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Distribución potencial del ocelote (*Leopardus pardalis*) en el noreste de México

Potential distribution of the ocelot (*Leopardus pardalis*) in Northeastern Mexico

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Introduction: The ocelot (*Leopardus pardalis*) is a Neotropical cat which is threatened by illegal hunt and habitat destruction in the Mexican territory. Mexican and American authorities are interested in promoting their conservation. The MaxEnt algorithm allows modeling the potential distribution of elusive species, for instance, the ocelot. This has been based on trustable presence records and some other information about the habitat condition. This work was developed with the aim of generating important information about the species in Northeastern Mexico, especially, with the purpose of determining its potential distribution.

***Methods*:** Our study was conducted in six physiographic subprovinces in the Mexican states of Tamaulipas and San Luis Potosí. Sixty-trhee recent records about the ocelot were obtained, 41 through literature and 22 from field surveys , between May 2006 to May 2009. In order to develop a prediction model which let us know the animal potential distribution, twenty-seven bioclimatic, topographic, vegetation and anthropic variables were used through the MaxEnt software.

Results: The model AUC was of 0.8221 ± 0.009. The most related variables about the ocelot presence were: precipitation of wettest month and quarter, vegetation cover, vegetation type, terrain elevation, precipitation of coldest quarter, terrain slope, human population density, and distance to roads. The potential distribution area overs 20.8 % of the study area. The physiographic subprovinces showing the highest potential distribution were: llanuras y lomerios (7.4 %), Carso Huasteco (4.8 %), Gran Sierra Plegada (4.5 %), and sierras and llanuras occidentales (3.4 %). The llanura costera Tamaulipeca subprovince showed lower potential distribution; meanwhile, llanuras de Coahuila y Nuevo Leon and sierras y llanuras del norte de Guanajuato were not suitable distribution for ocelot.

Discussions and conclusions: In order to obtain the ocelot potential distribution model we use recent information collected through field work and surveys. Through this, we could achieve a robust model, where were relevant both bioclimatic and landscape variables. There are patches of habitat important in size and quality for ocelot. The physiographic subprovinces with the roughest landscape were the ones where the highest presence of the species. This study complements the ocelot distributional range in Northeastern Mexico and providing important information about the habitat quality in that portion of the country, as well as the difficulty to possible connectivity between Mexico and USA.

Keywords: camera trap; field survey; huasteca region; MaxEnt; neotropical cats.

Introducción: El ocelote (*Leopardus pardalis*) es un felino neotropical que se encuentra amenazado en México por la cacería ilegal y la destrucción de su hábitat. Existe interés de las autoridades de Estados Unidos y de México para conservarlo. El algoritmo MaxEnt permite modelar la distribución potencial de especies elusivas, como el ocelote, con base en registros confiables de presencia, e información sobre condiciones del hábitat. Este trabajo se realizó con la finalidad de generar información relevante en torno a esta especie en el noreste de México, así como determinar su distribución potencial.

Métodos: El estudio se llevó a cabo en seis subprovincias fisiográficas en los estados mexicanos de Tamaulipas y San Luis Potosí. Se obtuvieron 63 registros recientes; 41 a partir de literatura y 22 de trabajo de campo, entre mayo de 2006 y mayo de 2009. Para realizar el modelo potencial de distribución del ocelote se utilizaron 27 variables entre bioclimáticas, topográficas, de vegetación y antrópicas. El modelo se realizó mediante el uso del programa MaxEnt.

Resultados: El modelo AUC fue de 0.8221 ± 0.009. Las variables que mejor se relacionaron con la presencia del ocelote fueron: precipitación del mes y del trimestre más húmedos, cobertura vegetal, tipo de vegetación, elevación del terreno, precipitación del mes más frío, pendiente del terreno, densidad de población humana y distancia a caminos. La distribución potencial abarcó 20.8 % del total del área de estudio. Las subprovincias fisiográficas que mostraron la distribución potencial más alta fueron: llanuras y lomerios (7.4 %), Carso Huasteco (4.8 %), Gran Sierra Plegada (4.5 %) y sierras y llanuras occidentales (3.4 %). La llanura costera tamaulipeca mostró poca extensión con distribución potencial; en cambio, las llanuras de Coahuila y Nuevo León y las sierras y llanuras del norte de Guanajuato no presentaron evidencia de distribución para el ocelote.

Discusión y conclusiones: Con el fin de obtener el modelo de distribución potencial del ocelote, se utilizó información reciente, obtenida de trabajo de campo y encuestas. Debido a lo anterior, se llegó a un modelo robusto, donde fueron relevantes variables bioclimáticas y del paisaje. Existen parches de hábitat importantes en tamaño y calidad para el ocelote. Las subprovincias fisiográficas con el paisaje más rugoso fueron las que mostraron mayor presencia de la especie. Este trabajo complementa el área de distribución del ocelote en el noreste de México y aporta información importante acerca de la calidad del hábitat, pero también sobre los problemas de conectividad entre las poblaciones de México y las de Estados Unidos.

Keywords: cámaras trampa; felinos neotropicales; MaxEnt; región Huasteca; trabajo de campo.

Introduction

In Mexico, there are six species of wild felids: puma (*Puma concolor*), bobcat (*Lynx rufus*), jaguar (*Panthera onca*), ocelot (*Leopardus pardalis*), jaguarundi (*Puma yagouaroundi*) and margay (*Leopardus wiedii*). All of these species may be found in the Northeastern region of the country, even though the last four are mainly neotropical distributed (Hall 1981; Aranda 2005). These four are also classified as threatened species under Mexican laws (NOM-059-ECOL-2010, SEMARNAT 2010). Specifically, the ocelot is an elusive and adaptable species which has been found in a gradient landscape condition: tropical and subtropical forests, temperate forests, semitropical scrub and semi desert scrub (Martínez-Calderas *et al.* 2011). Nevertheless, in this zone, the landscape has been fragmented (Trejo and Dirzo 2000; Reyes *et al.* 2007) affecting the wild populations connectivity (*e. g.* Wilcove 1985; Gehring 2000; Nupp and Swihart 2000). In this geographical region it may be possible to have certain connectivity between Mexican populations and southern USA populations. For this reason, both governments are interested in the feline long term conservation, by establishing corridors and priority protection areas (Haines *et al*. 2005). Nevertheless, there are no solid bases for such conservation, since just a study are focused on potential priority areas and biological corridors. Grigione and Mrykalo (2009) worked in the American state: Texas, New Mexico and Arizona, as in the Mexican states of Tamaulipas, Nuevo León, Coahuila, Chihuahua and Sonora.

In order to analyze the felids habitat, a great number of variables have been considered: vegetal cover, water sources, weather, altitude (Ortega-Huerta and Medley 1999; Harveson *et al*. 2004; Klar *et al*. 2008; Wolf and Ale 2009), human development and prey availability (Niedziałkowska *et al*. 2006; Doswald *et al*. 2007; Klar *et al.* 2008). One of the most effective tools that is used to predict the wild species potential distribution is the MaxEnt algorithm (MaxEnt, Phillips *et al*. 2006). In comparation with GARP, the other most widely used software, but this was not considered to have a high commission error (rate of false positive predictions) compared to MaxEnt answer (Peterson *et al*. 2007). Furthermore, Maxent, performs a better discrimination of the most significant predictive variables and has a higher precision in the results (Phillips *et al.* 2006). This is based on localities which have shown the presence of the species (Guisan and Zimmermann 2000; Elith *et al.* 2006; Hernandez *et al.* 2006; Pearson *et al.* 2007). Models generated by this algorithm predict and indicate availability of appropriate and inappropriate habitat for the species presence, generating a map which contains all this information (Phillips *et al.* 2006). Despite the adaptation to different and contrasting climatic conditions and types of habitats in the Northeast of Mexico, the ocelot has conservation problems due to illegal hunt, habitat destruction (López-González *et al.* 2003;

Aranda 2005) and feasible isolation within the population. The objective of the current study was to model and identify the ocelot potential distribution in the Northeast region of Mexico, as a basis for strengthening the criteria and the establishment of priority areas and corridors necessary for its conservation.

Methods

Study area. This work was carried out in the Northeast region of Mexico, considering the entire state of Tamaulipas and the central and eastern portion of San Luis Potosí, with an extension of 119,013.7 km^2 (Figure 1). The landscape was fragmented by crop fields, farmer lands, human settlements and roads. Terrain ranges from flat to rugged, meanwhile altitude ranges from 0 to 2,500 m and the annual precipitation varies from 600 to 2,500 mm (INEGI 2002a). In this region it is possible to find several physiographic subprovinces presenting great landscape variation (Cervantes-Zamora *et al.* 1990), each one presenting different kinds of native vegetation or land use (INEGI 2002a). The human settlements and agriculture are located mainly in intermontane valleys and other flat land areas.

Land use areas that may be associated to human activities (agricultural and urban) represent 21.8 %, meanwhile the areas designated for induced vegetation represent 13.2 %, being the most abundant. Natural areas occupy 47.1 % of the study area, where the most extensive is the desert

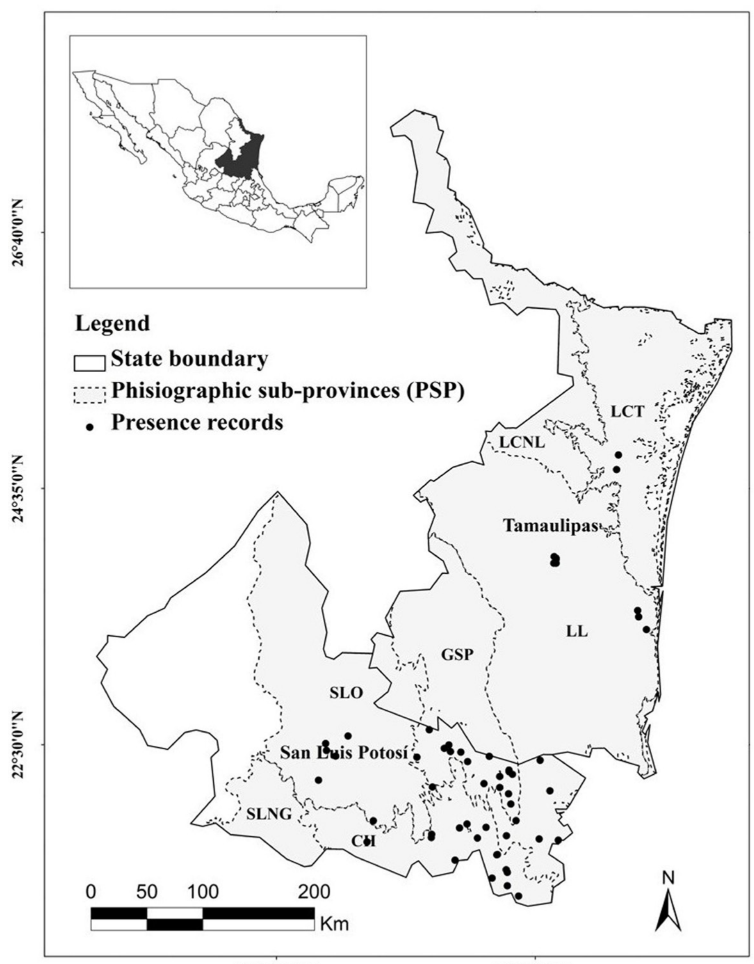

Figure 1. Study area map showing the state of Tamaulipas and San Luis Potosi; physiographic subprovinces (PSP) location and ocelot records location. Abbreviations of PSP: LCNL = Llanuras de Coahuila y Nuevo Leon; LCT = Llanura Costera Tamaulipeca; LL = Llanuras y Lomerios; GSP = Gran Sierra Plegada; SLO = Sierras y Llanuras Occidentales; CH = Carso Huasteco; SLNG = Sierras y Llanuras del Norte de Guanajuato.

scrub with 17.9 % (INEGI 2002a). The most important types of native vegetation are: semitropical thorn scrub, Tamaulipan thorn scrub and tropical deciduous forest. Basically, the physiographic subprovinces (PSP) of llanuras de Coahuila y Nuevo Leon are flat and dominated by induced vegetation (35.4 %) and Tamaulipan thorn scrub (33 %). The physiographic subprovince Llanura Costera Tamaulipeca is dominated by flat land with slight undulations. Here, the predominant land use is mainly agricultural and urban (35.5 %) and Tamaulipan thorn scrub (34.2 %). Llanuras y lomerios subprovince corresponds to a landscape ranging from flat to undulated; predominant land use is induced vegetation (38.7 %) and agricultural and urban (22.6 %). Gran Sierra Plegada corresponds to a karst mountain massif which shows an indefinite orientation and irregular intermontane valleys. Vegetation is constituted by tropical rain forest (34.1 %), pine-oak forest (22 %) and agricultural and urban (20.7 %). Sierras y llanuras occidentales is mainly covered by low mountains with extensive valleys and plains. Desert scrub vegetation (55.8 %) predominates, followed by agricultural and urban (18.7 %) and semitropical thorn scrub (16.9 %). The Carso Huasteco is dominated by abrupt karst mountains (north- south oriented) with intermontane valleys, agricultural and urban (17.9%), oak forest (17.5 %) and semitropical thorn scrub (17.0 %). Sierras y llanuras del norte de Guanajuato present vast mountains with extensive valleys and plains, were grasslands (39.0 %) and desert scrub (31.7 %) predominates (Table 1).

Ocelot records data and environmental predictors. The ocelot presence records (Appendix 1), as well as their geographic location were obtained through two different sources: 41 were obtained from literature (Martínez-Calderas *et al.* 2011), while 22 were collected through field work carried out from December 2008 to September 2010. From the last ones, 12 were obtained by using camera traps, 5 through surveys and 5 through tracks and signs. In order to make the model, 63 ocelot records and 27 variables were employed**:** 19 bioclimatic variables derived from WorldClim 1.4 dataset (Hijmans *et al*., 2005), vegetation cover (Hansen *et al.* 2000), vegetation type (INEGI 2005), digital elevation model (terrain elevation), topographic index, rugosity, slope (terrain slope) (INEGI 2008), distance to roads (INEGI 2002b) and human population density in the year 2000 (CIAT *et al.* 2005). For this purpose, a spatial 30 arc-seconds (~1 km) resolution was chosen. With the aim of minimizing the collinearity between variables, a Pearson correlation with ENM Tools 1.4 software was performed (Warren *et al.* 2009), selecting those with absolute value of correlation coefficients r < 0.5 (Booth *et al.* 1994; Rissler and Apodaca 2007; Dortmann *et al.* 2012).

Potential distribution modeling. In order to generate the ocelot potential distribution map we may use the MaxEnt software (version 3.3.3k) based on maximum entropy algorithm (Phillips *et al.* 2006). The following default settings were chosen: maximum number of background points = 10,000, regularization multiplier = 1, replicates = 20, replicate run type = bootstrap, convergence threshold = 0.00001 and maximum iterations number = 10,000. From the occurrence data 70 % (44 records) were used as training data set, while 30 % (19 records) were used as test data set. The logistic MaxEnt output presented prediction values ranging from 0 (unsuitable habitat) to 1 (optimal habitat). With the purpose of validating the model performance, omission error weight and commission error equally, were considered for the area under curve (AUC), which is generated by the algorithm (Hernandez *et al.* 2006) and is directly obtained from the model evaluation through ROC curves (*i. e.* Contreras-Medina *et al.* 2010).

Furthermore, the variables were assessed through a jackknife test which compares the models with all the possible combinations of environmental variables by measuring the variable importance. This expressed the relative importance of each predictor variable (in a separate way) in order to determine the percentage that each one provides to the model. Results obtained from the model (ASCII format) were processed and reclassified using ArcGIS (ESRI 2006). The binary map (absence-presence) for the ocelot potential distribution was generated (Figure 2), considering the average map that represents the induced and adjusted habitat of the species (Anderson *et al.* 2003; Burneo *et al.* 2009). For this purpose, the minimum presence training was employed as threshold reclassification (0.3575). Lastly, the map and levels were used for calculating the potential distribution area, showing the total area percentage for each SPF.

Results

The calculated average training AUC for the replicate run was of 0.8221 (± 0.009), indicating a excellent model (Hosmer and Lemeshow 2000). Based on the Pearson correlation, only nine variables were employed for the model generation. The most important variables (Table 2) for the ocelot potential distribution were: precipitation (wettest month, wettest quarter and coldest quarter), vegetation cover and type, terrain elevation and slope, human population density, and distance to roads. Collectively, these variables account for 100 % of the explained variance in the species distribution. The implication of predictive variables in regards of the ocelot distribution in Northeastern Mexico was reflected in the patches preserved for species development (Figure 2).

The ocelot potential distribution area in Northeastern Mexico covers 20.8 % of the study area. The physiographic subprovinces which presented the highest potential distribution relative to the total study area, were: llanuras y lomerios (7.4 %), Carso Huasteco (4.8 %), Gran Sierra Plegada (4.5 %) and sierras y llanuras Occidentales (3.4 %). On the other hand, llanura costera Tamaulipeca, llanuras de Coahuila y Nuevo León and sierras y llanuras del norte de Guanajuato subprovinces show a percentage of less than 0.8 % and while the last two show a percentage of less than 0.1 % (Table 3). The physiographic subprovinces which presented the highest potential distribution, relative to the each subprovince area, were: Carso Huasteco (59.9 %), Gran Sierra

Table 1. Vegetation types and land use percentage within physiographic subprovinces on the study area.

Vegetation types and land use	LCNL	LCT	LL	GSP	SLO	CH	SLNG	Total
Agricultural and urban	11.8	35.5	22.6	20.7	18.7	17.9	7.3	21.8
Induced vegetation	35.4	14.2	38.7	0	1.9	4.7	2.4	13.2
Desert scrub	12.6	0	0	9.8	55.8	4.2	31.7	17.9
Halophyte vegetation	0.8	10.3	0	0	0	0.5	0	1.7
Grassland	0	0	0	0	1.9	0	39	2.1
Oak forest	0	0	0	6.1	2.2	17.5	4.9	5
Pine-oak forest	0	0	0	22	0.4	10.4	2.4	4.2
Clouded forest	0	0	0	1.2	0	1.4	0	0.4
Tamaulipan thorn scrub	33	34.2	14.8	0	0	0	0	8.9
Semitropical thorn scrub	6.2	0	4.6	6.1	16.9	17	0	9.7
Tropical deciduous forest	0	1.9	16	0	0	8.5	0	6
Tropical rain forest	0	0	0	34.1	0	4.7	0	3.8
Tropical forest	0	0	2.9	0	0	6.6	0	2.1
Other	0.2	3.9	0.4	0	2.2	6.6	12.2	3.2

LCNL = llanuras de Coahuila y Nuevo Leon; LCT = llanura Costera de Tamaulipas; LL = llanuras y Lomeríos; GSP = Gran Sierra Plegada; SLO = sierras y llanuras Occidentales; CH = Carso Huasteco; SNG = sierras y llanuras del Norte de Guanajuato.

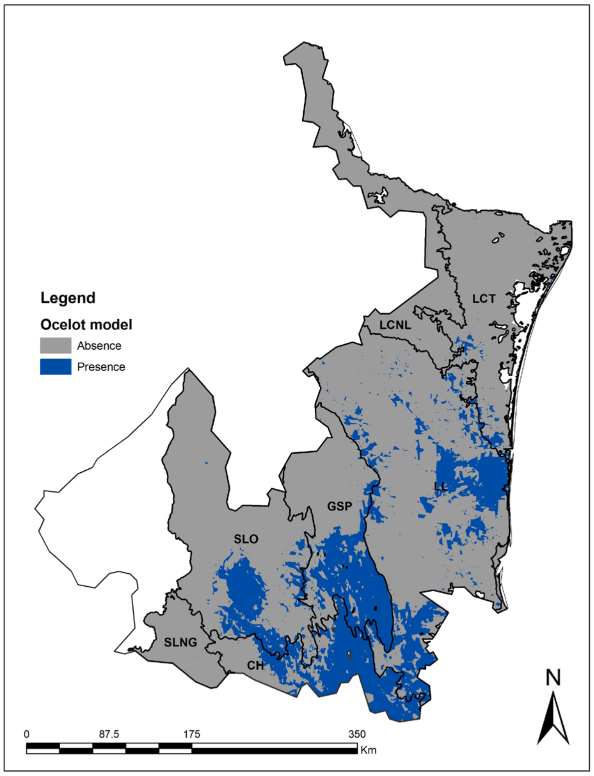

Figure 2. Potential distribution of ocelot in NE Mexico.

Plegada (36.9 %), llanuras y lomerios (22.4 %) and sierras y llanuras occidentales (16.9 %). The other physiographic subprovinces showed less than 5 %.

Discussion

The model which was used to generate the ocelot distribution map was robust for both model training and test confirmation, making our results reliable. In order of importance, the most significant variables were related to climate, landscape and human activities. In the case of landscape, the most important were terrain elevation, vegetation type and cover.

Based on our map, we may confirm that landscape is extremely fragmented with a heterogeneous patch distribution (size and location). Some patches are large and continuous even between adjacent physiographic subprovinces, while other appear to be small and isolated. Some physiographic subprovinces as Carso Huasteco, Gran Sierra Plegada, llanuras y lomerios and sierras y llanuras occidentales have preserved sites representing a suitable habitat for the species development. In Carso Huasteco, sierras y llanuras occidentales, llanuras y lomerios and llanura costera Tamaulipeca subprovinces the records were abundant; while in llanuras de Coahuila y Nuevo Leon and sierras y llanuras del norte de Guanajuato there were no records and ocelot potential distribution were minimal.

In our model, precipitation climatic variables during the wettest month and quarter (first and second, in order of importance) and coldest quarter (sixth in importance) presented the highest contribution to the ocelot distribution. It must be said that the kind of weather determines the most favorable habitat. Furthermore, it explains the ocelot distribution in the physiographic subprovinces where there is an appropriate habitat. Globally, this species is found in areas with predominant humid tropical

Table 2. Relevant variables for the ocelot potential distribution map in NE Mexico.

Variable	Contribution, %	Cumulative contribution %
Precipitation of wettest month	41.4	41.4
Precipitation of wettest quarter	17	58.4
Vegetation coverage	11.3	69.7
Vegetation type	6.7	76.4
Terrain Elevation	5.6	82
Precipitation of coldest quarter	4.9	86.9
Terrain slope	4.8	91.7
Density of human population	4.2	95.9
Distance to roads	4.1	100

climate (Vaughan 1983; Emmons 1988; Di Bitetti *et al.* 2006; Moreno and Giacalone 2006; Dillon y Kelly 2007); nevertheless, ocelots may be found in sub humid climates (Ludlow and Sunquist 1987; Trolle and Kerry 2003; Maffei *et al.* 2005). Furthermore, in its most Northern distribution of Mexico and the USA, ocelot also inhabit drier environments (Caso 1994; Martínez-Meyer 1997; Harveson *et al.* 2004).

Habitually, human disturbance is related to the ocelot absence. In this regard, Jackson *et al.* (2005) has reported that ocelots do not live in areas which present a high degree of disturbance. Several authors have mentioned that the wild felids are negatively affected by human settlements and road density *(e. g.* Woodroffe 2000; Cain *et al.* 2003; Grigione and Mrykalo 2009). The human population density in year 2000 occupied the third place in the list of variables regarding the ocelot distribution. However, we have found physical evidence of two ocelots wandering within small towns (inside a house and a yard); other four animals were seen in the vicinity. One of the reasons of the ocelot presence in small towns is represented by domestic animals and trash which is an alternative food source. In all the rural communities where ocelots were found, dense vegetation was predominant. Even so, the highest ocelot presence was found in areas showing a lower degree of disturbance.

The Carso Huasteco is a physiographic subprovinces which presents numerous human settlements; and where the largest city in the region (Ciudad Valles) is located.

Table 3. Potential distribution area for the ocelot in each physiographic subprovinces of the study area.

Name	Total	Potential habitat		Rtph**
	Km²	Km²	%*	%
Carso Huasteco	9,506.2	5,698.1	59.9	4.8
Gran Sierra Plegada	14,459.3	5,337.3	36.9	4.5
Llanuras y Lomerios	39,215.2	8,789.8	22.4	7.4
Sierras y Llanuras Occidentales	23,743.2	4,015.1	16.9	3.4
Llanura Costera Tamaulipeca	16,383.9	805.6	4.9	0.7
Llanuras de Coahuila y Nuevo Leon	11,351.3	57.8	0.5	0.1
Sierras y Llanuras del Norte de Guanajuato	4,354.6	3.7	0.1	0.0
Total of the study area	119,013.7	24,707.4	20.8	20.8

* Potential habitat percentage to each physiographic subprovince.
**Rtph: relative to the total area of potential distribution in the study area.

Nevertheless, this subprovinces represents a large proportion of areas offering suitable climate and habitat for the species. The Gran Sierra Plegada and sierras y llanuras occidentales subprovinces are less populated, maintaining a better potential distribution. In contrast, llanuras y lomerios is fragmented by settlements and occupies the third place in the potential distribution for this species. The llanura Costera Tamaulipeca is basically populated by humans and its potential distribution area is low. According to our results, the antagonistic effect of human density in regards to the ocelot presence is not clear. Possibly, it interferes with the existence of good conditions habitat patches, requiring further research. The study area still presents certain patches which show good condition.

Vaughan (1983) and Nowell and Jackson (1996) mentioned that this kind of feline prefers altitudes below 1200 m. Similar results were found where altitudinal gradients included a wide variety of habitat types (whether the habitats were suitable for ocelots or not). This species prefers habitats which present native vegetation (Nowell and Jackson 1996; Harveson *et al.* 2004; Aranda 2005) and dense cover (Jackson *et al.* 2005). High vegetation cover can improve the ocelot predatory skills, as it allows the animal to hide from its prey, especially during full moon periods (Emmons *et al.* 1989). In areas presenting limited vegetation cover, the ocelot is forced to use less dense areas (Caso 1994). We found continuity in potential distribution patches where this felid is well protected. Tewes and Hughes (2001) points out that roads are responsible of increasing the ocelot accidental death. Additionally, roads affect the ocelot distribution as they limit its mobility and gene flow between populations (Haines *et al.* 2005). Nonetheless, most of our records were located near roads.

Based on historical records from 1900 to 2002, and other opinions given by experts about biology and distribution of jaguar, ocelot and jaguarondi, it was possible to identify and delimit conservation areas of these wild felids in USA and NE Mexico (Grigione *et al.* 2009). However, the obtained information was not entirely accurate due to the fact that the main methodology used was "expertise opinion", which may be biased. Commonly, experts manifest contradictory or incompatible opinions resulting in inaccurate or subjective information (Bojorquez-Tapia *et al.* 2003). Grigione *et al.* (2009) points outs certain differences between the ocelot conservation areas and some other areas which represent a high potential distribution for the species. There are some contrasting results regarding the potential distribution areas in some portions. In our research, we increased the regional distribution of this species, including the central portion of the physiographic subprovince sierras and llanuras occidentales in San Luis Potosi. In Tamaulipas and San Luis Potosí, the potential distribution for the ocelot encompasses a variety of vegetation types, where dense vegetation cover is highly suitable, especially in the physiographic subprovinces Carso Huasteco, Gran Sierra Plegada and llanuras y lomerios. In the same manner, Grigione *et al.* (2009) identified portions of the region that may be important for long term ocelot conservation. Also, they mentioned areas with very high priority in the northeast of llanura costera Tamaulipeca. Instead, we found that this area does not have potential habitat. In addition, Grigione *et al.* (2009) have proposed an ocelot corridor that runs from the middle of the state of Tamaulipas northwards; however, we identified only scarce patches of potential habitat in that area.

The differences between the study Grigione *et al.* (2009) and ours are an example of the need for more accurate information and intensive field work, such as that undertaken in this study. However, both studies complement the distributional range of species in Northeastern Mexico and provides important information about the habitat quality in this portion of the country. In the same way, it provides information about the necessities for a correct connectivity with the southern USA populations, where now we can observe an unfavorable scenario with small and discontinuous patches. Through bi-national and long term conservation efforts, policies should be focused on minimizing the habitat loss, enhancing the habitat restoration and encouraging ecological and population studies. A key factor is to consider both the ocelot and the people needs.

Acknowledgments

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Appendix 1

Information about the ocelot records in Northeastern Mexico. Records obtained from literature are of Martínez-Calderas *et al.* 2011. Longitude = Long, latitude = Lat, % of cover = Cv , elevation in meters = Ev, degree of the slope = S, Human density = HD, meter to road = mR, meters to towns = mT. SPS: Physiographic Subprovinces LCT = llanura costera de Tamaulipas; LL = llanuras y lomeríos; GSP = Gran Sierra Plegada; SLO = sierras y llanuras occidentales; CH = Carso Huasteco.

					Vegetation	Terrain				Distance to	
No	Long	Lat	SPS	Source	Type	Cv	Ev	S	HD	mR	mT
1	-99.097	21.413	CH	Literature	Pine-oak forest	95	2,400	30	50	5,882	2,782.8
2	-99.437	22.439	GSP	Literature	Clouded forest	80	1,800	25	23	3,006	3183
3	-99.138	21.836	CH	Literature	Tropical forest	87	138	5	4	958	1,247.6
4	-98.884	21.266	CH	Literature	Tropical rain forest	92	985	45	255	176	467.8
5	-98.565	21.723	LL	Literature	Currently crop field	0	38	0	52	1,230	563
6	-100.437	22.507	SLO	Literature	Semitropical thorn scrub	89	1,472	30	0	336	2,264.9
7	-100.355	22.410	SLO	Literature	Semitropical thorn scrub	80	1,300	15	14	1,070	1497
8	-100.466	22.509	SLO	Literature	Semitropical thorn scrub	85	1,510	20	0	2,178	154
9	-100.430	22.450	SLO	Literature	Semitropical thorn scrub	89	1,241	10	0	2,139	875.9
10	-98.633	22.123	LL	Literature	Tropical deciduous forest	87	49	5	18	856	2,788.4
11	-99.585	21.774	CH	Literature	Semitropical thorn scrub	93	851	10	13	508	899.6
12	-98.905	21.881	GSP	Literature	Tropical deciduous forest	95	150	0	78	509	379
13	-98.905	21.881	GSP	Literature	Tropical deciduous forest	90	76	10	78	51	124
14	-98.905	21.881	GSP	Literature	Tropical deciduous forest	95	76	5	78	51	1409
15	-99.060	21.603	CH	Literature	Tropical forest	90	468	20	21	54	371
16	-99.347	22.441	GSP	Literature	Oak forest	90	260	45	2	2,850	2,991.4
17	-99.218	21.745	CH	Literature	Tropical forest	95	638	10	1	3,082	108
18	-99.332	22.520	GSP	Literature	Currently crop field	0	270	10	7	0	0
19	-99.332	22.520	GSP	Literature	Currently crop field	0	270	10	7	0	0
20	-98.973	21.461	CH	Literature	Tropical rain forest	97	120	15	128	1,087	221
21	-98.760	21.379	CH	Literature	Tropical rain forest	95	152	10	2	224	228
22	-99.394	22.105	CH	Literature	Oak forest	90	800	5	10	2,489	467
23	-100.258	22.568	SLO	Literature	Semitropical thorn scrub	79	1,353	0	16	10	100
24	-99.060	21.603	CH	Literature	Tropical forest	88	448	5	20	0	10
25	-98.951	22.017	GSP	Literature	Tropical deciduous forest	98	211	15	273	220	202
26	-98.965	22.100	GSP	Literature	Tropical deciduous forest	80	230	5	149	592	1,168
27	-99.034	22.235	GSP	Literature	Tropical deciduous forest	82	202	15	138	484	2,724
28	-99.122	22.407	GSP	Literature	Tropical deciduous forest	85	267	10	18	671	1292
29	-100.057	21.759	GSP	Literature	Semitropical thorn scrub	85	1,170	35	31	399	220
30	-98.701	22.396	LL	Literature	Tropical deciduous forest	83	30	5	1	1,711	6,387
31	-99.587	21.744	CH	Literature	Semitropical thorn scrub	93	764	40	6	48	154
32	-99.299	21.854	CH	Literature	Tropical deciduous forest	92	450	10	11	117	313
33	-99.360	21.822	CH	Literature	Oak forest	89	628	5	6	187	4,79.4
34	-99.036	22.151	GSP	Literature	Tropical deciduous forest	85	146	0	16	1,218	1,197
35	-99.163	22.183	GSP	Literature	Tropical deciduous forest	82	480	0	7	2,782	2,084
36	-99.184	22.252	GSP	Literature	Tropical deciduous forest	87	520	15	1	2,696	2,922
37	-99.445	22.497	GSP	Literature	Oak forest	80	1,058	25	23	98	235

Continuación Apendice I

					Vegetation		Terrain			Distance to	
No	**Long**	**Lat**	**SPS**	**Source**	**Type**	**Cv**	**Ev**	**S**	**HD**	**mR**	**mT**
38	-99.482	22.470	GSP	Literature	Oak forest	75	1,119	5	39	0	943
39	-99.603	22.621	GSP	Literature	Oak forest	92	1,300	35	11	1,737	1,362
40	-99.578	22.155	GSP	Literature	Desert scrub	86	1,480	20	1	29.3	1,875
41	-100.495	22.211	SLO	Literature	Semitropical thorn scrub	78	1,640	45	2	1,554	1,918
42	-98.597	24.029	LL	Camera trap	Tamaulipan thorn scrub	91	251	15	3	10	2,000
43	-98.583	24.016	LL	Camera trap	Tamaulipan thorn scrub	98	229	0	3	100	2,480
44	-98.601	23.976	LL	Camera trap	Tropical deciduous forest	95	95	0	3	25	8,908
45	-98.583	24.007	LL	Camera trap	Semitropical thorn scrub	80	95	14	3	2,000	2,600
46	-98.599	23.977	LL	Camera trap	Tropical deciduous forest	95	230	0	3	25	8,900
47	-97.863	23.601	LL	Camera trap	Tropical deciduous forest	92	82	45	4	25	900
48	-97.925	23.591	LL	Camera trap	Tropical deciduous forest	96	125	12	4	700	590
49	-97.917	23.539	LL	Camera trap	Tropical deciduous forest	80	80	20	4	400	900
50	-98.081	24.856	LCT	Camera trap	Tamaulipan thorn scrub	90	31	35	42	200	850
51	-98.095	24.738	LCT	Camera trap	Tamaulipan thorn scrub	100	10	10	10	10	1,200
52	-98.610	24.026	LL	Camera trap	Tamaulipan thorn scrub	100	225	5	3	867	2,300
53	-98.961	22.290	GSP	Camera trap	Tropical deciduous forest	99	397	30	7	5,378	7,457
54	-98.936	22.263	GSP	Tracks and signs	Tropical deciduous forest	98	348	32	4	7,897	7,572
55	-99.277	22.398	GSP	Tracks and signs	Tropical deciduous forest	98	266	10	2	1,888	3,459
56	-99.126	21.489	CH	Tracks and signs	Tropical deciduous forest	100	1,306	20	78	4,036	4,058
57	-99.014	21.449	CH	Tracks and signs	Tropical forest	79	900	5	2	663	557
58	-98.901	22.069	GSP	Tracks and signs	Tropical forest	100	488	38	70	2,435	2,996
59	-98.914	22.060	GSP	Tracks and signs	Tropical forest	98	402	35	135	689	803
60	-99.361	22.381	GSP	Surveys	Tropical deciduous forest	88	876	12	1	505	1614
61	-99.332	22.384	GSP	Surveys	Tropical deciduous forest-Oak forest	90	773	5	2	1,721	607
62	-99.292	22.249	GSP	Surveys	Tropical forest	87	308	0	1	200	616
63	-98.893	21.914	GSP	Surveys	Tropical deciduous forest	92	31	8	135	3,499	2,038