraction of flora*, especially large-scale deforestation due to the expansion of agriculture, cattle-raising, and urban development, which cause a progressive degradation of the rainforest and shrink the habitat of *A. palliata* (Galán-Acedo *et al.*, 2018). In addition, the *extraction of wild species* –including *A. palliata* itself– severely impacts existing populations (Acevedo-Ramírez, 2018). Consequently, eliminating these two forms of extraction would favor population conservation (Tobón *et al.*, 2012; SEMARNAT, 2013; González *et al.*, 2017).

BF 12 alludes to the *facility of visualization*; that is, the possibility of establishing visual contact with *A. palliata* troops (Valentine and Birtles, 2004). A low probability of sightings is unfavorable for the economic viability of ecotourism services. Smaller fragments of territory improve the odds of experiencing visual contact with *A. palliata* (Horwich, 1990; Horwich and Lyon, 1993) as do more extensive forested zones, such as islands or mangroves (Serio Silva, 2006). Evaluations of this aspect classify the size of the fragments identified in the study zone in 5 categories based on the facility of visualization, which increases in smaller extensions but is lower in larger ones (table 1). Finally, *BF 13* describes the *time required to search for the species* before establishing visual contact, a basic factor in determining visitor satisfaction. This can be affected by the fatigue that sets in during prolonged searches. In this regard, marking trails (Solórzano and Rodríguez, 2010; Aquino *et al.*, 2018) is an effective way to reduce waiting times before visual contact (Urbani *et al.*, 2018). During fieldwork, we determined that the time required for a first sighting of *A. palliata* in the fragments in the study area varied from a minimum of 10 minutes to a maximum of 5 hours. These findings led us to define the 5 categories shown in table 1.

Key socioeconomic factors for developing ecotourism

In this section, we turn our attention to important socioeconomic factors that affect the results of public policies for fomenting ecotourism in Mexico and elsewhere. These factors were analyzed in order to elaborate the questionnaire we applied during interviews with residents of areas near the fragments that house troops of *A. palliata*. The Likert scale was used to divide each factor into 5 categories (table 3).

The first socioeconomic factor (*SEF 1*) is *professional experience and training,* a frequent challenge for implementing ecotourism projects since the capacities of developing peoples for business management limits the ability of small community operations to generate jobs and significant revenue (Gasca *et al.,* 2010). The absence of personnel due to seasonal emigration is another aspect that impedes instrumenting efficacious training of potential service providers, while limited access to technologies and training opportunities may make it difficult for local people to acquire professional abilities (Neger and Propín, 2018), especially since it is essential to provide visitors with professional services and adequate environmental education in order to fulfill the goals of ecotourism mentioned earlier.

SEF 2 refers to the *formal right to usufruct resources*, which directly impacts the issue of access to the financial and logistical support granted by government agencies or organizations of civil society. At the same time, the security of land tenure deeply affects both the motivation to launch ecotourism activities and long-term commitments to initiatives at the community level (Brenner *et al*., 2016). *SEF* 3 defines degrees of *access to important resources for ecotourism.* As various studies point out (Brenner and Job, 2012; Stronza *et al*., 2019), the community must have socially-balanced access to the most important natural resources for the planned tourism activities. Excluding large sectors of the local population not only impedes consensus-based decision-making and the equitable distribution of benefits generated by ecotourism (Pérez *et al*., 2013), but can also exacerbate social inequality, trigger severe conflicts inside communities, and make it impossible to achieve some of the primary goals of ecotourism. It is clear that relatively equitable, legally-established access to key resources for tourism activities is crucial for turning ecotourism projects into socially-balanced economic options (Mayer *et al*., 2018). Access is also closely related to the land tenure regimen and the distribution of property deeds that guarantee the legal use of natural resources (Pérez *et al*., 2013).

SEF 4 is *community collaboration*, since many studies show that the success of ecotourism projects depends greatly upon cooperation, communication, and participation by the various parties interested in tourism (Brenner and Job, 2012; Diamantis, 2018; Stronza *et al*., 2019). In this context, effective spaces of social cooperation and collaboration become important by enabling local people to expound their views, make their voices heard, take consensual decisions, and receive collective training (Vargas and Brenner, 2013). Moreover, if the tourism services offered are not based on the inclusive cooperation of most residents, vast stores of local knowledge may be wasted. A local culture of cooperation among all people, in contrast, can contribute significantly to the professionalization of tourism services and environmental conservation at the community level (Hsu, 2019). *SEF 5* concerns *interest in ecotourism activities.* A significant obstacle to ecotourism

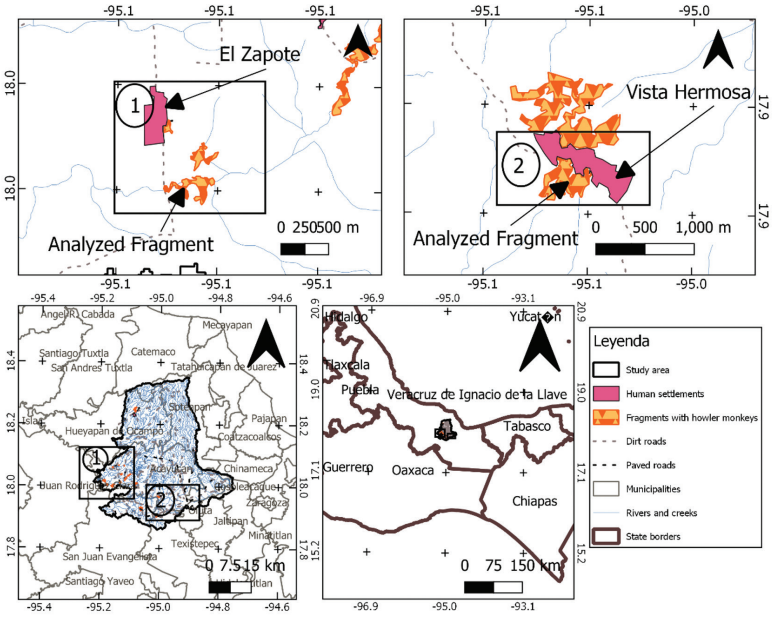
that often arises is a lack of genuine interest among locals in offering services of this kind. As various studies demonstrate (Brenner and Job, 2012; Vargas and Brenner, 2013), government agencies, non-governmental organizations (NGOs), and private consultants may attempt to impose activities of this kind on rural communities that lack other economic options or consider themselves powerless vis-á-vis influential external actors. However, such initiatives are often doomed to failure because they do not involve local people in their development (Young, 1999; Guzmán *et al.*, 2013; Carvache-Franco *et al.*, 2019). Community-based initiatives that begin to generate significant economic benefits, in contrast, tend to generate more favorable trajectories (Brenner *et al.*, 2016).

SEF 6 involves *contact with ecotourism resources*. Ecotourism service providers who gain broader knowledge through contact with the wild species of flora and fauna are often better positioned to offer higher-quality services (Valenzuela-Córdova *et al.*, 2015) that bring two advantages: satisfying visitors' needs and expectations (Oviedo-García *et al.*, 2017) and promoting the preservation of the natural environment (Pinkus-Rendón and Pinkus-Rendón, 2013). Guides who acquire adequate knowledge of the natural and cultural environment through daily contact with the habitat of *A. palliata* are better-equipped to perform activities like environmental education that may produce attitude changes in some visitors. Unfortunately, in many cases the knowledge of service providers is insufficient, while in others they fail to effectively transmit what they know (Pozo-Montuy *et al.*, 2017). We define *SEF 7* as *perceptions of public safety in the destination*, a factor that strongly impacts visitors' decision-making processes before undertaking a trip as they assess –consciously or tacitly– the perceived risks of potential destinations. Perceptions of personal safety have, in fact, always been a precondition for successful tourism development (Kövári and Zimányi, 2011). Signs of social disorder (like the presence of organized crime groups) tend to provoke perceptions of insecurity whose –logical– consequence can be a drastic reduction in the number of visitors and, as a result, in service providers' incomes (Vilalta, 2012). We operationalized this issue based on the interviewees' perceptions regarding public safety within their communities (see below).

Study area

The study area was defined by analyzing the system of surface hydrological connectivity based on processing a digital elevation model to 30 meters using Shuttle Radar Topography Mission (SRTM) and applying the r.watershed command of the GRASS program (Metz *et al.*, 2011). This allowed us to delimit the hydrographic basin that formed the study area. Figure 1 shows the location, the hydrographic basin itself, and the four divisions of the study area, while also highlighting the fragments of rainforest that house populations of *A. palliata,* existing human settlements, roadways, and bodies of water. We consider this an adequate procedure because *A. palliata* depends on bodies of surface water for survival. There are a total of 540 human settlements in the study area, both urban and rural, with a total population of 141 263.

Figure 1. Study area: the upper part shows the sample cases of "El Zapote" and "Vista Hermosa"; the lower part illustrates the spatial distribution of rain forest fragments in the four areas



Source: Own elaboration.

The climate is sub-humid with summer rains (Amf Cwa in Köppen's classification modified by Enriqueta-Garcia). Most of the surface area is covered by grasslands for raising livestock (58%) or agricultural zones (34%). These proportions indicate a high degree of fragmentation in the study region. The area that conserves forest cover is only 6%, while urban zones occupy 2%. The predominant species in the forested zones are native (such as *Andira galeottiana, Xylopia frutescens, Bursera simaruba, Ficus insípida,* and *Manikara zapota*), as well as non-native species (*Mangifera indica, Ficus benjamina*, *Tabebuia rosea* and *Apocynaceae*)(Rodrigo *et al.*, 2013). Thus, non-native species make up a considerable proportion of flora in the study area. During our fieldwork (see below) we noted that *Ficus insipida* (a native species) and *Mangifera indica* (non-native) were the most important food sources for *A. palliata.* Other relatively abundant species within the fragments were *Tamandúa mexicana*, *Dasypodidae*, *Didelfimorfia*, *Dendrocygna autummalis*, and *Atropoides olme*.

Progressive environmental deterioration of the study area explains the high degree of fragmentation of the extant rainforest. In 1870, a sawmill was established in Minatitlán that exported valuable tropical wood (mahogany, cedar) to the United States and Europe. This exploitative activity seriously disturbed the most accessible sites in the rainforest and in fewer than 30 years exhausted the sources of valuable timber (Laborde, 2004). A century later, from 1972 to 1983, the government's "National Deforestation Program" (*Programa Nacional de Desmonte*) cleared 12% of Mexico's national territory, mostly rainforests, to convert the land into grazing areas for cattle. The rainforest in the northern zone of the Isthmus of Tehuantepec was severely affected by this program. Then, in the 1980s and 90s, broad extensions of already disturbed rainforest were converted into pastureland. Today, over 90% of the area's original vegetation has been significantly modified, mainly by

deforestation due to commercial agriculture (especially mango plantations) and livestock raising. In addition, the introduction of non-native species like *Magnifera indica* from southern Asia has altered the composition of species in the study area. As a result, the remaining fragments of rainforest should be a priority for short-and medium-term conservation efforts (Arroyo-Rodríguez *et al.*, 2005).

Construction of the biological indices

The process of constructing the indices based on the factors just described generated 4 biological indices (BI) and 7 socioeconomic indices (SEI, see below), which facilitate an overall evaluation of the potential for successfully developing ecotourism (table 1). In the case of the biological factors, BI 1 (Index of potential habitat for *A. palliata*) refers to factors *BF 1*, *BF 2*, *BF 3*, *BF 7*, and *BF 8*. BI 2 (Index of the population's potential for natural ecotourism involving the species *A. palliata*) is related to factors *BF 4*, *BF 5*, and *BF 6*. BI 3 (Index of threats to *A. palliata's* habitat) is based on factors *BF 2*, *BF 7*, *BF 9*, *BF 10*, and *BF 11*. BI 4 (Index of potential for sightings) is associated with factors *BF 12* and *BF 13*.

To evaluate and quantify BI 1, we considered the vegetation classified previously, the size of the fragments, and the distances to roadways, human settlements, and bodies of water. These were categorized according to their benefit for the conservation of *A. palliata*, assigning higher values to those that provide better conditions for survival (range 1-5). BI 2 took into account the proportions of sex and age of the monkeys, and the number of males and females for each juvenile and infant, in order to categorize the viability of the species' conservation in the long-term. BI 3, which refers to the degree of threat that the monkeys' habitat confronts, assessed the size of the fragments, the proximity of human settlements, the presence of cattle, and the extraction of flora and fauna. Here, higher values were assigned to the factors that represent less pressure on the species and its habitat. With respect to BI 4, we considered the facility of finding and observing the species, assigning higher values (on a scale of 1-5) to the fragments that provide greater facility. It is important to note that this required contemplating factors *BF 2* and *BF 7* in BI 1 and BI 3 since they directly impact this species' habitat and the threats to which it is exposed (table 1).

Methods applied to quantify the biological indices

To quantify BIs 1-4, we compiled information during fieldwork (carried out from January 2018 to December 2019) and registered localizations of *A. palliata*. With this information and the aid of local residents, we searched for excretions and vocalizations in order to locate the monkeys and record such population data as sex, age, and the number of individuals. Later, using a GPS (Arc Maps, Qgis, Grass) and satellite images, we defined polygons in the fragments of rainforest that had troops of *A. palliata*. We then proceeded to measure their area parameters and distances to other fragments, roadways, urban zones, and bodies of water. We also defined the type of vegetation and recorded the search times required to locate troops of *A. palliata* in each fragment. In our fieldwork diaries we recorded the presence or absence of cattle and any signs that might indicate the extraction of flora and fauna in the different fragments. The final step consisted in defining, based on the factors and reference values described above, the categories we would use to quantitatively measure the potential for ecotourism (table 1).

Table 1. Biological indices: factors, categories, and values

Factors	Categories	Value	Index
BF 1	Matrix	1	BI 1
	Element of the matrix	2	
	Secondary forests/grown back after slash and burn (*acahual*)	3	
	Fragment of rainforest	4	
	Riverine	5	
BF 2	0.06-1.0 h	1	BI 1 and
	1.1-5.00 h	3	BI 3
	> 5.00 h	5	
BF 3	> 500 m	1	BI 1
	201-500 m	3	
	1-200 m	5	
BF 4	< 1	1	BI 2
	= 1	3	
	> 1	5	
BF 5	< 1	1	BI 2
	= 1	3	
	> 1	5	
BF 6	< 1	1	BI 2
	= 1	3	
	> 1	5	
BF 7	0-1000 m	1	BI 1 and
	1001-5000 m	3	BI 3
	> 5000 m	5	
BF 8	> 1000 m	1	BI 1
	501-1000 m	3	
	0-500 m	5	
BF 9	> 1000 m	1	BI 3
	501-1000 m	3	
	0-500 m	5	
BF 10	Absent	1	BI 3
	Present	5	
BF 11	Absent	1	BI 3
	Present	5	
BF 12	Very difficult (33.0-40.9 hectares)	1	BI 4
	Difficult (24.8-32.9 hectares)	2	
	Relatively easy (16.7-24.7 hectares)	3	
	Easy (8.5-16.6 hectares)	4	
	Very easy (0.2-8.4 hectares)	5	

Factors	Categories	Value	Index
BF 13	4:01-5:00 hrs	1	BI 4
	3:01-4:00 hrs	2	
	2:01-3:00 hrs	3	
	1:01-2:00 hrs	4	
	< 1:00 hrs	5	

Note: biological factors = BF; biological index = BI

Source: Own elaboration.

To define the degree of potential (high, medium, low, very low), we totaled the indices for each fragment of rainforest where populations of *A. palliata* were localized (table 2).

Table 2. Ranges of the values of the biological indices

Degree of potential	BI 1 Value	BI 2 Value	BI 3 Value	BI 4 Value
High	19-25	15-20	19-25	8-10
Medium	12-18	9-14	12-18	5-7
Low	5-11	3-8	5-11	2-4
Very low	< 4	< 2	< 4	< 1

Note: Based on the minimum and maximum values obtained for each BI, the range of those values was divided into four equidistant intervals.

Source: Own elaboration.

Constructing the socioeconomic indices

Turning to the socioeconomic factors, SEI 1 (Index of work experience and capacity) is related to factor *SEF 1*. SEI 2 (Index of formal right of usufruct of resources) is based on *SEF 2*. SEI 3 (Index of access to resources) reflects factor *SEF 3*. SEI 4 (Index of community collaboration) considers *SEF 4*. SEI 5 (Index of interest in ecotourism) relates to factor *SEF 5*. SEI 6 (Index of environmental contact) is based on *SEF 6*. Finally, SEI 7 (Index of perceived safety) corresponds to factor *SEF 7* (table 3).

Methods applied to quantify the socioeconomic indices

To obtain data (values) for these seven socioeconomic indicators, from March to November 2019 we applied a structured questionnaire using a 5-level Likert scale (Annex 1) to residents of nearby localities that are related to the digitalized fragments with troops of *A. palliata*. We located and digitalized polygons of the areas with human settlements where people held titles to agrarian rights and/or owned property in the different fragments of rainforest with *A. palliata* populations. This procedure allowed us to gather information on the following factors: interest in ecotourism

activities, knowledge of tourist attractions, activities of cooperation at the community level, and perceptions of safety in the area. The instrument also had several open questions designed to obtain more specific data, such as motivation, experience in providing services and business management, land tenure, and access to tourist attractions. As in the case of the biological indices, we defined categories based on the final results of the surveys before proceeding to standardize the biological factors with the socioeconomic ones.

Since no up-to-date statistical information on the number of residents in each locality was available, a first task was to elaborate the functional cartography of the inhabited houses locality-by-locality, complemented by a total count of those houses. After that, interviews were held with older members of those households, usually heads of family, their spouses, or their direct descendants. A total of 368 interviews were conducted in 16 localities in 5 municipalities, covering 45% of the inhabited houses. Results were used to define ranges for the corresponding indicators.

Socioeconomic factor 1 (SEI 1) identified the degree of experience in business management and administration. SEI 2 refers to formal usufruct rights to resources relevant to ecotourism. SEI 3 deals with the type of access that local people have to the resources required to offer ecotourism activities, distinguishing between extractive (e.g. exploitation of plants, hunting, cattle-raising) and non-extractive uses (e.g. using bodies of water, bird- and animal-watching). SEI 4 relates to the frequency of collaboration at the community level by estimating how often people participate in community activities. SEI 5 identifies the degree of interest in participating in ecotourism activities. SEI 6 quantifies the intensity of interaction with natural attractions that are related to ecotourism services (in the fragments of rainforest with troops of *A. palliata*). SEI 7, finally, measures the degree of security (or insecurity) for visitors and residents.

The categories that correspond to these factors were defined at a nominal level or were assigned values ranging from 1-5 (according to the Likert scale applied on the questionnaire). In the latter case, 5 indicates greater importance, while 1 marks lesser importance. The mode of the data was then obtained to classify the potential. As with the biological indices, we defined four ranges of values: high potential (4-5), medium potential (2-4), low potential (1-2), and very low potential (0-1).

Table 3. Parameters, types of questions, and indices by SEF

Factors	Categories	Scales	Index
SEF 1	Yes	5	SEI 1
	No	1	
SEF 2	Yes	5	SEI 2
	No	1	
SEF 3	Extractive	5	SEI 3
	Non-extractive	2.5	

Factors	Categories	Scales	Index
SEF 4	Very frequent collaboration	5	SEI 4
	Frequent collaboration	4	
	Occasional collaboration	3	
	Rare collaboration	2	
	No collaboration	1	
SEF 5	Very high interest	5	SEI 5
	High interest	4	
	Intermediate interest	3	
	Little interest	2	
	Lack of interest	1	
SEF 6	Daily	5	SEI 6
	2-3 times per week	4	
	Once a week	3	
	Once a month	2	
	Almost never	1	
SEF 7	Very safe	5	SEI 7
	Safe	4	
	More-or-less safe	3	
	Unsafe	2	
	Very unsafe	1	

Note: socioeconomic factor = SEF, socioeconomic indices = SEI

Source: Own elaboration.

Example of application: El Zapote and Vista Hermosa

As an example, we now present the evaluation of two fragments: El Zapote and Vista Hermosa (see tables 4, 5 and figure 1). With respect to the biological indices, BI 1 suggests a medium potential in both fragments, while BI 2 indicates a low potential in both cases. In contrast, BI 3 was low in El Zapote, but high in Vista Hermosa. In El Zapote, BI 4 indicates a medium potential, but low potential in Vista Hermosa. Therefore, Vista Hermosa has better biological potential than El Zapote.

Table 4. Results of the BIs

BI	Values El Zapote	Type of potential	Values Vista Hermosa	Type of potential
BI1	17	Medium	17	Medium
BI 2	6	Low	8	Low
BI 3	15	Low	21	High
BI 4	6	Medium	2	Low

Source: Own elaboration.

Regarding the socioeconomic indices (table 5), the fragment associated with Vista Hermosa shows greater potential than El Zapote for SEIs 3, 4, and 7, while SEIs 1, 2, 5, and 6 show equivalent values. Thus, the socioeconomic indices suggest greater potential in the case of Vista Hermosa.

Table 5. Results of the SEIs

SEI	El Zapote, Acayucan	Type of potential	Vista Hermosa	Type of potential
SEI 1	1	Very low	1	Very low
SEI 2	5	High	5	High
SEI 3	2.5	Medium	5	High
SEI 4	4	Medium	5	High
SEI 5	3	Medium	3	Medium
SEI 6	5	High	5	High
SEI 7	4	Medium	5	High

Source: Own elaboration.

Upon comparing these two fragments, we can conclude that Vista Hermosa has slightly higher values for the BI than El Zapote. Regarding the SEI values, the differences between the two fragments (with their associated human settlements) are more clearly marked, though indices BI 2 and SEI 1 indicate two types of problems that any possible ecotourism initiative will have to confront.

Discussion

Despite intense support for ecotourism in Mexico over the past three decades, no peer-reviewed, systematic, multidimensional evaluations have been conducted to identify, quantify, and georeference the potential of fragments of rainforest for the conservation of *A. palliata* by fostering ecotourism. Ecotourism is one strategy for conserving *A. palliata* in habitats of reduced extension (that is, fragments of rainforest) due to the economic incentives this activity provides, which can motivate local people to conserve the species and its habitat. However, knowledge of the possibilities (and limitations) of conserving *A. palliata* in fragmented areas through ecotourism generally turns out to be limited, a condition that can lead to failure, as has occurred in the past. For this reason, before promoting/implementing ecotourism projects it is necessary to carry out analyses and evaluations that take into consideration not only biological aspects, but also the various socioeconomic conditions that the local communities which co-exist with *A. palliata* confront.

Instrumenting a systematic methodology that analyzes both the biological aspect and socioeconomic features, and then represents this information in georeferenced (cartographic) form, will aid in ensuring a more efficient (and efficacious) use of public resources while simultaneously providing the information necessary to establish more realistic expectations among potential service providers. To accomplish this, we provided two sets of indicators that address crucial success factors for species' conservation and socially-balanced ecotourism development. In this way, it will become

possible to identify specific areas with particular natural and socioeconomic potentials. Thus, our sets of indicators will allow interested parties to focus financial support granted by government institutions or organizations of civil society on specific delimited areas; that is, fragments of forests and associated communities. At the same time, we provide tools to avoid eventually fruitless–funding of ecotourism in areas that lack adequate potentials for the conservation of *A. palliata* and/or ecotourism development.

However, establishing solid criteria for political decision-making demands conducting careful, thorough, and often costly evaluations of the potential of the fragments of rainforest that house troops of *A. palliata*. These efforts must be based on comprehensive indicators that provide quantifiable environmental data centered on a concrete series of biological features and the needs of the species in question. In addition, it is necessary to obtain detailed information regarding the abilities and expectations (existing or potential) of the human populations involved in terms of offering quality ecotourism services capable of generating significant economic benefits. It is essential, as well, that both data sets be quantifiable and georeferenced; that is, the indicators must make it possible to link the environmental and socioeconomic information with the conditions of the fragments of rainforest that (still) sustain populations of *A. palliata.* Only in this way will it be possible to identify spaces where fomenting ecotourism projects based on the observation of *A. palliata* and other primates have real perspectives of success.

In the interests of contributing to more efficacious decision-making that will lead to the development of more informed (and hopefully successful) policies for fomenting ecotourism, our research set out to provide various tools: on the one hand, two sets of indicators that make it possible to quantify the potential of certain fragments of rainforest for conserving *A. palliata* in the medium and long term and, at the same time, determine their potential for incentivizing sustainable tourism development. On the other, we applied a program which generates digital maps that allow researchers to identify fragments of vegetation with populations of *A. palliata* and human communities with distinct levels of potential for tourism development that can be both environmentally sustainable and socioeconomically viable.

It is important to note that we developed and applied the proposed evaluation in a region with little tourism development, one where professional services that offer observation of *A. palliata* do not yet exist. At present, it is only possible to hire, informally, some locals who can indicate places where troops of *A. palliata* are found. There are no formally-trained guides, nor is any type of accommodation available near this potential tourist attraction. We chose this particular study area intentionally because of our goal of developing tools for assessing potentials, specifically in regions that lack tourism infrastructure and where most local people have no prior experience in providing specialized tourism services. In addition, this is an area where the fragments of rainforest are not protected legally, nor are they subject to conservation actions funded by government agencies. In this sense, our approach constitutes an *ex ante* evaluation, designed primarily for zones with no earlier tourism development, as is the case of numerous community-based initiatives that seek to initiate ecotourism services despite conditions of socioeconomic marginalization and scarce infrastructure. Our research was conducted, moreover, in zones that lack legal protection, but

where troops of *A. palliata* live, with the objective of identifying concrete polygons that have notable biological and socioeconomic potential for the successful development of ecotourism and can serve as instruments of environmental conservation. The fragments with low socioeconomic potential, in contrast, would be well-served by performing activities of environmental protection, but abstaining from promoting tourism activities. Another important contribution refers to identifying areas where fostering nature-based tourism projects might confront severe obstacles that, in all likelihood, would impede successful development.

The limitations of our study lie primarily in its exploratory character. We recognize that it would be convenient to both broaden and specify the set of indicators proposed. Without doubt, it is appropriate to increase them in both number and scope. For example, additional indicators addressing participation in decision-making and economic benefits would enhance the scope of analysis. In addition, our focus on one sole species and one study area means that several indicators will have to be adapted for cases and areas/habitats in which the main ecotourism attraction is another primate species, such as the spider monkey (*Ateles geoffroyi*), black howler monkey (*Alouatta pigra*), or Capuchin monkey (*Cebus capucinus*).Despite its focus on a particular region and species, however, our set of indicators will most likely turn out to be useful when applied to other geographical areas and other monkey species.

Conclusions

We therefore invite the scientific community to contribute to developing additional indicators (preferably georeferenced) for identifying and quantifying ecotourism's potential for conserving threatened primate species, or those in danger of extinction, while also driving socioeconomic development in marginalized regions. In this way, decision-makers will have at their disposal solid, spatially-defined criteria for assigning the scarce resources available for fomenting ecotourism. In particular, we recommend developing our indicators further, focusing on other threatened species of monkeys and their habits that have potential for ecotourism development in fragmented environments. It would also be useful to define specific measures and actions to be implemented in fragments with high, medium, and low potentials. In general terms, we recommend fostering ecotourism only in fragments and communities *with high biological and socioeconomic potentials*. If, in contrast, the indicators suggest *a medium or low potential for ecotourism development*, other activities and instruments of environmental conservation should be pursued; for example, low-impact silviculture or beekeeping. Another point of great importance in the specific case of *A. palliata* is the need to collaborate with local people who reside in the fragments to enhance data gathering and monitoring. Finally, we encourage the research community to combine biological and socioeconomic indicators with Geographic Information Systems to provide georeferenced information to decision makers.

References

Acevedo-Ramírez, P. M. C. (2018). De animales silvestres a mascotas. *Ciencia*, 69(1), 78-83.

Aquino, R., López, L., Arévalo, I. & Daza, J. (2016). Diversidad y abundancia de primates y sus amenazas ene l interfluvio de los ríos Napo y Putumayo, Amazonía peruana. *Revista peruana de biología*, 23(3), 243-252. doi:10.15381/rpb.v23i3.12859.

Aquino, R., López, L., Dignum, J., Díaz, S. & Falcón, R. (2018). Diversidad y abundancia de primates en bosques de baja y alta perturbación humana de Los Chilchos, Amazona, Perú. *Revista Peruana de Biología*, 25(4), 407-416. doi:10.15381/rpb.v25i4.15532, [05 de mayo de 2020].

Arroyo-Rodríguez, V., Mandujano, S. & Cuende-Fanton, C. (2005). Ocupación de parches de selva por monos aulladores *Alouatta palliata mexicana* en tres paisajes con diferentes grados de fragmentación en Los Tuxtlas, México. *Universidad y Ciencia*, (2), 23-34.

Baddi, M. H., Guillen, A., Rodríguez, C. E., Lugo, O., Aguilar, J. y Acuña, M. (2015). Pérdida de Biodiversidad: Causas y Efectos. *International Journal of Good Conscience*. 10(2), 156-174.

Berovides, A. V. (2000). Método de valoración de la fauna para el ecoturismo. *Revista Biológica*, 14(2), 108-114.

Bonilla-Sánchez, Y. M., Serio-Silva, J. C., Pozo-Montuy, G. & Bynum, N. (2010). Population status and identification of potential habitats for the conservation of the endangered black howler monkey *Alouatta pigra* in northern Chiapas, Mexico. *Fauna & Flora International, Oryx*, 44(2), 293-299. doi:10.1017/S0030605310000025, [15 de mayo de 2020].

Brenner, L. (2010). Gobernanza ambiental, actores sociales y conflictos en las Áreas Naturales Protegidas mexicanas. *Revista Mexicana de Sociología*, 72(2), 284-310.

Brenner, L. & Job, H. (2012). Challenges to actor-oriented environmental governance: Examples from three Mexican Biosphere Reserves. *Economische en Sociate Geografie*, 103(1), 1-19. do i:10.1111/j.1467-9663.2011.00671, [15 de enero de 2018].

Brenner, L. & San Germán, S. (2012). Gobernanza local para el 'ecoturismo' en la Reserva de la Biosfera Mariposa Monarca, México. *Alteridades*, (44), 149-164.

Brenner, L. & Bosch, C. (2015). La certificación de empresas ecoturísticas comunitarias: ¿un instrumento adecuado para la gobernanza ambiental en México". In Rocío Rosales Ortega y Ludger Brenner. (eds.). *Geografía de la gobernanza: dinámicas multiescalares de los procesos económico-ambientales*. (pp. 23-41). Ciudad de México: Siglo XXI/Universidad Autónoma Metropolitana.

Brenner, L., Mayer, M. & Stadler, C. (2016). The economic benefits of whale watching in El Vizcaíno Biosphera Reserve, Mexico. *Economía, Sociedad y Territorio*, XVI(51), 429-457.

Cano-Huertes, B., Rangel-Negrín, A., Coyohua-Fuentes, A., Chavira-Ramírez, D. R., Canales-Espinosa, D. & Dias, P. A. D. (2017). Reproductive Energetics of Female mantled howlers (*Alouatta palliata*). *International Journal of Primatology*, (38), 942-961. doi:10.1007/s10764-017-9990-9, [21 de octubre de 2019].

Carabias, J., Sarukhán, J., Maza, J. & Galindo, C. (2010). *Patrimonio Natural de México Cien casos de éxito*. Ciudad de México: CONABIO-SEMARNAT.

Carvache-Franco, M., Segarra-Oña, M. & Carrascosa-López, C. (2019). Segmentation by motivation in ecotourism: Application to protected áreas in Guayas, Ecuador. *Sustainability*, 11(240), 1-19. doi:10.3390/su11010240, [18 de febrero de 2020].

Chapela, F., Pedraza, R. A., Álvarez, R., Hoyos, A., Trejo, I. Núñez, J. M., Rodríguez, Y. & Carrillo, F. (2012). El estado de los Bosques de México. In Chapela, F. (eds.). *Estado de los Bosques de México*. (pp. 25-60). Distrito Federal: Consejo Civil Mexicano para la Silvicultura Sostenible.

Days, D. P., Montero, D. I. & Rangel, N. A. (2020). Factors influencing infant sex ratio in howler monkeys (Alouatta spp.): A literatura review and analysis. *American Journal of Physical Anthropology*, (172), 172: 8-57. doi:10.1002/ajpa.24035, [30 de septiembre de 2020].

Diamantis, D. (2018). Stakeholder ecotourism management: exchanges, coordinations and adaptations. *Journal of Ecotourism*, 17(3), 203-205. doi:10.1080/14724049.2018.1502122, [19 de febrero de 2020].

De la Vega, A. C., Brenner, L. & Stoll-Kleemann, S. (2016). Sinergias y conflictos entre la producción cafetalera y la conservación ambiental: El caso de la Reserva de la biósfera Los Tuxtlas, México. In Rosales, O. R. & Brenner, L. (Eds.). *Geografía de la gobernanza: dinámicas multiescalares de los procesos económico-ambientales*. (pp. 94-127). Ciudad de México: Siglo XXI/Universidad Autónoma Metropolitana.

Estrada, A. & Coates-Estrada, R. (1996). Tropical rain forest fragmentation and wild populations of primates at Los Tuxtlas, Mexico. *International Journal of Primatology*, 17(5), 759-783.

Galán-Acedo, C., Arroyo-Rodríguez, V., Estrada, A. & Ramos-Fernández, G. (2018). Forest cover and matrix functionality drive the abundance and reproductive success of an endangered primate in two fragmented rainforests. *Landscape Ecology* (10), 12. doi:10.1007/s10980-018-0753-6.

Gasca, Z. J., López, P. G., Palomino, V. B. & Malthus, A. M. (2010). *La gestión comunitaria de recursos naturales y ecoturismo en la Sierra Norte de Oaxaca*. Ciudad de México: Universidad Nacional Autónoma de México.

Glander, K. E. (1980). Reproduction and population growth in free-ranging mantled howling monkeys. *American Journal of Physical Anthropology*, (53), 25-36. doi:10.1002/ajpa.1330530106, [21 de febrero de 2013].

González, P.G.E. Ortiz, M. T. J., Gerritsen, P. R. W. & Ramos, F. G. (2017). Percepción social sobre el mono araña (*Ateles geoffroyi*) e implicaciones para el emprendimiento de acciones de manejo y conservación en Oaxaca, México. *Sociedad y Ambiente,* 5(14), 53-73.

Guzmán, M., Figueroa, F. & Durand, L. (2013). En busca del ecoturismo. Casos y experiencias del turismo sustentable en México, Costa Rica, Brasil y Australia. En Guzmán, M., Figueroa, F. y Durand, L. EÓN-El Colegio de San Luis. (eds.). *Ecología política y ecoturismo en México: reflexiones desde la Huasteca Potosina y la Selva Lacandona* (pp. 29-57). San Luis Potosí: El Colegio de San Luis.

Horwich, R. H. (1990). How to develop a community sanctuary an experimental approach to the conservation of private lands. *Oryx*, *24*(2), 95-102.

Horwich, R. H. & Lyon, J. (1993). *A Belizean rain Forest the Community Sanctuary Baboom*. Wisconsin: Gay Mills.

Horwich, R. H. & Lyon, J. (2006). *Community conservation: a different voice, caught between biologist and sociologist*, Wisconsin: Gay Mills.

Hsu, P. (2019). Economic impact of wetland ecotourism: An empirical study of Taiwan's Cigu Lagoon area. *Tourism Management Perspectives*, (29), 31-40. doi:10.1016/j.tmp.2018.10.003, [12 de septiembre de 2020].

Jasso-del Toro, C., Márquez-Valdelamar, L. & Mondragón-Ceballos, R. (2016). Diversidad genética en grupos de monos aulladores de manto (*Alouatta palliata mexicana*) en la Reserva de la Biosfera Los Tuxtla (Veracruz, México). *Revista Mexicana de Biodiversidad*, (87), 1069-1079. doi:10.1016/j.rmb.2016.07.003, [27 de marzo de 2020].

Jones, R. G., Villalobos, S. C. & Menacho, O. R. M. (2021). Amenazas que enfrentan los monos congo (Alouatta palliata) en Costa Rica e iniciativa de conservación para el bienestar y una coexistencia sana con la especie. *Biocenosis*, 32(1), 5-14, doi: 10.22458/rb.v32i1.3522

Klippel, A. H., Oliveira, P. V., Britto, K. B., Freire, B. F., Moreno, M. R., Santos, A. R., Banhos, A. & Paneto, G. G. (2015). Using DNA barcodes to identify road-killed animals in tow Atlantic Forest Nature Reserves, Brazil. *Plos One,* 10(8), 1-15, doi:10.1371/journal.pone.0134877, [21 de octubre de 2019].

Kövári, I., & Zimányi, K. (2011). Safety and security in the age of global tourism. *Applied Studies in Agribusiness and Commerce*, (5), 59-61.

Laborde, D. J. (2004). Los habitantes. En Laborde, J., y Sánchez-Ríos, G. (Eds.). *Los Tuxtlas: el paisaje de la sierra*. (pp. 61-78). Xalapa: Instituto de Ecología.

Lanier., P. (2014). The positive impacts of ecoturism in protected areas. *Sustainable Tourism*, VI (187), 199- 209, doi:10.2495/ST140161, [27 de marzo de 2020].

López-Hernández, J. R. & Ixtacyu, L. O. (2018). Conservación y desarrollo, en el caso del ecoturismo: una política ambiental fallida en la Reserva de la Biosfera La Encrucijada, Chiapas. *El Periplo Sustentable*, (34), 82-108.

Magio, O. K., Velarde, V. M., Santillán, N. M. A. & Ríos, G. C. A. (2013). Ecotourism in developing countries: Acritical Analysis of the promise, the reality and the future. *Journal of Emerging Trends in Economics and Management Sciences*, 4(5), 481-486.

Marshall, A. J., Beaudrot, L. & Wittmer, H. U. (2014). Responses of primates and other frugivorous vertebrates to plant resource variability over space and time at Gunung Palung National Park. *International Journal of Primatology,* (35), 1178-1201, doi:10.1007/s10764-014-9774-4, [21 de octubre de 2019].

Martínez, C. J. & Veá, J. J. (2002). *Primates: Evolución, cultura y diversidad*. Ciudad de México: Centro de Estudios Filosóficos, Políticos y Sociales Vicente Lombardo Toledano.

Mayer, M., Brenner, L., Schauss, B., Arnegger, J. & Job, H. (2018). The nexus between governance and the economic impact of whalewatching. The case of the coastal lagoons in the El Vizcaíno Biosphere Reserve, Baja California, Mexico. *Ocean and Coastal Manegement*, (162), 46-59. doi:10.1016/j.ocecoaman.2018.04.016, [5 de julio de 2018].

Metz M., Mitasova H. & Harmon R. (2011). Efficient extraction of drainage networks from massive, radar-based elevation models with least cost path search, *Hydrological & Earth System Science*, (15), 667-678. doi:10.5194/hess-15-667-2011, [14 de octubre de 2011].

Monterrubio, J. C., Rodríguez-Muñoz, G. & Mendoza-Ontiveros, M. M. (2013). Social benefits of ecotourism: The monarch butterfly reserve in Mexico. *Enlightening Tourism. A Pathmaking Journal,* 3(2), 105-124.

Neger, C. & Propín, F. E. (2018). Regional ecotourism networks: Experiences and lessons from Los Tuxtlas, Mexico. *Annals of the Austrian Geographical Society*, (160), 143-162. doi:10.1553/moegg160s143, [2 de junio de 2020].

Onderdonk, D. A. & Chapman, C. A. (2000). Coping with forest fragmentation: The primates of Kibale National Park, Uganda. *International Journal of Primatology,* 21(4), 587-611.

Oropeza, H. P. & Rendón, H. E. (2012). *Programa de acción para la conservación de las especies: primates, mono araña (Ateles geoffroyi) y monos aulladores (Alouatta palliata, Alouatta pigra).* Ciudad de México: Comisión Nacional de Áreas Naturales Protegidas/Secretaría de Medio Ambiente y Recursos Naturales.

Oviedo-García, M. A., Castellanos-Verdugo, M., Vega-Vázquez, M. & Orgaz-Agûera, F. (2017). The mediating roles of the overall perceived value of the ecotourism site and attitudes towards ecotourism in sustainability through the key relationship ecotourism knowledge-ecotourist satisfaction. *International Journal of Tourism Research*, (19), 203-213. doi:10.1002/jtr.2097, [20 de febrero de 2020].

Peh, K. S., Lin, Y., Luke, S. H., Foster, W. A. & Turner, E. C. (2014). Forest fragmentation and ecosystem function. In Kettle, C. J. y Koh, L. P. (eds.). *Global Forest Fragmentation* (pp. 96-114). Wallingford: CABI.

Pérez, V. A., Leyva, T. D. A. & García, A. J. C. 2013. El ecoturismo: un estudio de caso del estado de Veracruz. *Revista Mexicana de Ciencia Agrícola*, (5), 1015-1025.

Pinkus-Rendón, M. J. & Pnikus-Rendón, M. A. (2013). El ecoturismo: quimera o realidad de desarrollo en la Reserva de la Biosfera Ría Celestún, México. *Revista LiminaR. Estudios Sociales y Humanísticos*, XIII(1), 69-80.

Pozo-Montuy, G., Sánchez-Bonilla, Y. M. & Pozo-Juárez, F. (2008). Las carreteras y su impacto sobre la fauna silvestre en una región de la cuenca baja del río Usumacinta. En Sánchez, A. L., Hidalgo, M. M. G., Arriaga, W. S. L. y Contreras, S. W. M. (eds.). *Perspectivas en zoología Mexicana* (pp. 253-265). Villahermosa: Universidad Autónoma de Tabasco.

Pozo-Montuy, G. & Serio-Silva, J. C. (2011). Influence of the lanscape matrix on the abundance of arboreal primates in fragmented landscapes. *Primates*, (52), 139-147. doi:10.1007/s10329-010-0231-5, [5 de abril de 2014].

Pozo-Montuy, G., Serio-Silva, J. C. & Chapman, C. A. (2013). Resource use in a landscape matrix by an arboreal primate: Evidence of supplementation in black howlers (*Alouatta pigra*). *International Journal of Primatology,* (34), 714-731. doi:10.1007/s10764-013-9691-y. [5 de abril de 2014].

Pozo- Montuy, G., Álvarez-Flores, J. L., Cedillo-Álvarez, C. V. & Bonilla-Sánchez, Y. M. (2017). Unidades de Manejo para la Conservación de vida silvestre: Oportunidades para la conservación de primates y otras especies. En Quintana, M. P., González, C.A., García, O. F. y Canales, E. D. (eds.). *La sierra de Santa Marta Los Tuxtlas, Veracruz* (pp. 233-251). Veracruz: Universidad Veracruzana.

Rodrigo, G., Arcos, D., Armando, R. A., Marco, A., Altamirano, B. & Luis, A.V. (2013). Uso del estrato vertical por el mono aullador (*Alouatta palliata*) (Primates: Atelidae) en un bosque subtropical del Noroccidente de Ecuador. *Boletín Técnico 11, Serie Zoológica*, 9(9), 58-73.

Rodríguez-Matamoros, J. V., Villalobos-Brenes, F. & Gutiérrez-Espeleta, A. (2012). Viabilidad poblacional de *Alouatta palliata* (Primates: Atelidae) y Cebus capucinus (Primates: Cebidae) en el Refugio de Vida Silvestre Privado Nogal, Sarapiqui, Heredia, Costa Rica. *Revista Biológica Tropical, 60*(2), 809-832.

Secretaría de Turismo (SECTUR) (2017). *5to Informe de Labores 2016-2017*. Ciudad de México: Secretaría de Turismo.

Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) (2013). *Tráfico ilegal de vida silvestre*. Ciudad de México: Centro de Educación y Capacitación para el Desarrollo Sustentable.

Serio-Silva, J. C. (2006). Las islas de los Changos (The monkey Islands); The economic Impact of Ecoturism in the region of Los Tuxtlas, Veracruz, México. *American Journal of Primatology*, (68), 1-8. doi:10.1002/ajp.00000. [20 de septiembre de 2013].

Serio-Silva, J. C., Bonilla-Sánchez, Y. M., Pozo-Montuy, G., Reyna-Hurtado, R. & Chapman, C. (2013). Identifying areas for ecoturism and conservation of threatened species: the model of blanck howler monkey in Playas de Catazajá, Mexico. In Yañez Arancibia, A., Dávalos-Sotelo, R., Day, J. W. y Reyes, E. (eds.). *Ecological Dimensions for sustainable socioeconomic development* (pp. 347-366). Boston: WITPRESS Southampton.

Solórzano, G. B. & Rodríguez, L. E. (2010). Cambios demográficos en poblaciones de primates de la región sur de Los Tuxtlas, México: Análisis longitudinal. *Neotropical Primates*, 17(1), 1-6.

Stronza, A. L., Hunt, C. A. & Fitzgerald, L. A. (2019). Ecotourism for conservation? *Annual Review of Environment and Resources*, (44), 229-253.

Tapia-Silva, F. O. (2014). Avances en geomática para la resolución de la problemática del agua de México. *Tecnología y Ciencia del Agua*, V(2), 131-148.

Tobón, W., T. Urquiza-Haas, G. Ramos-Fernández, E. Calixto Pérez, J. Alarcón, M. Kolb & P. Koleff. (2012). *Prioridades para la conservación de los primates en México*. Ciudad de México: Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, Asociación Mexicana de Primatología & Comisión Nacional de Áreas Naturales Protegidas.

Urbani, B., Kowalewski, M., Cunha, R. G. T., Torres, S. & Cortés-Ortiz, L. (2018). La primatología en Latinoamerica: una introducción. En Urbani, B., Kowalewski, M., Cunha, R. G. T., Torres, S. y Cortés-Ortiz, L. (eds.). *La primatología en Latinoamerica 2* (pp. 17-26). Caracas: Ediciones IVIC.

Valentine, P. & Birtles, A. (2004). Wildlife watching. En K. Higginbottom (eds.), *Wildlife Tourism: Impacts, Management and Planning* (pp. 15-34). Gold Coast: Common Ground Publishing & CRC for Sustainable Tourism.

Valenzuela-Córdova, B., Mata-Zayas, E. E., Pacheco-Figueroa, C. J., Chavez-Gordillo, E. J. Díaz-López, H. M., Gamma, L. & Valdez-Leal, J. D. D. (2015). Potencial ecoturístico del agrosistema cacao (*Theobroma cacao* L.) con monos saraguatos (*Alouatta palliata* Gray) en la Chontalpa, Tabasco. *AP Agro Productividad*, 8(5), 3-8.

Vargas, R. D. & Brenner, L. (2013). Ecoturismo comunitario y conservación ambiental: la experiencia de la Ventanilla, Oaxaca, México. *Estudios Sociales*, XXI(41), 32-63.

Vilalta, C. J. (2012). *Los determinantes de la percepción de inseguridad frente al delito en México*. Ciudad de México: Banco Interamericano de Desarrollo.

Yacob, M. R. S. A. (2007). How much ecotourism development contribute to local communities? An empirical study in small Island. *International Journal of Economics and Management*, 1(3), 1-14.

Young, O. P. (1982). Tree-rubbing behavior of a solitary male howler monkey. *Primates, 2*(23), 303-306.

Young, E. H. (1999). Balancing Conservation with Development in Small-Scale Fisheries: Is Ecotourism an Empty Promise? *Human Ecology*, 27(4), 581-620.