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DETERMINACIÓN DE CATEGORÍAS DE RIESGO BAJO UN CONTEXTO GEOGRÁFICO, PARA LAS ESPECIES DE VERTEBRADOS ENDÉMICOS DE MÉXICO A PARTIR DE MODELOS DE NICHO ECOLÓGICO

TESIS

QUE PARA OPTAR POR EL GRADO DE:

MAESTRO EN CIENCIAS BIOLÓGICAS

PRESENTA:

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P r e s e n t e

Me permito informar a usted que en la reunión del Subcomité por Campo de Conocimiento de Ecología y Manejo Integral de Ecosistemas, Biología Evolutiva y Sistemática del Posgrado en Ciencias Biológicas, celebrada el día 4 de noviembre de 2019, se aprobó el siguiente jurado para el examen de grado de **MAESTRO EN CIENCIAS BIOLÓGICAS** en el campo de conocimiento de **ECOLOGÍA** del alumno **MAYANI PARÁS FERNANDO** con número de cuenta **306508668** con la tesis titulada **"Determinación de categorías de riesgo bajo un contexto geográfico, para las especies de vertebrados endémicos de México a partir de modelos de nicho ecológico"**, realizada bajo la dirección del **DR. VÍCTOR MANUEL GUILLERMO SÁNCHEZ CORDERO DÁVILA,** quedando integrado de la siguiente manera:

Presidente:	DRA. LETICIA MARGARITA OCHOA OCHOA
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Sin otro particular, me es grato enviarle un cordial saludo.

A T E N T A M E N T E
"POR MI RAZA HABLARA EL ESPÍRITU"
Ciudad Universitaria, Cd. Mx., a 27 de noviembre de 2019.

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"No le digas que quieres recombinar su ADN con el tuyo, que juntos pueden ayudar con la selección natural. Dile que es el fenotipo más bello que una cadena de nucleótidos puede codificar.

No le digas que si fueses un ser fotosintético ella sería la luz que provoca excitación en tu clorofila. Dile que es la razón de que tu hipotálamo segregue la dopamina y oxitocina cada que la ves.

No sólo le digas que juntos son tan buena pareja como Watson y Crick. Dile que sea la guanina de tu citosina.

Dile que es la vesícula que te ayuda a sacar lo impuro, el lisosoma que degrada lo extraño en ti, la mitocondria que te llena de energía.

Dile que a pesar de no ser una simbiosis, su relación interespecífica es de mutualismo.

Dile que hace interferencias en tu sinapsis y que tu miocardio realiza sístole y diástole con rapidez cuando ella está cerca, que la fagocitarías a besos, que cuando estás con ella sientes un desequilibrio en tu homeostasis y que la llevas bajo la dermis.

Dile que es hexoquinasa para tu glucólisis, ciclinas para tu ciclo celular y polimerasa I para tu transcripción.

Pero sobre todo, dile que después de la biología, es lo mejor que ha llegado a tu vida."

(Tú eres mejor que la biología)

INDICE

RESUMEN EN ESPAÑOL

México es el cuarto país con el mayor número de especies de vertebrados, gran parte de ellos endémicos. Sin embargo, la pérdida de hábitat debido a las actividades antropogénicas pone en riesgo a la biodiversidad y puede llevar a la extinción o extirpación local de especies a corto, mediano o largo plazo. Evaluar el riesgo de extinción es fundamental para entender el estado actual de las especies y así poder conservar a las especies de manera adecuada. El riesgo de extinción de especies generalmente se analiza a nivel de su distribución completa (Unión Internacional para la Conservación de la Naturaleza) o a nivel nacional (Norma Oficial Mexicana), sin embargo en este trabajo consideramos que para establecer criterios apropiados de conservación también es necesario realizar análisis a nivel regional ya que puede permitir que entendamos cómo se encuentra la especie en cada región de su distribución (i.e. ecoregiones).

Con modelos de nicho ecológico obtuvimos la distribución potencial de 311 especies de vertebrados terrestres endémicos de México, así como su distribución actual al considerar únicamente las áreas con hábitat natural remanente. Se analizó la pérdida de cobertura vegetal, principalmente por agricultura, ganadería y zonas urbanas, y la disminución en la distribución de especies a nivel nacional para 6 diferentes periodos de tiempo con el fin de observar la disminución en la distribución de especies a lo largo del tiempo, así como la disminución en cada ecorregión del país para encontrar las áreas donde en promedio las especies han sido más afectadas. Posteriormente, se analizó el impacto combinado de la pérdida de cobertura vegetal y la minería sobre la distribución de especies de anfibios y reptiles endémicos de México, ya que la minería es un impacto humano que hasta el momento ha sido poco considerado en las evaluaciones de riesgo de extinción de especies pero que supone un gran riesgo para estas. Finalmente, se evaluó el riesgo de extinción de las 311 especies de vertebrados a nivel nacional, considerando los criterios y categorías de la UICN y los de la NOM-059-SEMARNAT utilizando los modelos de nicho ecológico como base para evaluar los criterios, y a nivel regional utilizando una propuesta de modificación a la NOM-059-SEMARNAT. Con esto se presenta una manera estandarizada de realizar las evaluaciones y una investigación a nivel regional para saber cómo se encuentran las especies por región.

El hábitat natural dentro de la distribución de las especies analizadas disminuyó significativamente entre 1986 y 2002, año a partir del cual la disminución no fue significativa debido a la reducción de las tasas de deforestación. Solo 84 especies (27% del total de especies analizadas) han mantenido >70% de hábitat no transformado dentro de su área de distribución, mientras que 160 especies (51.44%) han perdido ≥30%, 65 especies (20.90%) han perdido ≥50% y 2 especies (0.64%) han perdido ≥80% de su distribución. Las especies que se encuentran de las ecoregiones del Eje Neovolcánico, el Golfo de México y la Península de Yucatán sufrieron una mayor reducción en su distribución que las especies en otras ecoregiones, llegando a perder en promedio ≥80% de su distribución en esas ecoregiones. Además, la minería incrementó la pérdida de distribución de todas las especies de anfibios y reptiles, lo que sugiere que es un factor importante que podría incrementar el riesgo de extinción de especies, siendo este trabajo el primero en abordar el impacto combinado de la pérdida de hábitat y la minería sobre las especies. Finalmente, un mayor número de especies se consideraron en riesgo al usar los criterios de la NOM-059-SEMARNAT que los de la UICN. Con los criterios de la UICN solo 38 (12.21%) de las especies analizadas se consideraron en riesgo (13 anfibios, 3 aves, 7 mamíferos y 15 reptiles), mientras que 300 especies (60 anfibios, 76 aves, 49 mamíferos y 115 reptiles) entraron en alguna categoría de riesgo al usar los métodos de la NOM-059-SEMARNAT. Al evaluar el riesgo a nivel local, para cada especie se obtuvo su riesgo de extinción por ecoregión. Las especies que se encuentran en las ecoregiones de los desiertos mexicanos, la altiplanicie mexicana, la Sierra Madre Occidental y la Sierra Madre del Sur no se encuentran en riesgo o están bajo protección especial, mientras que las especies ubicadas en el Eje Neovolcánico Transversal, la Península de Yucatán y el Golfo de México, en donde predominan las sierras templadas y bosques tropicales húmedos, fueron las más afectadas y se encuentran amenazadas o en peligro de extinción.

Evaluar el riesgo de extinción de especies a ecalas ecoregionales es importante y clave para determinar el tipo de acciones de conservación. Las poblaciones de una misma especie podrían encontrarse en mayor riesgo de extirpación en una zona que en otra dependiendo el grado de antropización y esta condición se debería ver reflejada en análisis de priorización de conservación regional. Nuestro estudio es el primero en proponer los análisis de riesgo a escala regional y provee un método estandarizado, replicable y objetivo para realizar las evaluaciones.

RESUMEN EN INGLÉS

Mexico is the fourth country with the most vertebrate species, a large part being endemic. However, habitat loss due to anthropogenic activities threatens biodiversity and can lead to species´ extinction or regional extirpation in the short, medium or long term. Assessing extinction risk is essential to understand the current status of the species and thus be able to conserve them properly. Usually the risk status of the species is analyzed at the level of their entire distribution (International Union for Conservation of Nature) or at the country level (Mexican Official Norm), but in this study we consider that to establish appropriate conservation criteria it is also necessary to conduct analysis at a regional level since it could allow us to understand the status of the species at each region of its distribution (i.e. ecoregions).

With ecological niche models we obtained the potential distribution of 311 Mexican terrestrial endemic vertebrate species, as well as their extant distribution by considering only the areas with remnant natural habitat. We analyzed vegetation cover loss, specially due to agriculture, cattle raising and urban areas, and species distribution reduction at a national level at 6 different periods of time to observe the loss in species distributions over the years, as well as the reduction at each ecoregion of the country to know the areas where on average species have been most affected. We then analyzed the combined impact of vegetation cover loss and mining activities in Mexican endemic amphibian and reptile species, since mining is a human impact that so far has been little considered in the extinction risk assessments but suppose a big threat for species. Finally, we assessed extinction risk for the 311 vertebrate species at a national level, considering both IUCN and NOM-059-SEMARNAT criteria and categories using ecological niche models as the basis for assessing the criteria, and at a regional level using a proposed modification to NOM-059-SEMARNAT. A standardized way of conducting the assessments is presented here, as well as a regional research to find out how species are found by region.

The natural habitat within the distribution of the analyzed species decreased significantly between 1986 and 2002, year after which there was no significant reduction due to the decline in deforestation rates. Only 84 species (27% of the total analyzed species) have retained >70% of untransformed habitat within their distribution, while 160 species (51.44%) have lost ≥30%, 65 species (20.90%) have lost ≥50% and 2 species (0.64%) have lost ≥80% of their distribution. Species in the ecoregions of the Transvolcanic Belt, the Gulf of Mexico and the Yucatan Peninsula suffered greater distribution reduction than species in other ecoregions, some losing on average ≥80% of their distribution in those ecoregions. In addition, mining increased the distribution loss of all amphibian and reptile species, suggesting that it is an important factor that could increase the risk of species extinction, our study being the first one to address the combined impact of loss of habitat and mining on species. Finally, a greater number of species were considered at risk when using the NOM-059-SEMARNAT criteria than the IUCN criteria and categories. With the IUCN criteria and categories, only 38 (12.21%) of the analyzed species were considered at risk(13 amphibians, 3 birds, 7 mammals and 15 reptiles), while 300 species (60 amphibians, 76 birds, 49 mammals and 115 reptiles) entered some category of risk using the methods of the NOM-059-SEMARNAT. When assessing the risk at a local level, we obtained the extinction risk for each species by ecoregion. The species found in the ecoregions of the Mexican deserts, the Mexican high plateau, the Southern Sierra Madre and the Western Sierra Madre are not at risk or are under special protection, while the species located at the Transmexican Volcanic Belt, the Yucatan Peninsula and the Gulf of Mexico, where temperate Sierras and tropical humid forests predominate, were the most affected and are threatened or endangered.

Assessing species extinction risk at ecoregional levels, is important and key to determine the type of conservation actions. Populations of the same species could be at greater risk of extirpation in one area than in another depending on the degree of anthropization and this condition should be reflected in regional conservation prioritization analysis. Our study is the first to propose risk analyzes at a regional level and provides a standardized, replicable and objective method to perform assessments.

INTRODUCCIÓN GENERAL

La diversidad biológica está disminuyendo, con tasas de extinción actuales de 100 a 1,000 veces mayores a la tasa basal (Pimm et al., 2014; Ceballos et al., 2015), lo que sugiere que estamos entrando a una sexta extinción masiva (Barnowsky et al., 2011). De acuerdo a las estimaciones, en el planeta existen entre 5 y 9 millones de especies de animales, de los cuales estamos perdiendo entre 11 000 y 58 000 anualmente (Mora et al., 2013; Scheffers et al., 2012). En cuanto a vertebrados, al menos 322 especies se han extinto en los últimos 500 años (IUCN, 2019; Hoffman et al., 2010), 14-40% de las especies están amenazadas dependiendo de la clase (IUCN, 2019) y el número de individuos ha disminuido 28% (Butchart et al., 2010; Collen et al., 2009).

México, gracias a su alta diversidad de climas, su compleja topografía, su historia geológica y su ubicación geográfica, alberga al menos al 10% de la diversidad biológica del mundo, lo que lo convierte en uno de los países catalogados como megadiversos- países que alojan entre el 60 y 70% de la diversidad conocida en el planeta (Conabio, 2009). Aproximadamente 5 700 especies de vertebrados existen en el territorio mexicano, 9% de las especies del mundo, siendo el cuarto país con el mayor número de especies. Entre estos, es el segundo en número de especies de reptiles, segundo en mamíferos, cuarto en anfibios y décimo primero en aves. Pero además es un país con un alto grado de endemismos. Se calcula que el 66% de los anfibios, 56% de reptiles, 29% de mamíferos y 17% de las aves solo se distribuyen en nuestro país (Conabio, 2015). Sin embargo, la tasa de deforestación anual en México es mayor al 1% a nivel nacional (Sarukhán et al. 2009). En los últimos 50 años se han perdido más de 13.5 millones de hectáreas de vegetación, lo que ha llevado a que solamente alrededor del 70% de la superficie del país se encuentre cubierto por comunidades naturales y solo el 48% del territorio nacional conserve su estado primario. Esto significa que se están perdiendo de manera acelerada aquellas áreas donde su vegetación mantiene la mayoría de sus especies originales, donde no se han alterado los procesos ecológicos, donde no hay una perturbación considerable y que son importantes por su biodiversidad y los servicios ecosistémicos que ofrecen (Semarnat, 2016). Esta pérdida de hábitats naturales debido a las actividades humanas pone en peligro a la biodiversidad al disminuir la riqueza de especies, la abundancia de sus poblaciones, su diversidad genética y sus patrones de dispersión (Best et al., 2001; Challenger y Dirzo, 2009; Fahrig, 2003; Steffan-Dewenter et al., 2002; Vernier y Fahrig, 1996), lo que puede llevar a la extinción de las especies a corto, mediano o largo plazo.

Aunque los índices de pérdida de hábitat se han asociado con la pérdida de diversidad biológica (Toledo et al., 1989; Myers, 1998; Kinnaird et al., 2003), pocos estudios en México han analizado el impacto de la pérdida de hábitat a nivel de especies (Sánchez-Cordero et al. 2005a,b; Botello et al., 2015). Es por esto que existe la necesidad de llevar a cabo estudios que ayuden a entender el estado actual de las especies, estudiando su distribución y la pérdida de su hábitat de manera individual, para así poder generar proyectos de conservación específicos y anticipar su extinción. Una manera de estudiar el impacto de la pérdida de hábitat sobre la distribución de las especies a diferentes niveles de estudio es con los modelos de nicho ecológico o modelado de distribución potencial de especies (Peterson et al., 2000; Ortega-Huerta y Peterson, 2004; Sánchez-Cordero et al., 2005a,b; 2009). Existen diferentes definiciones de nicho ecológico de una especie. Hutchinson (1957) lo definió como la serie de condiciones bióticas y abióticas que dan lugar a un "hiperespacio" dentro del cual la especie puede sobrevivir y reproducirse. Soberón y Nakamura (2009) propusieron un modelo llamado *Diagrama BAM* (Figura 1), representado por un diagrama de Venn. Este diagrama es una representación del espacio ecológico y geográfico donde se relacionan las tres regiones del nicho ecológico descrito por Hutchinson: Biótico, Abiótico y Movimiento. La región *B* representa las regiones en el espacio donde las condiciones bióticas (competidores, depredadores, enfermedades) son favorables para que la especie tenga poblaciones viables. La región *A* representa las regiones con variables ambientales ideales para al especie. Una especie en teoría puede sobrevivir donde se encuentran estas dos regiones (*G1*) y es un espacio potencial de distribución, pero solo estará ahí si es un lugar accesible. A la región que ha sido accesible para la especie en algún periodo de tiempo gracias a su capacidad de dispersión y colonización y a la estructura existente de la geografía le llamamos *M*, y la especie existirá donde se encuentran las tres regiones del modelo *BAM* (*G0*). Por lo tanto, los modelos de nicho ecológico son modelos empíricos que buscan encontrar estas áreas que cuenten con las características adecuadas para las especies conocidas. Sin embargo, es muy difícil integrar las variables biológicas (la parte *B* del diagrama de *BAM*) y por lo tanto usualmente se utiliza solamente las variables no interactivas, las ambientales. Al integrar puntos georreferenciados de ocurrencia de las especies con variables ambientales usando sistemas de información geográfica, las áreas adecuadas para las especies se pueden identificar como distribuciones potenciales de las especies (Guisan y Thuiller, 2005; Merlow et al., 2013).

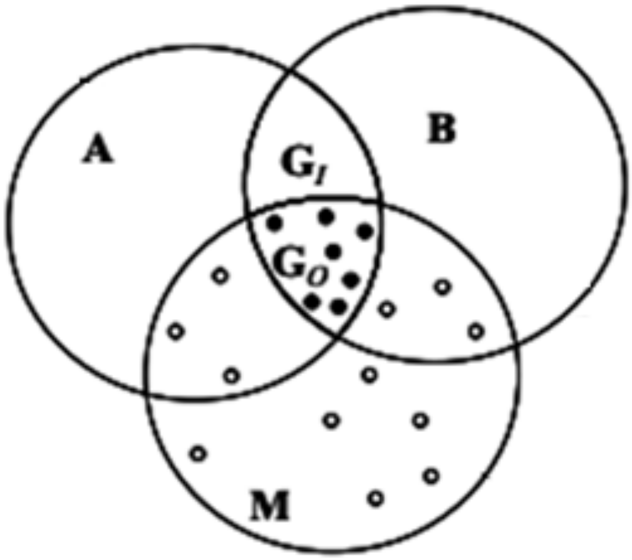

Figura 1- Diagrama *BAM*, tomado de Soberón y Nakamura (2009). **A** representa las regiones con variables ambientales adecuadas para la especie. **B** representa las regiones con condiciones biológicas favorables para la especie. **M** representa las regiones donde la especie tiene acceso debido a su capacidad de movimiento y colonización, así como la estructura de las barreras geográficas y distancias. Los puntos negros representan las presencias y puntos blancos las ausencias.

Tomando en cuenta la pérdida de hábitat, los modelos de "distribución potencial", a los cuales aquí nos referimos como aquellos modelos obtenidos mediante la predicción de variables ambientales climáticas y topográficas (hábitats potenciales), pueden reducirse espacialmente a aquellas áreas que aún conservan su hábitat natural al excluir los pixeles que coinciden con coberturas de terreno con poca o nula idoneidad de hábitat (i.e. zonas de agricultura, pastizales inducidos, zonas desprovistas de vegetación, zonas urbanas) bajo el supuesto de que las áreas con pérdida de hábitat natural no son las óptimas para las especies (Ortega-Huerta y Peterson, 2004; Sánchez-Cordero et al., 2009). Como resultado, se obtiene lo que aquí nos referimos como "distribución actual" (extant distribution, en inglés) de especies, los cuales son los mismos modelos pero reducidos a aquellas áreas que aún presentan la cobertura vegetal correspondiente a los hábitat adecuados a las especies (hábitats actuales; Sánchez-Cordero et al., 2005a,b; 2009; Botello et al., 2015). Al comparar la distribución potencial y la distribución actual de una especie es posible analizar el impacto de la pérdida de hábitat sobre las especies. Con este procedimiento, Sánchez-Cordero et at. (2005a,b) observó que más del 25% de las especies de mamíferos terrestres endémicas de nuestro país perdieron >50% de su distribución potencial.

Evaluar el riesgo de extinción de especies es fundamental para entender su estado actual y así poder construir una adecuada estrategia de conservación. La Unión Internacional para la Conservación de la Naturaleza (UICN) es la red ambiental más diversa del mundo compuesta por organizaciones gubernamentales y de la sociedad civil y se encarga de evaluar el estado de la diversidad biológica. Esta información está recopilada en la Lista Roja de Especies Amenazadas de la UICN, la fuente de información más completa del mundo sobre amenazas, requisitos ecológicos, hábitat y estado de las especies, así como acciones de conservación para reducir o prevenir las extinciones (www.iucn.org). La UICN asigna el riesgo de extinción al evaluar 5 criterios: (A) Reducción del tamaño poblacional, (B) Distribución geográfica, (C) Pequeño tamaño poblacional y disminución, (D) Población muy pequeña o restringida, (E) Análisis cuantitativo. Una especie se encuentra en riesgo si coincide con uno de los criterios a ese nivel de riesgo, aun cuando no haya coincidido con ningún otro criterio (IUCN, 2012; Mace et al., 2008). Existen 9 categorías de riesgo (IUCN, 2012): Especies No Evaluadas (NE) y Datos Insuficientes(DD), son dos categorías que no significan que la especies no está en riesgo, sino que no se ha podido hacer la evaluación por desconocimiento de la especie como por falta de datos o de especialistas en ellas. Las siguientes siete son para especies evaluadas. Preocupación Menor (LC) y Casi Amenazado (NT) se asignan a especies que *no* coincidieron con los criterios para ser considerados en riesgo, mientras que Vulnerable (VU), En Peligro (EN) y En Peligro Crítico (CR) son las categorías asignadas a las *especies amenazadas*. Las últimas dos categorías, Extinto (EX) y Extinto en Estado Silvestre (EW), son para especies que ya no existen o solo se conocen en cautiverio, respectivamente. Actualmente se han evaluado más de 77 300 especies y más de 27 000 se encentran amenazadas (IUCN, 2019). México es uno de los países con más especies en riesgo de extinción según la UICN, donde 665 especies de vertebrados se encuentran en riesgo: 219 anfibios, 71 aves, 118 peces, 96 mamíferos y 98 reptiles (www.iucnredlist.org).

Además de la Lista Roja de la UICN, nuestro país cuenta con un documento que enlista a las especies y subespecies que se encuentran en el país y están amenazadas: la Norma Oficial Mexicana NOM-059-SEMARNAT. Las categorías que representan un nivel de riesgo en este sistema son: Sujeta a Protección Especial (Pr), Amenazado (A), En Peligro (P) y Probablemente Extinto en el Medio Silvestre (E). Se asignan usando el Método de Evaluación del Riesgo de extinción de las especies silvestres de México (MER), el cual se basa en cuatro criterios: (A) Amplitud de la distribución del taxón en México, (B) Estado del hábitat con respecto al desarrollo natural del taxón, (C) Vulnerabilidad intrínseca del taxón, (D) Impacto de la actividad humana sobre el taxón. Cada criterio se divide en categorías de riesgo con valores numéricos, los valores más altos significando un mayor riesgo de extinción, y los cuatro valores se suman para obtener la puntuación total y una categoría de riesgo para la especie evaluada. En comparación con la UICN, la NOM-059-SEMARNAT sugiere que más de 1 300 especies de vertebrados terrestres en México están en riesgo.

Sin embargo, tanto la UICN como la NOM-059-SEMARNAT consideran el riesgo de extinción a escalas globales o nacionales pero no a una escala regional, y las especies son impactadas de diferente manera por la diferencia espacial que existe en la pérdida de hábitat dependiendo de la región (Sánchez-Cordero et al., 2005a; 2009; 2017), las características intrínsecas de la especie (como su vagilidad y masa corporal) y la distancia entre los fragmentos de hábitat natural (Sánchez-Cordero et al., 2005a; Sánchez-Cordero et al., 2009). Por lo tanto, las poblaciones de una misma especie podrían encontrarse en mayor riesgo de extirpación en distintas regiones dependiendo el grado de antropización (Fuller et al., 2006) y esta condición se debería ver reflejada en análisis de priorización de conservación (Botello et al., 2015).

Es por lo anterior que el objetivo general del estudio fue cuantificar a escala nacional la disponibilidad de hábitats adecuados (hábitat natural remanente) asociados a la distribución de especies de vertebrados terrestres endémicos de México y asignar categorías de riesgo de extinción a nivel nacional y regional para priorizar acciones de conservación. El estudio estuvo dividido en tres subproyectos, presentados aquí como capítulos. Los objetivos particulares de cada capítulo fueron:

- *Capítulo 1 (Artículo en proceso)*: Analizar la pérdida de hábitat y la disminución en la distribución de especies de vertebrados terrestres endémicos de México a nivel nacional para 6 diferentes periodos de tiempo, con el fin de observar la disminución en la distribución de especies a lo largo del tiempo y analizar en qué períodos la pérdida fue mayor. Además, se estimó la disminución en la distribución de especies en cada ecorregión del país para encontrar las áreas donde en promedio las especies han sido más afectadas y así contribuir con información básica para priorizar acciones de conservación.

- *Capítulo 2 (Artículo publicado)*: Analizar el impacto de la pérdida de hábitat y la minería sobre especies de anfibios y reptiles endémicos de México, ya que la minería es uno de los factores que hasta el momento han sido poco considerados en las evaluaciones de riesgo de extinción de especies pero que supone un gran riesgo para las especies.

- *Capítulo 3 (Artículo en proceso)*: Evaluar el riesgo de extinción de especies de vertebrados terrestres endémicos de México a nivel nacional y regional considerando los criterios y categorías tanto de la UICN como los de la NOM-059-SEMARNAT a partir de modelos de nicho ecológico. Además, se propone una manera estandarizada, replicable y objetiva de realizar las evaluaciones.

CAPÍTULO 1

Increasing deforestation affects conservation status of endemic species of terrestrial vertebrates in Mexico

Abstract: Mexico ranks fourth in number of vertebrate species worldwide, a large part being endemic. However, the loss of vegetation cover due to anthropogenic activities and climate conditions exacerbates threats to biodiversity conservation and risks to species persistence. Previous studies have documented the negative impact of habitat loss on the conservation status of terrestrial vertebrate species at global, continental, and national scales, determining species extinction risk using international (IUCN) or national law regulations (e.g., Mexican ecological regulation known as Norma Oficial Mexicana-059-SEMARNAT). However, species are impacted differently by deforestation processes depending on the location and this condition should be reflected in regional conservation prioritization analysis, analyzing extinction risk at a regional level. Based on ecological niche models we obtained the potential distribution of 311 species, as well as their extant distribution at different years by considering only the areas with remnant natural habitat. We compared these distributions and analyzed the impact of vegetation cover loss at a national level over the years, as well as the current impact of vegetation cover loss at a regional level to find the most affected ecoregions of the country. Species distribution area decreased between 1986 and 2002, and afterwards there was no significant reduction due to less deforestation rates. By 2017 only 84 species have retained >70% of untransformed habitat within their distributional area, while 160 species have lost ≥30% of their distributional area, 65 species have lost ≥50% and 2 species have lost ≥80%. Populations in the ecoregions of the Transmexican Volcanic Belt, the Gulf of Mexico and the Yucatan Peninsula suffered greater distribution reduction than populations in other ecoregions, some populations losing more than 80% of their distribution. As our study suggests, ecological niche models should be implemented to assess habitat loss at a national and local level in order to generate specific conservation projects.

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1. Introduction

Mexico, due to its high climate diversity, complex topography, geological history and geographical location, is a megadiverse country holding approximately 10% of the biota worldwide with a high species richness and an exceptional number of endemic species (Conabio, 2009). An estimated 5 700 vertebrate species occur in Mexico, representing 9% of the entire diversity worldwide, and ranks within the four countries globally with the most number of amphibian, reptile and mammal species. It is estimated that 66% of amphibians, 56% of reptiles, 29% of mammals and 17% of birds are endemic to Mexico (Semarnat, 2016).

Mexico shows high annual deforestation rates over 1% nationwide (FAO, 2001; Sarukhán et al., 2009). More than 13.7 million hectares of vegetation have been lost in the last 50 years, resulting in a cumulative natural vegetation loss of 30% nationwide (INEGI, 2017). This significant deforestation threatens biodiversity conservation by decreasing species richness, population abundance, genetic diversity and species range size both at a national and regional scales (Best et al., 2001; Challenger and Dirzo, 2009; Fahrig, 2003; Steffan-Dewenter et al., 2002; Vernier and Fahrig, 1996), which can lead to species´ extinction or regional extirpation in the short, medium or long term.

Habitat loss indices have been associated with the loss of biological diversity (Toledo et al., 1989; Myers, 1998; Kinnaird et al., 2003), but few studies in Mexico have analyzed its impact at a species level (Sánchez-Cordero et al. 2005; Botello et al., 2015a,b). The impact of regional deforestation on species distributional ranges is poorly known with potential consequences of severe habitat fragmentation and regional population extirpations (Botello et al., 2015a,b; Monroy-Gamboa et al., 2019). Furthermore, increasing deforestation can deteriorate critical areas holding remnant habitat in the distributional ranges of species affecting their conservation status.

Several studies have related reductions of distributional ranges of species for assigning their conservation status using IUCN criteria and Mexican ecological regulations (Norma Oficial Mexicana-059-SEMARNAT). For example, the conservation status of a species is partly assigned according to the percentage of distributional range loss due to deforestation or other factors (Peterson et al., 2000; Ortega-Huerta and Peterson, 2004; Sánchez-Cordero et al., 2005; 2009; Botello et al., 2015a,b). However, it is important to consider that species are impacted differently by deforestation processes depending on the location (Sánchez-Cordero et al., 2005; 2009; 2017) and this condition should be reflected in regional conservation prioritization analysis (Botello et al., 2015a,b). Here we aimed to quantify the remnant suitable habitats associated with the distribution of endemic species of terrestrial vertebrates by estimating the cumulative habitat loss during different periods of time. We hypothesized that increasing habitat loss increases the vulnerability of the conservation status of endemic species of terrestrial vertebrates. Furthermore, we analyzed species distribution loss at the different ecoregions of the country in order to contribute with basic information to prioritize conservation actions.

2. Materials and Methods

2.1. Study site and point occurrence data

The study included the Mexican endemic terrestrial vertebrate species. Point occurrence distributional data for each species were obtained from the Global Biodiversity Information Facility website (GBIF; https://www.gbif.org/; accessed on 25 January 2018). We obtained records for 996 species and excluded all occurrence data points prior to 1970, points that had a resolution lower than 2 decimals of degree or no geographic coordinates (decimal latitude = 0, empty, 99, -99), fossil records, alive specimens from zoos, data obtained from iNaturalist (www.iNaturalist.com.mx; since those records do not have collected and verifiable specimens), and records that were found within the same pixel of the bioclimatic variables from the WorldClim, used for constructing the models (see below; 1km^2). The remaining data were projected in ArcMap and all points that still did not coincide with the currently recognized distribution of the species were eliminated. We only used species with 10 or more point occurrence data after data cleaning, leaving a total of 37 366 records corresponding to 311 species (62 amphibians, 80 birds, 52 mammals and 117 reptiles). The minimum number of 10 records per species was defined based on published information for an adequately species distribution modeling approach in Maxent (Wisz et al., 2008).

2.2. Species potential distributions

In order to obtain the modeling area (M region; Soberón and Peterson, 2005), for each species we selected the polygons of the terrestrial ecoregions of Mexico (INEGI, CONABIO, INE, 2008; Barve et al., 2011; Di Febbraro et al., 2015; Mateo et al., 2015), that had some occurrence data in them and a buffer zone of 50 km was left around the polygons to be used as cutting template. Nineteen climatic variables (~1 km^2) from the WorldClim database (https://www.worldclim.org/; accessed on 31 January 2018) were used as environmental variables to construct the species potential distributions (Hijmans et al., 2005). For each species, a correlation analysis of variables was performed and those with a correlation $r > 0.7$ were considered redundant and only one was included in order to avoid possible multicolinearity problems and optimize the computing power (Venette, 2017).

Ecological niche models were generated in R software (R Core Team, 2014) with the ENMeval library (Muscarella et al., 2014) following the methodology of Sánchez-Cordero (2017). To parameterize the model, 10 000 background points were selected within the modeling area. Presence data were divided into training and testing groups using the block method (Hijmans, 2012) and 5 regularization multipliers and 13 feature classes were established in order to adjust the models, giving a total of 65 models per species. The best model was selected based on the omission rate and area under the curve (AUC) and it was projected into a discrete presence/absence map through a maximum sensitivity plus specificity threshold (Liu et al., 2005), giving us a map representing the points classified as inside or outside the species′ potential distribution (Liu et al., 2011). All maps were entered into the Consnet software (Ciarleglio et al., 2009; 2010), and we obtained the number of cells occupied by each species at a national level as well as for each ecoregion. To obtain the species potential distribution area each cell was multiplied by 0.78, size in km^2 of the used rack cells.

2.3. Species extant distributions

We used time series of Mexico's land use and vegetation coverage maps from 1968 to 2014 (INEGI, Capa Digital de Uso de Suelo y Vegetación, Series I-VI) and for each map we selected the areas transformed into agricultural, rural or urban settlements. We superimposed these maps as permanently excluded areas to the species potential distributions, projected as species extant distributions, including only remnant suitable habitat for each time series of land use and vegetation map for each species. Thus, for each species we obtained six maps of extant distributions (see Sánchez-Cordero et al., 2005; 2009). We then compared the area occupied by each species potential distribution with the area of its extant distributions and obtained the percentage of suitable habitat lost at each time series. Species were divided in four groups according to the percentage of suitable habitat lost, based on the categories given by the IUCN Criterion A: (1) species that lost <30% of their distribution; (2) species that lost between 30-50% of their distribution; (3) species that lost between 50-80% of their distribution; and (4) species that lost >80% of their distribution. Furthermore, we obtained the average distribution reduction of all the species occurring in each ecoregion to determine the impact at an ecoregion level.

2.4. Statistical analysis

Using the statistical package StatSoft (2007) STATISTICA, our data was tested using a Kolmogorov-Smirnov test for normality. Nationally, a one-way repeated measures analysis of variance (ANOVA) and a multiple comparison test (Tukey's HSD) were used to determine differences between series in the percentage of distribution lost. Then, considering only Series 6, we performed a one-way ANOVA to determine differences between groups of vertebrates in the present. For the ecoregions, using only Series 6 we performed a one-way ANOVA to determine differences in the loss of suitable hábitat inside species distributions between ecoregions.

3. Results

We obtained information from a total of 996 Mexican endemic vertebrate species. However, only 311 species had enough point occurrence data and robust species potential distributions were obtained for those species: 62 of 275 amphibian species from which data were obtained, 80 of 98 birds, 52 of 159 mammals and 117 of 474 reptiles. Most species were distributed in the Transmexican Volcanic Belt, followed by the Pacific Coast and Southern Mexico. Very few endemic species were found in the North, the Baja California Peninsula and the Yucatan Peninsula.

National level analysis

When analyzing all species together, distribution loss was significant between series of land use and vegetation coverage (F = 304.437, df = 5, $p < 0.001$; Figure 1a). By 1968-1986 (Series 1), of the 311 species studied, 149 species had lost <30% of their distribution, while 122 species had lost between 30-50% of their distribution, 39 species had lost between 50-80% of their distribution and 1 species had lost >80% of its distribution. The loss of species distributions increased significantly by 1993 (Series 2; HSD: $p < 0.001$; Figure 2), which was the greatest change between series: only 110 species lost <30% of their distribution, while 24 species increased from group 1 (<30% of distribution lost) to group 2 (30-50% of distribution lost); 15 species increased from group 2 to group 3 (50-80% of distribution lost); and 1 species entered group 4 (>80% of distribution lost). Another big change was observed from 1993 to 2002 (Series 3; HSD: $p < 0.001$; Figure 2): another 16 species lost >30% of their distributions and 7 species past from group 2 to group 3. Afterwards, the percentage of distribution lost did not increase significantly between 2002 (Series 3) and 2007 (Series 4), between 2007 and 2011 (Series 5), and between 2011 and 2014 (Series 6; HSD: $p = 0.214$; $p = 0.053$; and $p = 0.945$, respectively; Figure 1a, Figure 2). By 2014 (Series 6), only 84 species retained >70% of untransformed habitat within their distributional area (Figure 2; Figure 3), while 227 (72.99% of endemics: 43 amphibians, 87 reptiles, 60 birds, 37 mammals) lost >30% of their distributions: 160 species lost ≥30% of their distributional area, 65 species lost ≥50% and 2 species have critically lost ≥80%. When comparing Series 1 and Series 6, 92 species (15 amphibians, 31 birds, 14 mammals, 32 reptiles) lost enough percentage of their distribution to uplist them to a higher category (Figure 2).

When analyzing each vertebrate group independently (Figure 1b-e), the pattern of distribution lost was the same: a big change from 1986 to 1993, and from 1993 to 2002, and no significant difference afterwards. There were no significant differences in the percentage of distribution lost at Series 6 between the different groups of vertebrates (amphibians: % of distribution lost [Mean ± SD] = 40.56 ± 1.99, n = 62; birds: 35.14 ± 1.52, n = 80; mammals: 37.37 ± 2.25, n = 52; reptiles: 40.49 ± 1.50, n = 117; F = 1.753, df = 3, $p = 0.156$).

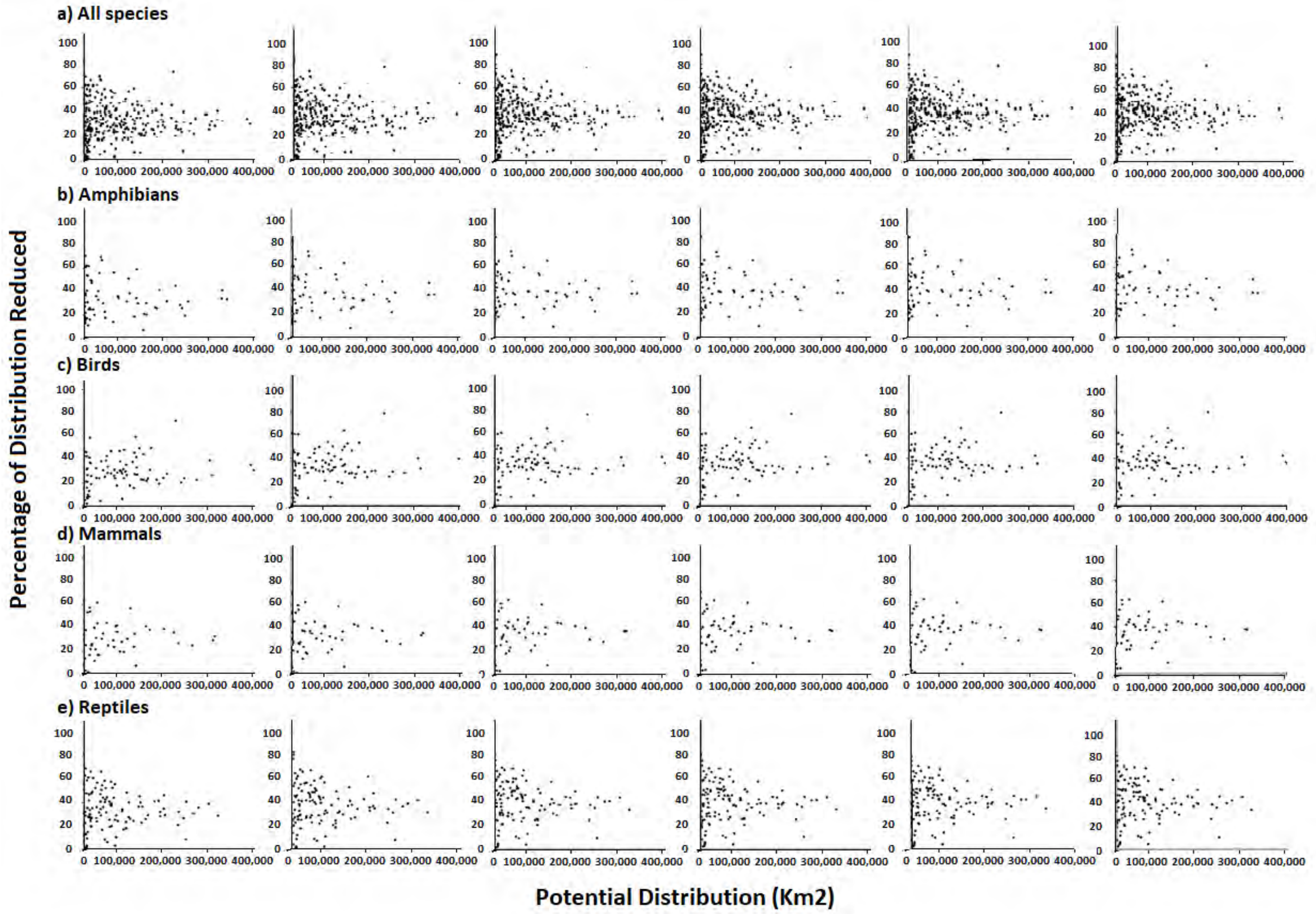

Figure 1- Comparison between species potential distribution (X-axis) and percentage of potential distribution reduction (Y-axis) at different years (Series 1-6), (a) considering all species together, (b-e) each vertebrate group separately.

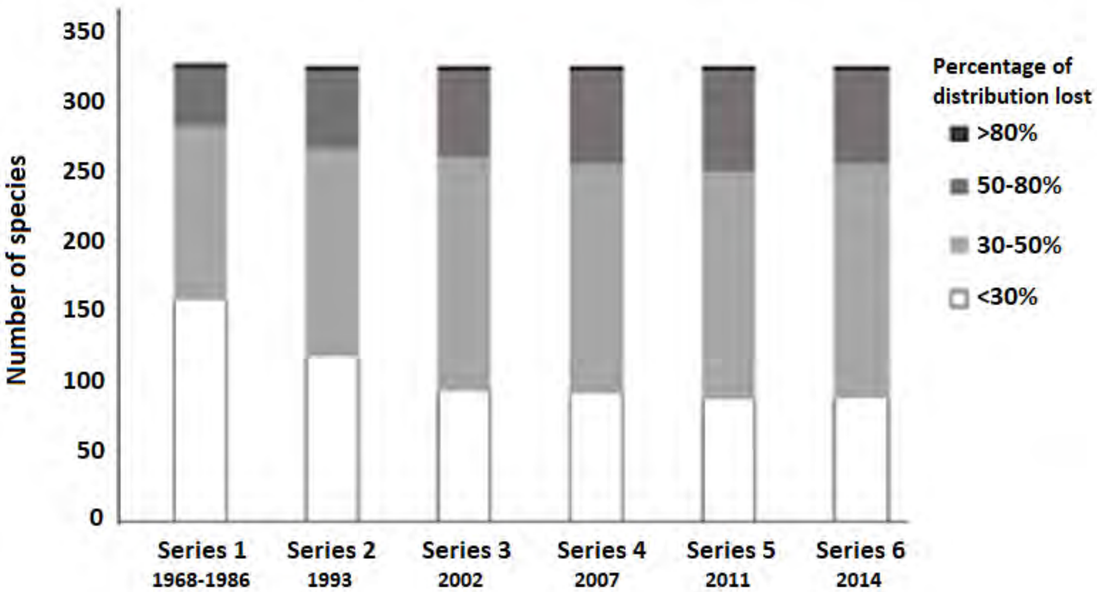

Figure 2- Cummulative number of species in each group at each series.

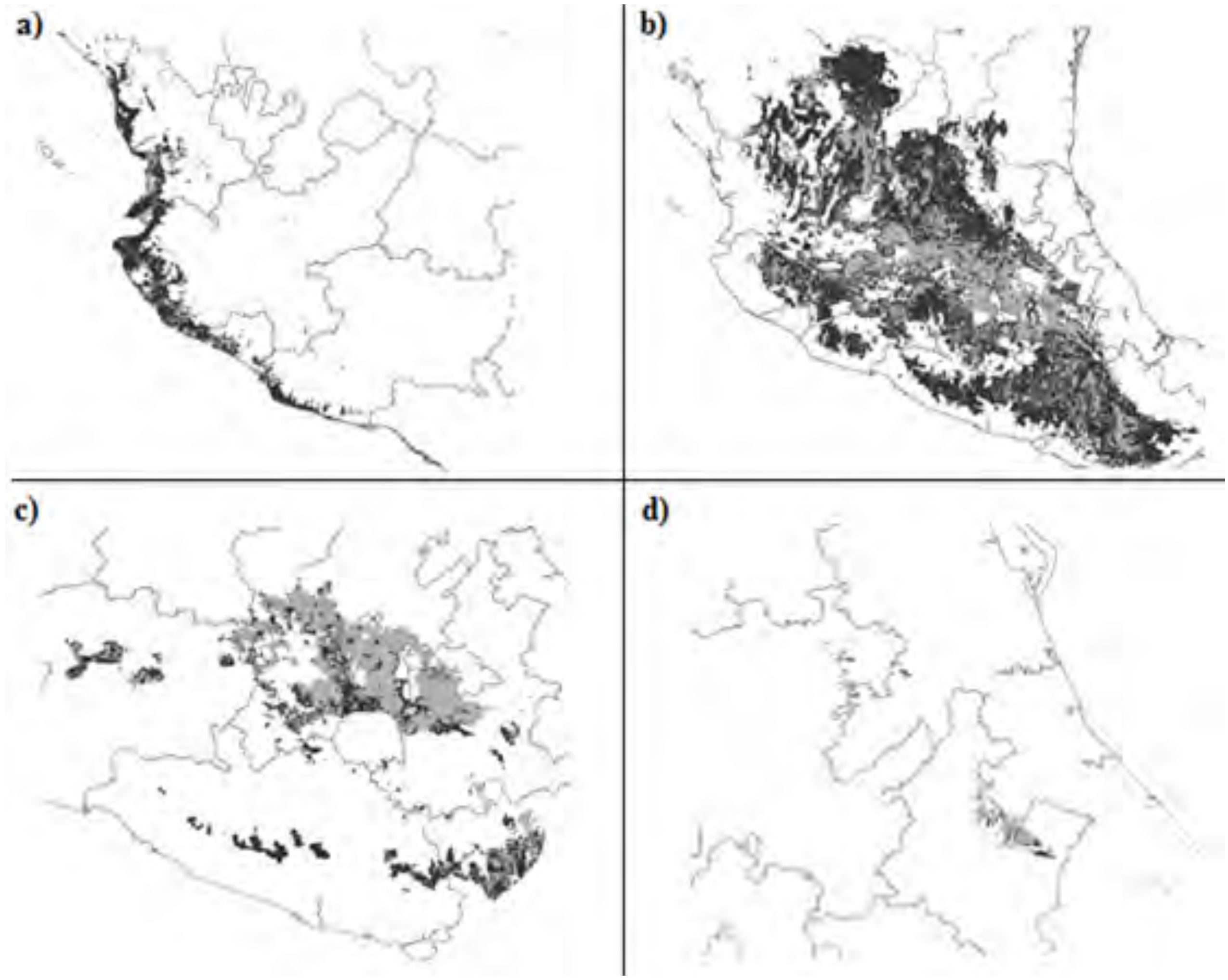

Figure 3. Impact of deforestation on four endemic vertebrates that are categorized as Least Concerned by the IUCN. (a) *Cyanocorax sanblasianus* (bird) representing group 1 (distribution loss <30%); (b*) Incilius occidentalis* (amphibian) representing group 2 (distribution loss between 30-49.9%); (c) *Cratogeomys merriami* (mammal) represenging group 3 (distribution loss between 50-79.9%); (d) *Lepidophyma sylvaticum* (reptile) representing group 4 (distribution loss >80%). ▭ Indicates the species potential distribution; ■ indicates areas with remnant natural habitat which are interpreted as the species extant distribution.

Ecoregion-level analysis

Distribution loss was different depending on the ecoregion (F=124.088, df=94, p<0.001). As shown in Figure 4, species occurring in 49 ecoregions (most of them located in the north of Mexico corresponding to the ecoregions of the Great Plains, the North American Deserts and the Western Sierra Madre, as well as some ecoregions in the Southern Sierra Madre) have not suffered great habitat loss, losing on average <30% of their potential distributions. In the other 46 ecoregions the species distributed in them lost on average ≥30% of their distributions. The ecoregions where species lost a greater percentage of their distribution were the Transmexican Volcanic Belt, the Mexican High Plateau and the Gulf of Mexico Humid Coastal Plains and Hills, corresponding mainly to the Temperate Sierras, Southern Semi-Arid Highlands and Tropical Humid Forests (INEGI, CONABIO, INE, 2008). There are 7 critical cases of ecoregions where the species that are found in them have lost on average ≥ 80% of their distribution, which should suggest that the part of the distribution of all the species found in them are in critical danger.

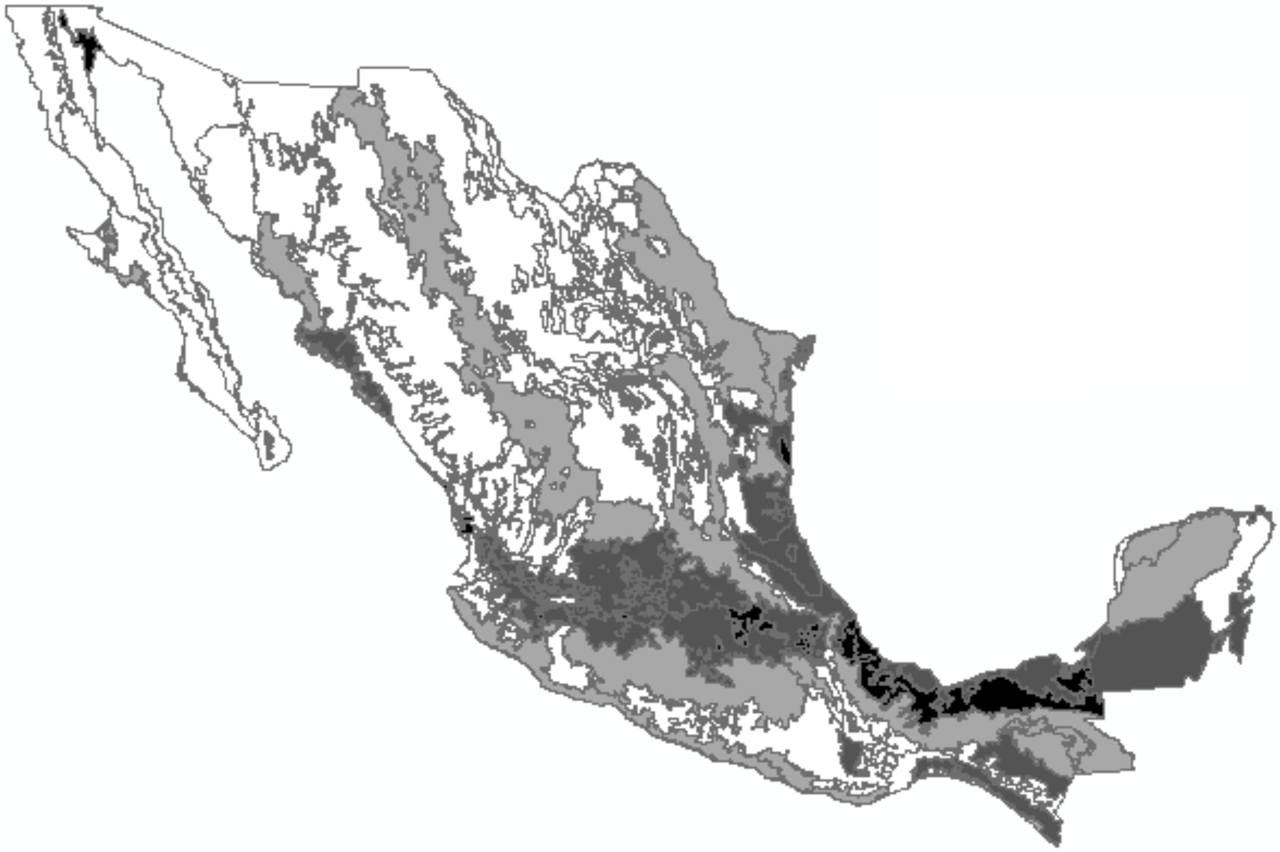

Figure 4- Average distribution reduction of species by ecoregion. ☐ ecoregions where on average the species lost <30% of their distributions; ■ ecoregions where on average the species lost 30-49.9% of their distributions; ■ ecoregions where on average the species lost 50-79.99% of their distributions; ■ ecoregions where on average the species lost >80% of their distributions.

4. Discussion

Because most of the endemic species have restricted distributions and there is little information and number of records about them, for some species it was not possible to make ecological niche models with our method and other methods should be used (Pearson et al., 2007). We were able to analyze 311 of 996 species (22.54% of amphibians, 81.63% of birds, 32.70% of mammals and 24.68% of reptiles), which represents one third of Mexico´s endemic terrestrial vertebrate species. However, because we analyzed four different vertebrate taxa, the situation of species at the national and ecoregion-level could be adequately represented (Monroy et al., 2018).

Habitat loss is one of the biggest threats affecting biodiversity and, as represented in our study, the habitat loss suffered in Mexico over the years (13.7 million ha lost in the last 50 years) has reduced species distributions continuously. The ecosystems that have suffered the greatest impact in Mexico are the temperate and tropical forests (Semarnat, 2016), and because they are the ecosystems with the highest diversity, the loss of this habitat represents one of the top threats of biodiversity (Brooks et al., 2002). The most significant loss in species distributions was between 1986 and 1993, followed by the period between 1993 and 2002 (Semarnat, 2016). This coincides with the periods with the highest deforestation rates: 7.9 million ha were transformed from 1970 to 1993, while 3 million ha were lost between 1993 and 2002. Following these years, habitat loss, and therefore the loss of species distributions, has decreased due to less deforestation and because there is less habitat to transform, although it has not stopped. Especially for locally-adapted endemic species, which can persist mainly in untransformed habitat (Sánchez-Cordero et al., 2005), habitat loss and the reduction of species distribution is critical and can lead to their extinction or local extirpation because they usually have small ranges of distribution and rapid adaptation to new environments produced by anthropogenic transformation is unlikely (Peterson and Holt, 2003).

The IUCN is a valuable source for assessing the status of species worldwide, as well as for conservation planning and for assigning priorities for the financing of conservation and action (Rodrigues et al., 2006). However, improvement in the accuracy of the IUCN Red List is needed, since species are not always categorized as they should (Tracewski et al., 2016). According to the IUCN, only 79 of the species analyzed in this study are at some risk of extinction, while 222 do not have a risk category assigned to them and 15 have not been evaluated or are under the Data Deficient (DD) category. However, we believe that it is risky that the IUCN Criterion A only evaluates the loss of species distributions over the last 10 years (IUCN) because, despite the fact that deforestation and land use transformation has been reduced, most species have lost a great part of their potential distributions and it is dangerous not to give them a risk category. For conservation purposes it is more convenient to impose a higher risk category for a species than to leave the species under the same risk category under the assumption that habitat loss does not harm that species (Sánchez-Cordero at al., 2005; 2009). This is particularly true for endemic species that usually have restricted distributions and have lost >30% of their distributions and we could lose them in a short period of time with bad policies if we don´t consider them as threatened. Fifty years ago, half of the species evaluated had lost >30% of their distributions. Today, 73% of the species (227 species) have lost at least 30% of their distributions and most of them are not considered endangered. If we continue not to consider them as threatened then we could be putting biodiversity at risk. Besides, other factors such as mining activities and climate change, which are not usually considered by the IUCN and will become big threats for species in the near future, could increase species extinction risk (Mayani et al., 2019).

Although amphibians are the most vulnerable vertebrate taxa and the one with the highest proportion of threatened species (Stuart et al. 2004; Beebeeand Griffiths, 2005) due, among other factors, to their low vagilities and narrow habitat tolerances (Gibbs, 1998; Bowne and Bowers, 2004; Houlahan and Findlay, 2003), we did not find significant differences in the impact of habitat loss in the reduction of species distribution between the different vertebrate taxa. However, we did not take into account habitat fragmentation and it could be that fragmentation impacts amphibians and reptiles to a greater extent due to their low vagility and less ability to move between fragments.

Niche loss appears to be related to geographic locations of species´ ranges rather than to distributional area *per se* (Sánchez-Cordero et al., 2005), thus assessing distribution loss at an ecoregion-level enables us to identify the areas of the country where species are more vulnerable. Most of the species used in our study were found in the Transmexican Volcanic Belt, followed by the Pacific Coast and Southern Mexico. These areas have a complex topography and a great variety of habitats (Rzedowski, 1986), being an important center of endemisms for vertebrates and other taxonomic groups (Peterson and Navarro, 2000). However, these areas coincide with the ecoregions that have suffered the greatest land use transformation, which are the Transmexican Volcanic Belt and the Mexican High Plateau, followed by the Gulf of Mexico Humid Coastal Plains and Hills. Species living in those regions have lost on average >50% of their distribution. If the species analyzed in this study effectively represent other taxonomic groups that are not considered here (Monroy et al., 2018), probably all species populations living in these ecoregions could be endangered. Generally the centers of endemism have many species with restricted distributions, so destroying these areas increases the risk of extinction of species because they are not found anywhere else. Centers of endemism worldwide are disproportionately threatened by human activity (Cincotta et al., 2000) and have lost more than 70% of their original geographic extent (Myers et al., 2000). It has been estimated that the hotspot of Mesoamerica will be one of the hotspots that will lose more plant and vertebrate species due to habitat loss if the land use transformation continuous as it is today (Brooks et al., 2002). Unfortunately, nearly 40% of Mexican endemics are restricted to the Transmexican Volcanic Belt and the Pacific Coast (Hall, 1981), which is critical for Mexico´s biodiversity since populations living there appear to have a higher extinction risk compared with populations in other parts of the country. With this scenario, the marked loss of biodiversity in these regions could lead to the collapse of ecosystems and ecosystem services provided to humans in the most populated region of the country. Thus, paying attention to this situation should be a priority.

We believe our method is important to determine the impact of habitat loss in species distributions and could help to assess extinction risk for species that have limited information. It could also allow us to modify risk categories rapidly when new information about land use and vegetation cover is available, and thus have an updated assessment every few years. Our study confirms the potential benefits of using geographical information systems and ecological niche models to assess habitat loss and extinction risk in a fast, easy and less expensive way. It is a repeatable method that provides estimates that can be globally used and comparable across taxa. This information will help us to better understand the status of each species not only at a national level but also at finer scales, such as ecoregions, and thus be able to create better conservation projects depending on the species´local extirpation risk. Knowing the areas of the country with the highest risk for species can help to target the locations that are of greater conservation concern and need more resources.

Today, it becomes fundamental to reassign species extinction risk and consider the risk at different regions, especially for lesser known species with restricted distribution ranges. Also, there is a need to obtain more information about these species, since not having enough data means losing the opportunity to know the species´current situation, which can be critical for small range endemic species.

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Impact of Habitat Loss and Mining on the Distribution of Endemic Species of Amphibians and Reptiles in Mexico

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Abstract: Mexico holds an exceptional diversity and endemicity of amphibian and reptile species, but several factors pose a threat to their conservation. Here, we produced ecological niche models for 179 Mexican endemic amphibian and reptile species and examined the impact of habitat loss and mining activities on their projected potential distributions, resulting in their extant distributions. We compared extant species distributions to the area required to conserve a minimum proportion of the species distribution. The combined impact of habitat loss and mining on extant species distribution was significantly higher than the impact of habitat loss alone. Only 40 species lost <30% of their distribution, while 83 species lost between 30–50%, 54 species lost between 50–80%, and 2 species lost more than 80% of their distribution. Furthermore, the size and configuration of the area required to conserve 20% of the extant species distributions changed considerably by increasing the number of fragments, with a potential increase in local population extirpations. Our study is the first to address the combined impact of habitat loss and mining on a highly vulnerable rich endemic species group, leading to a decrease in their potential distribution and a potential increase in the extinction risk of species.

Keywords: ecological niche modeling; potential species distribution; extant species distribution; conservation areas

1. Introduction

Mexico holds an exceptional species richness and endemicity of amphibians and reptiles, ranking in the top three countries worldwide [1]. It has over 376 species of amphibians and 864 species of reptiles, and approximately 65% and 57% of these species, respectively, are endemic [2,3]. However, it has been argued that both amphibians and reptiles are the two most vulnerable groups of terrestrial vertebrates, being at significantly higher risk than mammals and birds [4–6] for threats such as habitat loss and fragmentation. One third of the species of amphibians worldwide are threatened with extinction according to IUCN [7], and only 35% of Neotropical and Nearctic species are in the IUCN Least Concern Category [5,6]. Species of reptiles have been less studied, but they are also highly vulnerable to these threats [8], and it is likely that reptiles are at high risk of extinction as well [4]. In general, both groups are highly dependent on the environmental conditions and are very vulnerable to pathogens, invasive species, ultraviolet-B exposure, and pollution [9–12]. Several factors, such as habitat loss and fragmentation, water pollution, climate change, and mining have been identified to negatively affect their breeding activities, reproduction, and survival performance [13,14], leading to the reduction of species range size and local population extirpation.

Mexico has lost over 13.5 million ha of natural vegetation in the last 50 years [1] due to annual deforestation rates greater than 1% nationwide [15]. This habitat loss and fragmentation affects most ecosystems and species of flora and fauna, increasing the vulnerability and extinction risk of species [16]. Since species of amphibians and reptiles have dispersal limitations [17], their movements between habitat fragments are limited and going from unfavorable to favorable habitats is unlikely [13,14]. As a result, the Global Amphibian Assessment suggests that habitat loss impacts 89% of the threatened amphibian species in the Americas, which is three times the impact of any other threat [18]. Recent studies have proposed that human-induced habitat loss is important, affecting the diversity and abundance of amphibian and reptile species [19] in Neotropical habitats [20], xeric habitats [21], and dry plains [22]. Furthermore, small-range species are more likely to show population declines [23]. For example, 70% of Mexican species of amphibians and 80% of species of reptiles have restricted distributional ranges and high environmental specialization, increasing their vulnerability [24]. In fact, the distributions of endemic amphibian and reptile species have declined 80% and 70%, respectively [25].

In addition to habitat loss, mining activities are suspected to impose a high risk to species of amphibians and reptiles, but this has been poorly studied. Mexico ranks second in silver production worldwide and is one of the countries with the largest production of gold, zinc, copper, and other minerals [26]. There are currently 1531 mining projects (884 more than in 2010), of which 1113 projects are in the exploration stage (where perforations are made to determine the available minerals), 63 are under the construction of the mine, 274 are in the production stage where the minerals are being extracted, and 81 have been postponed [27]. After exploitation, environmental regulations recommend closing and restoring the affected areas. However, the companies are not forced to elaborate an integrated plan of mining closure and restoration [27]. Most mining projects are open pit mining, which is conducted at large scale, generating pollution of rivers and aquifers with heavy metals, large quantities of polluting debris, acid drainage, continuous emissions of gases and dust into the atmosphere, and the local removal of all plant and animal species [28,29]. Mining activities are considered of public utility. They are prioritized over any other use or activity in the territory and can be conducted regardless of the regime of land tenure, such as territories of indigenous people, urban areas, and private and social property [29]. There are currently more than 24,000 terrestrial active mining concessions covering over 20 million ha, and 14 marine concessions covering approximately 740 marine ha [30–32]. A total of 85% of mining activities are located in areas with vegetation cover holding ecological integrity [33,34]. Furthermore, the legislation does not restrict the possibility of establishing mining activities in most categories of protected areas [29], which has resulted in 73 mining projects covering more than 2 million ha inside protected areas and Ramsar sites; while 60,000 ha are located inside the core zones of protected areas [31,35,36].

Academic and NGO organizations assessing species extinction risk at a global level (IUCN) and at a national level (Mexican governmental ecological regulations) consider habitat loss and habitat fragmentation as the main variables to assign species extinction risk; the higher the proportion of habitat loss in their distributions, the higher the category assigned for species extinction risk [37]. However, other potential factors affecting the conservation status of species, such as mining activities, are largely underestimated. In this study, we (1) analyzed the combined impact of habitat loss and mining activities on potential species distributions of Mexican endemic amphibian and reptile species, and (2) determined the modifications and area needed to conserve a minimum proportion (20%) of the extant distribution of these species.

2. Materials and Methods

2.1. Point Occurrence Data

The study included Mexican endemic species of amphibians and reptiles. We compiled point occurrence data for 275 species of amphibians and 474 species of reptiles from the Global Biodiversity Information Facility website (GBIF; https://www.gbif.org/; accessed on 25 January 2018). We excluded (1) all point occurrence data prior to 1970; (2) points that had a resolution lower than 2 decimals of degree or no geographic coordinates (decimal latitud = 0, empty, 99, −99); (3) fossil records; (4) alive specimens (from zoos); (5) data obtained from iNaturalist (www.iNaturalist.com.mx), since those records do not have collected and verifiable specimens, and (6) records that were found within the same pixel of the bioclimatic variables from the WorldClim, used for constructing the models (see below; 1km^2). In ArcMap, we eliminated all points that did not coincide with the currently recognized distribution of the species. Once the databases were refined, we included only the species with a minimum of 10 records. The minimum number of 10 records per species was defined based on published information for an adequate species distribution modeling approach in Maxent [38].

2.2. Potential Species Distributions

For each species, the polygons of the Mexican terrestrial ecoregions, including occurrence points, were selected, leaving a 50 km buffer zone surrounding them to be used as the modeling area (M region) [39,40]. The environmental variables used to construct potential species distributions were nineteen bioclimatic variables (~1 km^2) from the WorldClim database (https://www.worldclim.org/; accessed on 31 January 2018) [41]. Variables with a correlation $r > 0.7$ were considered redundant and only one was included [42].

We generated the ecological niche models following the methodology described by Sánchez-Cordero [43]. Using the ENMeval library [44] in the R software [45], 10,000 background points were selected within the modeling area to parameterize the model, the block method was used to divide the presence data into training and testing groups [46], and 5 regularization multipliers and 13 feature classes were established to adjust the models. From a total of 65 models per species, the best model was selected based on the omission rate and the area under the curve (AUC), and projected into a discrete presence/absence map through a maximum sensitivity plus specificity threshold [47]. The area of each potential species distribution was obtained using the Consnet software package [16,48,49] by obtaining the number of cells occupied by each species and multiplying this number by 0.78, the size in km^2 of the used rack cells.

2.3. Extant Species Distributions

From the potential species distribution models, we obtained two scenarios, as follows: (1) Extant species distributions due to habitat loss, and (2) extant species distributions due to habitat loss and mining activities. Habitat loss was estimated based on the land use and vegetation coverage map [33], which contains information on habitat transformation since 1968, and includes transformed areas into agricultural, rural, or urban settlements. For mining activities, we used the official mining concession map, which has information of all mining concessions since 1942 that are still active today [50]. Furthermore, we used the software package ConsNet on potential species distribution, extant species distribution due to habitat loss, and extant species distribution due to habitat loss and mining activities to analyze the area of occupancy of each species under each scenario.

Potential species distributions were compared with extant species distributions under each scenario and the percentage of the reduction in their distributions was obtained. We divided species in four groups according to percentage ranges of their distribution loss, as follows: (1) Species that lost <30% of their distribution; (2) species that lost between 30–50% of their distribution; (3) species that lost between 50–80% of their distribution, and (4) species that lost >80% of their distribution.

2.4. Selection of Priority Areas for Conservation

For each scenario of potential species distribution, extant species distributions due to habitat loss, and extant species distribution due to both habitat loss and mining activities, we obtained the selection of priority areas for conservation using the ConsNet software package, which allows the identification of conservation solutions by defining multiple previously set criteria [16,48,49]. ConsNet allows searching for the best solutions for different objectives according to the required conservation plan. For example, it can search for the minimum selected area and the best surrogate representation without considering any other restrictions, such as shape or connectivity. Similarly, a conservation solution can be searched for by considering, for example, the best representation, minimum area, connectivity, and/or shape configuration. The conservation target for all species was set to 20% of their distribution under the three scenarios, considering that all species are endemic and have limited distributions. We searched for the best representation with the minimum area and shape using the RF4 adjacency algorithm with a basic neighbor selection, and running 200,000 iterations to find the best solution. We obtained the total area (km^2) of conservation, perimeter, number of clusters, shape, and total representation of the species on the conservation area network.

2.5. Statistical Analysis

Using the statistical package StatSoft STATISTICA [51], we analyzed the differences in the reduction of extant species distributions due to habitat loss and extant species distribution due to habitat loss and mining activities, respectively (Student's *t*-test). We also performed two different one-way ANOVAs to determine differences between species of amphibians and reptiles under each scenario.

3. Results

Of a total of 749 endemic species of amphibians and reptiles, we produced robust potential species distributions for 62 species of amphibians and 117 species of reptiles. There were a total of 10,079 records, ranging from 10 as in *Sceloporus zosteromus*, *Phyllodactylus unctus*, *Lithobates sierramadrensis*, *Craugastor pozo*, and *Incilius cavifrons*, to 514 as in *Sceloporus torquatus*.

3.1. Extant Species Distributions

A total of 49 species showed a reduction of less than 30% of their potential distribution due to habitat loss. The remaining 130 species lost more than 30% of habitat, as follows: A total of 79 species lost between 30–50% of their distribution, 49 species lost between 50–80%, and 2 species lost more than 80% (Figure 1; Figure 2; Supplementary Material: Table S1). There was no significant difference in the impact of habitat loss on species of amphibians and reptiles ($F = 0.203$, $df = 1$, $p = 0.65$).

The combined impact of habitat loss and mining activities in extant species distribution was significantly higher (extant species distribution due to habitat loss: 40.56 ± 16.15; extant species distribution due to habitat loss and mining: 42.16 ± 15.67; $t = -20.10$, $df = 178$, $p < 0.001$), but it did not differ between species of amphibians and reptiles ($F = 0.341$, $df = 1$, $p = 0.56$). Of the 179 endemic species of amphibians and reptiles, only 40 species lost less than 30% of their distribution, while 83 species lost between 30–50%, 54 species lost between 50–80%, and two species lost more than 80% of their distribution (Figure 1; Table S1). The contribution of mining activities increased the percentage of distribution loss of all species, and resulted in nine species increasing from a loss <30% to a loss between 30–50%, and five species increased from a loss between 30–50% to a loss between 50–80% of their distribution (Figure 1; Table S1).

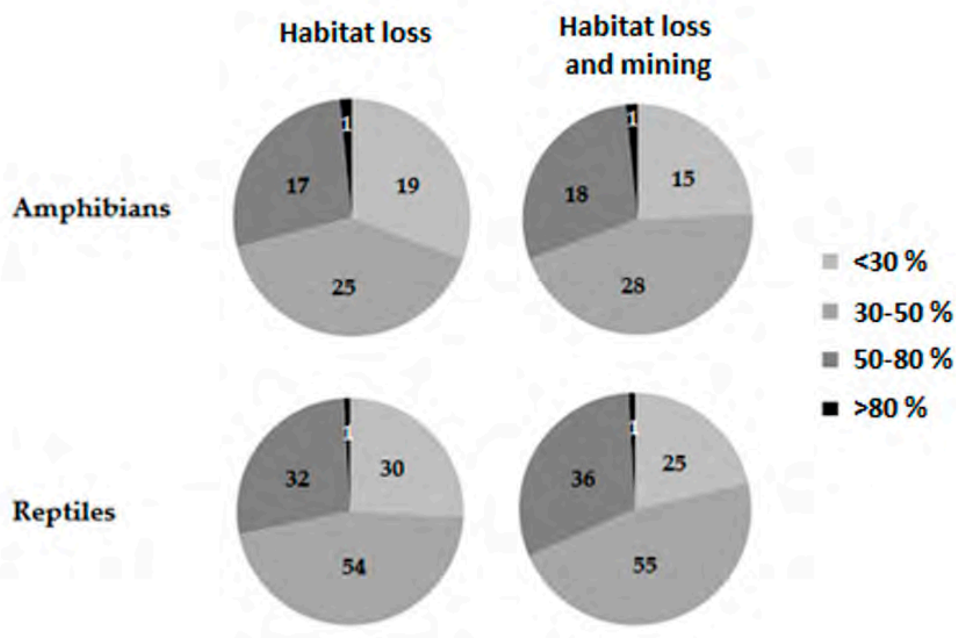

Figure 1. Number of Mexican endemic species of amphibians and reptiles in each group of percentage of distribution lost under each scenario.

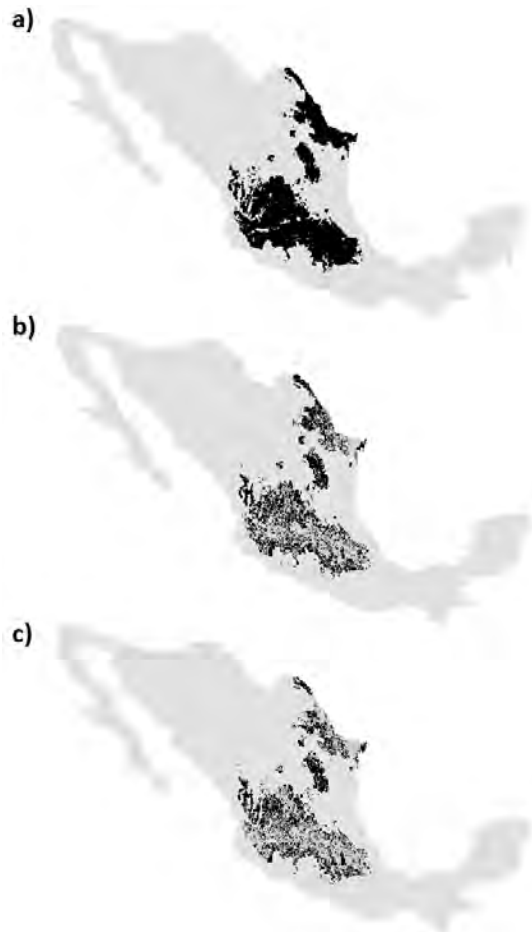

Figure 2. Distribution of *Anaxyrus compactilis* under three scenarios: (**a**) Potential species distribution; (**b**) extant species distribution due to habitat loss; and (**c**) extant species distribution due to habitat loss and mining activities.

3.2. Conservation Area Network under Three Scenarios

Under the scenario of potential species distribution, the conservation area network representing 20% of species distributions, resulted in a total of 237,195 km^2 contained in 2624 clusters, with a perimeter of 222,715.21 km, and a shape of 0.50 (perimeter/area). Under the scenario of extant species distribution due to habitat loss in a total of 250,563 km^2 contained in 8010 clusters, a perimeter of 222,715.21 km and a shape of 0.88 resulted. Under the scenario of extant species distribution due to habitat loss and mining activities in a total of 251,678.80 km^2, a perimeter of 237,148.20 km, 8706 clusters and a shape of 0.94 resulted (Figure 3).

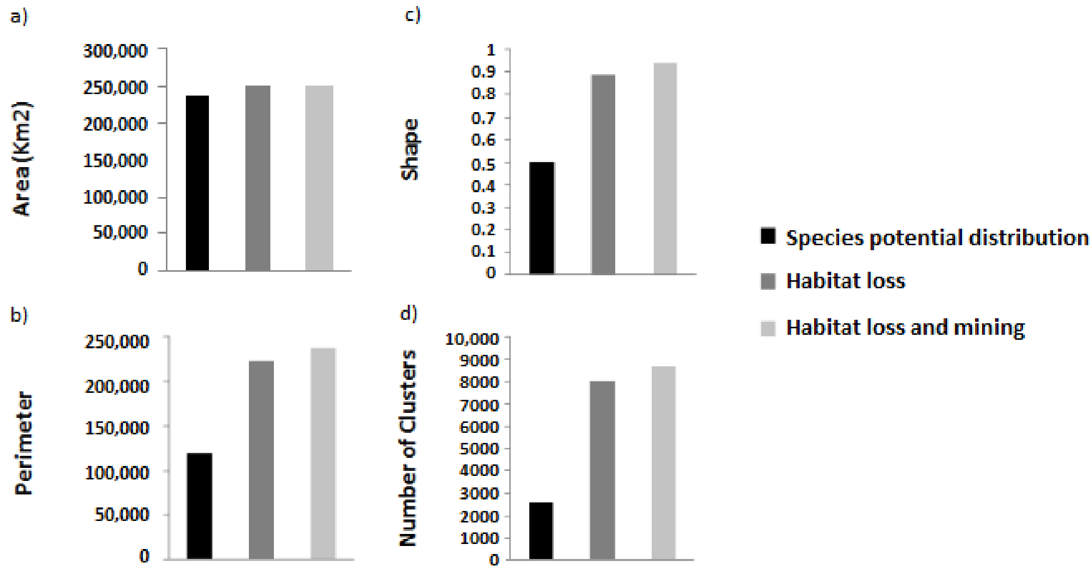

Figure 3. Area and configuration of the conservation area network (area, perimeter, shape, and number of clusters or fragments) including 20% of the 179 species potential distribution, species extant distribution due to habitat loss, and species extant distributions due to habitat loss and mining activities, respectively.

4. Discussion

Habitat loss has been identified as a major factor negatively affecting biodiversity and threatening species conservation worldwide [13–15], but there is a need to study the impact of other large-scale factors such as mining. Here, we based our analyses assuming that habitat loss and habitat fragmentation affects the conservation status of the endemic species of amphibians and reptiles included in this study. We argue that it is more convenient for conservation purposes to impose a higher risk for a species due to habitat loss (even if this does not harm a species), than to leave the species under the same risk category under the assumption that habitat loss does not harm that species [19,52,53]. This argument is particularly important for endemic species showing small ranges of distribution.

Our results show that the combined negative impact of habitat loss and mining activities increased the loss of distribution of all species of amphibians and reptiles. For example, when considering only habitat loss, 49 species out of 179 species of amphibians and reptiles retained enough remnant natural habitat in their distribution, but 130 species lost more than 30% of their distributions, which could increase their vulnerability. When we added the combined impact of habitat loss and mining, all species distributions were reduced. Only 40 species showed less than 30% of habitat loss in their distributions, while 83 lost more than 30% of their distribution, 54 lost more than half of their potential distribution, and two species are in a critical situation where they only have less than 20% of their distribution remaining (Figure 1; Table S1).

Mining activities have become a relevant threat and could be causing species to increase their extinction risk. Of the 179 species included in our study, only 50 species (35 amphibians and 15 reptiles) are currently included in the IUCN red list of endangered species [4]. However, we believe that if other factors such as mining were systematically included into the assessment of species extinction risk, more species of amphibians and reptiles should be included in an extinction risk category. Furthermore, of the 179 species included in our study, 10 species have not been assessed by the IUCN or are under the data deficient (DD) category. When all of the species occurring in Mexico are considered, the number increases to over 38 amphibians (10% of all species in Mexico) in the DD category [19] and 307 reptiles (36.2% of all species in Mexico) in the DD or not evaluated (NE) categories [54]. Moreover, IUCN does not consider species of amphibians extinct in the wild, but some reports suggest that at least 35 species are possibly extinct, and IUCN categorizes them as DD, EN, or CR [55,56]. Clearly, more efforts are needed to improve the assessment of species of amphibians and reptiles given that many species have not been assigned with a proper risk category.

Our study only analyzed the impact of mining over species distributions, but other factors caused by mining activities, such as pollution of rivers and aquifers, polluting debris, acid drainage, gas and dust emissions, and local removal of all vegetation [28], could increase the impact of mining over species and further increase species extinction risks. It has been recently reported that 84 of the 632 highly contaminated sites in Mexico are caused by mining activities, of which 11 are found inside protected areas [57]. Therefore, further studies should focus on obtaining an integrated scenario of the impact of mining activities on biodiversity conservation. In Mexico, more than 20 million ha have concessions to carry out mining activities, and this area could double by the end of 2019 [29]. There is an increasing concern that current law regulations consider mining activities as a priority, to the point that they can even be established inside protected areas. In order to adequately conserve biodiversity and meet the international conservation commitments to conserve 17% of the territory and not to allow mining activities inside protected areas, the Mexican government must urgently change sections of the environmental legislation.

Besides reducing species range size, habitat fragmentation has other implications on species conservation status. The configuration of the conservation area network solution ranked worst when including the combined impact of habitat loss and mining activities by increasing its area, perimeter, number of habitat fragments, and shape, with expected negative consequences for endemic and micro endemic species with dispersal limitations [58]. This increases risks of local population extirpation, and a decreasing genetic diversity of species [59]. Other factors, such as climate change, have also been considered to have a negative impact on species of amphibians and reptiles. It has been proposed that climate change will significantly increase the extinction risks in the short term. For example, it has been reported that an average reduction of about 64% in the current geographical range of endemic amphibians could be expected by the year 2080, with 50% of the species losing more than 60% of their distributions [60].

Protected areas are keystone initiatives to conserve biodiversity worldwide [61,62]. Thus, their adequate management, to ensure their long-term viability and to support the strategic development of conservation area networks, is essential [63,64]. Worldwide, these areas have helped to protect more than 2000 million ha [65] and in Mexico they protect around 25 million ha, representing more than 12% of the Mexican territory [66]. However, protected areas do not appear to adequately represent most biodiversity in Mexico, as shown by some studies using well-studied faunistic groups [16,63,67], and some biodiversity hotspots remain unprotected [67]. The population decline of species of amphibians and reptiles has been well documented, but these groups are not often taken into account when establishing conservation objectives [68,69]. Only 31% of the amphibians (29% of endemics) and 76% of the reptiles (46% of endemics) living in Mexico occur inside protected areas [70]. Furthermore, biodiversity representation in protected areas will be inadequate under current and climate change scenarios [71–73]. Our study provides baseline information suggesting that, as a result of the combined impact of habitat loss and mining activities, species of amphibians and reptiles are in greater danger of extinction than previously known and these factors should be included in more integrated criteria for adequately assigning species conservation status.

Supplementary Materials: The following are available online at http://www.mdpi.com/1424-2818/11/11/210/s1, Table S1: Percentage of distribution lost caused by the impact of habitat loss and habitat loss and mining activities for the Mexican endemic species of amphibians and reptiles.

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CAPÍTULO 3

Using ecological niche models to assess the extinction risk of Mexican terrestrial endemic vertebrates at a national and local level

Abstract: World´s biodiversity is at risk, with extinction rates measured at 100-1,000 times the background rate. Organizations like IUCN or the NOM-059-SEMARNAT (Mexico) compile information and assess species extinction risk at a global or national level, helping to understand the current status of species and support species conservation. However, we consider that to establish better conservation projects it is necessary to asses species extinction risk at a local level. Here, we used the ecological niche models and potential distributions of 311 Mexican terrestrial endemic vertebrates and used the IUCN and Nom-059-SEMARNAT categories and criteria to asses extinction risk at a national level, as well as the extinction risk at each of Mexico´s ecoregions using a proposed modification of the NOM-059-SEMARNAT. 300 species were considered at risk when using the NOM-059-SEMARNAT criteria, while only 38 species were considered at risk when using the IUCN criteria and categories. When assessing the risk at a local level, species found in the ecoregions of the Mexican deserts, the Mexican high plateau, the Southern Sierra Madre and the Western Sierra Madre where considered not at risk or under special protection, while the species occurring at the Transmexican Volcanic Belt, the Great Plains and the Yucatan Peninsula, where temperate Sierras and tropical humid forests predominate, were the most affected and are threatened or endangered. Our study is the first one in Mexico to assess local extirpation risks and shows that populations face different extirpation risks according to geographic location, thus providing a geographical context toward designing local conservation plans.

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1. Introduction

World´s biodiversity is declining, with extinction rates measured at 100-1 000 times the background rate (Pimm et al., 2014; Ceballos et al., 2015), suggesting we are entering the sixth mass extinction (Barnowsky et al., 2011). According to estimations, 5-9 million animal species exist on the planet, of which we are losing between 11 000 and 58 000 species annually (Mora et al., 2013; Scheffers at al., 2012). For vertebrates, at least 322 species have become extinct in the last 500 years (IUCN, 2019; Hoffmann et al., 20110), 14-40% of species are threatened depending on the class (IUCN, 2019) and the number of individuals has declined 28% (Butchart et al., 2010; Collen et al., 2009).

The main processes driving this loss of species are habitat loss, overexploitation, introduced species and, more recently, anthropogenic climate disruption (Hoffmann et al., 2010; Sala et al., 2000). Habitat loss has reduced species distributions continuously, which can lead to species´ extinction or regional extirpation in the short, medium or long term. Extinction occurs when the mortality (and emigration) rate is greater than the birth (and immigration) rate for a sufficiently long time that the population size reaches zero. Purvis et al. (2000) summarized hypothesis found in the literature about attributes that correlate with vulnerability to extinction. Species are, in theory, more vulnerable to extinction if: they have small population densities and small geographical ranges (Gaston, 1994); are at a higher trophic level (Diamond, 1984; Crooks and Soulé, 1999); have slow life histories (MacArthur and Wilson, 1967); have complex social structures (Courchamp et al., 1999); have large home ranges which makes them vulnerable to habitat loss, degradation and edge effects (Woodroffe and Ginsberg, 1998); or have large body size, since they tend to have low population densities, slower life histories and larger home ranges (McKinney, 1997).

Assessing risk of extinction is key for understanding the current status of species and critical for building appropriate conservation actions. The International Union for Conservation of Nature (IUCN) is the world´s most diverse environmental network composed of government and civil society organizations and is in charge of assessing the status of the natural world. This information is compiled in the IUCN Red List of Threatened Species, the world´s most comprehensive information source on threats, ecological requirements, habitat and status of species, as well as conservation actions to reduce or prevent extinctions (www.iucn.org). There are 9 categories in which species are assigned, and a species can only be classified into one of these 9 categories (IUCN, 2012). The first one is for species Not Evaluated (NE) against the criteria, and the second is assigned to species for which information to make an assessment is lacking, defined as Data Deficient (DD). However, it does not mean that species with either one of these two categories are not at risk of extinction. The next seven categories are assigned after assessing species extinction risk, for species that have enough information to make the assessment. The categories Least Concern (LC) and Near Threatened (NT) are used for species that do not meet the criteria to be considered threatened, or for species that fail to qualify as threatened but are close or are likely to qualify in the near future, respectively. Then there are two categories for extinct species: Extinct (EX), when there are no individuals left, and Extinct in the Wild (EW), when a species is known to survive only in cultivation or captivity. The last 3 categories are the ones representing threat level: Vulnerable (VU), Endangered (EN) and Critically Endangered (CR). They are defined depending on the probability of extinction of the species according to five criteria: A) Population size reduction; B) Geographic range in the form of extent of occurrence or area of occupancy; C) Small population size and decline; D) Very small or restricted population; E) Quantitative analysis. A species is considered in any of these threat categories if it meets 1 of the 5 criteria at that level, even if it does not meet any other criteria (IUCN, 2012; Mace et al., 2008). Currently, more than 77 300 species have been assessed and more than 27 000 species are threatened with extinction (IUCN, 2019). But this system is often criticized because it requires a large amount of data difficult to acquire and the use of simpler systems adequate to each country is often recommended, due to each countries policies and conservation threats, and can thus better satisfy the needs of each nation (Soberón and Medellín, 2007). Other studies suggest that national systems have deficiencies and the IUCN system should be used instead (Grammont and Cuarón, 2006).

According to the IUCN red list (www.iucnredlist.org), Mexico, which has around 10 to 12% of the world´s biodiversity (Conabio, 2009), is one of the countries with the most number of endangered species and it has 665 vertebrate species at risk: 71 birds, 96 mammals, 98 reptiles, 118 fishes and 219 amphibians. But Mexico has its own document that enlists the species and subspecies that are found in the country and are at risk of extinction, the Official Mexican Norm-059-SEMARNAT (Norma Oficial Mexicana NOM-059-SEMARNAT; Denisse, 2010). In comparison with IUCN, the NOM-059-SEMARNAT suggests that over 2 600 species are at some level of threat, more than 1 300 species being terrestrial vertebrates. The categories representing threat level in this system are Endangered (P), Threatened (A), Subject to Special Protection (Pr) and Probably Extinct in the wild (E), and they are assigned by using the Method to Asses the Risk of Extinction of Wild species in Mexico (MER, for its acronym in Spanish). The four criteria used to determine risk categories are: A) magnitude of the distribution range of the taxon in Mexico; B) status of the habitat with respect to the natural development of the taxon; C) intrinsic biological vulnerability of the taxon; D) impact of human activities on the taxon. Each criterion is divided into risk categories with numerical scores, higher numbers meaning higher extinction risk. The four scores are added up to obtain the total score and the risk category of the assessed species.

Nonetheless, studies suggest that both the IUCN and NOM-059-SEMARNAT have little consensus regarding how to evaluate some criteria, that assessments are often left to the subjective evaluation of each researcher and that biases in collection data compromises risk assessments (Arroyo et al., 2009). Besides, there is a lot of information missing and more studies assessing risk of extinction are needed (Mayani-Parás et al., 2019). Furthermore, it is common that risk assessments consider species extinction risk at a global or national level but not at a local level when it has been proven that habitat loss is different depending on the degree of human activity at each region and that this loss impacts species in different ways depending on their intrinsic characteristics (such as vagility and body size) and distance between fragments of natural habitat (Sánchez-Cordero et al., 2005; 2009). Additionally, populations of the same species could be more at risk in one region than another, so analyzing the risk of local extirpation is important to know the status of species by location and for planning good conservation projects.

In this study we assessed the extinction risk of Mexican endemic terrestrial vertebrates at a national level considering the criteria and categories of both the IUCN red list and the NOM-059-SEMARNAT, and at a local level, using Mexico´s ecoregions, considering a proposed modification of the NOM-059-SEMARNAT criteria and categories.

2. Materials and Methods

2.1. Study site, selection of species and species potential distributions

The study was conducted with continental terrestrial vertebrate species endemic to Mexico. We used the species potential distributions of a total of 311 species: 117 reptiles, 80 birds, 62 amphibians and 52 mammals.

Species were assessed according to the IUCN Red List of Endangered Species Criteria and Categories (IUCN, 2012) at a national level, since this system can only be used at a global or national level. The NOM-059 SEMARNAT (Denisse, 2010) was used to assess extinction risk at a national level and also at a ecoregion level, since we believe this system can, and should, be used to analyze extinction risk in Mexico at fines scales.

2.2. IUCN Criteria and Categories

Using the potential distribution models based on point occurrence data obtained for each species, we were able to estimate population size reduction (Criterion A) and species geographic range (Criterion B). Each criterion was assessed separately and a threat category was given if the species met at least one of the criteria. Because there is not enough information about census data for species, we could not assess population size (Criterion C), detection of very small or restricted populations (Criterion D) or quantitative estimates of extinction risk (Criterion E).

Criterion A- population size reduction over 10 years- was assessed based on category A2 "[p]opulation reduction observed, estimated, inferred, or suspected in the past where the causes of reduction may not have ceased OR may not be understood OR may not be reversible", considering the decline in area of occupancy (subcriteria "c"). Using two maps of Mexico´s land use and vegetation coverage (INEGI, Capa Digital de Uso de Suelo y Vegetación, Series III, 2005; Series VI, 2017) we excluded from both maps the areas transformed into agricultural, rural or urban settlements, which are unsuitable habitats for terrestrial species (Sánchez-Cordero et al., 2005; 2009). We entered both maps into the Consnet software (Ciarleglio at al., 2009; 2010) as permanently excluded areas and obtained the species extant distributions in both years by retaining only the areas with remnant natural habitat. Then we obtained the species area of occupancy by multiplying the number of cells occupied by the species by 0.78 (size in km2 of each cell). We compared species area of occupancy from 2002 with the area of occupancy from 2014 to provide an estimate of the percentage of the decline in area of occupancy over the last 10 years. A threat level was assigned to a species if it lost more than 30% of its distribution. If a species lost ≥30% of its distribution, the category assigned was Vulnerable, if it lost ≥50% of its distribution the species was considered Endangered and it was considered Critically Endangered if it lost ≥80% of its distribution. A species was considered not at risk if the decline in the area of occupancy was <30%.

Criterion B- geographic range- was assessed by quantifying the area of occupancy of the species extant distribution (B2). Species were considered Vulnerable if their area of occupancy was <2,000 km^2, Endangered if they were distributed in <500 km^2, and Critically Endangered if they occupied <10 km^2. Species were not considered at risk if their area of occupancy was >2,000 km^2.

2.3. NOM-059-SEMARNAT, MER Criteria and Categories

To identify species at risk using Mexico´s system, we applied the MER Criteria and Categories (Denisse, 2010). It has four risk criteria, which are assessed separately and contribute with a number that represents risk according to that criterion. Values are added up to give a final score. Species with a total score of 8-9 were considered Subject to Special Protection (Pr), 10-11 points were considered Threatened (A) and 12-14 points were considered Endangered (P). Species with a total score <7 were not considered at risk.

Criterion A, "magnitude of the distribution range of the taxon in Mexico", was analyzed by comparing the area of the species extant distribution with the total area of Mexico (1,964,375 km^2). Species occurring in <5% of Mexican territory are considered highly restricted with a risk category of 4; between 5-15% are restricted with a risk category of 3; between 15-40% are moderately restricted with a risk category of 2; and >40% are considered widely distributed with a risk category of 1.

Criterion B, "status of the habitat with respect to the natural development of the taxon", evaluates the habitat impact over the natural requirements of the taxon considering biological and physical conditions. We used Conabio´s Ecological Integrity Map (Equihua et al., 2014) to assess this criterion, since this map integrates the functional, structural and compositional attributes of a specific area and thus evaluates the condition of ecosystems across the country, giving a value to each area according to its ecological integrity. We classified the ecological integrity values in 3 classes using a geometrical interval classification and then we obtained the percentage of the species potential distribution allocated in each class and multiplied the percentage by the class value (1, 2 or 3), resulting on a score between 100 and 300. We divided this range in 3 and the risk category was given depending on the species ecological integrity score. A risk category of 3 was given if the ecological integrity of the species distribution was between 233.33 and 300 (Hostile or very limiting), 2 if the value was between 166.66 and 233.33 (intermediate or limiting), and 1 if the value was between 100 and 166.66 (auspicious or not limiting).

Criterion C assesses the "intrinsic biological vulnerability of the taxon", but the MER does not provide guidelines as to how this criterion should be assessed and scaled, as it is assigned according to the researcher´s consideration. To give this criterion a more objective value, we used the species niche breadth using ENMTools software (Warren et al., 2010). We used niche breadth as a proxy because it considers different parts of the species life history and the conditions it requires to survive and reproduce. We entered the species potential distribution ASCII file and obtained a value between 0 (for very specialist species) and 1 (for very generalist species) for their niche breadth. Species with a value from 0-0.33 were given a risk value of 3, from 0.33-0.66 were given a risk value of 2, and from 0.66-1 the risk value assigned was 1.

Criterion D, "impact of human activities on the taxon", was assessed by comparing the species potential distributions with their extant distributions and obtaining the percentage of distribution lost. Species with a distribution loss >66.66% were given a risk category of 4; species losing between 33.33-66.66% of their distribution were given a risk category of 3; and species losing <33.33% had a risk category value of 2.

To assess extinction risk at a local level, instead of using all of Mexico´s surface we analyzed (A) percentage of the ecoregion´s area occupied by the species, (B) status of the habitat used by the species in each ecoregion and (D) percentage of the species distribution lost at each ecoregion. The only criterion that remained the same was Criterion C.

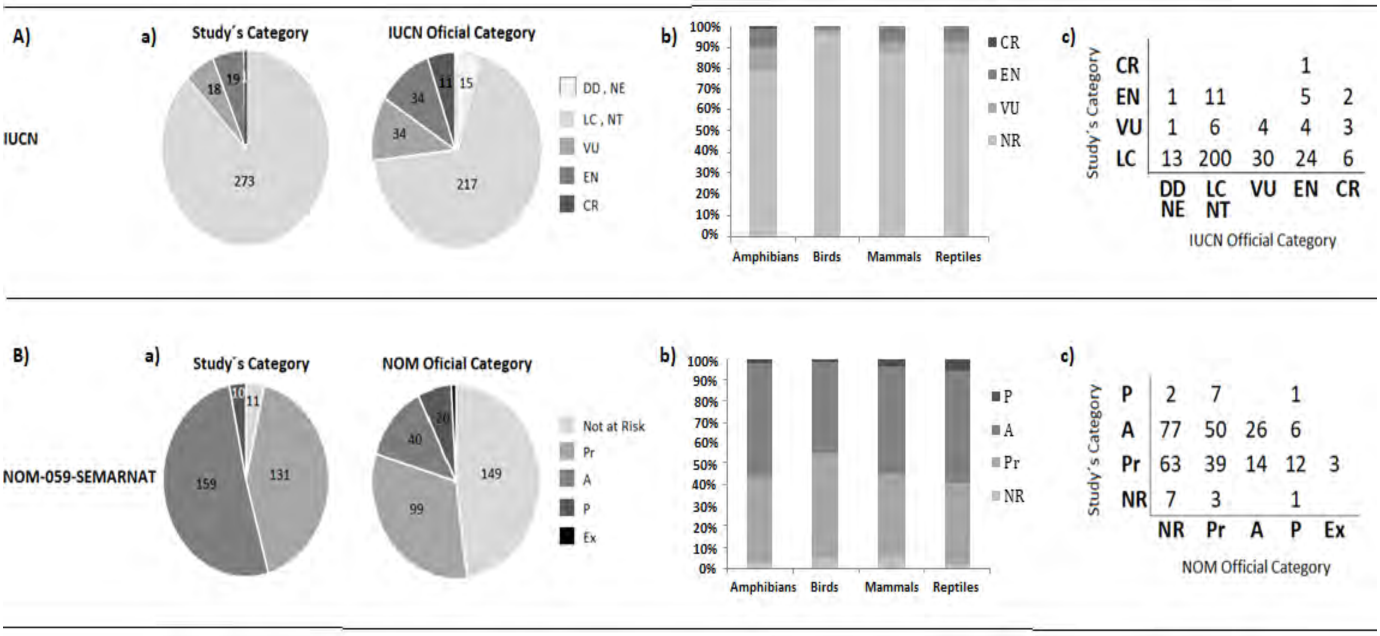
3. Results

3.1. Risk category at a national level

More species were considered at risk when applying the NOM-059-SEMARNAT criteria than IUCN criteria and categories (Figure 1; Appendix I).

The IUCN Red List of Threatened Species has 79 of the 311 species in it and 15 have not been evaluated of are data deficient, while our study only considers that 38 species are threatened: 18 are vulnerable, 19 are endangered and 1 is critically endangered (Figure 1-Aa; Appendix I). Birds were the less affected group, were only 3 species (3.75% of bird species) had a risk category assigned; 13 amphibians (20.96%), 7 mammals (13.46%) and 15 reptiles (12.82%) had a risk category assigned to them (Figure 1-Ab). We obtained the same risk category as the IUCN Red List for 209 species, while only 33 species had a smaller category according to the IUCN Red List and 69 species are at greater risk in the IUCN Red List than in our study (Figure 1- Ac; Appendix I). None of the 311 species have lost >30% of their distribution over the last 10 years, so the LC category was assigned to all species according to Criterion A. Only 38 species had an AOO <2000 km^2 and a risk category was assigned to them according to Criterion B.

Currently, 162 of the 311 species studied are listed in the NOM-059-SEMARNAT, but our study suggests that 300 species are at risk: 131 should be considered under special protection, 159 threatened and 10 endangered (Figure 1-Ba; Appendix I). All groups of vertebrates were similarly affected: 60 amphibians (96.77% of species), 76 birds (95%), 49 mammals (94.23%) and 115 reptiles (98.29%) had a risk category assigned to them, although the bird group had fewer percentage of species under the threatened (A) and endangered (P) categories (Figure 1- Bb). When comparing the official categories with the ones assigned in this study, 73 species were found at the same level of threat, while 199 are considered more threatened by our results and only 39 are at greater risk according to the official category (Figure 1-Bc, Appendix I). As all species are endemic and occupy <15% of the country, the score assigned for criterion A to all species was 3 or 4. Also, all species had an ecological integrity (criterion B) score of 1 or 2, since only small regions of the country had an ecological integrity of 3 and did not occupy major proportions of the species distributions. When analyzing criterion C, species niche breadths were >0.33, suggesting no species were greatly specialists and the scores assigned were 1 or 2. Finally, 107 species lost <33.33% of their distribution (score of 2), 190 species lost between 33.33 and 66.66% (score of 3) and 14 species lost >66% (score of 4) of their distribution.



Study's Category	DD NE	LC NT	VU	EN	CR
CR				1	
EN	1	11		5	2
VU	1	6	4	4	3
LC	13	200	30	24	6

Study's Category	NR	Pr	A	P	Ex
P	2	7		1	
A	77	50	26	6	
Pr	63	39	14	12	3
NR	7	3		1	

Figure 1- (a) Risk category assigned to the 311 species according to (A) IUCN criteria and categories and (B) NOM-059-SEMARNAT criteria and categories, comparing (b) the percentages of each category by group and (c) the categories assigned by our study and the oficial categories.

3.2. Risk category at an ecoregion-level

For each ecoregion we applied the NOM-059-SEMARNAT criteria and categories, obtaining a species risk category at each ecoregion (Figure 2B-E). On average, species occurring in 18 ecoregions were considered not at risk (NR), while the other 75 ecoregions had a risk category assigned to the species found in them (Figure 2A). The 18 ecoregions considered NR and the 51 ecoregions with an average category of under special protection (Pr) were mostly found in the Mexican Deserts, the Western Sierra Madre, the Mexican High Plateau and Southern Sierra Madre. The ecoregions corresponding mainly to the Temperate Sierras, Southern Semi-Arid Highlands and Tropical Humid Forests (INEGI, CONABIO, INE, 2008) are the most affected ecoregions: 23 ecoregions, located mainly at the Transmexican Volcanic Belt, the Great Plains and the Yucatan Peninsula, had an average extinction risk of threatened, while 3 ecoregions, at the Sonoran Desert, the Gulf of Mexico and the Transmexican Volcanic Belt, were considered endangered. Two ecoregions did not have species found in them, so no average risk category was obtained (Figure 2A, Appendix II).

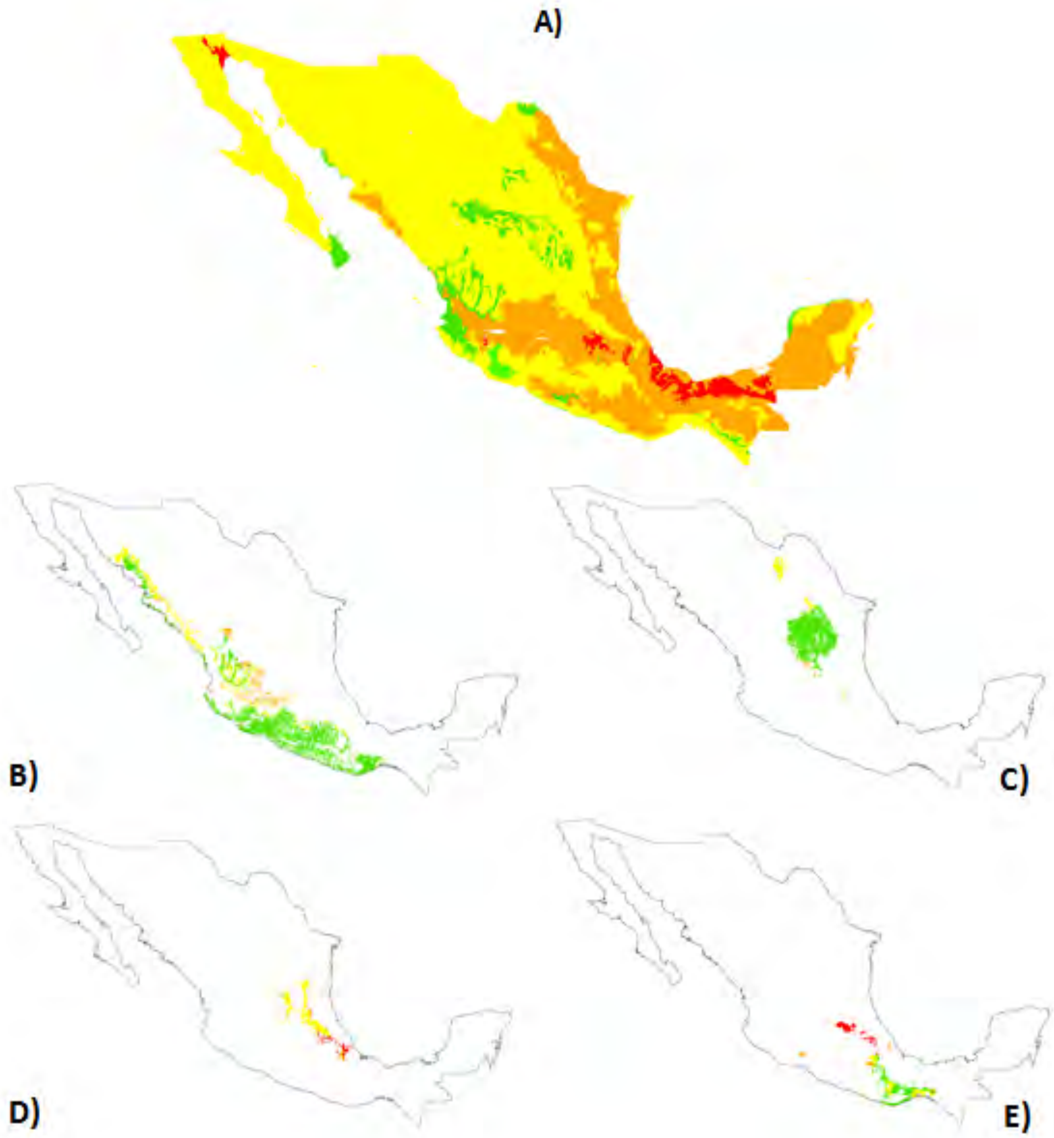


Figure 2- Average risk category for the species at each ecoregion (A), and examples of the risk category by ecoregion for 4 species (B) Artibeus hirsutus (mammal), (C) Sceloporus cautus (reptile), (D) Chiropterotriton chondrostega (amphibian), (E) Calothorax pulcher (bird). The most threatened species were found at the Transmexican Volcanic Belt, the Gulf of Mexico and the Yucatan Peninsula.

4. Discussion

In the Mexican endemic vertebrate terrestrial species, we found very different results between the IUCN and NOM-059-SEMARNAT methods, with the IUCN risk categories being much lower than the categories assigned by the NOM-059-SEMARNAT. According to the IUCN Red List of Endangered Species, Mexico is one of the countries with the highest number of threatened vertebrate species, where more than 350 endemic vertebrate species (more than 30% of the species) are threatened (IUCN, 2019). This reflects the country´s biodiversity status after 50 years of great habitat loss, were more than 13 million ha of vegetation have been lost due to anthropogenic activities (Semarnat, 2016). Of the 311 species assessed in our study, 79 are in the Red List and 15 have not been evaluated or do not have enough data to be assessed (IUCN, 2019). However, our study only considers 38 species as threatened: 18 are vulnerable, 19 are endangered and 1 is critically endangered. One major reason for this result is that this method requires a large amount of census data difficult to obtain, especially for endemic species with few collection data, and such data are necessary for the assessments of population size and quantitative estimates of extinction risk, so the only criteria that could be assessed were A and B. Furthermore, criterion A only considers the reduction of species area of occupancy over the last 10 years and in Mexico the loss of habitat has decreased considerably in this period of time. Thus, no species were considered threatened according to this criterion because non of them lost more than 30% of their distribution. However, if we look at species distribution loss over the last 50 years, only 84 species have retained more than 70% of their potential distributions and 67 species have lost more than half of their distributions. Even though they still retain a big enough area of occupancy as not to be considered threatened by criterion B, we believe it is dangerous not to consider them at some level of threat since they have restricted distributions and dispersal limitations, with an unlikely chance to move from unfavorable to favorable habitats (Gardner et al., 2007; Becker et al., 2007). Thus means we could lose them in a short period of time without good policies to protect them. The most affected groups were amphibians and reptiles, which supports the idea that habitat loss is an important threat affecting these groups. Furthermore, Tracewski et al. (2016) found that, of the species that should have a higher extinction risk than the one assigned by the IUCN, 40.5% of species are amphibians.

Even though it has been debated that the IUCN method is superior to national systems to assess extinction risk (de Grammont and Cuarón, 2006), in this study we could better assess extinction risk according to the NOM-059-SEMARNAT method since all criterion could be assessed and we believe this method fit and satisfied better the needs and conservation threats of the country. Currently, more than 50% of the total endemic vertebrate species are considered at some level of threat according to the NOM-059-SEMARNAT, of the 311 species assessed in this study, 162 of the species are listed in the NOM-059-SEMARNAT. However, our results show that 300 species should be considered at risk: 131 under special protection, 159 are threatened and 10 are endangered. For conservation purposes, we believe the risk categories assigned here by the NOM-059-SEMARNAT should be used over the IUCN categories, since it is better to impose a higher risk category for a species and generate more precautionary conservation policies, than to believe that species are at lower risk of extinction.

One major flaw in the NOM-059-SEMARNAT is that is takes a lot of time to be updated and thus the information of the current conservation status of biodiversity can be outdated. This is why it is extremely important that studies assess species extinction risk and that an alternative platform is built so that researchers and decision makers have the latest information and can offer adequate policies and conservation projects. We believe our method using ecological niche models is a good approach to assess extinction risk in a fast and reliable way. It allows us to assess three of the four criteria with a method that is repeatable, objective and comparable across taxa. Criteria A and D were assessed from the species distribution models, and every time a new map of land use and vegetation cover is available they can be modified. Even though criteria B and D seem redundant and it could be difficult to assess them independently, we believe that our method is a good approach since one map (criterion B) integrates the functional, structural and compositional attributes of a specific area and thus evaluates the condition of ecosystems across the country, while the other (criterion D) only considers the habitat transformed into agricultural, rural or urban settlements. Finally, the NOM-059-SEMARNAT does not specify how criterion C should be assessed, leaving it to the researchers consideration. Thus, it becomes very subjective to assess this criterion since each evaluation is different. With our proposal, we can also assess this criterion with ecological niche models and have a general feature to use as a proxy to assess the intrinsic vulnerability. Niche breadth is a good feature to analyze since it considers different parts of the species life history and the conditions it requires to survive and reproduce, and is comparable between taxa. Therefore, with our method we could be assessing more species and assigning risk categories to them every time a new map of land use and vegetation cover is available, and thus update the category every few years.

Another advantage of our method is that, with the way we took the NOM-059-SEMARNAT and applied it to ecoregions, it can be used to assess extinction risk at different scales. Here we decided to use ecoregions to analyze extinction risk at a local level, but it could also be used at other scales such as states, and governments could apply it to generate policies according to the conservation status of species inside their state. This could not be done with the IUCN criteria, as they are made for bigger scales such as a global, continental or national level and it cannot be altered to apply it at smaller scales. Assessing extinction risk at local levels is of the utmost importance, since habitat loss is different at each region depending on the human activity and thus the impact on species varies along their distributional area. The species found at the ecoregions of the Transmexican Volcanic Belt, the Gulf of Mexico and the Yucatan Peninsula suffered the greatest impact, where temperate and tropical forests are the main ecosystems. However, these are the areas with the highest diversity and most of our species were found here, as it is an important center of endemisms (Peterson and Navarro, 2000). Thus, protecting these areas is critical for conserving Mexico´s biodiversity. Species can be prone to extirpation in certain areas of their ranges, while in others they retain untransformed habitats and are thus under less extirpation risk. For example, *Calothorax pulcher* was considered threatened at a national level, but in some parts of its range (Transmexican Volcanic Belt) the risk category assigned was endangered, while in other areas (Southern Sierra Madre) it was considered not at risk. On the other hand, *Lithobates tarahumarae* was nationally considered not at risk but in some areas of its distribution the risk category assigned was threatened or endangered. Our results show that populations face different extirpation risks according to geographic location, thus providing a geographical context toward designing local conservation plans. Knowing the areas of the country with the highest risk for species can help to target the locations that are of greater conservation concern and need more resources.

Today, it is not enough to have risk categories of species at global or national levels, since the world is changing rapidly and we are losing species by the minute. Thus, more species-specific conservation plans, which vary depending on each area of their distributional ranges, are needed. The first step is to have a better knowledge of each species conservation status under a geographical context, and our study is the first one in Mexico to look for a method that can help us achieve this goal. If we do not act quickly and look at local solutions, climate change and the anthropogenic activities, such as deforestation and mining, will accelerate species local extirpation and extinction.

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DISCUSIÓN GENERAL

Distribución de especies

México es un país con una gran diversidad de especies de vertebrados con alrededor del 9% de las especies del planeta, de las cuales una gran parte sólo se encuentran en nuestro país (Conabio, 2009). En este estudio se obtuvieron datos de presencia de 996 especies de vertebrados endémicos de México, de los cuales al final pudimos analizar a 311, representando casi una tercera parte de las especies (22.54% del total de anfibios, 81.63% del total de aves, 32.70% del total de mamíferos y 24.68% del total de reptiles). Esto se debe a que la mayoría de las especies endémicas tienen distribuciones restringidas y hay poca información y cantidad de registros sobre ellas, además de que es difícil que haya especialistas en estas especies por lo que son poco estudiadas. Asimismo, consideramos que son nescasarios llevar a cabo prospecciones de campo actuales, para confirmar el estado de las poblaciones de las especies. Ya que este estudio está basado en la información disponible en línea de grandes bases de datos y no representan el estado actual de las poblaciones estudiadas, debido a que pueden pasar años entre la recolección de los datos de campo, el proceso curatorial y hasta la integración de éstos datos en los formatos digitales de la bases de datos. Por lo tanto, para una gran parte de las especies no fue posible obtener modelos de nicho ecológico con nuestro método y deberían usarse otros métodos (Pearson et al., 2007). Sin embargo, debido a que las especies que se analizaron corresponden a cuatro taxones de vertebrados diferentes, se sugiere que la proporción que representa refleja de manera adecuada la situación de las especies a nivel nacional y regional (Monroy et al., 2018).

La mayoría de las especies estudiadas se encontraron en el Eje Neovolcánico Transversal, seguido por la costa del Pacífico y el Sur de México. Estas son zonas con una topografía compleja y una gran variedad de hábitats (Rzedowski, 1986), por lo que se convierten en un gran centro de endemismo de especies de vertebrados y otros grupos taxonómicos (Peterson y Navarro, 2000).

Impacto de pérdida de cobertura vegetal y minería

Una de las principales amenazas a la biodiversidad es la pérdida de hábitat. En México la tasa de deforestación anual es mayor al 1% (Sarukhán et al., 2009), lo que ha llevado a que se pierdan más de 13.5 millones de hectáreas de vegetación natural en los últimos 50 años. Como consecuencia, la distribución de las especies se ha reducido a través de los años de forma continua, tal como se demostró en este estudio. Para 1986, primer fecha en la que se evaluó la pérdida de distribución de las especies comparado con su distribución potencial, la mitad de las especies estudiadas habían perdido más del 30% de su distribución. Posteriormente, entre los años de 1986 y 2002 es cuando se observó la mayor disminución en la distribución de las especies, ya que fueron las etapas de mayor pérdida de cobertura vegetal en el país (Semarnat, 2016). A partir de ahí, en lo últimos años la pérdida ha disminuido y podemos encontran contrastes en cuanto al cambio de vegetación. Por una parte, tenemos estados como Jalisco, Chiapas, Aguascalientes y Yucatán que han tenido una pérdida muy rápida de vegetación entre 2002 y 2007, mientras que en otras zonas del país, como Hidalgo, Puebla, Nayarit y Morelos se ha observado una recuperación en la cobertura vegetal. Esto se ve reflejado en la distribución de especies, donde podemos observar que más de la mitad de las especies han recuperado parte de su distribución del 2002 a la fecha, aunque otras siguen disminuyendo. En la actualidad, el 73% de las especies evaluadas (227 especies) han perdido al menos el 30% de su distribución y esta pérdida de hábitat y la consecuente reducción en la distribución de especies, especialmente para las especies endémicas que pueden persistir principalmente en hábitats no transformados (Sánchez-Cordero et al., 2005), es crítica y de conyinuar así puede conducir a su extinción o extirpación poblacional porque generalmente tienen pequeñas áreas de distribución y la rápida adaptación a los nuevos ambientes producidos por la transformación antropogénica es poco probable (Peterson y Holt, 2003).

Además de la pérdida de hábitat, existen otros factores menos estudiados y que podrían aumentar el riesgo de extinción de especies, como es el caso de las actividades mineras. En México, más de 20 millones de hectáreas tienen concesiones para llevar a cabo actividades mineras, y esta superficie podría duplicarse para fines de 2019 (Fundar, 2018). En este estudio podemos observar que el mayor impacto hacia las especies de anfibios y reptiles efectivamente es por la pérdida de cobertura vegetal, pero las actividades mineras redujeron la distribución de todas las especies. Nuestro estudio solo analizó el impacto de la minería sobre la distribución de especies debido al área concesionada. Sin embargo, otros factores causados por las actividades mineras, como la contaminación de ríos y acuíferos, desechos contaminantes, drenaje ácido, emisiones de gas y polvo y la eliminación local de toda la vegetación (Armendáriz-Villegas, 2016), podrían aumentar el impacto negativo de la minería sobre las especies, por lo que la actividad minera representa una amenaza relevante y podría estar ocasionando que las especies aumenten su riesgo de extinción. De las 179 especies incluidas en este trabajo, solo 50 especies (35 anfibios y 15 reptiles) están actualmente incluidas en la lista roja de especies en peligro de extinción de la UICN. Sin embargo, si se incluyeran otros factores antrópicos como la minería en la evaluación del riesgo, un número mayor de especies de anfibios y reptiles estarían incluidas en una categoría de riesgo de extinción. Otro gran problema es que las actividades de exploración, extracción y beneficio de minerales son considerados de utilidad pública y son preferentes sobre cualquier otro uso o actividad del territorio, con excepción de la extracción de petróleo y la distribución de energía eléctrica. Por lo tanto, existe una creciente preocupación de que las regulaciones legales actuales consideren las actividades mineras como una prioridad, hasta el punto de que incluso se puedan establecer dentro de áreas protegidas. Este último punto es de suma importancia y de altísima gravedad, ya que se pasa por alto el trabajo que se ha hecho en los últimos 50 años en cuanto a la proclamación de áreas naturales protegidas y en la disminución en las tasas de deforestación y permite actividades en zonas dedicadas a la conservación de la naturaleza, incluso en zonas núcleo que deberían ser intocables. Si queremos que en nuestro país se conserve la biodiversidad de manera adecuada y se cumplan los compromisos internacionales de conservación para conservar el 17% del territorio, se deben hacer grandes cambios en términos de políticas y el gobierno mexicano debe cambiar urgentemente secciones de su legislación ambiental, como por ejemplo no permitir actividades mineras dentro de las áreas naturales protegidas.

Riesgo de extinción de especies a nivel nacional

En México, 665 especies de vertebrados se encuentran en riesgo según la UICN, mientras que la NOM-059-SEMARNAT sugiere que 1300 especies se encuentran en riesgo. De las 311 especies estudiadas, solo 79 se encuentran en la lista roja de la UICN, mientras que 162 especies se encuentran en la NOM-059-SEMARNAT. En este estudio también se encontraron resultados muy diferentes al analizar el riesgo de extinción de especies usando los criterios y categorías de la UICN y de la NOM-059-SEMARNAT, pero además las especies en riesgo fueron muy diferentes a las que se encuentran oficialmente en la UICN y la NOM-059-SEMARNAT. Mientras que en la UICN oficialmente 79 de las 311 especies estudiadas presentan algún riesgo de extinción, en este trabajo solamente 38 especies se consideraron en alguna categoría de riesgo de la UICN: 18 están vulnerables, 19 están en peligro y 1 está en peligro crítico. En este contexto es importante notar que este método requiere una gran cantidad de datos de censos difíciles de efectuar, especialmente para especies endémicas de las cuales se tienen pocos datos de colecta, así como registros actuales. Dichos datos son necesarios para las evaluaciones del tamaño de la población y las estimaciones cuantitativas del riesgo de extinción, por lo que solo se pudieron evaluar los criterios A (reducción del tamaño poblacional, con base en la reducción en el área de ocupación) y B (distribución geográfica). Además, el criterio A solo considera la reducción del área de ocupación de las especies en los últimos 10 años. Sin embargo, en México la pérdida de hábitat ha disminuido considerablemente en este período de tiempo y se requieren datos de campo recientes, ya que los registros de las fuentes mencionadas por lo general fueron registrados hace ya un tiempo considerable. Por lo tanto, ninguna especie se consideró amenazada de acuerdo con este criterio, ya que ninguna de ellas perdió más del 30% de su distribución. Sin embargo, si observamos la pérdida de distribución de especies en los últimos 50 años, solo 84 especies han retenido más del 70% de sus distribuciones potenciales y 67 especies han perdido más de la mitad de sus distribuciones. Es por esto que, a pesar de que aún conservan un área de ocupación lo suficientemente grande como para no ser considerados amenazados por el criterio B, puede ser peligroso no considerarlos en algún nivel de amenaza ya que tienen distribuciones restringidas y limitaciones de dispersión, con poca probabilidad de pasar de hábitats desfavorables a hábitats favorables (Gardner et al., 2007; Becker et al., 2007). Esto significa que podrían estar seriamente afectados en un corto período de tiempo si no contamos con buenas acciones, estrategias y políticas públicas para protegerlas.

Aunque la UICN es una fuente valiosa para evaluar el estado de las especies en todo el mundo, así como para la planificación de la conservación y para asignar prioridades para el financiamiento de la conservación y su acción (Rodrigues et al., 2006), y se ha debatido que el método de la UICN es superior a los sistemas nacionales para evaluar el riesgo de extinción (Grammont y Cuarón, 2006), en este estudio se pudo evaluar mejor el riesgo de extinción de acuerdo los criterios y categorías de la NOM-059-SEMARNAT ya que todos los criterios pudieron ser evaluados y este método se ajusta y satisface mejor las necesidades y amenazas de conservación del país. Actualmente, 162 de las especies estudiadas están consideradas con algún riesgo de extinción, pero nuestros resultados muestran que 300 especies deberían considerarse en riesgo: 131 se deberían considerar bajo protección especial, 159 amenazadas y 10 en peligro. Para fines de conservación, en este trabajo se plantea que las categorías de riesgo asignadas aquí por la NOM-059-SEMARNAT deben usarse sobre las categorías de la UICN, ya que es mejor definir una categoría de riesgo más alta para una especie y generar políticas publicas de conservación precautorias, que asumir que las especies están en menor riesgo de extinción.

Una falla importante en la NOM-059-SEMARNAT es que tarda mucho tiempo en actualizarse y, por lo tanto, carece de información sobre el estado actual de conservación de la biodiversidad. Es por esto que es extremadamente importante que más estudios evalúen el riesgo de extinción de especies y se construya una plataforma alternativa para que los investigadores y los tomadores de decisiones tengan la información más reciente y puedan ofrecer políticas y proyectos de conservación adecuados. El método propuesto en este estudio, con la ayuda de sistemas de información geográfica y modelos de nicho ecológico, ataca esta problemática, ya que permite modificar rápidamente las categorías de riesgo en cuanto se encuentre disponible nueva información sobre el uso del suelo y vegetación, y así tener una evaluación actualizada de cada especie en periodos de tiempo cortos. Además, representa una manera rápida, fácil y económica de hacer las evaluaciones, necesita de pocos datos y es un método repetible, comparable entre taxones y que proporciona estimaciones que con pequeñas variaciones puede usarse globalmente.

Riesgo de extinción de especies a nivel local

Debido a que la pérdida de hábitat parece estar relacionada con la región geográfica en donde las especies se distribuyen (Sánchez-Cordero et al., 2005a,b), evaluar la pérdida de distribución a nivel de ecorregión nos permite identificar las áreas del país donde se encuentran las especies más vulnerables. Debido al método utilizado se pudieron aplicar los criterios y categorías de la NOM-059-SEMARNAT para evaluar el riesgo de extinción de cada especie por ecorregión y así saber cuál es su estado de conservación a nivel regional. Aquí se decidió usar las ecorregiones, pero también se podrían usar otras escalas, como a nivel estado, y los gobiernos estatales lo podrían generar y aplicar políticas públicas de acuerdo con el estado de conservación de las especies dentro de su estado. Estas evaluaciones no pudieron efectuarse con los criterios de la UICN ya que están hechos para escalas más grandes, como un nivel global, continental o nacional, y no se pueden modificar para aplicarlo a escalas más pequeñas. Las especies encontradas en las ecorregiones del Eje Neovolcánico Transversal, el Golfo de México y la Península de Yucatán sufrieron el mayor impacto, donde predominan las sierras templadas y los bosques tropicales húmedos. Además, el Eje Neovolcánico Transversal es de las zonas donde se pueden encontrar más especies endémicas. Por lo tanto, proteger estas áreas es fundamental para conservar a la biodiversidad mexicana. Si las especies analizadas en este estudio representan efectivamente a otros grupos taxonómicos que no se consideran aquí, probablemente muchas más las poblaciones de especies que viven en estas ecorregiones podrían estar en peligro. Con este escenario, la marcada pérdida de biodiversidad en estas regiones podría conducir al colapso de las comunidades, los ecosistemas y los servicios ecosistémicos proporcionados a los humanos en la región más poblada del país. Consecuentemente, prestar atención a esta situación del estado de la biodiversidad debería ser una prioridad.

México, al ser un país con gran diversidad de ecosistemas y especies, no puede tener políticas homogéneas de conservación y uso de suelo y recursos, sino que se deben considerar diferentes enfoques y políticas territoriales adecuados a la gran diversidad y distribución heterogénea de las especies a lo largo del país. Se deben implementar diferentes instrumentos de conservación dependiendo del grupo taxonómico. Por ejemplo, para las aves las reservas de la biósfera y áreas naturales protegidas pueden ser adecuadas ya que ocupan áreas extensas, pero para anfibios y reptiles se deberían considerar otras estrategias como los corredores biológicos, así como el manejo sustentable y de bajo impacto en zonas fuera de áreas protegidas. Por otro lado, es importante recalcar que el hecho de que una especie no tenga reducción en su distribución en una región no significa que las acciones para su conservación deban disminuir. Aunque nos permite ver cómo se encuentra la especie en diferentes zonas de su distribución y esta condición debería verse reflejada en análisis de priorización de conservación regional, no se debe asumir que donde la especie se encuentra con su hábitat conservado entonces se deba descuidar o asumir que la especie estará bien sin ayuda de proyectos de conservación, sino que las acciones de conservación podrían diferir en cada localidad.

CONCLUSIONES

En la actualidad estamos viviendo una crisis de la biodiversidad que debe atenderse y considerarse prioritario en las agendas de todos los gobiernos del mundo. Estamos perdiendo nuestros escositemas y un número exagerado de especies anualmente, entrando así a la sexta extinción masiva. Pero a diferencia de las otras, esta es la primera ocasionada por otra especie: el humano. La pérdida de hábitat por deforestación y cambio de uso de suelo para cuestiones agrícolas, ganaderas y urbanización, ha generado que las especies pierdan su área de distribución, incrementando su riesgo de extinción en los últimos años. Pero además de estas prácticas, existen otros factores, como la minería y el cambio climático, que han tomado fuerza y se están convirtiendo en nuevas amenazas para la biodiversidad.

Esta biodiversidad, junto con el capital natural- recursos naturales vistos como medios de producción de bienes y servicios ecosistémicos-, son dos recursos importantes que hacen que un país pueda conseguir el bienestar social y proyectar su desarrollo futuro. Por lo tanto, no podemos esperar que exista un crecimiento y desarrollo de nuestro país si no protegemos la riqueza biológica que tenemos aquí. Este punto se debe tomar con cuidado, ya que puede llevar, y lo ha hecho durante muchos años, a que sobreexplotemos nuestros recursos de manera acelerada para satisfacer nuestras necesidades sin pensar en las consecuencias futuras. Sin embargo, es momento de que cambiemos esta visión y busquemos alternativas donde exista un desarrollo social y económico, pero también se proteja a la naturaleza, ya que estamos empezando a sentir el impacto de nuestros actos y estos sólo incrementarán, provocando que cada vez perdamos más especies y que la calidad de vida y bienestar de la humanidad se vea afectada.

Para lograr frenar esta problemática es indispensable que los gobiernos cambien los términos de su legislación ambiental actual, en cuestión de emisión de gases de efecto invernadero, de minería y de sobreexplotación de recursos, entre otros. Se debe buscar un cambio hacia el desarrollo sostenible, involucrando a la sociedad científica, a los expertos y a las instituciones encargadas de estudiar la biodiversidad y los ecosistemas, además de tomarlos en cuenta para la evaluación y desarrollo de megaproyectos que podrían poner en riesgo a la naturaleza.

Asimismo, es indispensable incrementar los esfuerzos para evaluar el riesgo de extinción de especies y conocer con la mayor exactitud posible la situación de las especies tanto a nivel mundial y nacional, como a niveles más pequeños, como ecoregiones. Como podemos observar, muchas especies no han sido evaluadas o tienen asignado un riesgo de extinción que podría no ser el adecuado, y es mejor ser precavidos y asignarles a las especies un mayor riesgo en vez de pensar que se encuentran mejor de lo que podrían estar. Por otro lado, es necesario que se realicen prospecciones de campo actuales para confirmar el estado de conservación de las poblaciones de las especies con mayor riesgo de extinción. Esto permitirá crear proyectos adecuados de conservación, específicos para cada especie en un contexto geográfico que varíen según cada región de su rango de distribución.

En este trabajo se propone una modificarción a la NOM-059-SEMARNAT que nos permite evaluar el riesgo de extinción de especies a escalas menores, siendo así el primer trabajo en México en buscar un método para evaluar la situación de las especies bajo un contexto geográfico. Este estudio confirma los beneficios potenciales del uso de sistemas de información geográfica y modelos de nicho ecológico para evaluar la pérdida de hábitat y el riesgo de extinción de especies. Este método es adecuado debido a que: 1) es una manera rápida, fácil y económica de hacer las evaluaciones; 2) necesita de pocos datos y puede ayudar a evaluar el riesgo de extinción de especies con información limitada; 3) es un método repetible, comparable entre taxones y que proporciona estimaciones que con pequeñas variaciones puede usarse globalmente; 4) permite modificar rápidamente las categorías de riesgo en cuanto se encuentre disponible nueva información sobre el uso del suelo y vegetación, y así tener una evaluación actualizada de cada especie en periodos de tiempo cortos.

Aunque el daño ya está hecho, aún estamos a tiempo de evitar que las consecuencias sean irreversibles. Si no actuamos rápidamente y buscamos soluciones locales, el cambio climático y las actividades antropogénicas acelerarán aún más la extinción y extirpación local de las especies.

APÉNDICES

CAPÍTULO 1

Apéndice I. Porcentaje de la distribución perdida para vertebrados terrestres endémicos de México para cada Serie

Appendix I. Percentage of distribution lost for Mexican endemic terrestrial vertebrates at each Series

Species	Group	Series 1	Series 2	Series 3	Series 4	Series 5	Series 6
Ambystoma altamirani	Amphibians	38.77	39.77	40.05	38.47	41.44	40.33
Ambystoma rosaceum	Amphibians	7.35	8.03	9.22	9.49	9.79	10.09
Ambystoma velasci	Amphibians	69.91	73.58	73.74	73.14	74.14	75.11
Anaxyrus compactilis	Amphibians	41.33	46.84	48.17	48.8	49.62	49.85
Aquiloeurycea cephalica	Amphibians	56.7	59.42	59.97	59.64	60.56	60.73
Bolitoglossa alberchi	Amphibians	24.93	35.47	41.46	41.9	42.76	43.19
Bolitoglossa platydactyla	Amphibians	59.28	63.71	65.72	66.11	65.84	65.88
Charadrahyla nephila	Amphibians	13.28	14.36	18.86	20.41	20.77	21.7
Charadrahyla taeniopus	Amphibians	54.22	50.37	52.71	52.39	52.23	52.56
Chiropterotriton chiropterus	Amphibians	47.54	49.41	49.75	49.31	51.66	52.02
Chiropterotriton chondrostega	Amphibians	36.31	36.41	37.47	37.32	37.75	37.08
Chiropterotriton multidentatus	Amphibians	35.06	38.6	39.03	38.79	39.33	38.94
Craugastor decoratus	Amphibians	56.05	54.19	55.59	55.53	55.6	56.25
Craugastor hobartsmithi	Amphibians	31.72	32.97	34.8	34.78	35.7	35.01
Craugastor mexicanus	Amphibians	30.27	33.66	38.21	39.26	40.07	40.71
Craugastor montanus	Amphibians	23.02	29.81	36.77	38.91	39.53	42.57
Craugastor occidentalis	Amphibians	20.98	24.9	26.59	27.03	27.27	27.14
Craugastor pozo	Amphibians	15.28	14.76	13.98	22.02	21.76	25.64
Craugastor rhodopis	Amphibians	30.19	34.18	39.44	40.36	40.9	43.25
Craugastor rugulosus	Amphibians	20.65	26.22	31.03	32.79	33.66	35.43
Dryophytes euphorbiaceus	Amphibians	50.06	52.13	54.1	53.04	53.63	52.34
Dryophytes eximius	Amphibians	34.43	36.46	37.52	38.01	38.6	38.32
Dryophytes plicatus	Amphibians	67.11	69.69	69.88	69.36	70.72	70.94
Ecnomiohyla miotympanum	Amphibians	36.41	38.22	39.88	40.35	40.71	42.2
Eleutherodactylus longipes	Amphibians	38.84	49.68	53.46	53.43	54.25	55.03
Eleutherodactylus nitidus	Amphibians	28.95	32.98	34.47	34.82	35.42	33.75
Eleutherodactylus verrucipes	Amphibians	34.64	38.43	39.75	39.85	40.29	40.61
Exerodonta melanomma	Amphibians	11.29	13.76	17.67	17.48	18.06	18.42
Exerodonta smaragdina	Amphibians	20.23	25.42	28.54	29.9	30.09	29.25
Incilius cavifrons	Amphibians	70.94	83.57	86.03	86.12	86.03	85.57
Incilius cristatus	Amphibians	62.5	60.82	62.66	62.68	62.64	62.2
Incilius marmoreus	Amphibians	31.75	38.36	41.93	43.14	43.73	42.84
Incilius mazatlanensis	Amphibians	18.88	23.32	24.48	25.8	27.83	28.17
Incilius occidentalis	Amphibians	33.71	36.81	37.8	38.06	38.56	37.93
Incilius perplexus	Amphibians	40.68	47.41	48.26	46.34	46.57	44.69
Lithobates magnaocularis	Amphibians	14.31	17	17.26	17.66	18.95	19.38
Lithobates montezumae	Amphibians	45.29	47.98	48.74	49.68	50.36	50.37
Lithobates neovolcanicus	Amphibians	51.51	54.02	54.74	56.11	56.44	56.08
Lithobates pustulosus	Amphibians	26.12	30.95	32.05	32.77	33.2	32.1
Lithobates sierramadrensis	Amphibians	17.86	22.75	28.13	28.8	29.36	29.87
Lithobates spectabilis	Amphibians	41.76	45.06	45.91	45.46	46	45.1

Lithobates tarahumarae	Amphibians	19.51	21.65	22.24	23.26	24.07	24.23
Lithobates zweifeli	Amphibians	32.11	36.73	38.74	39.22	39.83	38.05
Parvimolge townsendi	Amphibians	41.08	40.7	42.91	42.99	43.13	46.52
Plectrohyla lacertosa	Amphibians	17.57	20.19	22.03	23.71	23.9	24.51
Pseudoeurycea cochranae	Amphibians	24.91	23.14	26.41	25.92	26.63	23.46
Pseudoeurycea gadovii	Amphibians	37.12	44.9	46.73	47.12	48.28	50.38
Pseudoeurycea juarezi	Amphibians	16.43	16.69	20.7	20.67	21.09	20.62
Pseudoeurycea leprosa	Amphibians	49.48	50.26	51.3	50.57	52.61	52.86
Pseudoeurycea lineola	Amphibians	61.41	61.72	63.07	63.1	63.28	65.02
Pseudoeurycea longicauda	Amphibians	17.84	13.01	13.75	14.12	14.86	14.49
Pseudoeurycea melanomolga	Amphibians	31.26	32.53	34.33	34.1	36.12	36.81
Pseudoeurycea smithi	Amphibians	22.15	22.66	25.41	25.32	25.13	25.09
Pseudoeurycea werleri	Amphibians	30.76	76.92	53.84	53.84	53.84	53.84
Ptychohyla leonhardschultzei	Amphibians	16.29	20.88	27.22	27.29	28.02	29.07
Ptychohyla zophodes	Amphibians	19.14	19.53	25	25	27.34	28.9
Thorius boreas	Amphibians	27.65	25.46	31.02	30.69	31.53	31.02
Thorius macdougalli	Amphibians	13.49	12.27	16.21	16.09	16.15	15.74
Thorius narisovalis	Amphibians	26.19	23.38	26.33	25.6	26.25	24.68
Thorius pennatulus	Amphibians	53.88	52.91	56.05	55.81	55.48	54.61
Tlalocohyla godmani	Amphibians	24.92	29.28	30.99	31.26	31.5	51.41
Tlalocohyla smithii	Amphibians	25.99	32.11	35.03	35.77	36.35	35.2
Aimophila notosticta	Birds	46.41	47.13	47.78	46.86	46.79	41.07
Amazona finschi	Birds	20.26	24.31	26.76	27.95	28.64	28.36
Antrostomus salvini	Birds	41.78	49.83	52.22	52.43	52.99	53.34
Aphelocoma ultramarina	Birds	38.58	40.48	41.2	41.36	41.96	41.38
Arremon virenticeps	Birds	39.3	40.02	40.73	41.1	42.14	40.99
Atlapetes pileatus	Birds	31.05	32.43	33.55	33.6	34.2	33.42
Atthis heloisa	Birds	28.51	30.08	32.3	32.52	33.09	32.59
Calocitta colliei	Birds	23.86	27.47	28.47	29.55	30.37	30.21
Calothorax pulcher	Birds	31.47	37.3	39.07	40.06	40.82	38.72
Campylopterus excellens	Birds	46.23	60.87	60.58	60.51	61,00	61.91
Campylorhynchus chiapensis	Birds	73.04	78.45	77.42	77.98	79.17	79.28
Campylorhynchus gularis	Birds	32.49	34.84	35.21	36.18	36.48	35.9
Campylorhynchus jocosus	Birds	42.92	47.96	49.06	48.65	48.97	46.29
Campylorhynchus megalopterus	Birds	30.53	30.43	31.83	31.99	32.9	31.87
Catharus occidentalis	Birds	33.08	34.77	35.99	36.07	36.65	35.81
Chlorostilbon auriceps	Birds	23.92	28.47	31.35	32.55	33.19	32.5
Colaptes auricularis	Birds	17.54	20.77	22.25	23.12	23.23	22.88
Cyanocorax beecheii	Birds	23.91	28.61	30.03	31.56	33.69	33.67
Cyanocorax dickeyi	Birds	0.16	0.48	0.48	0.81	0.81	0.81
Cyanocorax sanblasianus	Birds	18.79	22.73	25.03	27.39	27.63	26.85
Cyanolyca mirabilis	Birds	12.96	12.41	15.18	15.12	15.38	14.36
Cyanolyca nanus	Birds	25.78	24.9	28.04	27.18	27.77	27.15
Cynanthus sordidus	Birds	38.2	44.02	45.39	45.28	45.74	44.19
Deltarhynchus flammulatus	Birds	25.97	32.73	37.11	39.1	39.63	39.27
Dendrortyx barbatus	Birds	36.84	35.75	38.16	38.41	37.85	37.55
Dendrortyx macroura	Birds	30.56	31.71	33.27	33.2	33.85	32.54
Doricha eliza	Birds	41.52	42.85	48.47	48.21	48.07	49.13
Dryobates stricklandi	Birds	41.51	43.89	44.7	44.97	46.49	45.63
Eupherusa cyanophrys	Birds	6.5	9.87	15.06	14.96	15.58	16.7

Eupherusa poliocerca	Birds	9.79	12.27	15.02	15.28	15.37	14.53
Forpus cyanopygius	Birds	29.83	34.71	36.2	37.99	38.66	38.07
Geothlypis beldingi	Birds	5.1	5.84	9.16	11.28	11.57	11.72
Geothlypis nelsoni	Birds	45.66	47.26	49.17	49,00	49.58	49.63
Geothlypis speciosa	Birds	49.53	52.68	53.43	55.32	55.65	55.15
Geotrygon carrikeri	Birds	15,00	61.66	32.5	31.66	31.66	31.66
Glaucidium palmarum	Birds	19.22	23.91	26.56	27.37	27.94	27.82
Glaucidium sanchezi	Birds	21.11	29.36	30.6	30.94	31.05	31.6
Granatellus venustus	Birds	22.63	28,00	32.13	33.66	34.34	34.26
Hylocharis xantusii	Birds	2.22	2.49	3.96	5.05	5.11	5.27
Hylorchilus navai	Birds	42.79	45.06	51.02	50.95	51.64	52.2
Hylorchilus sumichrasti	Birds	20.84	25.41	32.34	33.31	34.77	37.44
Icterus abeillei	Birds	44.48	46.68	47.56	48.6	49.17	48.38
Lepidocolaptes leucogaster	Birds	21.58	23.49	24.69	24.9	25.41	24.92
Lophornis brachylophus	Birds	8.11	13.2	20.19	21.29	21.49	19.22
Megascops seductus	Birds	31.18	38.22	39.41	39.14	39.48	38.02
Melanerpes chrysogenys	Birds	27.35	33.39	36.04	36.82	37.21	36.25
Melanerpes hypopolius	Birds	39.05	44.43	46.08	44.71	45.02	43.14
Melanotis caerulescens	Birds	30.68	64.01	35.92	36.85	37.34	36.82
Melozone albicollis	Birds	32.18	35.54	36.32	37.51	37.76	37.08
Melozone kieneri	Birds	49.94	53.41	54.77	53.91	54.03	48.69
Momotus coeruliceps	Birds	47.14	53.81	56.75	56.96	57.5	58.73
Nyctiphrynus mcleodii	Birds	15.57	18.73	19.51	20.37	20.72	20.44
Oriturus superciliosus	Birds	37.82	38.99	39.74	40.05	40.63	40.62
Ortalis poliocephala	Birds	25.05	32.15	37.44	39.34	40.17	39.27
Ortalis wagleri	Birds	22.8	26.97	28.85	30,00	34.08	31.26
Passerina leclancherii	Birds	28.67	36.21	40.14	42.27	42.92	42.17
Passerina rositae	Birds	26.52	33.66	35.77	40.75	41.08	38.16
Peucaea humeralis	Birds	35.46	41.68	42.83	43.71	44.31	41.94
Peucaea sumichrasti	Birds	37.16	44.09	47.76	51.12	52.08	49.92
Pheugopedius felix	Birds	22.51	27.31	29.87	31.07	31.76	31.29
Philortyx fasciatus	Birds	31.75	38.12	39.25	39.1	39.5	37.19
Pipilo ocai	Birds	28.06	28.81	30.28	30.49	31.11	30.05
Piranga erythrocephala	Birds	17.54	19.72	21.63	22.17	22.6	22.18
Rallus tenuirostris	Birds	48.14	50.3	50.97	53.82	54.33	54.1
Rhodothraupis celaeno	Birds	24.16	31.88	32.79	33.16	33.33	33.53
Rhynchopsitta pachyrhyncha	Birds	6.24	6.78	7.98	8.25	8.49	8.62
Rhynchopsitta terrisi	Birds	8.21	8.47	8.53	8.63	8.73	8.63
Ridgwayia pinicola	Birds	27.75	29.26	30.91	30.98	31.43	31.09
Spizella wortheni	Birds	15.65	14.61	15.16	16.54	17.66	18.74
Streptoprocne semicollaris	Birds	23.53	26.58	27.92	28.71	29.15	27.97
Thryophilus sinaloa	Birds	24.13	28.9	31.26	32.82	33.83	33.88
Toxostoma cinereum	Birds	4.5	5.94	6.98	7.46	7.48	7.86
Toxostoma ocellatum	Birds	47.08	49.69	51.32	50.97	51.71	50.22
Trogon citreolus	Birds	26.61	32.33	36.3	38.02	38.77	38.16
Turdus rufopalliatus	Birds	35.38	39.55	41.45	42.53	43.1	42.17
Vireo brevipennis	Birds	28.02	29.16	32.39	32.2	32.49	31.47
Vireo hypochryseus	Birds	26.42	31.06	33.94	34.85	35.46	34.5
Vireo nelsoni	Birds	29.64	32.14	34.59	34.41	34.81	33.6
Xenospiza baileyi	Birds	58.45	60.52	61.75	61.25	61.99	59.95

Xenotriccus mexicanus	Birds	33.76	37.5	38.88	38.68	39.04	37.37
Artibeus hirsutus	Mammals	33.39	38.82	40.78	42.11	43.05	42.18
Chaetodipus artus	Mammals	31.57	38.35	40.19	42.64	45.33	44.06
Chaetodipus goldmani	Mammals	23.88	30.05	31.8	33.58	36.98	37.3
Chaetodipus pernix	Mammals	28.14	33.88	35.43	37.17	39.67	39.62
Corynorhinus mexicanus	Mammals	41.44	44.13	44.46	44.31	44.92	44.73
Cratogeomys fumosus	Mammals	56.99	59.91	60.19	61.47	62.04	61.78
Cratogeomys goldmani	Mammals	25.05	27.3	28.16	28.92	29.48	29.46
Cratogeomys merriami	Mammals	62,00	63.24	64.17	63.84	64.74	63.48
Cratogeomys perotensis	Mammals	62.82	70.68	71.02	70.68	70.85	79.23
Cryptotis goldmani	Mammals	30.82	32.32	35.55	35.53	36.46	36.02
Cryptotis magna	Mammals	26.35	29.04	34.16	33.98	34.71	36.09
Cryptotis mexicana	Mammals	35.18	36.41	38.94	39.1	39.37	40.08
Dasyprocta mexicana	Mammals	46.29	54.22	62.9	65.5	68.69	69.88
Dipodomys nelsoni	Mammals	7.81	7.94	8.27	10.09	9.23	9.42
Dipodomys phillipsii	Mammals	38.44	42.86	44.03	43.44	44.29	43.5
Glossophaga morenoi	Mammals	23.98	30.79	34.95	37.45	38.39	37.5
Habromys lepturus	Mammals	7.11	6.95	7.76	7.65	7.65	7.87
Lepus flavigularis	Mammals	38.22	46.61	47.16	52.28	52.42	49.15
Megadontomys cryophilus	Mammals	25.1	27.24	32.38	32.21	32.05	33.13
Megadontomys thomasi	Mammals	16.92	19.05	23.36	23.94	24.49	24.04
Microtus oaxacensis	Mammals	36.77	41.84	49.06	50.15	50.67	53.03
Microtus quasiater	Mammals	42.21	42.96	44.96	45.07	45.54	46.27
Musonycteris harrisoni	Mammals	22.05	27.99	31.22	32.28	32.48	31.75
Neotamias bulleri	Mammals	3.45	3.8	3.66	3.72	3.72	4.42
Neotamias durangae	Mammals	2.17	2.59	3.29	4.1	2.23	4.46
Neotoma goldmani	Mammals	17.05	20.06	20.52	20.48	21.29	20.9
Neotomodon alstoni	Mammals	54.02	56.57	56.98	56.56	58.64	59.2
Osgoodomys banderanus	Mammals	25.02	32.16	35.82	37.59	38.2	37.32
Pappogeomys bulleri	Mammals	44.37	46.58	46.98	48.44	49.28	49.22
Peromyscus difficilis	Mammals	39.1	41.12	41.67	41.78	42.52	42.29
Peromyscus furvus	Mammals	40.24	39.06	41.97	42.02	41.66	41.77
Peromyscus hylocetes	Mammals	44.13	45.01	45.27	45.77	47,00	46.35
Peromyscus levipes	Mammals	36.38	38.69	40.19	40.23	40.75	40.23
Peromyscus megalops	Mammals	21.85	24.9	28.35	28.22	28.76	28.17
Peromyscus melanophrys	Mammals	33.08	36.63	37.33	37.59	38.19	37.69
Peromyscus ochraventer	Mammals	9.11	11.96	12.25	11.96	11.96	11.96
Peromyscus perfulvus	Mammals	13.88	21.75	24.33	27.24	27.58	26.13
Peromyscus spicilegus	Mammals	27.08	29.73	30.3	31.31	31.62	31.14
Peromyscus yucatanicus	Mammals	11.82	14.7	18.29	19.71	19.57	20.55
Peromyscus zarhynchus	Mammals	25.33	28.99	40.03	40.89	42.54	46.41
Reithrodontomys chrysopsis	Mammals	53.57	54.13	54.52	54.42	56.46	54.7
Rhogeessa parvula	Mammals	29.5	36.27	39.33	40.7	41.04	40.64
Sciurus alleni	Mammals	29.81	31.45	32.15	32.15	32.15	33.09
Sciurus oculatus	Mammals	34.46	37.32	38.57	39.19	40,00	39.64
Sigmodon alleni	Mammals	19.67	22.92	25.09	26.05	26.49	26.92
Sigmodon leucotis	Mammals	19.85	20.03	20.63	21.42	21.63	21.67
Sigmodon mascotensis	Mammals	29.65	34.88	37.2	38.36	38.9	38.11
Sorex ventralis	Mammals	57.38	60.52	61.05	60.04	61.9	63.05
Spilogale pygmaea	Mammals	16.87	20.77	25.45	25.73	26.17	25.77

Sylvilagus cunicularius	Mammals	35.1	38.09	40.56	41.13	41.87	41.65
Thomomys sheldoni	Mammals	7.59	8.85	8.83	8.5	8.58	8.58
Tlacuatzin canescens	Mammals	30.86	38.37	41.7	41.77	42.31	42.15
Abronia graminea	Reptiles	48.08	45.77	46.68	46.55	46.64	46.17
Abronia taeniata	Reptiles	49.13	50.98	51.53	50.76	51.33	51.34
Adelphicos nigrilatum	Reptiles	21.51	15.11	18.02	20.34	21.51	22.09
Anelytropsis papillosus	Reptiles	16.69	24.21	24.97	25.37	25.44	25.4
Anolis anisolepis	Reptiles	22.77	28.3	39.56	39.2	40.66	41.58
Anolis barkeri	Reptiles	28.88	46.85	50.52	50.68	50.83	51.63
Anolis compressicauda	Reptiles	36.2	43.15	50.09	51.47	52.45	54.57
Anolis liogaster	Reptiles	19.72	18.97	21.31	21.91	22.41	21.12
Anolis naufragus	Reptiles	69.33	66.19	67.13	66.98	66.72	66.57
Anolis nebuloides	Reptiles	22.77	27.37	30.7	31.56	32.37	31.67
Anolis nebulosus	Reptiles	27.6	32.43	33.28	33.7	33.87	32.74
Anolis pygmaeus	Reptiles	34.53	42.37	50.06	51.66	52.03	56.94
Anolis quercorum	Reptiles	50.91	55.94	57.67	56.93	57.29	56.18
Aspidoscelis communis	Reptiles	30.72	37.8	40.89	41.99	42.33	39.76
Aspidoscelis costatus	Reptiles	34.37	39.25	41.03	42.3	42.87	41.65
Aspidoscelis guttata	Reptiles	35.27	42.46	47.46	49.45	50.42	50.24
Aspidoscelis lineattissima	Reptiles	24.2	30.34	33.53	35.85	36.07	36.17
Aspidoscelis parvisocia	Reptiles	42.67	50.03	51.79	50.09	49.71	48.93
Aspidoscelis sackii	Reptiles	37.44	43.84	44.93	42.94	43.09	41.19
Barisia imbricata	Reptiles	59.11	61.5	62.05	61.43	62.47	62.33
Cerrophidion tzotzilorum	Reptiles	30.56	31.69	36.6	38.49	39.24	40.37
Conophis vittatus	Reptiles	31.61	39.87	43.75	46.09	46.8	44.92
Conopsis biserialis	Reptiles	39.28	40.63	41.19	41.56	42.44	41.68
Conopsis lineata	Reptiles	55.86	58.37	58.77	58.13	59	58.5
Conopsis megalodon	Reptiles	27.06	26.34	29.4	28.23	28.96	28.49
Conopsis nasus	Reptiles	40.81	43.58	44.51	44.92	45.69	45.28
Crotalus basiliscus	Reptiles	19.37	23.07	23.91	25.9	26.66	25.93
Crotalus enyo	Reptiles	3	2.8	4.22	5.28	5.48	5.39
Crotalus intermedius	Reptiles	44.1	45.2	46.63	46.25	47.01	46.27
Crotalus ravus	Reptiles	57.97	61.99	63.18	62.33	63.46	62.18
Ctenosaura acanthura	Reptiles	52.69	63.16	67.79	68.39	68.84	69.37
Ctenosaura hemilopha	Reptiles	18.06	23.38	25.01	26.62	28.87	29.27
Ctenosaura pectinata	Reptiles	29.28	35.65	38.16	39.36	39.99	38.44
Ficimia olivacea	Reptiles	30.09	38.35	39.53	39.86	39.59	39.73
Geophis mutitorques	Reptiles	63.33	57.92	59.77	59.49	59.45	58.52
Geophis semidoliatus	Reptiles	55.63	55.38	58.48	58.39	58.39	59.02
Gerrhonotus liocephalus	Reptiles	32.18	35.48	38.03	38.52	39.03	38.4
Hypsiglena torquata	Reptiles	10.39	12.02	13.05	13.65	14.37	14.33
Kinosternon creaseri	Reptiles	0.86	2.12	2.19	3.04	3.09	5.04
Kinosternon herrerai	Reptiles	45.4	54.15	57.84	58.05	58.65	59.56
Kinosternon integrum	Reptiles	35.83	40.32	41.3	42.17	42.7	41.8
Lepidophyma gaigeae	Reptiles	26.25	30.76	31.17	30.98	31.44	30.74
Lepidophyma pajapanensis	Reptiles	50.96	82.14	71.97	71.67	71.42	71.73
Lepidophyma sylvaticum	Reptiles	82.3	78.93	80.89	80.89	80.05	80.19
Lepidophyma tuxtlae	Reptiles	27.65	39.91	46.11	47.25	48.23	51.57
Leptodeira maculata	Reptiles	32.68	39.05	41.99	43.84	44.59	43.66
Leptodeira splendida	Reptiles	44.31	50.03	50.14	51.35	51.98	48.99

Leptophis diplotropis	Reptiles	26.62	32.34	35.49	36.35	36.91	35.7
Manolepis putnami	Reptiles	24.37	30.87	34.1	35.85	36.61	35.04
Mesaspis gadovii	Reptiles	14.91	13.25	16.03	15.45	15.9	15.27
Mesaspis juarezi	Reptiles	6.78	5.11	8.54	8.54	8.38	8.21
Mesaspis viridiflava	Reptiles	33.59	34.02	36.41	36.03	36.53	34.17
Micrurus distans	Reptiles	29.01	34.21	36.03	38.17	39.06	38.3
Micrurus limbatus	Reptiles	56	84.44	76.31	76.25	76.09	75.87
Ophryacus undulatus	Reptiles	21.95	21.03	22.97	22.63	23.14	23.14
Phrynosoma orbiculare	Reptiles	40.13	42.56	42.96	42.76	43.55	43.64
Phrynosoma taurus	Reptiles	44.64	51.52	52.29	51.09	51.16	49.39
Phyllodactylus bordai	Reptiles	46.94	53.4	53.94	51.72	51.74	50.55
Phyllodactylus lanei	Reptiles	19.66	27.11	40.5	32.88	33.05	32.54
Phyllodactylus muralis	Reptiles	32.37	41.32	42.37	46.94	47.53	46.52
Phyllodactylus unctus	Reptiles	3.11	3.4	4.94	6.05	6.34	6.46
Pituophis deppei	Reptiles	41.11	44.02	44.81	44.88	45.63	45.31
Plestiodon copei	Reptiles	66.73	69.23	69.79	69.39	71.27	71.07
Plestiodon lynxe	Reptiles	36.49	38.23	38.5	38.74	39.25	39.16
Rena maxima	Reptiles	40.96	46.4	47.23	46.07	46.27	44.83
Rena myopica	Reptiles	31.6	49.4	52.67	52.04	52.81	53.87
Rhadinaea fulvivittis	Reptiles	28.46	26.62	29.55	28.43	29.19	26.8
Rhadinaea gaigeae	Reptiles	40.95	45.7	46.07	45.91	46.32	45.38
Rhadinaea laureata	Reptiles	41.8	42.98	42.95	43.44	44.36	43.39
Rhadinaea taeniata	Reptiles	27.87	29.13	31.46	30.5	30.9	29.72
Salvadora bairdi	Reptiles	54.83	30.25	60.62	60.8	61.25	60.54
Salvadora intermedia	Reptiles	32.14	34.88	36.71	37.07	37.02	35.92
Salvadora mexicana	Reptiles	26.32	33.5	37.56	39.08	40.06	38.2
Sceloporus adleri	Reptiles	9.21	9.86	11.64	11.97	12.18	11.91
Sceloporus aeneus	Reptiles	58.85	59.86	60.44	59.93	61.13	60.84
Sceloporus bicanthalis	Reptiles	52.6	53.2	54.17	53.57	54.71	54.77
Sceloporus bulleri	Reptiles	8.42	10.01	10.72	11.75	11.89	11.36
Sceloporus cautus	Reptiles	18.12	19.94	20.91	20.9	21.9	21.89
Sceloporus cozumelae	Reptiles	13.8	22.01	25.31	24.86	25.63	25.36
Sceloporus dugesii	Reptiles	57.05	58.05	57.9	61.64	61.79	61
Sceloporus formosus	Reptiles	29.04	28.23	30.21	30	30.31	29
Sceloporus gadoviae	Reptiles	38.56	45.44	46.47	45.79	46.04	43.18
Sceloporus horridus	Reptiles	31.97	37	38.08	38.76	39.17	37.36
Sceloporus hunsakeri	Reptiles	1.81	2.09	3.51	4.4	4.66	4.81
Sceloporus jalapae	Reptiles	52.65	57.55	58.34	57.8	58.45	56.21
Sceloporus licki	Reptiles	0.97	0.73	1.64	2.39	2.37	2.47
Sceloporus maculosus	Reptiles	20.91	23.85	24.93	25.71	26.16	26.29
Sceloporus megalepidurus	Reptiles	61.12	67.59	67.99	66.26	67.19	68.56
Sceloporus minor	Reptiles	26.08	28.32	29.17	29.06	29.97	29.61
Sceloporus mucronatus	Reptiles	48.58	50.69	51.71	51.41	52.15	51.36
Sceloporus nelsoni	Reptiles	19.95	25.66	26.88	27.84	30.79	30.83
Sceloporus ochoterenae	Reptiles	36.19	42.85	43.85	42.59	42.71	41.22
Sceloporus ormis	Reptiles	25.36	30.17	32.27	32.69	32.91	33.25
Sceloporus palaciosi	Reptiles	61.53	63.71	64.22	63.97	65.39	63.45
Sceloporus parvus	Reptiles	23.49	25.85	26.12	26.05	26.77	26.39
Sceloporus pyrocephalus	Reptiles	24.31	32.31	35.35	37.03	37.59	35.2
Sceloporus salvini	Reptiles	35.41	47.14	48.18	48.72	48.91	51.04

Sceloporus scalaris	Reptiles	36.61	39.14	39.68	39.55	40.03	39.81
Sceloporus siniferus	Reptiles	25.29	31.5	35.87	37.84	38.87	38.6
Sceloporus spinosus	Reptiles	34.8	37.91	38.84	38.42	39.13	39.64
Sceloporus torquatus	Reptiles	41.6	63.38	44.23	44.4	45.02	44.72
Sceloporus zosteromus	Reptiles	11.9	15.13	17	18.7	19.21	19.21
Scincella gemmingeri	Reptiles	40.15	44.54	48.36	49.37	50.14	51.15
Scincella silvicola	Reptiles	37.23	40.9	43.55	43.48	43.56	44.37
Storeria hidalgoensis	Reptiles	26.81	27.91	28.52	28.26	29.25	29.24
Storeria storerioides	Reptiles	40.61	41.41	43.08	43.05	44.02	42.59
Tantilla bocourti	Reptiles	39.26	43	44.25	44.68	45.35	44.84
Tantilla calamarina	Reptiles	23.92	29.51	31.09	31.66	32.12	31.23
Tantilla rubra	Reptiles	28.46	34.18	35.1	35.37	36.21	36.42
Thamnophis chrysocephalus	Reptiles	19.66	18.89	21.74	21.1	21.73	20.24
Thamnophis melanogaster	Reptiles	46.32	49.03	49.66	50.41	50.92	50.92
Thamnophis scalaris	Reptiles	47.2	47.88	48.78	48.68	50.03	49.14
Thamnophis scaliger	Reptiles	66.58	68.73	69.25	69.16	70.41	70.23
Thamnophis valida	Reptiles	21.33	25.33	29.33	28	28	24
Trimorphodon tau	Reptiles	28.9	32.65	33.96	34.23	34.84	33.89
Urosaurus bicarinatus	Reptiles	29.37	36.03	39.1	39.93	40.46	38.89
Xenosaurus platyceps	Reptiles	12.84	24.08	24.81	25.31	25.81	25.1

CAPÍTULO 2.

Apéndice I. Porcentaje de distribución perdida a causa del impacto de la pérdida de hábitat y la pérdida hábitat y actividades mineras para las especies de anfibios y reptiles endémicos de México

Table S1. Percentage of distribution lost caused by the impact of habitat loss and habitat loss and mining activities for the Mexican endemic species of amphibians and reptiles.

Species	Group	Percentage of distribution lost due to habitat loss	Percentage of distribution lost due to habitat loss and mining
Ambystoma altamirani	Amphibians	40.33	42.70
Ambystoma rosaceum	Amphibians	10.09	14.34
Ambystoma velasci	Amphibians	75.11	75.83
Anaxyrus compactilis	Amphibians	49.86	51.80
Aquiloeurycea cephalica	Amphibians	60.74	62.10
Bolitoglossa alberchi	Amphibians	43.20	43.96
Bolitoglossa platydactyla	Amphibians	65.88	66.38
Charadrahyla nephila	Amphibians	21.71	22.89
Charadrahyla taeniopus	Amphibians	52.57	53.38
Chiropterotriton chiropterus	Amphibians	52.02	53.74
Chiropterotriton chondrostega	Amphibians	37.09	38.52
Chiropterotriton multidentatus	Amphibians	38.94	40.77
Craugastor decoratus	Amphibians	56.25	57.42
Craugastor hobartsmithi	Amphibians	35.02	36.64
Craugastor mexicanus	Amphibians	40.72	41.71
Craugastor montanus	Amphibians	42.57	43.17
Craugastor occidentalis	Amphibians	27.15	29.23
Craugastor pozo	Amphibians	25.65	26.17
Craugastor rhodopis	Amphibians	43.25	44.11
Craugastor rugulosus	Amphibians	35.43	36.42
Dryophytes euphorbiaceus	Amphibians	52.34	53.11
Dryophytes eximius	Amphibians	38.32	40.34
Dryophytes plicatus	Amphibians	70.94	71.70
Ecnomiohyla miotympanum	Amphibians	42.21	43.81
Eleutherodactylus longipes	Amphibians	55.03	56.78
Eleutherodactylus nitidus	Amphibians	33.75	35.42
Eleutherodactylus verrucipes	Amphibians	40.62	42.31
Exerodonta melanomma	Amphibians	18.43	19.23
Exerodonta smaragdina	Amphibians	29.25	31.64
Incilius cavifrons	Amphibians	85.58	85.95
Incilius cristatus	Amphibians	62.20	62.89
Incilius marmoreus	Amphibians	42.85	44.36
Incilius mazatlanensis	Amphibians	28.18	31.46
Incilius occidentalis	Amphibians	37.94	39.61
Incilius perplexus	Amphibians	44.70	46.39
Lithobates magnaocularis	Amphibians	19.38	23.05
Lithobates montezumae	Amphibians	50.38	51.85
Lithobates neovolcanicus	Amphibians	56.08	57.27
Lithobates pustulosus	Amphibians	32.10	34.09
Lithobates sierramadrensis	Amphibians	29.87	30.86
Lithobates spectabilis	Amphibians	45.11	46.46

Lithobates tarahumarae	Amphibians	24.24	27.31
Lithobates zweifeli	Amphibians	38.05	39.80
Parvimolge townsendi	Amphibians	46.53	47.10
Plectrohyla lacertosa	Amphibians	24.52	25.25
Pseudoeurycea cochranae	Amphibians	23.46	24.46
Pseudoeurycea gadovii	Amphibians	50.39	52.06
Pseudoeurycea juarezi	Amphibians	20.62	21.77
Pseudoeurycea leprosa	Amphibians	52.87	54.00
Pseudoeurycea lineola	Amphibians	65.03	65.52
Pseudoeurycea longicauda	Amphibians	14.50	15.61
Pseudoeurycea melanomolga	Amphibians	36.81	38.63
Pseudoeurycea smithi	Amphibians	25.09	26.77
Pseudoeurycea werleri	Amphibians	53.85	53.85
Ptychohyla leonhardschultzei	Amphibians	29.08	29.89
Ptychohyla zophodes	Amphibians	28.91	30.08
Thorius boreas	Amphibians	31.03	31.70
Thorius macdougalli	Amphibians	15.75	16.56
Thorius narisovalis	Amphibians	24.69	25.93
Thorius pennatulus	Amphibians	54.61	55.25
Tlalocohyla godmani	Amphibians	31.41	33.59
Tlalocohyla smithii	Amphibians	35.20	36.81
Abronia graminea	Reptiles	46.17	47.44
Abronia taeniata	Reptiles	51.34	52.49
Adelphicos nigrilatum	Reptiles	22.09	26.16
Anelytropsis papillosus	Reptiles	25.40	27.69
Anolis anisolepis	Reptiles	41.58	42.19
Anolis barkeri	Reptiles	51.63	52.10
Anolis compressicauda	Reptiles	54.57	55.21
Anolis liogaster	Reptiles	21.12	22.07
Anolis naufragus	Reptiles	66.57	67.55
Anolis nebuloides	Reptiles	31.67	32.95
Anolis nebulosus	Reptiles	32.74	34.63
Anolis pygmaeus	Reptiles	56.94	57.40
Anolis quercorum	Reptiles	56.18	57.46
Aspidoscelis communis	Reptiles	39.76	41.69
Aspidoscelis costatus	Reptiles	41.65	43.31
Aspidoscelis guttata	Reptiles	50.24	51.31
Aspidoscelis lineattissima	Reptiles	36.17	38.50
Aspidoscelis parvisocia	Reptiles	48.93	50.44
Aspidoscelis sackii	Reptiles	41.19	43.01
Barisia imbricata	Reptiles	62.33	63.28
Cerrophidion tzotzilorum	Reptiles	40.37	43.01
Conophis vittatus	Reptiles	44.92	46.47
Conopsis biserialis	Reptiles	41.68	43.11
Conopsis lineata	Reptiles	58.50	59.54
Conopsis megalodon	Reptiles	28.49	29.41
Conopsis nasus	Reptiles	45.28	46.92
Crotalus basiliscus	Reptiles	25.93	29.63
Crotalus enyo	Reptiles	5.39	9.57
Crotalus intermedius	Reptiles	46.27	47.46

Crotalus ravus	Reptiles	62.18	63.14
Ctenosaura acanthura	Reptiles	69.37	70.04
Ctenosaura hemilopha	Reptiles	29.28	32.65
Ctenosaura pectinata	Reptiles	38.45	40.07
Ficimia olivacea	Reptiles	39.73	40.66
Geophis mutitorques	Reptiles	58.53	59.53
Geophis semidoliatus	Reptiles	59.03	59.57
Gerrhonotus liocephalus	Reptiles	38.40	39.80
Hypsiglena torquata	Reptiles	18.17	14.34
Kinosternon creaseri	Reptiles	5.05	10.48
Kinosternon herrerai	Reptiles	59.56	61.24
Kinosternon integrum	Reptiles	41.81	43.61
Lepidophyma gaigeae	Reptiles	30.74	32.80
Lepidophyma pajapanensis	Reptiles	71.73	72.40
Lepidophyma sylvaticum	Reptiles	80.20	80.90
Lepidophyma tuxtlae	Reptiles	51.57	52.29
Leptodeira maculata	Reptiles	43.67	45.24
Leptodeira splendida	Reptiles	48.99	50.36
Leptophis diplotropis	Reptiles	35.71	37.27
Manolepis putnami	Reptiles	35.04	36.66
Mesaspis gadovii	Reptiles	15.28	16.36
Mesaspis juarezi	Reptiles	8.21	9.22
Mesaspis viridiflava	Reptiles	34.17	35.07
Micrurus distans	Reptiles	38.31	41.21
Micrurus limbatus	Reptiles	75.87	76.43
Ophryacus undulatus	Reptiles	23.14	24.75
Phrynosoma orbiculare	Reptiles	43.64	45.65
Phrynosoma taurus	Reptiles	49.39	50.96
Phyllodactylus bordai	Reptiles	50.56	52.23
Phyllodactylus lanei	Reptiles	32.54	36.27
Phyllodactylus muralis	Reptiles	46.53	48.08
Phyllodactylus unctus	Reptiles	6.47	10.45
Pituophis deppei	Reptiles	45.31	47.03
Plestiodon copei	Reptiles	71.07	71.77
Plestiodon lynxe	Reptiles	39.17	41.14
Rena maxima	Reptiles	44.84	46.66
Rena myopica	Reptiles	53.87	55.39
Rhadinaea fulvivittis	Reptiles	26.81	27.95
Rhadinaea gaigeae	Reptiles	45.39	46.53
Rhadinaea laureata	Reptiles	43.40	45.45
Rhadinaea taeniata	Reptiles	29.72	31.10
Salvadora bairdi	Reptiles	60.54	61.80
Salvadora intermedia	Reptiles	35.93	37.15
Salvadora mexicana	Reptiles	38.21	40.03
Sceloporus adleri	Reptiles	11.92	12.96
Sceloporus aeneus	Reptiles	60.84	61.84
Sceloporus bicanthalis	Reptiles	54.77	56.08
Sceloporus bulleri	Reptiles	11.36	14.03
Sceloporus cautus	Reptiles	21.89	25.39
Sceloporus cozumelae	Reptiles	26.37	27.58

Sceloporus dugesii	Reptiles	61.01	62.41
Sceloporus formosus	Reptiles	29.00	30.38
Sceloporus gadoviae	Reptiles	43.18	44.82
Sceloporus horridus	Reptiles	37.36	39.05
Sceloporus hunsakeri	Reptiles	4.81	8.86
Sceloporus jalapae	Reptiles	56.21	57.29
Sceloporus licki	Reptiles	2.48	6.81
Sceloporus maculosus	Reptiles	26.30	29.39
Sceloporus megalepidurus	Reptiles	68.57	69.32
Sceloporus minor	Reptiles	29.62	32.31
Sceloporus mucronatus	Reptiles	51.36	52.60
Sceloporus nelsoni	Reptiles	30.83	34.09
Sceloporus ochoterenae	Reptiles	41.22	42.81
Sceloporus ornatus	Reptiles	33.25	35.00
Sceloporus palaciosi	Reptiles	63.45	64.52
Sceloporus parvus	Reptiles	26.39	29.05
Sceloporus pyrocephalus	Reptiles	35.21	37.20
Sceloporus salvini	Reptiles	51.04	51.60
Sceloporus scalaris	Reptiles	39.82	41.75
Sceloporus siniferus	Reptiles	38.60	39.69
Sceloporus spinosus	Reptiles	38.64	40.62
Sceloporus torquatus	Reptiles	44.72	46.26
Sceloporus zosteromus	Reptiles	19.22	22.96
Scincella gemmingeri	Reptiles	51.15	52.29
Scincella silvicola	Reptiles	44.37	45.76
Storeria hidalgoensis	Reptiles	29.24	32.65
Storeria storerioides	Reptiles	42.60	43.95
Tantilla bocourti	Reptiles	44.84	46.55
Tantilla calamarina	Reptiles	31.23	33.83
Tantilla rubra	Reptiles	36.42	38.81
Thamnophis chrysocephalus	Reptiles	20.24	21.22
Thamnophis melanogaster	Reptiles	50.93	52.37
Thamnophis scalaris	Reptiles	49.14	50.27
Thamnophis scaliger	Reptiles	70.23	71.10
Thamnophis valida	Reptiles	24.00	29.33
Trimorphodon tau	Reptiles	33.89	36.01
Urosaurus bicarinatus	Reptiles	38.90	40.47
Xenosaurus platyceps	Reptiles	25.10	27.97

CAPÍTULO 3

Apéndice I. Categorías de riesgo de extinción para los vertebrados terrestres endémicos de México utilizando los criterios y categorías de la UICN y NOM-059-SEMARNAT

Appendix 1. Extinction risk categories for the Mexican endemic terrestrial vertebrates using ICUN and NOM-059-SEMARNAT criteria and categories

Species	Group	MER (NOM-059-SEMARNAT)										IUCN						
		% of country occupied	Value CRITERION A	Value CRITERION B	Niche Breadth	Value CRITERION C	% Area lost	Value CRITERION D	Total Score	Study´s Category	NOM Official Category	AOO 2005	AOO 2017	% Lost 2005-2017	Category CRITERION A	Category CRITERION B	Study´s Category	IUCN Official Category
Ambystoma altamirani	Amphibians	0,05	4	1	0,49	2	40,33	3	10	A	A	1008,54	1003,86	0,46	LC	VU	VU	EN
Ambystoma rosaceum	Amphibians	6,28	3	1	0,76	1	10,09	2	7	-	Pr	124474	123293	0,95	LC	LC	LC	LC
Ambystoma velasci	Amphibians	0,49	4	2	0,68	1	75,11	4	11	A	Pr	10061,2	9534,72	5,23	LC	LC	LC	LC
Anaxyrus compactilis	Amphibians	8,19	3	2	0,81	1	49,86	3	9	Pr	-	166316	160905	3,25	LC	LC	LC	LC
Aquiloeurycea cephalica	Amphibians	1,37	4	2	0,72	1	60,74	3	10	A	A	27482,5	26954,5	1,92	LC	LC	LC	NT
Bolitoglossa alberchi	Amphibians	0,24	4	1	0,59	2	43,20	3	10	A	-	4931,94	4786,08	2,96	LC	LC	LC	LC
Bolitoglossa platydactyla	Amphibians	0,35	4	2	0,64	2	65,88	3	11	A	Pr	6821,88	6789,9	0,47	LC	LC	LC	NT
Charadrahyla nephila	Amphibians	0,06	4	1	0,48	2	21,71	2	9	Pr	-	1224,6	1181,7	3,50	LC	VU	VU	VU
Charadrahyla taeniopus	Amphibians	0,14	4	2	0,56	2	52,57	3	11	A	A	2736,24	2744,82	-0,31	LC	LC	LC	VU
Chiropterotriton chiropterus	Amphibians	0,40	4	2	0,63	2	52,02	3	11	A	Pr	8205,6	7835,88	4,51	LC	LC	LC	CR
Chiropterotriton chondrostega	Amphibians	0,87	4	1	0,66	2	37,09	3	10	A	Pr	16926	17031,3	-0,62	LC	LC	LC	EN
Chiropterotriton multidentatus	Amphibians	2,47	4	1	0,73	1	38,94	3	9	Pr	Pr	48424,7	48501,2	-0,16	LC	LC	LC	EN
Craugastor decoratus	Amphibians	0,77	4	2	0,67	1	56,25	3	10	A	Pr	15369,9	15143,7	1,47	LC	LC	LC	VU
Craugastor hobartsmithi	Amphibians	3,26	4	2	0,74	1	35,02	3	10	A	-	64244,7	64038	0,32	LC	LC	LC	EN
Craugastor mexicanus	Amphibians	4,35	4	2	0,76	1	40,72	3	10	A	Pr	89054,9	85451,3	4,05	LC	LC	LC	LC
Craugastor montanus	Amphibians	1,38	4	2	0,69	1	42,57	3	10	A	Pr	29795,2	27064,4	9,17	LC	LC	LC	EN
Craugastor occidentalis	Amphibians	5,17	3	2	0,76	1	27,15	2	8	Pr	-	102229	101464	0,75	LC	LC	LC	DD
Craugastor pozo	Amphibians	0,01	4	2	0,39	2	25,65	2	10	A	-	258,96	223,86	13,55	LC	EN	EN	CR

Craugastor rhodopis	Amphibians	3,60	**4**	**2**	0,75	1	43,25	3	**10**	**A**	**-**	75362,8	70621,2	6,29	**LC**	**LC**	**LC**	**VU**
Craugastor rugulosus	Amphibians	4,74	**4**	**2**	0,76	1	35,43	3	**10**	**A**	**-**	99556,1	93206,9	6,38	**LC**	**LC**	**LC**	**LC**
Dryophytes euphorbiaceus	Amphibians	0,35	**4**	**2**	0,62	2	52,34	3	**11**	**A**	**-**	6559,8	6811,74	- 3,84	**LC**	**LC**	**LC**	**NT**
Dryophytes eximius	Amphibians	10,05	**3**	**2**	0,81	1	38,32	3	**9**	**Pr**	**-**	200029	197474	1,28	**LC**	**LC**	**LC**	**LC**
Dryophytes plicatus	Amphibians	0,60	**4**	**2**	0,68	1	70,94	4	**11**	**A**	**A**	12115,7	11691,4	3,50	**LC**	**LC**	**LC**	**LC**
Ecnomiohyla miotympanum	Amphibians	2,29	**4**	**2**	0,72	1	42,21	3	**10**	**A**	**-**	46722	44917,1	3,86	**LC**	**LC**	**LC**	**NT**
Eleutherodactylus longipes	Amphibians	2,40	**4**	**2**	0,74	1	55,03	3	**10**	**A**	**-**	48849,8	47204,8	3,37	**LC**	**LC**	**LC**	**VU**
Eleutherodactylus nitidus	Amphibians	7,52	**3**	**2**	0,79	1	33,75	3	**9**	**Pr**	**-**	146078	147693	- 1,11	**LC**	**LC**	**LC**	**LC**
Eleutherodactylus verrucipes	Amphibians	3,65	**4**	**1**	0,75	1	40,62	3	**9**	**Pr**	**Pr**	72671,8	71634,4	1,43	**LC**	**LC**	**LC**	**VU**
Exerodonta melanomma	Amphibians	0,34	**4**	**1**	0,58	2	18,43	2	**9**	**Pr**	**Pr**	6787,56	6725,16	0,92	**LC**	**LC**	**LC**	**VU**
Exerodonta smaragdina	Amphibians	0,84	**4**	**2**	0,65	2	29,25	2	**10**	**A**	**Pr**	16621,8	16456,4	0,99	**LC**	**LC**	**LC**	**LC**
Incilius cavifrons	Amphibians	0,01	**4**	**2**	0,49	2	85,58	4	**12**	**P**	**Pr**	260,52	269,1	- 3,29	**LC**	**EN**	**EN**	**EN**
Incilius cristatus	Amphibians	0,08	**4**	**2**	0,55	2	62,20	3	**11**	**A**	**Pr**	1648,92	1669,2	- 1,23	**LC**	**VU**	**VU**	**CR**
Incilius marmoreus	Amphibians	7,05	**3**	**2**	0,80	1	42,85	3	**9**	**Pr**	**-**	140600	138392	1,57	**LC**	**LC**	**LC**	**LC**
Incilius mazatlanensis	Amphibians	4,23	**4**	**1**	0,75	1	28,18	2	**8**	**Pr**	**-**	87293,7	83022,4	4,89	**LC**	**LC**	**LC**	**LC**
Incilius occidentalis	Amphibians	10,51	**3**	**2**	0,82	1	37,94	3	**9**	**Pr**	**-**	206821	206392	0,21	**LC**	**LC**	**LC**	**LC**
Incilius perplexus	Amphibians	0,91	**4**	**2**	0,67	1	44,70	3	**10**	**A**	**-**	16715,4	17869	- 6,90	**LC**	**LC**	**LC**	**EN**
Lithobates magnaocularis	Amphibians	2,73	**4**	**1**	0,71	1	19,38	2	**8**	**Pr**	**-**	55136,6	53722,5	2,56	**LC**	**LC**	**LC**	**LC**
Lithobates montezumae	Amphibians	5,36	**3**	**2**	0,79	1	50,38	3	**9**	**Pr**	**Pr**	108769	105305	3,18	**LC**	**LC**	**LC**	**LC**
Lithobates neovolcanicus	Amphibians	2,29	**4**	**2**	0,74	1	56,08	3	**10**	**A**	**A**	46438,9	45069,2	2,95	**LC**	**LC**	**LC**	**NT**
Lithobates pustulosus	Amphibians	7,86	**3**	**2**	0,79	1	32,10	2	**8**	**Pr**	**Pr**	154569	154463	0,07	**LC**	**LC**	**LC**	**LC**
Lithobates sierramadrensis	Amphibians	1,73	**4**	**2**	0,69	1	29,87	2	**9**	**Pr**	**Pr**	34727,2	33889,4	2,41	**LC**	**LC**	**LC**	**VU**
Lithobates spectabilis	Amphibians	4,87	**4**	**2**	0,78	1	45,11	3	**10**	**A**	**-**	94215,4	95621	- 1,49	**LC**	**LC**	**LC**	**LC**
Lithobates tarahumarae	Amphibians	9,03	**3**	**1**	0,79	1	24,24	2	**7**	**-**	**-**	182047	177374	2,57	**LC**	**LC**	**LC**	**VU**
Lithobates zweifeli	Amphibians	6,06	**3**	**2**	0,78	1	38,05	3	**9**	**Pr**	**-**	117644	118972	- 1,13	**LC**	**LC**	**LC**	**LC**
Parvimolge townsendi	Amphibians	0,14	**4**	**2**	0,56	2	46,53	3	**11**	**A**	**A**	3040,44	2847,78	6,34	**LC**	**LC**	**LC**	**CR**
Plectrohyla lacertosa	Amphibians	0,21	**4**	**1**	0,56	2	24,52	2	**9**	**Pr**	**Pr**	4343,04	4204,98	3,18	**LC**	**LC**	**LC**	**EN**
Pseudoeurycea	Amphibians		**4**	**2**		2		2	**10**	**A**	**A**	9412,26	9789,78	-	**LC**	**LC**	**LC**	**EN**

cochranae		0,50			0,61		23,46							4,01				
Pseudoeurycea gadovii	Amphibians	0,05	**4**	**2**	0,50	2	50,39	3	**11**	**A**	**Pr**	1067,82	994,5	6,87	**LC**	**VU**	**VU**	**EN**
Pseudoeurycea juarezi	Amphibians	0,12	**4**	**1**	0,52	2	20,62	2	**9**	**Pr**	**A**	2378,22	2380,56	- 0,10	**LC**	**LC**	**LC**	**CR**
Pseudoeurycea leprosa	Amphibians	0,40	**4**	**2**	0,63	2	52,87	3	**11**	**A**	**A**	8041,8	7783,62	3,21	**LC**	**LC**	**LC**	**VU**
Pseudoeurycea lineola	Amphibians	0,05	**4**	**2**	0,52	2	65,03	3	**11**	**A**	**Pr**	1107,6	1049,1	5,28	**LC**	**VU**	**VU**	**EN**
Pseudoeurycea longicauda	Amphibians	0,01	**4**	**1**	0,38	2	14,50	2	**9**	**Pr**	**Pr**	180,96	179,4	0,86	**LC**	**EN**	**EN**	**EN**
Pseudoeurycea melanomolga	Amphibians	0,22	**4**	**1**	0,57	2	36,81	3	**10**	**A**	**Pr**	4447,56	4279,86	3,77	**LC**	**LC**	**LC**	**EN**
Pseudoeurycea smithi	Amphibians	0,06	**4**	**1**	0,49	2	25,09	2	**9**	**Pr**	**A**	1247,22	1252,68	- 0,44	**LC**	**VU**	**VU**	**CR**
Pseudoeurycea werleri	Amphibians	0,00	**4**	**1**	0,52	2	53,85	3	**10**	**A**	**Pr**	4,68	4,68	-	**LC**	**CR**	**CR**	**EN**
Ptychohyla leonhardschultzei	Amphibians	0,45	**4**	**2**	0,61	2	29,08	2	**10**	**A**	**Pr**	8994,18	8764,86	2,55	**LC**	**LC**	**LC**	**EN**
Ptychohyla zophodes	Amphibians	0,01	**4**	**2**	0,38	2	28,91	2	**10**	**A**	**-**	149,76	141,96	5,21	**LC**	**EN**	**EN**	**DD**
Thorius boreas	Amphibians	0,02	**4**	**1**	0,41	2	31,03	2	**9**	**Pr**	**-**	319,02	319,02	-	**LC**	**EN**	**EN**	**EN**
Thorius macdougalli	Amphibians	0,06	**4**	**1**	0,47	2	15,75	2	**9**	**Pr**	**Pr**	1128,66	1134,9	- 0,55	**LC**	**VU**	**VU**	**VU**
Thorius narisovalis	Amphibians	0,45	**4**	**1**	0,61	2	24,69	2	**9**	**Pr**	**Pr**	8650,2	8843,64	- 2,24	**LC**	**LC**	**LC**	**CR**
Thorius pennatulus	Amphibians	0,17	**4**	**2**	0,58	2	54,61	3	**11**	**A**	**Pr**	3159,78	3263,52	- 3,28	**LC**	**LC**	**LC**	**CR**
Tlalocohyla godmani	Amphibians	0,33	**4**	**1**	0,59	2	31,42	2	**9**	**Pr**	**A**	6468,54	6428,76	0,61	**LC**	**LC**	**LC**	**VU**
Tlalocohyla smithii	Amphibians	5,56	**3**	**2**	0,77	1	35,20	3	**9**	**Pr**	**-**	109558	109278	0,26	**LC**	**LC**	**LC**	**LC**
Aimophila notosticta	Birds	0,15	**4**	**2**	0,55	2	41,08	3	**11**	**A**	**-**	2563,08	2892,24	- 12,84	**LC**	**LC**	**LC**	**NT**
Amazona finschi	Birds	8,33	**3**	**2**	0,79	1	28,36	2	**8**	**Pr**	**P**	167288	163632	2,19	**LC**	**LC**	**LC**	**VU**
Antrostomus salvini	Birds	2,03	**4**	**2**	0,73	1	53,35	3	**10**	**A**	**A**	40868,1	39912,6	2,34	**LC**	**LC**	**LC**	**LC**
Aphelocoma ultramarina	Birds	3,69	**4**	**2**	0,75	1	41,39	3	**10**	**A**	**-**	72674,2	72451,9	0,31	**LC**	**LC**	**LC**	**LC**
Arremon virenticeps	Birds	1,26	**4**	**2**	0,69	1	41,00	3	**10**	**A**	**-**	24774,4	24665,2	0,44	**LC**	**LC**	**LC**	**LC**
Atlapetes pileatus	Birds	4,26	**4**	**1**	0,75	1	33,42	3	**9**	**Pr**	**Ex**	83510,7	83673,7	- 0,20	**LC**	**LC**	**LC**	**LC**
Atthis heloisa	Birds	5,35	**3**	**2**	0,77	1	32,60	2	**8**	**Pr**	**Pr**	105578	105120	0,43	**LC**	**LC**	**LC**	**LC**
Calocitta colliei	Birds	4,35	**4**	**1**	0,75	1	30,21	2	**8**	**Pr**	**-**	87506,6	85377,2	2,43	**LC**	**LC**	**LC**	**LC**
Calothorax pulcher	Birds	1,16	**4**	**2**	0,68	1	38,73	3	**10**	**A**	**Pr**	22681,6	22809,5	- 0,56	**LC**	**LC**	**LC**	**LC**
Campylopterus excellens	Birds	0,15	**4**	**2**	0,58	2	61,91	3	**11**	**A**	**Pr**	3100,5	2995,98	3,37	**LC**	**LC**	**LC**	**NT**
Campylorhynchus chiapensis	Birds	0,07	**4**	**2**	0,57	2	79,28	4	**12**	**P**	**P**	1565,46	1436,76	8,22	**LC**	**VU**	**VU**	**LC**
Campylorhynchus gularis	Birds	7,05	**3**	**2**	0,79	1	35,91	3	**9**	**Pr**	**-**	140055	138555	1,07	**LC**	**LC**	**LC**	**LC**

Campylorhynchus jocosus	Birds	0,82	**4**	**2**	0,66	1	46,29	3	**10**	**A**	**-**	15299,7	16132	-5,44	**LC**	**LC**	**LC**	**LC**
Campylorhynchus megalopterus	Birds	1,90	**4**	**1**	0,70	1	31,87	2	**8**	**Pr**	**-**	37333,9	37312,9	0,06	**LC**	**LC**	**LC**	**LC**
Catharus occidentalis	Birds	4,06	**4**	**2**	0,75	1	35,81	3	**10**	**A**	**-**	79619,3	79842,4	-0,28	**LC**	**LC**	**LC**	**LC**
Chlorostilbon auriceps	Birds	8,11	**3**	**2**	0,79	1	32,51	2	**8**	**Pr**	**Pr**	162018	159299	1,68	**LC**	**LC**	**LC**	**LC**
Colaptes auricularis	Birds	3,08	**4**	**1**	0,72	1	22,88	2	**8**	**Pr**	**A**	60935,2	60441,4	0,81	**LC**	**LC**	**LC**	**LC**
Cyanocorax beecheii	Birds	2,50	**4**	**1**	0,72	1	33,67	3	**9**	**Pr**	**P**	51832,6	49136,9	5,20	**LC**	**LC**	**LC**	**LC**
Cyanocorax dickeyi	Birds	0,02	**4**	**1**	0,42	2	0,82	2	**9**	**Pr**	**Ex**	475,8	474,24	0,33	**LC**	**EN**	**EN**	**NT**
Cyanocorax sanblasianus	Birds	0,67	**4**	**1**	0,63	2	26,86	2	**9**	**Pr**	**A**	13473,7	13145,3	2,44	**LC**	**LC**	**LC**	**LC**
Cyanolyca mirabilis	Birds	0,59	**4**	**1**	0,61	2	14,37	2	**9**	**Pr**	**P**	11510,5	11621,2	-0,96	**LC**	**LC**	**LC**	**VU**
Cyanolyca nanus	Birds	0,68	**4**	**1**	0,63	2	27,15	2	**9**	**Pr**	**A**	13146,1	13309,9	-1,25	**LC**	**LC**	**LC**	**VU**
Cynanthus sordidus	Birds	2,45	**4**	**2**	0,73	1	44,19	2	**9**	**Pr**	**-**	47128,4	48168,9	-2,21	**LC**	**LC**	**LC**	**LC**
Deltarhynchus flammulatus	Birds	2,23	**4**	**2**	0,72	1	39,27	3	**10**	**A**	**-**	45312,5	43759,6	3,43	**LC**	**LC**	**LC**	**LC**
Dendrortyx barbatus	Birds	0,55	**4**	**2**	0,63	2	37,55	3	**11**	**A**	**-**	10754,6	10861,5	-0,99	**LC**	**LC**	**LC**	**VU**
Dendrortyx macroura	Birds	1,59	**4**	**1**	0,69	1	32,55	2	**8**	**Pr**	**A**	30983,9	31320,1	-1,09	**LC**	**LC**	**LC**	**LC**
Doricha eliza	Birds	0,36	**4**	**2**	0,62	2	49,13	3	**11**	**A**	**-**	7197,84	7106,58	1,27	**LC**	**LC**	**LC**	**NT**
Dryobates stricklandi	Birds	0,39	**4**	**2**	0,62	2	45,64	3	**11**	**A**	**P**	7785,18	7653,36	1,69	**LC**	**LC**	**LC**	**LC**
Eupherusa cyanophrys	Birds	0,40	**4**	**1**	0,59	2	16,71	2	**9**	**Pr**	**Ex**	7938,84	7785,18	1,94	**LC**	**LC**	**LC**	**EN**
Eupherusa poliocerca	Birds	0,47	**4**	**1**	0,60	2	14,54	2	**9**	**Pr**	**P**	9192,3	9245,34	-0,58	**LC**	**LC**	**LC**	**VU**
Forpus cyanopygius	Birds	2,76	**4**	**1**	0,73	1	38,07	3	**9**	**Pr**	**P**	55809	54176,5	2,93	**LC**	**LC**	**LC**	**NT**
Geothlypis beldingi	Birds	0,19	**4**	**1**	0,54	2	11,72	3	**10**	**A**	**Pr**	3843,84	3735,42	2,82	**LC**	**LC**	**LC**	**EN**
Geothlypis nelsoni	Birds	3,04	**4**	**2**	0,75	1	49,63	3	**10**	**A**	**-**	60365	59813,5	0,91	**LC**	**LC**	**LC**	**LC**
Geothlypis speciosa	Birds	2,99	**4**	**2**	0,76	1	55,16	3	**10**	**A**	**Pr**	60930,5	58673,9	3,70	**LC**	**LC**	**LC**	**EN**
Geotrygon carrikeri	Birds	0,00	**4**	**1**	0,36	2	31,67	2	**9**	**Pr**	**-**	63,18	63,96	-1,23	**LC**	**EN**	**EN**	**EN**
Glaucidium palmarum	Birds	6,50	**3**	**1**	0,78	1	27,82	2	**7**	**-**	**Pr**	129869	127639	1,72	**LC**	**LC**	**LC**	**LC**
Glaucidium sanchezi	Birds	0,24	**4**	**1**	0,57	2	31,61	2	**9**	**Pr**	**-**	4846,92	4776,72	1,45	**LC**	**LC**	**LC**	**NT**
Granatellus venustus	Birds	5,72	**3**	**2**	0,77	1	34,26	3	**9**	**Pr**	**A**	116083	112437	3,14	**LC**	**LC**	**LC**	**LC**
Hylocharis xantusii	Birds	0,38	**4**	**1**	0,58	2	5,28	2	**9**	**Pr**	**Pr**	7551,18	7448,22	1,36	**LC**	**LC**	**LC**	**LC**
Hylorchilus navai	Birds	0,23	**4**	**1**	0,57	2	37,44	3	**10**	**A**	**A**	4796,22	4435,08	7,53	**LC**	**LC**	**LC**	**VU**
Hylorchilus sumichrasti	Birds		**4**	**2**		2		3	**11**	**A**	**P**	4417,92	4311,84	2,40	**LC**	**LC**	**LC**	**NT**

		0,22			0,59		52,20											
Icterus abeillei	Birds	3,70	**4**	**2**	0,76	1	48,38	3	**10**	**A**	**P**	73782,5	72631,3	1,56	**LC**	**LC**	**LC**	**LC**
Lepidocolaptes leucogaster	Birds	5,63	**3**	**2**	0,76	1	24,93	2	**8**	**Pr**	**-**	111017	110680	0,30	**LC**	**LC**	**LC**	**LC**
Lophornis brachylophus	Birds	0,39	**4**	**1**	0,59	2	19,22	2	**9**	**Pr**	**P**	7590,18	7683	-1,22	**LC**	**LC**	**LC**	**CR**
Megascops seductus	Birds	2,29	**4**	**2**	0,72	1	38,03	3	**10**	**A**	**-**	44074,7	45080,1	-2,28	**LC**	**LC**	**LC**	**NT**
Melanerpes chrysogenys	Birds	3,90	**4**	**2**	0,75	1	36,25	3	**10**	**A**	**-**	76858,1	76610,8	0,32	**LC**	**LC**	**LC**	**LC**
Melanerpes hypopolius	Birds	1,53	**4**	**2**	0,70	1	43,14	3	**10**	**A**	**A**	28508,2	30063,5	-5,46	**LC**	**LC**	**LC**	**LC**
Melanotis caerulescens	Birds	12,82	**3**	**2**	0,83	1	36,83	3	**9**	**Pr**	**P**	255346	251737	1,41	**LC**	**LC**	**LC**	**LC**
Melozone albicollis	Birds	0,24	**4**	**2**	0,59	2	48,70	3	**11**	**A**	**Pr**	4168,32	4728,36	-13,44	**LC**	**LC**	**LC**	**LC**
Melozone kieneri	Birds	5,06	**3**	**2**	0,77	1	37,08	3	**9**	**Pr**	**Pr**	100684	99489	1,19	**LC**	**LC**	**LC**	**LC**
Momotus coeruliceps	Birds	1,78	**4**	**2**	0,73	1	58,73	3	**10**	**A**	**Pr**	36714,6	35033,7	4,58	**LC**	**LC**	**LC**	**LC**
Nyctiphrynus mcleodii	Birds	4,78	**4**	**1**	0,75	1	20,45	2	**8**	**Pr**	**-**	95064,8	93958	1,16	**LC**	**LC**	**LC**	**LC**
Oriturus superciliosus	Birds	3,48	**4**	**1**	0,75	1	40,63	3	**9**	**Pr**	**-**	69463,7	68448,1	1,46	**LC**	**LC**	**LC**	**LC**
Ortalis poliocephala	Birds	1,56	**4**	**2**	0,70	1	39,27	3	**10**	**A**	**-**	31470,7	30551,8	2,92	**LC**	**LC**	**LC**	**LC**
Ortalis wagleri	Birds	4,72	**4**	**1**	0,76	1	31,27	2	**8**	**Pr**	**-**	95899,4	92657	3,38	**LC**	**LC**	**LC**	**LC**
Passerina leclancherii	Birds	2,34	**4**	**2**	0,73	1	42,18	3	**10**	**A**	**-**	47585,5	45974	3,39	**LC**	**LC**	**LC**	**LC**
Passerina rositae	Birds	0,31	**4**	**2**	0,59	2	38,17	3	**11**	**A**	**-**	6257,94	6024,72	3,73	**LC**	**LC**	**LC**	**NT**
Peucaea humeralis	Birds	2,97	**4**	**2**	0,74	1	41,95	3	**10**	**A**	**Pr**	57422	58316,7	-1,56	**LC**	**LC**	**LC**	**LC**
Peucaea sumichrasti	Birds	0,40	**4**	**2**	0,62	2	49,92	3	**11**	**A**	**-**	8284,38	7941,96	4,13	**LC**	**LC**	**LC**	**NT**
Pheugopedius felix	Birds	9,26	**3**	**1**	0,80	1	31,30	2	**7**	**-**	**P**	185619	181858	2,03	**LC**	**LC**	**LC**	**LC**
Philortyx fasciatus	Birds	2,97	**4**	**2**	0,74	1	37,19	3	**10**	**A**	**-**	56461,9	58379,1	-3,40	**LC**	**LC**	**LC**	**LC**
Pipilo ocai	Birds	3,22	**4**	**1**	0,73	1	30,06	2	**8**	**Pr**	**-**	62996,7	63197,9	-0,32	**LC**	**LC**	**LC**	**LC**
Piranga erythrocephala	Birds	4,30	**4**	**1**	0,75	1	22,19	2	**8**	**Pr**	**-**	85099,6	84504,4	0,70	**LC**	**LC**	**LC**	**LC**
Rallus tenuirostris	Birds	2,24	**4**	**2**	0,74	1	54,11	3	**10**	**A**	**Pr**	46942	43944,4	6,39	**LC**	**LC**	**LC**	**NT**
Rhodothraupis celaeno	Birds	1,05	**4**	**1**	0,67	1	33,54	3	**9**	**Pr**	**-**	20816,6	20588,1	1,10	**LC**	**LC**	**LC**	**LC**
Rhynchopsitta pachyrhyncha	Birds	4,23	**4**	**1**	0,73	1	8,62	2	**8**	**Pr**	**-**	83592,6	83017	0,69	**LC**	**LC**	**LC**	**EN**
Rhynchopsitta terrisi	Birds	0,63	**4**	**1**	0,62	2	8,64	2	**9**	**Pr**	**P**	12438,7	12425,4	0,11	**LC**	**LC**	**LC**	**EN**
Ridgwayia pinicola	Birds	6,87	**3**	**1**	0,78	1	31,09	2	**7**	**-**	**-**	135229	134871	0,27	**LC**	**LC**	**LC**	**LC**
Spizella wortheni	Birds	0,36	**4**	**1**	0,59	2	18,75	2	**9**	**Pr**	**-**	7289,1	6981	4,23	**LC**	**LC**	**LC**	**EN**

Streptoprocne semicollaris	Birds	5,53	**3**	**1**	0,77	1	27,98	2	**7**	**-**	**-**	108794	108716	0,07	**LC**	**LC**	**LC**	**LC**
Thryophilus sinaloa	Birds	6,29	**3**	**1**	0,78	1	33,89	3	**8**	**Pr**	**P**	128489	123588	3,81	**LC**	**LC**	**LC**	**LC**
Toxostoma cinereum	Birds	1,83	**4**	**1**	0,68	1	7,86	2	**8**	**Pr**	**P**	36277,8	35934,6	0,95	**LC**	**LC**	**LC**	**LC**
Toxostoma ocellatum	Birds	1,64	**4**	**2**	0,71	1	50,23	3	**10**	**A**	**Pr**	31576	32286,5	-2,25	**LC**	**LC**	**LC**	**LC**
Trogon citreolus	Birds	3,19	**4**	**2**	0,74	1	38,17	3	**10**	**A**	**P**	64623	62726,8	2,93	**LC**	**LC**	**LC**	**LC**
Turdus rufopalliatus	Birds	11,50	**3**	**2**	0,83	1	42,17	3	**9**	**Pr**	**P**	228786	225964	1,23	**LC**	**LC**	**LC**	**LC**
Vireo brevipennis	Birds	2,26	**4**	**2**	0,71	1	31,47	2	**9**	**Pr**	**-**	43833,7	44429,6	-1,36	**LC**	**LC**	**LC**	**LC**
Vireo hypochryseus	Birds	10,04	**3**	**2**	0,81	1	34,51	3	**9**	**Pr**	**-**	198884	197195	0,85	**LC**	**LC**	**LC**	**LC**
Vireo nelsoni	Birds	3,32	**4**	**2**	0,74	1	33,60	3	**10**	**A**	**-**	64191,7	65162,8	-1,51	**LC**	**LC**	**LC**	**LC**
Xenospiza baileyi	Birds	0,32	**4**	**2**	0,62	2	59,96	3	**11**	**A**	**-**	5911,62	6190,08	-4,71	**LC**	**LC**	**LC**	**EN**
Xenotriccus mexicanus	Birds	1,82	**4**	**2**	0,71	1	37,38	3	**10**	**A**	**-**	34879,3	35740,4	-2,47	**LC**	**LC**	**LC**	**NT**
Artibeus hirsutus	Mammals	8,70	**3**	**2**	0,81	1	42,19	3	**9**	**Pr**	**-**	175030	170898	2,36	**LC**	**LC**	**LC**	**LC**
Chaetodipus artus	Mammals	0,87	**4**	**1**	0,67	1	44,06	3	**9**	**Pr**	**-**	18204,4	17027,4	6,47	**LC**	**LC**	**LC**	**LC**
Chaetodipus goldmani	Mammals	2,29	**4**	**2**	0,72	1	37,30	3	**10**	**A**	**-**	48962,2	45015,4	8,06	**LC**	**LC**	**LC**	**NT**
Chaetodipus pernix	Mammals	2,76	**4**	**1**	0,73	1	39,62	3	**9**	**Pr**	**-**	57966,5	54209,2	6,48	**LC**	**LC**	**LC**	**LC**
Corynorhinus mexicanus	Mammals	4,12	**4**	**2**	0,76	1	44,73	3	**10**	**A**	**-**	81262	80875,1	0,48	**LC**	**LC**	**LC**	**NT**
Cratogeomys fumosus	Mammals	2,14	**4**	**2**	0,75	1	61,79	3	**10**	**A**	**A**	43835,2	42084,9	3,99	**LC**	**LC**	**LC**	**LC**
Cratogeomys goldmani	Mammals	9,12	**3**	**1**	0,80	1	29,47	2	**7**	**-**	**-**	182523	179221	1,81	**LC**	**LC**	**LC**	**LC**
Cratogeomys merriami	Mammals	0,60	**4**	**2**	0,67	1	63,48	3	**10**	**A**	**-**	11533,9	11755,4	-1,92	**LC**	**LC**	**LC**	**LC**
Cratogeomys perotensis	Mammals	0,00	**4**	**2**	0,41	2	79,23	4	**12**	**P**	**-**	129,48	92,82	28,31	**LC**	**EN**	**EN**	**LC**
Cryptotis goldmani	Mammals	3,35	**4**	**2**	0,74	1	36,02	3	**10**	**A**	**Pr**	66225,9	65748,5	0,72	**LC**	**LC**	**LC**	**LC**
Cryptotis magna	Mammals	0,66	**4**	**2**	0,64	2	36,09	3	**11**	**A**	**Pr**	13324	12933,2	2,93	**LC**	**LC**	**LC**	**VU**
Cryptotis mexicana	Mammals	1,42	**4**	**2**	0,69	1	40,09	3	**10**	**A**	**-**	28378	27846,8	1,87	**LC**	**LC**	**LC**	**LC**
Dasyprocta mexicana	Mammals	0,02	**4**	**2**	0,46	2	69,88	4	**12**	**P**	**-**	390	316,68	18,80	**LC**	**EN**	**EN**	**CR**
Dipodomys nelsoni	Mammals	5,67	**3**	**1**	0,75	1	9,43	2	**7**	**-**	**-**	112856	111445	1,25	**LC**	**LC**	**LC**	**LC**
Dipodomys phillipsii	Mammals	4,46	**4**	**1**	0,77	1	43,51	3	**9**	**Pr**	**Pr**	86829,6	87654,1	-0,95	**LC**	**LC**	**LC**	**LC**
Glossophaga morenoi	Mammals	3,76	**4**	**2**	0,75	1	37,50	3	**10**	**A**	**-**	76902,5	73888,6	3,92	**LC**	**LC**	**LC**	**LC**
Habromys lepturus	Mammals	0,07	**4**	**1**	0,48	2	7,87	2	**9**	**Pr**	**-**	1334,58	1333,02	0,12	**LC**	**VU**	**VU**	**CR**
Lepus flavigularis	Mammals		**4**	**2**		2		3	**11**	**A**	**P**	3162,9	3043,56	3,77	**LC**	**LC**	**LC**	**EN**

		0,15			0,56		49,16											
Megadontomys cryophilus	Mammals	0,63	**4**	**1**	0,63	2	33,13	3	**10**	**A**	**A**	12590	12451,1	1,10	**LC**	**LC**	**LC**	**EN**
Megadontomys thomasi	Mammals	1,41	**4**	**1**	0,68	1	24,05	2	**8**	**Pr**	**Pr**	27920,1	27669,7	0,90	**LC**	**LC**	**LC**	**EN**
Microtus oaxacensis	Mammals	1,87	**4**	**2**	0,72	1	53,03	3	**10**	**A**	**A**	39862,7	36759,8	7,78	**LC**	**LC**	**LC**	**EN**
Microtus quasiater	Mammals	2,14	**4**	**2**	0,72	1	46,28	3	**10**	**A**	**Pr**	42986,6	41966,3	2,37	**LC**	**LC**	**LC**	**NT**
Musonycteris harrisoni	Mammals	0,58	**4**	**2**	0,63	2	31,76	2	**10**	**A**	**P**	11512	11423,1	0,77	**LC**	**LC**	**LC**	**VU**
Neotamias bulleri	Mammals	0,23	**4**	**1**	0,55	2	4,43	2	**9**	**Pr**	**-**	4616,82	4580,16	0,79	**LC**	**LC**	**LC**	**VU**
Neotamias durangae	Mammals	0,58	**4**	**1**	0,61	2	4,46	2	**9**	**Pr**	**-**	11456,6	11318,6	1,21	**LC**	**LC**	**LC**	**LC**
Neotoma goldmani	Mammals	1,36	**4**	**1**	0,60	2	20,91	2	**9**	**Pr**	**-**	26871	26743,1	0,48	**LC**	**LC**	**LC**	**LC**
Neotomodon alstoni	Mammals	0,33	**4**	**2**	0,62	2	59,21	3	**11**	**A**	**-**	6837,48	6484,14	5,17	**LC**	**LC**	**LC**	**LC**
Osgoodomys banderanus	Mammals	1,84	**4**	**2**	0,71	1	37,33	3	**10**	**A**	**-**	36981,4	36113,2	2,35	**LC**	**LC**	**LC**	**LC**
Pappogeomys bulleri	Mammals	1,41	**4**	**2**	0,70	1	49,22	3	**10**	**A**	**-**	28852,2	27636,2	4,21	**LC**	**LC**	**LC**	**LC**
Peromyscus difficilis	Mammals	5,53	**3**	**2**	0,78	1	42,29	3	**9**	**Pr**	**-**	109852	108684	1,06	**LC**	**LC**	**LC**	**LC**
Peromyscus furvus	Mammals	0,76	**4**	**2**	0,65	2	41,77	3	**11**	**A**	**-**	14862,1	14913,6	-0,35	**LC**	**LC**	**LC**	**DD**
Peromyscus hylocetes	Mammals	0,89	**4**	**2**	0,67	1	46,35	3	**10**	**A**	**-**	17873,7	17551,6	1,80	**LC**	**LC**	**LC**	**LC**
Peromyscus levipes	Mammals	6,44	**3**	**2**	0,79	1	40,24	3	**9**	**Pr**	**-**	126649	126557	0,07	**LC**	**LC**	**LC**	**LC**
Peromyscus megalops	Mammals	1,02	**4**	**1**	0,66	1	28,18	2	**8**	**Pr**	**-**	19989,1	20039	-0,25	**LC**	**LC**	**LC**	**LC**
Peromyscus melanophrys	Mammals	9,74	**3**	**1**	0,81	1	37,70	3	**8**	**Pr**	**-**	192423	191302	0,58	**LC**	**LC**	**LC**	**LC**
Peromyscus ochraventer	Mammals	0,01	**4**	**1**	0,39	2	11,97	2	**9**	**Pr**	**-**	240,24	241,02	-0,32	**LC**	**EN**	**EN**	**EN**
Peromyscus perfulvus	Mammals	0,15	**4**	**2**	0,54	2	26,13	2	**10**	**A**	**-**	2978,82	2907,84	2,38	**LC**	**LC**	**LC**	**LC**
Peromyscus spicilegus	Mammals	7,78	**3**	**1**	0,79	1	31,15	2	**7**	**-**	**-**	154697	152830	1,21	**LC**	**LC**	**LC**	**LC**
Peromyscus yucatanicus	Mammals	1,06	**4**	**1**	0,66	2	20,55	2	**9**	**Pr**	**-**	21456,2	20864,2	2,76	**LC**	**LC**	**LC**	**LC**
Peromyscus zarhynchus	Mammals	0,15	**4**	**2**	0,56	2	46,41	3	**11**	**A**	**Pr**	3233,1	2889,12	10,64	**LC**	**LC**	**LC**	**VU**
Reithrodontomys chrysopsis	Mammals	0,22	**4**	**2**	0,59	2	54,71	3	**11**	**A**	**-**	4416,36	4399,2	0,39	**LC**	**LC**	**LC**	**LC**
Rhogeessa parvula	Mammals	2,12	**4**	**2**	0,72	1	40,64	3	**10**	**A**	**-**	42535,7	41620	2,15	**LC**	**LC**	**LC**	**LC**
Sciurus alleni	Mammals	0,01	**4**	**1**	0,40	2	33,10	3	**10**	**A**	**-**	225,42	222,3	1,38	**LC**	**EN**	**EN**	**LC**
Sciurus oculatus	Mammals	0,03	**4**	**2**	0,45	2	39,64	3	**11**	**A**	**Pr**	536,64	527,28	1,74	**LC**	**VU**	**VU**	**LC**
Sigmodon alleni	Mammals	3,50	**4**	**1**	0,74	1	26,93	2	**8**	**Pr**	**-**	70572,1	68848,3	2,44	**LC**	**LC**	**LC**	**VU**
Sigmodon leucotis	Mammals	3,41	**4**	**1**	0,73	1	21,67	2	**8**	**Pr**	**-**	67785,1	66893,6	1,32	**LC**	**LC**	**LC**	**LC**

Sigmodon mascotensis	Mammals	9,53	**3**	**2**	0,81	1	38,11	3	**9**	**Pr**	**-**	190017	187270	1,45	**LC**	**LC**	**LC**	**LC**
Sorex ventralis	Mammals	0,28	**4**	**2**	0,62	2	63,05	3	**11**	**A**	**-**	5885,1	5583,24	5,13	**LC**	**LC**	**LC**	**LC**
Spilogale pygmaea	Mammals	0,53	**4**	**1**	0,62	2	25,78	2	**9**	**Pr**	**A**	10504,3	10459	0,43	**LC**	**LC**	**LC**	**VU**
Sylvilagus cunicularius	Mammals	3,55	**4**	**2**	0,75	1	41,65	3	**10**	**A**	**-**	70987	69689,1	1,83	**LC**	**LC**	**LC**	**LC**
Thomomys sheldoni	Mammals	0,04	**4**	**1**	0,45	2	8,59	2	**9**	**Pr**	**-**	861,12	863,46	-0,27	**LC**	**VU**	**VU**	**-**
Tlacuatzin canescens	Mammals	1,27	**4**	**2**	0,69	1	42,15	3	**10**	**A**	**-**	25138,6	24946,7	0,76	**LC**	**LC**	**LC**	**LC**
Abronia graminea	Reptiles	0,19	**4**	**2**	0,57	2	46,17	3	**11**	**A**	**A**	3777,54	3813,42	-0,95	**LC**	**LC**	**LC**	**EN**
Abronia taeniata	Reptiles	0,52	**4**	**2**	0,64	2	51,35	3	**11**	**A**	**Pr**	10139,2	10179	-0,39	**LC**	**LC**	**LC**	**VU**
Adelphicos nigrilatum	Reptiles	0,01	**4**	**2**	0,37	2	22,09	2	**10**	**A**	**Pr**	109,98	104,52	4,96	**LC**	**EN**	**EN**	**LC**
Anelytropsis papillosus	Reptiles	1,68	**4**	**1**	0,69	1	25,40	2	**8**	**Pr**	**P**	33096,2	32905,9	0,58	**LC**	**LC**	**LC**	**LC**
Anolis anisolepis	Reptiles	0,13	**4**	**2**	0,55	2	41,59	3	**11**	**A**	**Pr**	2711,28	2620,8	3,34	**LC**	**LC**	**LC**	**LC**
Anolis barkeri	Reptiles	0,11	**4**	**2**	0,55	2	51,63	3	**11**	**A**	**Pr**	2268,24	2217,54	2,24	**LC**	**LC**	**LC**	**VU**
Anolis compressicauda	Reptiles	1,08	**4**	**2**	0,69	1	54,58	3	**10**	**A**	**-**	23250,2	21159,8	8,99	**LC**	**LC**	**LC**	**LC**
Anolis liogaster	Reptiles	0,70	**4**	**1**	0,63	2	21,12	2	**9**	**Pr**	**Pr**	13701,5	13735	-0,24	**LC**	**LC**	**LC**	**LC**
Anolis naufragus	Reptiles	0,09	**4**	**2**	0,56	2	66,58	4	**12**	**P**	**Pr**	1757,34	1786,98	-1,69	**LC**	**VU**	**VU**	**VU**
Anolis nebuloides	Reptiles	4,74	**4**	**2**	0,76	1	31,67	2	**9**	**Pr**	**Pr**	94365,2	93043,9	1,40	**LC**	**LC**	**LC**	**LC**
Anolis nebulosus	Reptiles	3,62	**4**	**2**	0,74	1	32,75	2	**9**	**Pr**	**-**	70528,4	71097	-0,81	**LC**	**LC**	**LC**	**LC**
Anolis pygmaeus	Reptiles	0,89	**4**	**2**	0,68	1	56,94	3	**10**	**A**	**Pr**	20234	17448,6	13,77	**LC**	**LC**	**LC**	**EN**
Anolis quercorum	Reptiles	0,95	**4**	**2**	0,69	1	56,19	3	**10**	**A**	**-**	17939,2	18567,1	-3,50	**LC**	**LC**	**LC**	**LC**
Aspidoscelis communis	Reptiles	2,78	**4**	**2**	0,73	1	39,76	3	**10**	**A**	**Pr**	53631,2	54659,3	-1,92	**LC**	**LC**	**LC**	**LC**
Aspidoscelis costatus	Reptiles	7,63	**3**	**2**	0,80	1	41,66	3	**9**	**Pr**	**Pr**	151492	149889	1,06	**LC**	**LC**	**LC**	**LC**
Aspidoscelis guttata	Reptiles	2,31	**4**	**2**	0,73	1	50,25	3	**10**	**A**	**-**	47873,3	45334,4	5,30	**LC**	**LC**	**LC**	**-**
Aspidoscelis lineattissima	Reptiles	0,68	**4**	**2**	0,64	2	36,17	3	**11**	**A**	**Pr**	13907,4	13356,7	3,96	**LC**	**LC**	**LC**	**-**
Aspidoscelis parvisocia	Reptiles	0,44	**4**	**2**	0,63	2	48,94	3	**11**	**A**	**Pr**	8115,9	8596,38	-5,92	**LC**	**LC**	**LC**	**LC**
Aspidoscelis sackii	Reptiles	1,54	**4**	**2**	0,70	1	41,19	3	**10**	**A**	**-**	28281,2	30200,8	-6,79	**LC**	**LC**	**LC**	**LC**
Barisia imbricata	Reptiles	1,09	**4**	**2**	0,70	1	62,33	3	**10**	**A**	**Pr**	21468,7	21314,3	0,72	**LC**	**LC**	**LC**	**LC**
Cerrophidion tzotzilorum	Reptiles	0,01	**4**	**2**	0,38	2	40,38	3	**11**	**A**	**Pr**	131,04	123,24	5,95	**LC**	**EN**	**EN**	**LC**
Conophis vittatus	Reptiles	1,50	**4**	**2**	0,70	1	44,92	3	**10**	**A**	**-**	30062	29438	2,08	**LC**	**LC**	**LC**	**LC**
Conopsis biserialis	Reptiles		**4**	**2**		1		3	**10**	**A**	**A**	38744,2	38416,6	0,85	**LC**	**LC**	**LC**	**LC**

		1,96			0,71		41,69											
Conopsis lineata	Reptiles	1,56	**4**	**2**	0,72	1	58,51	3	**10**	**A**	**-**	30413	30608,8	-0,64	**LC**	**LC**	**LC**	**LC**
Conopsis megalodon	Reptiles	0,71	**4**	**1**	0,64	2	28,49	2	**9**	**Pr**	**-**	13809,1	13988,5	-1,30	**LC**	**LC**	**LC**	**LC**
Conopsis nasus	Reptiles	6,70	**3**	**2**	0,80	1	45,29	3	**9**	**Pr**	**-**	133418	131549	1,40	**LC**	**LC**	**LC**	**LC**
Crotalus basiliscus	Reptiles	2,36	**4**	**1**	0,71	1	25,94	2	**8**	**Pr**	**Pr**	47659,6	46391,3	2,66	**LC**	**LC**	**LC**	**LC**
Crotalus enyo	Reptiles	0,39	**4**	**1**	0,58	2	5,39	2	**9**	**Pr**	**A**	7775,04	7680,66	1,21	**LC**	**LC**	**LC**	**LC**
Crotalus intermedius	Reptiles	1,94	**4**	**2**	0,72	1	46,27	3	**10**	**A**	**A**	37947,8	38206,7	-0,68	**LC**	**LC**	**LC**	**LC**
Crotalus ravus	Reptiles	1,25	**4**	**2**	0,71	1	62,18	3	**10**	**A**	**A**	23843,8	24491,2	-2,72	**LC**	**LC**	**LC**	**LC**
Ctenosaura acanthura	Reptiles	1,05	**4**	**2**	0,72	1	69,37	4	**11**	**A**	**Pr**	21785,4	20719,1	4,89	**LC**	**LC**	**LC**	**-**
Ctenosaura hemilopha	Reptiles	3,61	**4**	**1**	0,74	1	29,28	2	**8**	**Pr**	**Pr**	75236,5	70958,2	5,69	**LC**	**LC**	**LC**	**-**
Ctenosaura pectinata	Reptiles	4,73	**4**	**2**	0,77	1	38,45	3	**10**	**A**	**A**	93323,1	92904,2	0,45	**LC**	**LC**	**LC**	**-**
Ficimia olivacea	Reptiles	0,48	**4**	**2**	0,62	2	39,73	3	**11**	**A**	**-**	9433,32	9402,12	0,33	**LC**	**LC**	**LC**	**-**
Geophis mutitorques	Reptiles	0,09	**4**	**2**	0,54	2	58,53	3	**11**	**A**	**Pr**	1664,52	1716	-3,09	**LC**	**VU**	**VU**	**LC**
Geophis semidoliatus	Reptiles	0,04	**4**	**2**	0,49	2	59,03	3	**11**	**A**	**-**	772,98	762,84	1,31	**LC**	**VU**	**VU**	**LC**
Gerrhonotus liocephalus	Reptiles	6,99	**3**	**2**	0,79	1	38,40	3	**9**	**Pr**	**Pr**	138171	137361	0,59	**LC**	**LC**	**LC**	**LC**
Hypsiglena torquata	Reptiles	3,34	**4**	**1**	0,72	1	14,34	2	**8**	**Pr**	**Pr**	66496,6	65516,1	1,47	**LC**	**LC**	**LC**	**LC**
Kinosternon creaseri	Reptiles	0,34	**4**	**1**	0,57	2	5,05	2	**9**	**Pr**	**-**	6861,66	6661,2	2,92	**LC**	**LC**	**LC**	**LC**
Kinosternon herrerai	Reptiles	2,71	**4**	**2**	0,76	1	59,56	3	**10**	**A**	**Pr**	55535,2	53275,6	4,07	**LC**	**LC**	**LC**	**NT**
Kinosternon integrum	Reptiles	7,96	**3**	**2**	0,80	1	41,81	3	**9**	**Pr**	**Pr**	157687	156346	0,85	**LC**	**LC**	**LC**	**LC**
Lepidophyma gaigeae	Reptiles	0,61	**4**	**1**	0,63	2	30,74	2	**9**	**Pr**	**Pr**	11855,2	11930,1	-0,63	**LC**	**LC**	**LC**	**VU**
Lepidophyma pajapanensis	Reptiles	0,02	**4**	**2**	0,47	2	71,73	4	**12**	**P**	**Pr**	361,14	364,26	-0,86	**LC**	**EN**	**EN**	**LC**
Lepidophyma sylvaticum	Reptiles	0,01	**4**	**2**	0,42	2	80,20	4	**12**	**P**	**Pr**	106,08	109,98	-3,68	**LC**	**EN**	**EN**	**LC**
Lepidophyma tuxtlae	Reptiles	0,36	**4**	**2**	0,62	2	51,57	3	**11**	**A**	**A**	7963,8	7157,28	10,13	**LC**	**LC**	**LC**	**DD**
Leptodeira maculata	Reptiles	2,60	**4**	**2**	0,73	1	43,67	3	**10**	**A**	**Pr**	52536,1	51019	2,89	**LC**	**LC**	**LC**	**LC**
Leptodeira splendida	Reptiles	1,19	**4**	**2**	0,69	1	48,99	3	**10**	**A**	**-**	22826,7	23353,2	-2,31	**LC**	**LC**	**LC**	**LC**
Leptophis diplotropis	Reptiles	7,65	**3**	**2**	0,79	1	35,71	3	**9**	**Pr**	**A**	150843	150343	0,33	**LC**	**LC**	**LC**	**LC**
Manolepis putnami	Reptiles	3,87	**4**	**2**	0,75	1	35,04	3	**10**	**A**	**-**	77187,2	76084,3	1,43	**LC**	**LC**	**LC**	**LC**
Mesaspis gadovii	Reptiles	0,43	**4**	**1**	0,60	2	15,28	2	**9**	**Pr**	**Pr**	8424	8499,66	-0,90	**LC**	**LC**	**LC**	**LC**
Mesaspis juarezi	Reptiles	0,04	**4**	**1**	0,45	2	8,21	2	**9**	**Pr**	**Pr**	850,98	854,1	-0,37	**LC**	**VU**	**VU**	**EN**

Mesaspis viridiflava	Reptiles	0,50	**4**	**1**	0,62	2	34,17	3	**10**	**A**	**Pr**	9552,66	9888,84	-3,52	**LC**	**LC**	**LC**	**LC**
Micrurus distans	Reptiles	2,41	**4**	**1**	0,72	1	38,31	3	**9**	**Pr**	**Pr**	48997,3	47257,9	3,55	**LC**	**LC**	**LC**	**LC**
Micrurus limbatus	Reptiles	0,02	**4**	**2**	0,48	2	75,87	4	**12**	**P**	**Pr**	333,84	340,08	-1,87	**LC**	**EN**	**EN**	**LC**
Ophryacus undulatus	Reptiles	0,04	**4**	**1**	0,45	2	23,14	2	**9**	**Pr**	**Pr**	711,36	709,8	0,22	**LC**	**VU**	**VU**	**VU**
Phrynosoma orbiculare	Reptiles	3,83	**4**	**1**	0,76	1	43,64	3	**9**	**Pr**	**A**	76207,6	75309	1,18	**LC**	**LC**	**LC**	**-**
Phrynosoma taurus	Reptiles	1,41	**4**	**2**	0,70	1	49,39	3	**10**	**A**	**A**	26119,9	27707,2	-6,08	**LC**	**LC**	**LC**	**LC**
Phyllodactylus bordai	Reptiles	0,33	**4**	**2**	0,61	2	50,56	3	**11**	**A**	**Pr**	5997,42	6438,9	-7,36	**LC**	**LC**	**LC**	**LC**
Phyllodactylus lanei	Reptiles	0,02	**4**	**2**	0,41	2	32,54	2	**10**	**A**	**-**	273,78	310,44	-13,39	**LC**	**EN**	**EN**	**LC**
Phyllodactylus muralis	Reptiles	0,05	**4**	**2**	0,49	2	46,53	3	**11**	**A**	**Pr**	984,36	913,38	7,21	**LC**	**VU**	**VU**	**LC**
Phyllodactylus unctus	Reptiles	0,37	**4**	**1**	0,58	2	6,47	2	**9**	**Pr**	**Pr**	7463,82	7344,48	1,60	**LC**	**LC**	**LC**	**NT**
Pituophis deppei	Reptiles	4,63	**4**	**2**	0,77	1	45,31	3	**10**	**A**	**A**	91699,9	90869,2	0,91	**LC**	**LC**	**LC**	**LC**
Plestiodon copei	Reptiles	0,25	**4**	**2**	0,63	2	71,07	4	**12**	**P**	**Pr**	5204,94	4985,76	4,21	**LC**	**LC**	**LC**	**LC**
Plestiodon lynxe	Reptiles	4,00	**4**	**2**	0,76	1	39,17	3	**10**	**A**	**Pr**	79468	78613,1	1,08	**LC**	**LC**	**LC**	**LC**
Rena maxima	Reptiles	1,71	**4**	**2**	0,71	1	44,84	3	**10**	**A**	**-**	32178,9	33640,6	-4,54	**LC**	**LC**	**LC**	**LC**
Rena myopica	Reptiles	0,86	**4**	**2**	0,68	1	53,87	3	**10**	**A**	**-**	17397,1	16957,2	2,53	**LC**	**LC**	**LC**	**LC**
Rhadinaea fulvivittis	Reptiles	0,46	**4**	**2**	0,61	2	26,81	2	**10**	**A**	**-**	8772,66	9115,08	-3,90	**LC**	**LC**	**LC**	**VU**
Rhadinaea gaigeae	Reptiles	1,12	**4**	**2**	0,68	1	45,39	3	**10**	**A**	**-**	21766,7	22046,7	-1,29	**LC**	**LC**	**LC**	**DD**
Rhadinaea laureata	Reptiles	0,37	**4**	**2**	0,61	2	43,40	3	**11**	**A**	**-**	7393,62	7336,68	0,77	**LC**	**LC**	**LC**	**LC**
Rhadinaea taeniata	Reptiles	0,42	**4**	**2**	0,61	2	29,72	2	**10**	**A**	**-**	8086,26	8292,18	-2,55	**LC**	**LC**	**LC**	**LC**
Salvadora bairdi	Reptiles	0,88	**4**	**2**	0,69	1	60,54	3	**10**	**A**	**Pr**	17218,5	17257,5	-0,23	**LC**	**LC**	**LC**	**LC**
Salvadora intermedia	Reptiles	0,14	**4**	**2**	0,54	2	35,93	3	**11**	**A**	**Pr**	2701,14	2734,68	-1,24	**LC**	**LC**	**LC**	**LC**
Salvadora mexicana	Reptiles	3,43	**4**	**1**	0,75	1	38,21	3	**9**	**Pr**	**Pr**	68158	67453,6	1,03	**LC**	**LC**	**LC**	**LC**
Sceloporus adleri	Reptiles	0,38	**4**	**1**	0,59	2	11,92	2	**9**	**Pr**	**Pr**	7489,56	7466,94	0,30	**LC**	**LC**	**LC**	**LC**
Sceloporus aeneus	Reptiles	1,00	**4**	**2**	0,70	1	60,84	3	**10**	**A**	**-**	19793,3	19594,4	1,00	**LC**	**LC**	**LC**	**LC**
Sceloporus bicanthalis	Reptiles	1,20	**4**	**2**	0,70	1	54,77	3	**10**	**A**	**-**	23886,7	23573,9	1,31	**LC**	**LC**	**LC**	**LC**
Sceloporus bulleri	Reptiles	2,26	**4**	**1**	0,70	1	11,36	2	**8**	**Pr**	**-**	44624,6	44304,8	0,72	**LC**	**LC**	**LC**	**LC**
Sceloporus cautus	Reptiles	3,97	**4**	**1**	0,74	1	21,89	2	**8**	**Pr**	**-**	78911	77939,9	1,23	**LC**	**LC**	**LC**	**LC**
Sceloporus cozumelae	Reptiles	0,09	**4**	**1**	0,51	2	26,37	2	**9**	**Pr**	**Pr**	1822,86	1797,12	1,41	**LC**	**VU**	**VU**	**LC**
Sceloporus dugesii	Reptiles		**4**	**2**		1		3	**10**	**A**	**-**	13501,8	12507,3	7,37	**LC**	**LC**	**LC**	**LC**

		0,64			0,67		61,01											
Sceloporus formosus	Reptiles	1,48	**4**	**2**	0,68	1	29,00	2	**9**	**Pr**	**-**	28560,5	29055,8	-1,73	**LC**	**LC**	**LC**	**LC**
Sceloporus gadoviae	Reptiles	1,82	**4**	**2**	0,71	1	43,18	3	**10**	**A**	**-**	33707,7	35785,6	-6,16	**LC**	**LC**	**LC**	**LC**
Sceloporus horridus	Reptiles	5,72	**3**	**2**	0,78	1	37,36	3	**9**	**Pr**	**-**	110994	112286	-1,16	**LC**	**LC**	**LC**	**LC**
Sceloporus hunsakeri	Reptiles	0,37	**4**	**1**	0,58	2	4,81	2	**9**	**Pr**	**Pr**	7393,62	7293,78	1,35	**LC**	**LC**	**LC**	**LC**
Sceloporus jalapae	Reptiles	0,62	**4**	**2**	0,66	2	56,21	3	**11**	**A**	**-**	11573,6	12166,4	-5,12	**LC**	**LC**	**LC**	**LC**
Sceloporus licki	Reptiles	0,19	**4**	**1**	0,54	2	2,48	2	**9**	**Pr**	**Pr**	3774,42	3742,44	0,85	**LC**	**LC**	**LC**	**LC**
Sceloporus maculosus	Reptiles	8,28	**3**	**1**	0,79	1	26,30	2	**7**	**-**	**Pr**	165981	162747	1,95	**LC**	**LC**	**LC**	**VU**
Sceloporus megalepidurus	Reptiles	0,37	**4**	**2**	0,65	2	68,57	4	**12**	**P**	**Pr**	7332	7201,74	1,78	**LC**	**LC**	**LC**	**VU**
Sceloporus minor	Reptiles	5,22	**3**	**1**	0,76	1	29,62	2	**7**	**-**	**-**	103125	102485	0,62	**LC**	**LC**	**LC**	**LC**
Sceloporus mucronatus	Reptiles	2,52	**4**	**2**	0,74	1	51,36	3	**10**	**A**	**-**	49080,7	49438	-0,73	**LC**	**LC**	**LC**	**LC**
Sceloporus nelsoni	Reptiles	2,34	**4**	**1**	0,71	1	30,83	2	**8**	**Pr**	**-**	48597,9	45974	5,40	**LC**	**LC**	**LC**	**LC**
Sceloporus ochoterenae	Reptiles	0,93	**4**	**2**	0,67	1	41,22	3	**10**	**A**	**-**	17440	18258,2	-4,69	**LC**	**LC**	**LC**	**LC**
Sceloporus ormis	Reptiles	2,08	**4**	**1**	0,71	1	33,25	3	**9**	**Pr**	**-**	41365	40770,6	1,44	**LC**	**LC**	**LC**	**???**
Sceloporus palaciosi	Reptiles	0,22	**4**	**2**	0,61	2	63,45	3	**11**	**A**	**-**	4178,46	4268,94	-2,17	**LC**	**LC**	**LC**	**LC**
Sceloporus parvus	Reptiles	3,74	**4**	**1**	0,74	1	26,39	2	**8**	**Pr**	**-**	73683,5	73415,2	0,36	**LC**	**LC**	**LC**	**LC**
Sceloporus pyrocephalus	Reptiles	2,65	**4**	**2**	0,73	1	35,21	3	**10**	**A**	**-**	51882,5	51998,7	-0,22	**LC**	**LC**	**LC**	**LC**
Sceloporus salvini	Reptiles	0,24	**4**	**1**	0,59	2	51,04	3	**10**	**A**	**A**	4995,12	4719,78	5,51	**LC**	**LC**	**LC**	**DD**
Sceloporus scalaris	Reptiles	4,22	**4**	**2**	0,76	1	39,82	3	**10**	**A**	**-**	83080,1	82892,9	0,23	**LC**	**LC**	**LC**	**LC**
Sceloporus siniferus	Reptiles	2,31	**4**	**2**	0,72	1	38,60	3	**10**	**A**	**-**	47455,2	45435	4,26	**LC**	**LC**	**LC**	**LC**
Sceloporus spinosus	Reptiles	5,86	**3**	**1**	0,78	1	38,64	3	**8**	**Pr**	**-**	114682	115062	-0,33	**LC**	**LC**	**LC**	**LC**
Sceloporus torquatus	Reptiles	4,95	**4**	**2**	0,78	1	44,72	3	**10**	**A**	**-**	98139,6	97285,5	0,87	**LC**	**LC**	**LC**	**LC**
Sceloporus zosteromus	Reptiles	0,02	**4**	**1**	0,41	2	19,22	2	**9**	**Pr**	**Pr**	380,64	370,5	2,66	**LC**	**EN**	**EN**	**LC**
Scincella gemmingeri	Reptiles	2,65	**4**	**2**	0,74	1	51,15	3	**10**	**A**	**Pr**	54952,6	51983,9	5,40	**LC**	**LC**	**LC**	**LC**
Scincella silvicola	Reptiles	1,86	**4**	**1**	0,71	1	44,37	3	**9**	**Pr**	**A**	37045,3	36507,9	1,45	**LC**	**LC**	**LC**	**LC**
Storeria hidalgoensis	Reptiles	1,12	**4**	**1**	0,67	1	29,24	2	**8**	**Pr**	**-**	22128,6	21905,5	1,01	**LC**	**LC**	**LC**	**VU**
Storeria storerioides	Reptiles	1,48	**4**	**2**	0,70	1	42,60	3	**10**	**A**	**-**	28857,7	29103,4	-0,85	**LC**	**LC**	**LC**	**LC**
Tantilla bocourti	Reptiles	8,21	**3**	**2**	0,81	1	44,84	3	**9**	**Pr**	**-**	163055	161349	1,05	**LC**	**LC**	**LC**	**LC**
Tantilla calamarina	Reptiles	1,11	**4**	**2**	0,67	1	31,23	2	**9**	**Pr**	**Pr**	21883,7	21839,2	0,20	**LC**	**LC**	**LC**	**LC**

Tantilla rubra	Reptiles	5,82	**3**	**1**	0,78	1	36,42	3	**8**	**Pr**	**Pr**	116595	114229	2,03	**LC**	**LC**	**LC**	**LC**
Thamnophis chrysocephalus	Reptiles	0,76	**4**	**1**	0,63	2	20,24	2	**9**	**Pr**	**A**	14563,4	14843,4	-1,92	**LC**	**LC**	**LC**	**LC**
Thamnophis melanogaster	Reptiles	4,70	**4**	**2**	0,78	1	50,93	3	**10**	**A**	**A**	94761,4	92374,6	2,52	**LC**	**LC**	**LC**	**EN**
Thamnophis scalaris	Reptiles	1,03	**4**	**2**	0,68	1	49,14	3	**10**	**A**	**A**	20440,7	20297,9	0,70	**LC**	**LC**	**LC**	**LC**
Thamnophis scaliger	Reptiles	0,63	**4**	**2**	0,69	1	70,23	4	**11**	**A**	**A**	12871,6	12460,5	3,19	**LC**	**LC**	**LC**	**VU**
Thamnophis valida	Reptiles	0,00	**4**	**1**	0,36	2	24,00	2	**9**	**Pr**	**-**	41,34	44,46	-7,55	**LC**	**EN**	**EN**	**LC**
Trimorphodon tau	Reptiles	10,59	**3**	**1**	0,81	1	33,89	3	**8**	**Pr**	**-**	207801	208041	-0,12	**LC**	**LC**	**LC**	**LC**
Urosaurus bicarinatus	Reptiles	5,93	**3**	**2**	0,78	1	38,90	3	**9**	**Pr**	**-**	116172	116570	-0,34	**LC**	**LC**	**LC**	**LC**
Xenosaurus platyceps	Reptiles	0,24	**4**	**1**	0,57	2	25,10	2	**9**	**Pr**	**Pr**	4744,74	4726,8	0,38	**LC**	**LC**	**LC**	**EN**

Apéndice II. Número de especies en cada ecorregión asignadas a cada categoría de riesgo de extinción de la NOM-059-SEMARNAT.

Appendix II. Number of species at each ecoregion assigned to each Nom-059-SEMARNAT risk category.

Region	Ecoregion	NR	Pr	A	P	Ex	Average Category
Planicie costera de Texas-Louisiana	**9.5.1.1**	1	4	2	0	0	Pr
	9.5.1.2	1	2	3	0	1	A
Planicie semiárida de Tamaulipas y Texas	**9.6.1.1**	0	7	9	1	0	A
	9.6.1.2	4	42	5	1	0	Pr
Desiertos Cálidos	**10.2.2.1**	0	0	0	1	1	P
	10.2.2.2	0	3	3	1	0	Pr
	10.2.2.3	0	0	0	0	0	
	10.2.2.4	10	3	1	0	0	NR
	10.2.2.6	3	7	0	0	0	Pr
	10.2.2.7	7	13	1	0	0	Pr
	10.2.2.8	3	14	6	0	1	Pr
	10.2.3.1	2	4	0	0	0	Pr
	10.2.3.2	4	3	2	0	0	Pr
	10.2.3.3	2	7	0	0	0	Pr
	10.2.3.4	2	0	2	0	0	Pr
	10.2.3.5	3	5	0	0	0	Pr
	10.2.4.1	3	40	10	0	0	Pr
	10.2.4.2	6	51	1	0	0	Pr
	10.2.4.3	1	0	0	0	0	NR
	10.2.4.4	3	7	0	0	0	Pr
	10.2.4.5	2	1	1	0	0	NR
	10.2.4.6	28	35	1	0	0	NR
	10.2.4.7	22	39	15	0	0	Pr
	10.2.4.8	30	22	0	0	0	NR
California mediterránea	**11.1.1.2**	0	0	0	0	0	
	11.1.1.3	1	2	2	0	0	Pr
	11.1.3.1	1	3	0	0	0	Pr
	11.1.3.2	1	4	0	0	0	Pr
Piedemonte de la Sierra Madre Occidental	**12.1.1.1**	5	17	0	0	0	Pr
	12.1.2.1	2	78	25	1	0	Pr
Altaplanicie mexicana	**12.2.1.1**	0	10	112	7	21	A
	12.2.1.2	1	68	103	13	4	A
Sierra Madre Occidental	**13.2.1.1**	48	69	13	0	0	Pr
Sierra Madre Oriental	**13.3.1.1**	44	56	57	1	2	Pr
	13.3.1.2	10	79	20	1	0	Pr

Sistema Neovolcánico Transveral	**13.4.1.1**	0	1	103	40	14	A
	13.4.1.2	0	1	129	24	22	P
	13.4.2.1	0	40	113	11	10	A
	13.4.2.2	6	114	110	15	1	A
	13.4.2.3	84	31	9	0	2	NR
	13.4.2.4	71	93	30	13	3	Pr
Sierra Madre del Sur	**13.5.1.1**	79	67	3	0	1	NR
	13.5.1.2	1	49	10	0	0	Pr
	13.5.1.3	75	47	3	0	0	NR
	13.5.1.4	58	43	3	0	0	NR
	13.5.2.1	82	102	51	0	0	Pr
	13.5.2.2	39	95	31	1	2	Pr
	13.5.2.3	63	46	17	3	0	Pr
	13.5.2.4	93	32	1	0	0	NR
Sierra Madre Centroamericana y Altos de Chiapas	**13.6.1.1**	40	44	6	0	0	Pr
	13.6.1.2	30	37	1	0	0	NR
	13.6.2.1	4	25	30	1	2	A
	13.6.2.2	14	15	17	1	0	Pr
Planicies costeras y lomeríos secor del Colfo de México	**14.1.1.1**	5	1	1	2	0	Pr
	14.1.1.2	0	3	20	3	1	A
	14.1.2.1	0	0	7	0	1	A
	14.1.2.2	9	8	5	0	1	Pr
	14.1.2.3	12	29	2	1	0	Pr
	14.1.2.4	0	2	75	13	6	A
Planicie noroccidental de la Península de Yucatán	**14.2.1.1**	4	0	0	0	0	NR
	14.2.1.2	0	2	0	1	0	Pr
Planicie costera, lomeríos y cañones del occidente	**14.3.1.1**	18	12	3	1	1	Pr
	14.3.1.2	0	5	33	0	1	A
	14.3.1.3	13	18	2	0	1	Pr
	14.3.2.1	21	43	18	0	0	Pr
	14.3.2.2	47	49	3	0	0	NR
Depresiones intermontanas	**14.4.1.1**	30	79	5	0	6	Pr
	14.4.2.1	0	26	44	3	5	A
	14.4.3.1	47	84	22	1	0	Pr
	14.4.3.2	14	116	43	4	11	Pr
	14.4.3.3	4	53	52	3	4	A
Planicie costera y lomeríos del Pacífico Sur	**14.5.1.1**	1	36	26	0	1	Pr
	14.5.1.2	63	49	39	1	1	Pr
	14.5.2.1	58	19	12	0	0	NR
	14.5.2.3	28	89	40	1	1	Pr
	14.5.2.4	33	60	20	1	1	Pr
Sierra y planicies del Cabo	**14.6.1.1**	9	1	1	0	1	NR
	14.6.2.1	7	1	0	0	0	NR
Planicie costera y lomeríos del Golfo de México	**15.1.1.1**	0	8	21	4	0	A
	15.1.1.2	0	0	35	16	30	P
	15.1.2.1	2	12	1	0	0	Pr

	15.1.2.2	0	12	24	2	2	A
	15.1.2.3	0	12	88	22	8	A
	15.1.2.4	2	48	53	13	7	A
Planicie y lomeríos de la Península de Yucatán	**15.2.1.1**	0	2	4	0	0	A
	15.2.2.1	1	2	1	0	2	A
	15.2.2.2	2	1	1	0	0	Pr
	15.2.3.1	1	3	5	1	2	A
Sierra de los Tuxtlas	**15.3.1.1**	0	3	26	5	1	A
Planicie y lomeríos de occidente	**15.5.1.1**	43	7	5	1	0	NR
	15.5.1.2	0	1	48	3	3	A
	15.5.2.1	29	11	21	0	1	Pr
	15.5.2.2	45	31	9	1	0	NR
Planicie costera y lomeríos de Soconusco	**15.6.1.1**	15	25	3	0	1	Pr
	15.6.1.2	0	44	13	5	1	Pr

MAPAS DE DISTRIBUCIÓN POTENCIAL

ANFIBIOS

Ambystoma altamirani

Ambystoma rosaceum

Ambystoma velasci

Anaxyrus compactilis

Aquiloeurycea cephalica

Bolitoglossa alberchi

Bolitoglossa platydactyla

Charadrahyla nephila

Charadrahyla taeniopus

Chiropterotriton chiropterus

Chiropterotriton chondrostega

Chiropterotriton multidentatus

Craugastor decoratus

Craugastor hobartsmithi

Craugastor mexicanus

Craugastor montanus

Craugastor occidentalis

Craugastor pozo

Craugastor rhodopis

Craugastor rugulosus

Dryophytes euphorbiaceus

Dryophytes eximius

Dryophytes plicatus

Eleutherodactylus longipes

Eleutherodactylus nitidus

Eleutherodactylus verrucipes

Exerodonta melanoma

Exerodonta smaradigna

Incilius cavifrons

Incilius cristatus

Incilius marmoreus

Incilius mazatlanensis

Incilius occidentalis

Incilius perplexus

Lithobates magnaocularis

Lithobates montezumae

Lithobates neovolcanicus

Lithobates pustulosus

Lithobates sierramadrensis

Lithobates spectabilis

Lithobates tarahumarae

Lithobates zweifeli

Parvimolge townsendi

Plectrohyla lacertosa

Pseudoeurycea cochranae

Pseudoeurycea gadovii

Psudoeurycea juarezi

Pseudoeurycea leprosa

Pseudoeurycea lineola

Pseuroeurycea longicauda

Pseuroeurycea melanomolga

Pseudoeutycea smithi

Ptychohyla leonhardschultzei

Ptychohyla zophodes

Thorius boreas

Thorius macdougalli

Thorius narisovalis

Thorius pennatulus

Tlalocohyla godmani

Tlalocohyla smithii

AVES

Aimophila notostica

Amazona finschi

Antrostomus salvini

Aphelocoma ultramarina

Arremon virenticeps

Atlapetes pileatus

Atthis heloisa

Calothorax pulcher

Calocitta colliei

Campylopterus excellens

Campylorhunchus chiapensis

Campylorhynchus gularis

Campylorhynchus jocosus

Campylorhynchus megalopterus

Catharus occidentalis

Chlorostilbon auriceps

Colaptes auricularis

Cyanocorax beecheii

Cyanocorax dickeyi

Cyanocorax sanblasianus

Cyanolyca mirabilis

Cyanolyca nanus

Cynanthus sordidus

Deltarhynchus flammulatus

Dendrortyx barbatus

Dendrortyx macroura

Doricha eliza

Dryobates stricklandi

Eupherusa cyanophrys

Eupherusa poliocerca

Forpus cyanopygius

Geothlypis beldingi

Geothlypis nelsoni

Geothlypis speciosa

Geotrygon carrikeri

Glaucidium palmarum

Glaucidium sanchezi

Granatellus venustus

Hylocharis xantusii

Hylorchilus navai

Hylorchilus sumichrasti

Icterus abeillei

Lepidocolaptes laucogaster

Lophornis brachylophus

Megascops seductus

Melanerpes chrysogenys

Melanerpes hypopolius

Melanotis caerulescens

Melozone albicollis

Melozone kieneri

Momotus coeruliceps

Nyctiphrynus mcleodii

Oriturus superciliosus

Ortalis poliocephala

Ortalis wagleri

Passerina leclancherii

Passerina rositae

Peucaea humeralis

Peucaea sumichrasti

Pheugopedius felix

Philortyx fasciatus

Pipilo ocai

Piranga erythrocephala

Rallus tenuirostris

Rhodothraupis celaeno

Rhynchopsitta pachyrhyncha

Rhynchopsitta terrisi

Ridgwayia pinicola

Spizella wortheni

Streptoprocne semicollaris

Thryophilus sinaloa

Toxostoma cinereum

Toxostoma ocellatum

Trogon citreolus

Turdus rufopalliatus

Vireo brevipennis

Vireo hypochryseus

Vireo nelsoni

Xenospiza baileyi

Xenotriccus mexicanus

MAMÍFEROS

Artibeus hirsutus

Chaetodipus artus

Chaetodipus goldmani

Chaetodipus pernix

Corynorhinus mexicanus

Cratogeomys fumosus

Cratogeomys goldmani

Cratogeomys merriami

Cratogeomys perotensis

Cryptotis goldmani

Cryptotis magna

Cryptotis mexicana

Dasyprocta mexicana

Dipodomys nelsoni

Dipodomys phillipsii

Glossophaga morenoi

Habromys lepturus

Lepus flavigularis

Megadontomys cryophilus

Megadontomys thomasi

Microtus oaxacensis

Microtus quasiater

Musonycteris harrisoni

Neotamias bulleri

Neotamias durangae

Neotoma goldmani

Neotomodon alstoni

Osgoodomys banderanus

Pappogeomys bulleri

Peromyscus difficilis

Peromyscus furvus

Peromyscus hylocetes

Peromyscus levipes

Peromyscus megalops

Peromyscus melanophrys

Peromyscus ochraventer

Peromyscus perfulvus

Peromyscus spicilegus

Peromyscus yucatanicus

Peromyscus zarhynchus

Reithrodontomys chrysopsis

Rhogeessa parvula

Sciurus alleni

Sciurus oculatus

Sigmodon alleni

Sigmodon leucotis

Sigmodon mascotensis

Sorex ventralis

Spilogale pygmaea

Sylvilagus cunicularis

Thomomys sheldoni

Tlacuatzin canescens

REPTILES

Abronia gramínea

Abronia taeniata

Adelphicos nigrilatum

Anelytropsis papillosus

Anolis anisolepis

Anolis barkeri

Anolis compressicauda

Anolis liogaster

Anolis naufragus

Anolis nebuloides

Anolis nebulosus

Anolis pygmaeus

Anolis quercorum

Aspidoscelis communis

Aspidoscelis costatus

Aspidoscelis guttata

Aspidoscelis lineatissima

Aspidoscelis parvisocia

Aspidoscelis sackii

Barisia imbricata

Cerrophidion tzotzilorum

Conophis vittatus

Conopsis biseralis

Conopsis lineata

Conopsis megalodon

Conopsis nasus

Crotalus basiliscus

Crotalus enyo

Crotalus intermedius

Crotalus ravus

Ctenosaura acanthura

Ctenosaura hemilopha

Ctenosaura pectinata

Ficimia olivacea

Geophis mutitorques

Geophis semidoliatus

Gerrhonotus liocephalus

Hypsiglena torquata

Kinosternon creaseri

Kinosternos herrerai

Kinosternon integrum

Lepidophyma gaigeae

Lepidophyma pajapensis

Lepidophyma sylvaticum

Lepidophyma tuxtlae

Leptodeira maculata

Leptodeira splendida

Leptophis diplotropis

Manolepis putnami

Mesaspis gadovii

Mesaspis juarezi

Mesaspis viridiflava

Micrurus distans

Micrurus limbatus

Ophryacus undulatus

Phrynosoma orbiculare

Phrynosoma taurus

Phyllodactylus bordai

Phyllodactylus lanei

Phyllodactylus muralis

Phyllodactylus unctus

Pituophis deppei

Plestiodon copei

Plestiodon lynxe

Rena maxima

Rena myopica

Rhadinaea fulvivittis

Rhadinaea gaigeae

Rhadinaea laureata

Rhadinaea taeniata

Salvadora bairdi

Salvadora intermedia

Salvadora mexicana

Sceloporus adleri

Sceloporus aeneus

Sceloporus bicanthalis

Sceloporus bulleri

Sceloporus cautus

Sceloporus cozumelae

Sceloporus dugesii

Sceloporus formosus

Sceloporus gadoviae

Sceloporus horridus

Sceloporus hunsakeri

Sceloporus jalapae

Sceloporus licki

Sceloporus maculosus

Sceloporus megalopidurus

Sceloporus minor

Sceloporus mucronatus

Sceloporus nelsoni

Sceloporus ochoterenae

Sceloporus ormis

Sceloporus palaciosi

Sceloporus parvus

Sceloporus pyrocephalus

Sceloporus salvini

Sceloporus scalaris

Sceloporus siniferus

Sceloporus spinosus

Sceloporus torquatus

Sceloporus zosteromus

Scincella gemmingeri

Scincella silvicola

Storeria hidalgoensis

Storeria storerioides

Tantilla bocourti

Tantilla calamarina

Tantilla rubra

Thamnophis chrysocephalus

Thamnophis melanogaster

Thamnophis scalaris

Thamnophis scaliger

Trimorphodon tau

Urosaurus bicarinatus

Xenosaurus platyceps