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Abstract: Jaguars inhabit a modified and human dominated landscape in western Mexico. Its habitat has been reduced and fragmented, and the pressure from agriculture and cattle ranching continues. Jaguars has been extirpated from large areas within its historic range, but its current situation is unknown. Using interviews, field records and topographic maps, and the National Forest Inventory, the potential distribution and critical areas for the species in Nayarit, Jalisco, Colima and Michoacán states was determined. In order to know the perception and social acceptance of jaguar conservation, interviews were conducted in areas where jaguars are known to be present. The results indicate that jaguars occupies a large portion of the historical range but with fragmented populations and in low population densities. It is better represented in the tropical forests of Jalisco and Nayarit, while in Colima and Michoacán the records are scarce. Six priority areas were identified (3 in Jalisco and 3 in Nayarit). In most of these areas there were conflicts with cattle ranchers. In general, local people agree to protect jaguars if the problems of livestock predation are solved.

# DISTRIBUTION AND STATUS OF JAGUARS IN WESTERN MEXICO

RODRIGO NÚÑEZ PÉREZ

## Resumen

El jaguar habita un paisaje modificado y dominado por el hombre en el occidente de México. El hábitat se ha reducido en extensión, está fragmentado y continúa sufriendo fuerte presión para dar paso al desarrollo y a la frontera agrícola-ganadera. El jaguar ha desaparecido de grandes áreas de su área de distribución, pero se desconoce su situación actual. Mediante el empleo de entrevistas, registros en campo y revisión de cartas topográficas y el uso del del Inventario Nacional Forestal, se determinó la distribución potencial y áreas críticas para el jaguar en los estados de Nayarit, Jalisco, Colima y Michoacán. Para conocer la percepción y aceptación social sobre la conservación del jaguar se realizaron entrevistas en localidades donde el jaguar está presente. Los resultados indican que el jaguar aún ocupa gran parte de su rango de distribución histórico pero con poblaciones fragmentadas y en bajas densidades. Se encuentra mejor representado en las selvas de Jalisco y Nayarit, mientras que, en Colima y Michoacán son escasos los registros. Seis áreas fueron identificadas como prioritarias (3 en Jalisco, 3 en Nayarit). En la mayor parte de las áreas donde se identificó la presencia del jaguar existía el conflicto con los ganaderos. En general, los pobladores están de acuerdo que se conserve al jaguar, siempre y cuando se atienda la problemática que existe con los felinos que depredan ganado.

Palabras clave: occidente de Mexico, hábitat potencial, áreas prioritarias, percepción social.

## Summary

*Jaguars inhabit a modified and human dominated landscape in western Mexico. Its habitat has been reduced and fragmented, and the pressure from agriculture and cattle ranching continues. Jaguars has been extirpated from large areas within its historic range, but its current situation is unknown. Using interviews, field records and topographic maps, and the National Forest Inventory, the potential distribution and critical areas for the species in Nayarit, Jalisco, Colima and Michoacán states was determined. In order to know the perception and social acceptance of jaguar conservation, interviews were conducted in areas where jaguars are known to be present. The results indicate that jaguars occupies a large portion of the historical range but with fragmented populations and in low population densities. It is better represented in the tropical forests of Jalisco and Nayarit, while in Colima and Michoacán the records are scarce. Six priority areas were identified (3 in Jalisco and 3 in Nayarit). In most of these areas there were conflicts with cattle ranchers. In general, local people agree to protect jaguars if the problems of livestock predation are solved.*

*Key words: West Mexico, potential jaguar habitat, priority areas, social perception.*

## **Introduction**

In Mexico, jaguars are a protected species listed as endangered (Semarnat, 2002). In 1987, it was considered that jaguar populations in Mexico had declined by as much as 65% (Swank and Teer, 1989). However, the distribution and current conservation status of the species are unknown in most of the country. Habitat loss has been one of the leading causes of the disappearance of large carnivores (Nowell and Jackson, 1996), and jaguars are no exception.

In western Mexico, jaguars used to be present in the Pacific coastal lowlands, the Sierra Madre del Sur and part of the Sierra Madre Occidental (Ceballos and Oliva, 2005; Hall, 1981; Leopold, 2000). Although the abundance of jaguars in those areas is not known, the species is considered to have been abundant in the wetlands and forests of Nayarit and Jalisco, according to reports by hunters and some authors (Carmony, 1995; Leopold, 2000).

For a long time, the rugged terrain, dense vegetation and lack of roads protected the jaguar from human activities. Yet, this changed in the 1970s with the construction of federal coastal road No. 200. Changes in land use accelerated and jaguar habitat was transformed and fragmented. Although jaguar populations in this part of the country were considered to be declining, fragmented and to have low densities in 1987 (Swank and Teer, 1989), there were still opportunities to conserve the species if the existing threats –deforestation and persecution of jaguars– are eliminated (Navarro, 1993).

The Wildlife Conservation Society considers western Mexico as a Type 1 jaguar conservation unit (JCU 3) which may contain 500 breeding individuals (Marieb, 2005). Although jaguars have traditionally been associated to dense tropical vegetation (Chávez et al., 2005; Guggissber, 1975; Seymour, 1989), they have been observed in temperate forests and semi-arid regions (Brown and López-González, 2001; Núñez, 2007; Monroy *et al.*, 2005, in press). In spite of the significant changes in the landscape caused by human activities, the jaguar is a versatile species and can be found in areas with a certain degree of disturbance (Brown and López-González, 2001; Sanderson *et al.*, 2002; Núñez, 2007). Along the coast of Jalisco and Nayarit, the jaguar coexists and continually interacts with humans. In fact, the dramatic increase in the human population of coastal areas in the last decade (Conapo, 2000) has already put greater pressure on jaguar populations. In order to implement an appropriate and practical conservation strategy, it is necessary to determine the status of the species and identify where its populations occur (Bailey, 1994).

According to the National Forest Inventory, western Mexico no longer contains large areas of well-conserved forests. The landscape is fragmented and subjected to different degrees of disturbance. In this part of Mexico, jaguar conservation must be compatible with human activities. Conservation of large carnivores that coexist with

humans implies broad social participation. The acceptance of such participation in conservation activities will be key in successfully protecting the species (Naughton-Treves *et al.*, 2003; Oli *et al.*, 1994). The coast of Jalisco and Nayarit is currently under great pressure by the construction of major tourist resorts and associated infrastructure, such as roads and freeways. In Jalisco, most coastal land has been privatized in the last few years (Del Castillo, 2007) and some activities are already having a negative impact on jaguar habitat around the Chamela-Cuixmala Biosphere Reserve (RBCC; Instituto de Biología, 2007). Moreover, the Mexican Federal Electricity Commission (CFE) did not report jaguar presence in its environmental impact statements for the series of hydroelectric dams it is building along the Santiago river, with a total water surface that is 150 km long so far. The artificial lakes formed undoubtedly displaced an unknown number of jaguars, formed a barrier to dispersal and fragmented the local population, one of the most important ones because of the large amount of habitat available.

It is important to determine the current status of jaguars and identify key conservation areas. This will be needed to design a management and/or recovery plan that matches the current situation, and to make recommendations and take mitigation measures to reduce the impact of human activities on jaguar populations. Livestock farmers and rural people are quite familiar with jaguars in the states of Jalisco, Nayarit and Michoacán, and the presence or absence of the species is usually reported in specific areas. Few studies have attempted to determine the status of jaguars in the region. In 1995, an informal data collection initiative was set up to obtain information on jaguars presence along the coast of Jalisco, Colima and Michoacán, in parallel to the Jaguar Project carried out in the RBCC.

This paper presents and discusses the results of the study carried out between 2005 and 2007 to determine the distribution of jaguars and its current status in western Mexico and identify key conservation areas in the states of Nayarit, Jalisco, Colima and Michoacán.

## **Study area**

The study area basically comprises the coast and coastal mountain ranges of the states of Nayarit, Jalisco, Colima and Michoacán. There are many towns and villages scattered across this area, which includes 4 physiographic regions: Sierra Madre Occidental, Neovolcanic Belt, Northwest Coastal Plain and Sierra Madre del Sur. The area has two basic climate types: tropical sub-humid and temperate sub-humid (Challenger, 1998). Elevation ranges from sea level to 2500 masl. The most important vegetation types are tropical deciduous forest, semi-evergreen forest, oak and oak-pine forest, mangrove and secondary grassland (Rzedowski, 1994). The landscape is dominated by land that has been cleared for livestock farming, and there are few large stretches of undisturbed native vegetation. Most original vegetation cover is fragmented and subjected to some degree of disturbance, and large areas have

been totally cleared for agriculture. Eight priority conservation areas identified by the federal government's National Commission on Biodiversity (Conabio) are totally or partially located within the study area: No. 59-Cuenca del Río Jesús María, No. 60-Sierra de los Huicholes, No. 61-Marismas Nacionales, No. 62-Sierra de Vallejo-Río Ameca, No. 63-Chamela-Cabo Corrientes, No. 64-Manantlán-Nevado de Colima, No. 115-Sierra de Coalcoman, and No. 116-Infiernillo (Arriaga *et al.*, 2000).

The most common human activities in rural areas are agriculture, extensive livestock farming, logging, fishing and tourism (Coplade, 2005; Seplan, 2001). Most of the seasonal and oak forests in Jalisco and Nayarit are invaded by cattle. Although there is also extensive livestock farming in the state of Michoacán, although it is not as important as in Nayarit and Jalisco; the latter is the second largest livestock producer in Mexico. Three large indigenous communities live in the study area –the Nahua on the coast of Michoacán and the Cora and Huichol in the northeast of Nayarit (Conabio, 2006), as well as some Nahua groups in the south of Jalisco.

## Methods

In order to find the possible areas where jaguars of the RBCC may disperse and areas where jaguars are present in the state of Jalisco, we looked for records and conducted interviews occasionally from 1995 onwards. The interviews showed two main topics: the presence of the jaguar and conflict due to jaguar predation on livestock. In July and August of 2005 and 2006, livestock farmers, ranch owners and hunters in over 35 sites were surveyed with open and closed interviews (Karanth and Nichols, 2000, Medellín *et al.*, 2006; Rabinowitz, 1997) to learn about the distribution of jaguars and obtain physical records and feedback about the perception and attitude of these groups regarding jaguar conservation and conflict due to livestock predation. Additionally, open interviews were conducted with veterinarians, forestry officials, researchers and government officials of Semarnat, Profepa and Conanp in each of the states involved in fieldwork.

Fieldwork involved looking for records such as skulls, skins, photographs and tracks; camera traps were used in 5 sites. Reports of predation on livestock were one of the most reliable indicators of jaguar presence because ranchers and/or cowboys are continually present in the field and have experience in recognizing tracks of felids and marks on carcasses. Reports of livestock predation were dealt with by the author and/or staff of Semarnat and Profepa in Nayarit and Jalisco. We visited 16 sites in Jalisco, 11 in Nayarit and 4 in Michoacán, where livestock predation and/or jaguar sightings were reported. Camera traps were placed in 5 sites to record jaguar presence: 2 sites in Jalisco (n=3 and 5 stations, 2 in Nayarit (n=4 and 2 stations) and 1 in the state of Michoacán (n=1 station). Eleven groups of active community observers cooperated in these activities-interviews and field visits. Records such as tracks and camera traps were georeferenced with a Global Positioning System receiver (GPS, Garmin, USA), and the features of the relevant habitat were recorded.

We determined the potential area of distribution and the most important areas for conservation based on the interviews, human presence, referenced records and type of habitat available. Given that habitat characterization is mainly based on vegetation (Ojasti, 2000), 1:250,000 vegetation maps (INEGI, 1996) and the 2000 National Forest Inventory were used to identify critical areas. Potential habitat within protected areas in the region was determined by using Series III vegetation maps (INEGI).

To obtain feedback on the social perception and attitudes of communities towards jaguar conservation and conflict caused by predation on livestock, intensive interviews were conducted in the summers of 2005 and 2006 in 3 different areas with frequent reports of sightings of jaguars and their tracks, and reports of livestock predation. We interviewed 120 ejidatarios (peasants with communal lands) from Sierra de Vallejo-Zapotán in Nayarit, 20 from Cabo Corrientes in Jalisco, and 40 members of agrarian communities of the Pomaro indigenous community in Michoacán. The interviews included 24 questions on these people's perception about the historical and current abundance and presence of jaguars, the conflict caused by livestock predation and their attitudes towards the conservation of the species and its habitat.

## **Results and discussion**

This study is still under way, so results on jaguar distribution are preliminary; in some areas, jaguar presence has not been confirmed but there are reliable reports about its presence.

### **Distribution**

Jaguars are well known in rural areas of Jalisco and Nayarit, but there is little evidence of its presence in rural communities in Michoacán and Colima. In Jalisco and Nayarit, jaguar is present in much of its original range, although populations are fragmented and dispersed; in some areas, population density is low or the presence of the species is only temporary. According to the interviews, jaguar has been extirpated or is only occasionally present in Colima and Michoacán. In Jalisco and Nayarit, 75% of records were associated to tropical rainforest and semi-evergreen forest, 12.5% were associated to oak forest and 12.5% were associated to wetlands. In Michoacán, the most recent records were taken in the tropical deciduous forest and oak forests. Records corresponded to an elevation range between 0 and 1400 masl, although jaguar presence has been reported at elevations greater than 2000 masl. Six critical areas for jaguar conservation were identified, 3 in Jalisco and 3 Nayarit. In Michoacán, it was suggested that the most important areas may be in the municipalities of Aguila and Arteaga (Figure 1), although no recent physical records of jaguar presence are known to exist.

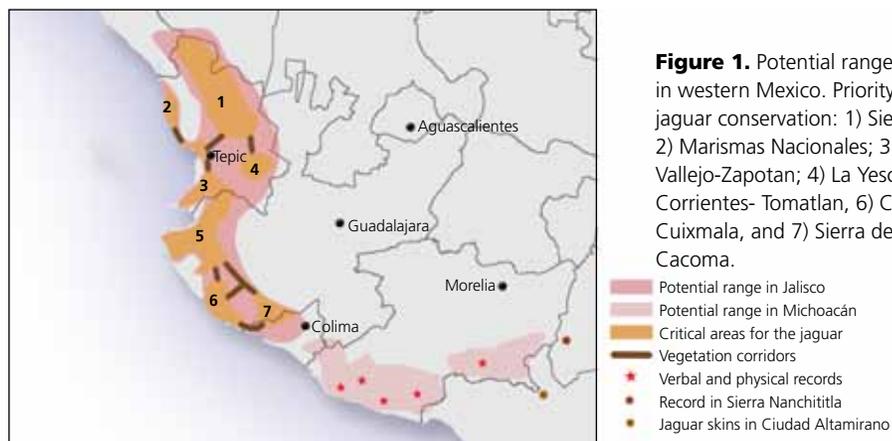
## Nayarit

Jaguar records were recorded in 26 sites, in 18 out of the 22 municipalities of the state. Most records (65%) were obtained in areas with semi-evergreen forest and tropical deciduous forest, followed by mangroves (25%, in Marismas Nacionales), and the remaining 10% were obtained in oak forests.

This suggests that jaguar still occupies most of its original range in the state (Figure 1); however, its habitat is fragmented. Nayarit is believed to contain between 9,000 and 11,000 km<sup>2</sup> of potential jaguar habitat. The addition of several sections of the Basin of Irrigation District 043 (CADNR 043) to the protected area system – Aguamilpa, Sierra de los Huicholes and Vallejo-Ameca– means that 450,000 ha of suitable jaguar habitat are now protected in different parts of the state. Although the region with the highest number of reports on jaguar presence is the southern coast of the state and the Marismas Nacionales Fauna and Flora Protection Area, information is biased towards these regions because they are more accessible and there are more people working there. In the Sierra region there are few records of jaguar presence because access is difficult. In the neighboring state of Durango, just on the other side of the state boundary, Dr Jorge Servín (pers. comm.) recorded jaguar presence around small creeks with semi-evergreen forest near the village of San José Peyotán (municipality of El Nayar) and near El Cajón dam. In the municipality of Santa María del Oro, in the same region, a calf was killed by a jaguar in a landscape dominated by pine-oak forest and secondary grassland, with some tropical deciduous forest around small creeks.

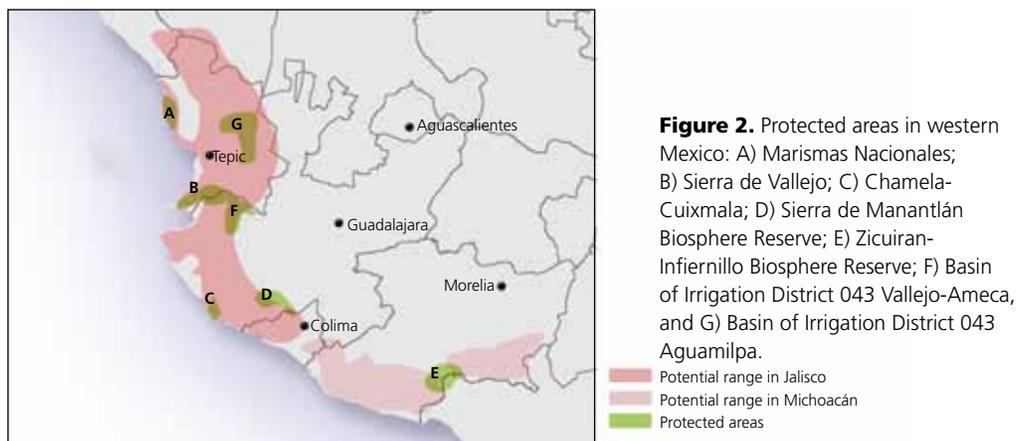
Based on the quality and type of vegetation and human presence, three priority areas for jaguar conservation were identified in the state:

a) Marismas Nacionales: These wetlands were listed in the RAMSAR convention for the conservation of wetlands in 1995 and are in the process of being declared a protected area. The part located in Nayarit comprises 130,000 ha. Vegetation is mostly represented by mangroves (60,000 ha) in the tropical deciduous forest and



by halophytic vegetation (UAN, 2004). Wetlands in the state of Nayarit are gradually becoming isolated due to deforestation. In this area, the annual deforestation rate is 2.7% for the tropical deciduous forest, and 0.8% for mangroves (Berlanga *et al.*, 2004; Berlanga and Luna, 2007). A narrow corridor of mangroves along the coast connects the region to the wetlands in Sinaloa, the forest areas of the “Pie de la Sierra” region and to rocky volcanic areas associated to the Cerro de San Juan volcano in the south. According to reports by fishermen and farmers, reptiles (turtles) and medium-sized mammals such as coatis and raccoons are important in the jaguar’s diet.

b) Sierra de Vallejo-Sierra Zapotan: According to the records, jaguars were heavily hunted in this area in the past and was still hunted illegally until a couple of years ago, mainly by hunters from Guadalajara. Information obtained by camera trapping shows that the jaguar is still common in these mountain ranges. Seven camera stations were placed in five sites for one month, for a total of 240 trap nights. No jaguars were recorded in two sites, and six different jaguars were recorded in the remaining three sites. Sierra de Vallejo-Zapotan is covered with semi-evergreen forest, tropical deciduous forest, secondary grassland and patches of oak-pine forest (Conanp, 2005). The terrain is rugged and there is little availability of natural prey due to intense poaching and a high presence of livestock. The underbrush has disappeared in large areas because of overgrazing. This area covers a surface of about 100,000 ha and is connected to the mountain ranges of the north of Jalisco. It is one of the last large patches of semi-evergreen forest that remain in this part of the country (more than 1,500 km<sup>2</sup>; Arriaga *et al.*, 2000). The Vallejo-Ameca portion of the CADNR 043 conservation unit is attached to the Sierra de Vallejo. It comprises 350,000 ha, out of which 170,000 ha are potential jaguar habitat –mainly tropical deciduous forest and semi-evergreen deciduous forest– (Table 1, Figures 1 and 2). The Sierra de Vallejo-Zapotan may lose connectivity with the rest of the state unless appropriate mitigation measures are taken in the construction of the road from Jala to Las Varas (Semarnat, 2007).



c) Region of La Sierra: In the municipalities of El Nayar and La Yesca, the dominant vegetation is pine-oak forests and secondary grassland, and there is tropical vegetation around small creeks. This region has large stretches of vegetation with a low level of disturbance and the lowest population density of the state 4.2 people/km<sup>2</sup> (COPLADENAY, 2003). In the low part of the mountain range there are areas of semi-evergreen forest and tropical deciduous forest where jaguar presence has been recorded, near the Aguamilpa dam and on Picacho Mountain. In July 2007, a jaguar female and two cubs were found in a canyon close to El Cajón hydroelectric dam (pers. obs.). The size of this area –more than 1,000 km<sup>2</sup>– makes it highly important for the conservation of the species. Although the landscape is dominated by oak forests and there are large areas of secondary grassland, the low human presence, difficult access and rugged terrain may contribute to the conservation of the jaguar. The Aguamilpa and Sierra de los Huicholes sections of CADNR 043 represent 300,000 ha of potential jaguar habitat. A fourth area in the eastern part of the state in La Yesca region may be important for jaguars, but large areas of tropical deciduous forest have been transformed into grassland. Small creeks that still have some elements of tropical vegetation around them are of great importance in these areas. Although the mountain ranges of El Nayar and La Yesca are still interconnected, they have lost connectivity with the south of the state. The construction of the Aguamilpa-La Yesca series of hydroelectric dams in Nayarit and Jalisco at their maximum capacity may create a barrier for the dispersal of individuals. Besides, the construction of the road connecting Tepic with the state of Zacatecas will imply paving 64 km; the paved road will reach La Mesa del Nayar, which may accelerate fragmentation and loss of connectivity.

**Table 1.** Potential jaguar habitat in protected areas (PA) of western Mexico

	Category	Total surface PA (ha)	Approx. potential jaguar habitat	Dominant vegetation in PA
Chamela-Cuixmala	BR	13,000	12,000	SB
Sierra de Manantlán	BR	140,000	60,000	BQ, BQP, SM
Marismas Nacionales	APFF*	110,000	60,000	VM, SB, VH
Sierra de Vallejo	BR**	70,000	45,000	SM, SB
Zicuiran-Infiernillo	BR	262,000	146,000	SB, SE
Aguamilpa	CDR 43	315,000	165,965	SB, BQ
Sierra Vallejo-Ameca	CDR 43	352,000	171,213	SB, SM, BQ
Sierra Los Huicholes	CDR 43	195,000	122,850	BQ, SB

\* BR pending decree

\*\* State BR pending decree

BR: Biosphere Reserve

APFF: Fauna and Flora Protection Area

CDR: Basin of irrigation district

SB: tropical deciduous forest; BQ: oak forest; BQP: pine-oak forest; SM: semi-evergreen forest; SE: thorn forest;

VM: mangroves; VH: salt-adapted vegetation

## Jalisco

In Jalisco, it was estimated that jaguars may still occupy about 8,000 km<sup>2</sup> of its original range. There are published records of jaguar presence mainly in coastal municipalities and mountain ranges near the coast such as the sierras of Cacoma, Manantlán and El Tuito (Ceballos and Miranda, 2000; Conanp, 2000; Gallo, 1989; Núñez, 2006; Núñez *et al.*, 1981). No data are available for the Sierra Madre Occidental. Although jaguars have disappeared from large stretches of land cleared of its original vegetation and subjected to intense human activity, there is still connectivity between the different forests where jaguars are present. Jaguar presence was identified in 22 sites. Sixty percent of records came from areas with tropical deciduous forest, 25% came from areas with semi-evergreen forest and 15% came from pine-oak forests. Seventy percent of records were obtained in areas with some degree of disturbance, such as secondary grassland. The distribution of jaguar are concentrated in the forests and mountain ranges of the municipalities of La Huerta, Cihuatlan, Tomatlan, Cabo Corrientes, Puerto Vallarta, Casimiro Castillo and Talpa. According to livestock farmers and Huichol indigenous people, jaguar still occurs around the small creeks of the Sierra Madre Occidental and one jaguar was killed in mid 2006 because it had attacked livestock. In the range of the jaguar in Jalisco, two areas are considered essential to conserve wildlife and maintain corridors because of their size and the quality of their plant cover: the San Sebastián- Cabo Corrientes and Cabo Corrientes-Tomatlán corridors (Curiel and Ramos, 2003).

Based on habitat availability, 3 priority areas for jaguar conservation were identified:

a) Cabo Corrientes-Ameca: A large area with semi-evergreen forest, tropical deciduous forest and pine-oak forest, which is considered very important because of its size and quality (Arriaga *et al.*, 2000; Curiel and Ramos, 2003). It is connected to the mountain ranges of the south of Nayarit (Vallejo-Zapotán) and the municipality of Tomatlán, Jalisco. Part of the CADNR 043 Sierra Vallejo-Río Ameca (350,000 ha) is located in this region, and about half of its plant cover (170,000 ha) is favorable to jaguar presence. Cabo Corrientes has few paved roads, with the exception of federal coastal road No. 200. In the first semester of 2007, 3 camera trap stations were placed and jaguar and puma presence was recorded in several sites in the region. Photo records show that jaguars can use disturbed areas, but more fieldwork is necessary. The initiative of protecting some areas of this region through the creation of the biosphere reserve in the north coast of Jalisco has been given a new impulse, although it has not taken place yet for different reasons (Figures 1 and 2). In the municipality of Cabo Corrientes, extensive livestock farming is a deeply rooted activity and complaints of livestock predation are frequent.

b) Chamela-Cuixmala-Tomatlán: This region includes the Chamela-Cuixmala Biosphere Reserve (RBCC), which protects 13,000 ha; an increase in the number of jaguars has been observed over the last 10 years (Núñez, 2006b). This region is connected to the forests of Tomatlán and the south of the state. However, the re-

cent construction of roads and tourist developments (Semarnat, 2005; Instituto de Biología-UNAM, 2007) is compromising jaguar conservation in this area and connectivity with the forests of the municipality of Tomatlán (Figure 2). There are more than 10,000 ha of natural vegetation in adjoining areas of the biosphere reserve where jaguars still occurs, as well as vegetation corridors that maintain connectivity with the forests of the municipality of Tomatlán and the state of Colima to the south.

c) Sierras Cacoma-Manantlán: Jaguar presence and attacks on livestock are often reported in these mountain ranges. The jaguar is present in Manantlán Biosphere Reserve (RBSM; Conanp, 2000). The Reserve covers 120,000 ha and includes Cerro Grande in Colima. Jaguars have been recorded mainly in areas with tropical deciduous forest, semi-evergreen forest and oak forests in areas in the south of the RBSM and Cerro Grande with coastal orientation. The Reserve contains about 60,000 hectares of suitable jaguar habitat (Table 1). The presence of the species has recently been recorded in the region, but there seem to be few individuals, dispersed in low areas (Aranda, pers. comm). The mountain ranges of Manantlán, Cacoma, Perote and Mamey can be a refuge for the jaguar if the existing threats –reduction of natural prey, destruction of the forest and hunting– are eliminated. This area is connected to the north of Colima and the RBCC by vegetation corridors. Habitat fragmentation and the construction of new roads (Semarnat, 2005) threaten the connectivity between the two biosphere reserves.

## **Colima**

A male jaguar was hunted in the municipality of Manzanillo, Colima in 2006. Jaguar presence is reported in the mountain ranges of the north of the state that are adjacent to Jalisco, including the RBSM (Figure 1). This area provides shelter to the jaguar because of the rugged terrain and the existence of habitat. Jaguar presence is also reported around the small creeks of Cerro Grande in the RBSM. The Natural History Museum of Los Angeles County has 3 jaguar specimens that were collected in El Terrero, in Cerro Grande, Colima, in the late 1960s. The jaguar can thrive if it is well protected in the Sierras de Perote and Mamey, north of the state and next to Jalisco. Some hunters claim to have seen jaguar tracks in the tropical deciduous forest of areas adjacent to the state of Michoacán, but jaguar presence has not been confirmed. There are jaguar records in Michoacán. The forests of the north and south of the state are separated by agricultural land and the Colima-Manzanillo freeway. Some very narrow ravines cross this area below the Guadalajara-Manzanillo highway, and may act as wildlife corridors, but they are very narrow.

## **Michoacán**

Very little is known about the current status of jaguars in the state of Michoacán. Historically, jaguars occupied the mixed forests and other forest types of the coast

and the Sierra Madre del Sur (Government of the state of Michoacán, 1974). Brand (1961) reported jaguar presence in pine and oak forests near Coalcomán. The most recent record (tracks) was obtained by Núñez *et al.* in May 2007, in a coastal Nahuatl indigenous community. Previously, Gallo Reynoso (pers. comm.) found a jaguar skin in the municipality of Arteaga in 1987, but the place where it was hunted is unknown. Between 1993 and 1995, a male jaguar was killed near Motín del Oro, in the municipality of Aquila. According to the size of the skull and the state of the canines, it was a subadult individual. A skull of a male jaguar killed in 1980 near Chuta, in the municipality of Lázaro Cárdenas, was also inspected. Recent reports from 2005 and 2006 mention that a male jaguar was killed in a coastal indigenous community as a reprisal for killing a horse. A person also reported having captured a jaguar cub in a place between the boundaries of the municipalities of Coalcomán and Aquila (oak-pine forests) and the death of the cub a few weeks later. Jaguar presence has also been reported in the most inaccessible areas in the municipality of Coahuayana, in areas adjacent to Colima. The coast of Michoacán is mainly covered by tropical deciduous forest. In spite of being relatively inaccessible, it is fragmented and the vegetation has some degree of disturbance (COFOM, 2001). The complex topography, habitat availability, and low human activity in this part of the state may still provide a chance for the conservation and recovery of jaguars. The jaguar seems to be uncommon in the state, or less known than in Jalisco and Nayarit, but fieldwork is needed in much of its potential range to confirm the presence and status of jaguars and also to implement conservation measures in this state.

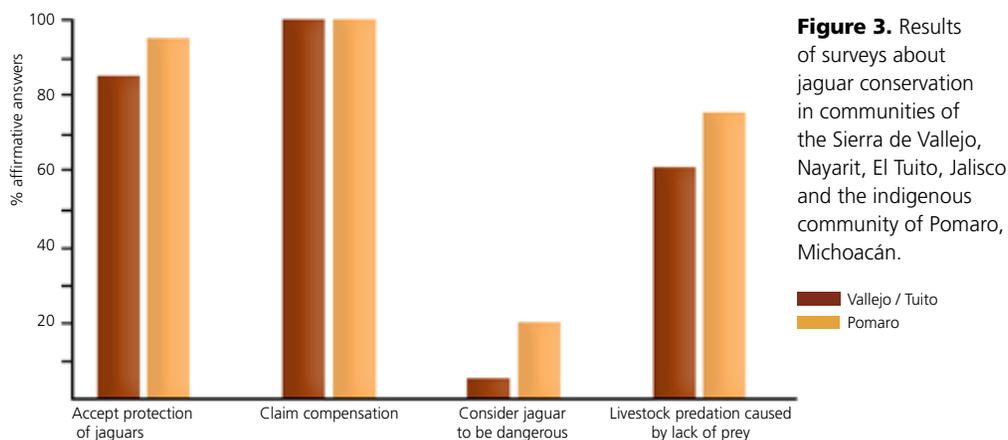
Jaguar presence has not been confirmed in the regions of Tierra Caliente and the Balsas Depression, where there is tropical deciduous forest and thorn forest. In 1987, however, Gallo (1989) found two jaguar skins in Ciudad Altamirano, Guerrero, in the intersection of the Balsas and Cutzamala rivers, and adjacent to the municipality of San Lucas Michoacán in the Tierra Caliente region. In 2004, the first jaguar record for State of Mexico (Monroy *et al.*, 2005; this volume) was obtained near the boundary with Michoacán. It was a photograph of an individual taken in the Sierra de Nanchititla (1,800 masl), in the municipality of Tejupilco, next to the municipalities of Tiquicheo and Tuzantla, Michoacán. The site where the photograph was taken is 20 km from the boundary with Michoacán and 70 km north east of Ciudad Altamirano. This makes it logical to consider that there may be jaguar individuals in some areas of Tierra Caliente, especially in tributaries of the Tuzantla and Balsas rivers with little human presence. After the search for physical records in Michoacán began in 2005, reports of jaguar presence and livestock depredation were obtained in the municipalities of Arteaga and Huacana, but it was not possible to verify them. In Arteaga, jaguar records are associated to the transition area between the tropical deciduous forest and oak forests. In La Huacana, they are associated to thorn forest and small creeks with elements of semi-evergreen forest. The previous study carried out to justify the creation of Zicuiran-Infiernillo Biosphere Reserve mentions the

importance of the tropical deciduous forest (100,000 ha) for jaguar conservation (Conanp, 2005), although jaguar presence is not confirmed. The biosphere reserve (Conanp, 2005) covers a surface of 270,000 ha in the lower basin of the Balsas River and may represent an opportunity for the conservation and/or recovery of felids in this region of the state. The Wildlife Management Units (known as UMAs) established in the Costa-Sierra region will also be relevant for the conservation and recovery of jaguars.

### Popular perception and attitudes towards jaguar conservation

In the Sierra de Vallejo in Nayarit and Cabo Corrientes in Jalisco, 25% of people surveyed did not know jaguars occurred in the region. Five percent of those surveyed consider jaguars as being dangerous. Ninety percent accept conservation of jaguars and protection of its habitat, and 70% consider that the jaguar is disappearing because of humans. Out of the livestock farmers and crop farmers interviewed 85% (n = 180), accept the importance of protecting the jaguar and admit that the cause of livestock predation is the lack of natural prey; they agree to protect the species and not persecute it as long as a compensation scheme is in place. Ten percent of livestock farmers do not want the jaguar or puma to be present under any circumstance (Figure 3). Over one-fourth of livestock farmers would agree to change their activity or make better management of livestock to reduce losses caused by predators and consider that livestock farming is an activity that generates little profit.

In the Nahua community of the coast of Michoacán, 95% of people surveyed agree that jaguars and natural resources must be protected, as long as there are no impositions and their rights to the land are not limited. Seventy three percent consider the species to be uncommon (Figure 3) and to occur in the most inacces-



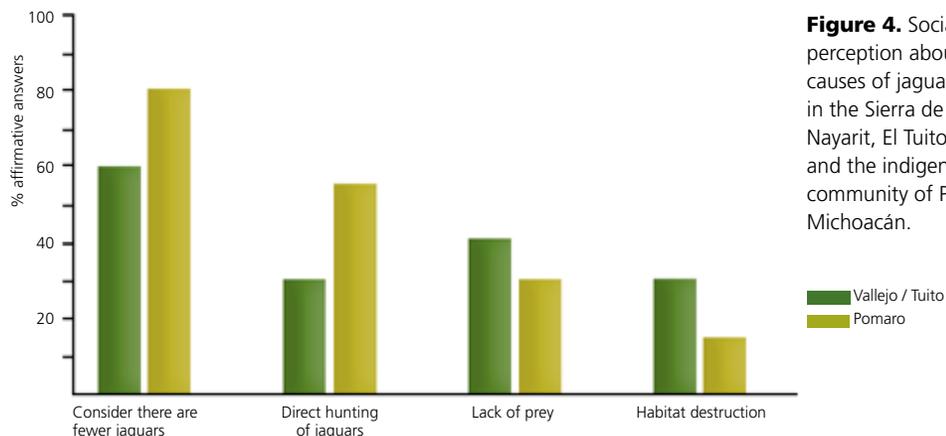
**Figure 3.** Results of surveys about jaguar conservation in communities of the Sierra de Vallejo, Nayarit, El Tuito, Jalisco and the indigenous community of Pomaro, Michoacán.

sible areas. In the municipalities of Lázaro Cárdenas and Arteaga, some groups are interested in conserving the jaguar through the creation of Wildlife Management Units. Regarding the decline of jaguar populations, the indigenous community of the coast of Michoacán openly admits that jaguara are uncommon because they are killed whenever there is a chance. In northern coastal Jalisco and southern coastal Nayarit, people surveyed consider that jaguar decline is also due to the destruction of forests and the decline of its natural prey (Figure 4). In the Sierra de Vallejo, the big livestock farmers of Bahía de Banderas are against any jaguar conservation scheme, whereas smaller farmers on the Pacific side and in the mountains are more willing to protect the species.

### Main issues and conservation implications

Habitat loss has been one of the main causes of the disappearance of jaguars (Núñez *et al.*, 2000). In western Mexico –particularly Jalisco– jaguar habitat started to shrink in the 1940s as a consequence of coastal settlement programs. The construction of federal coastal road No. 200 in 1970 dramatically increased the human population, the use of resources and the development of agriculture (Miranda, 1998). Jaguar habitat is currently fragmented. On the coast of Jalisco, an annual deforestation rate of 3.2% was estimated for the tropical deciduous forest, and a rate of 2.3% for the region of Marismas Nacionales (Berlanga *et al.*, 2004; Miranda, 1998). At the current rate, the tropical deciduous forest of the coast of Jalisco may have disappeared by 2050. The trend is very similar in Nayarit.

The introduction of cattle in the forest ecosystems of Jalisco and Nayarit has reduced the quality of the habitat because of the competition for food and habitat with other wild herbivores. Although livestock farming and sustainable use of forests are



**Figure 4.** Social perception about causes of jaguar decline in the Sierra de Vallejo, Nayarit, El Tuito, Jalisco and the indigenous community of Pomaro, Michoacán.

not necessarily mutually exclusive, they are not integrated at present and livestock farming is displacing the forest (Curiel and Ramos, 2003).

The continuous construction of roads on the coast of Jalisco and in the mountains of Nayarit (Semarnat, 2005) is creating significant, permanent fragmentation of the habitat and natural corridors of wild animals (Ruediger, 1996). Paved roads have been proven to increase large felids mortality caused by road accidents and poaching and modify the behavior of the animals, which avoid using areas close to roads (Kerley *et al.*, 2002; Maehr, 1997; Zarza *et al.*, 2005; this volume). Roads also contribute to the establishment of new human settlements (Ruediger, 1996). The municipalities of Cabo Corrientes and Puerto Vallarta in Jalisco and Bahía de Banderas in Nayarit, which include one of the key areas for jaguar conservation, are experiencing the highest population growth in the region (Conapo, 2000; Juárez and Sánchez, 2003). Tourist developments have been planned in areas of great importance for jaguar conservation, such as the Chamela-Cuixmala Biosphere Reserve in Jalisco (Instituto de Biología, 2007), Marismas Nacionales and Sierra de Vallejo in Nayarit, among others (COPLANEDAY, 2003).

Other infrastructure works such as the hydroelectric dams built by the Federal Electricity Commission in Aguamilpa, El Cajón, and La Yesca in the near future, will have a major impact on jaguar populations. The dams will form a series of artificial lakes at different elevations with a length of more than 150 km from the center of the state of Nayarit to the boundary with Jalisco. This may limit the dispersal of felids, among other negative effects.

To reduce the impact of development on carnivores, infrastructure development must be planned in close coordination between specialists, authorities and institutions in charge of the works. It is also necessary to monitor the effect of the infrastructure on felid populations and apply mitigation measures in areas where problems are detected.

### **Livestock-jaguar conflict**

The greatest threat for the jaguar is lethal control resulting from livestock predation and other causes. According to the reports of the active community observers in the state of Jalisco, it was estimated that 14 to 18 jaguars were killed for this reason in 2006. For example, at least two jaguars were poisoned and one was shot dead in the Sierra de Vallejo. In the municipality of Aguila, Michoacán, one jaguar was killed in 2005 because it had attacked and eaten a horse. Livestock depredation by jaguars has been attributed to different causes, from individuals unable to hunt natural prey due to consumption by humans –old individuals, inexperienced juveniles or injured animals– to the lack of natural prey or the high availability of free-grazing livestock (Hoogesteijn, 2001; Polisar *et al.*, 2003; Rabinowitz, 1986). In the study area, the lack of natural prey is probably the most important cause of livestock predation. In Sierra de Vallejo, the lack of natural prey such as the peccary (*Tayassu tajacu*) and the

white-tailed deer (*Odocoileus virginianus*) and high availability of cattle aggravate the problem. In contrast, reports of livestock predation are not frequent in the Chamela-Cuixmala Biosphere Reserve, in Jalisco, where jaguars are common and natural prey are abundant (Núñez, 2006). Some areas such as Sierra de Vallejo and Cabo Corrientes are under strong hunting pressure. Camera trapping showed a low abundance of peccary and white-tailed deer compared to the relative abundance of the jaguar, 2 or 3 times higher than that of its prey; in the biosphere reserve, however, the relative abundance of deer is 3 times higher than that of jaguars.

In Jalisco, 3 areas with the greatest level of conflict with livestock farming were identified: a) Sierra de Manantlán, b) Tomatlán and c) Cabo Corrientes. In Nayarit, 3 conflict areas were identified: a) Sierra de Vallejo-Zapotán, b) Marismas-San Blás and c) the municipality of Santa María del Oro. Livestock farming is extensive and unmanaged in all these areas. The lack of natural prey and availability of livestock contribute to the attacks. The jaguar is an opportunist (Seymour, 1989) and versatile species. If natural prey is not available, it readily uses other resources, from cattle to dogs to poultry. Jaguars usually attack young or newborn livestock. According to livestock farmers and cowboys interviewed, 'in the country, when cows are about to calve, they go to a remote place in the woods and stay there with their calf for a few days.' Lack of management and surveillance of these calving females facilitates attacks.

To reduce the conflict between livestock and jaguars, the problem must be tackled on three fronts: a) livestock farmers must be given advice on how to improve management and care of their herds, b) there must be more surveillance and increased awareness among hunters, and c) alternative sources of income must be implemented to reduce overexploitation of wildlife. It is very important to assist livestock farmers promptly when they ask for help after a felid has attacked their herd; if they are ignored they will bring hunters in to solve the problem.

### **Long-term conservation**

Due to habitat fragmentation, there is no continuous population, but rather, a number of more or less isolated small populations –some of which are of a larger size and greater importance– connected by vegetation corridors, forming a metapopulation. According to Eizirik *et al.* (2002), 650 individuals are necessary for long-term conservation of the jaguar and to maintain genetic variability in a region. To maintain a population of this size, roughly 24,000 km<sup>2</sup> to 38,000 km<sup>2</sup> and would be necessary. Calculation of the values was based on a density of 1.7 and 2.7 individuals/100 km<sup>2</sup>, obtained by radio telemetry in the RBCC from 1996 to 1997 (Núñez *et al.*, 2000) and 2000 to 2003 (Núñez, 2006).

In western Mexico, ideally, a population of 140 individuals (3.5 individuals/100 km<sup>2</sup>) could occupy an area of 4,500 km<sup>2</sup>; without human threats, it would have a 90% probability of persisting for more than 100 years. When the anthropogenic ef-

fect is included in the model, the population declines to 50% in 10 to 20 years, and is practically extirpated at 40 years (Carrillo *et al.*, this volume). It is not possible to maintain one single large population in western Mexico. Yet, if connectivity between the protected areas that maintain the jaguar is ensured (Table 1), the exchange of individuals will continue (Beier, 1993). For example, the region that encompasses Tomatlán-Cabo Corrientes-Rio Ameca-Sierra de Vallejo covers about 2,700 km<sup>2</sup> and must be protected in its entirety as a jaguar conservation unit; this area can sustain over 50 jaguars (Allen *et al.*, 2001) and is also connected to the region of the RBCC. The creation of corridors and protection zones must be supported by other schemes providing economic and productive alternatives that reduce the pressure on wildlife.

## Perspectives

In western Mexico several groups are cooperating in the ongoing search for physical records of jaguar presence. It is important to increase the effort devoted to the search for records in oak and pine forests in Nayarit, Jalisco and Michoacán, as this vegetation type might be a refuge for jaguars because it is under less pressure than other types of forests. The thorn forests of Tierra Caliente in Michoacán must also be explored to confirm the presence of the jaguar in the region and determine whether there is a population or just dispersing individuals. It is important to define and protect corridors that guarantee the exchange of individuals between populations. Radio telemetry studies are needed to determine the use of fragmented areas by jaguars and identify potential corridors. The conflict caused by livestock predation must urgently be studied and dealt with in order to achieve a greater acceptance of jaguar conservation and reduce the persecution of the species. The first studies to determine the status of the jaguar in Marismas Nacionales (Nayarit) are now under way. It is necessary to conduct a population assessment of the jaguar in this region, which may contain a considerable number of individuals.

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