Herpetofauna in Risk of Extinction: Amphibians and Reptiles in Mexico, Critical Areas, and Conservation Strategies

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Abstract

This article reviews the conservation of threatened herpetofauna of Mexico, (243 amphibian and 101 reptile species) compiled from the IUCN Red List (2020). A geographic analysis was performed to identify areas or centers of species concentration. These are considered top priority areas for Mexican amphibian and reptile conservation. Four areas were recognized for amphibians and two for reptiles (in addition to sea turtle beaches on both Pacific and Atlantic shorelines). Amphibian centers are situated essentially at the Sierra Madre del Sur from Guerrero to Chiapas, and in Veracruz mountains to the east. Reptiles centers coincides with two amphibian ones, at the mountainous regions of Guerrero and Oaxaca. The importance of the presence of Natural Protected Areas (NPAs), as well as non-protected ones for the conservation of Mexican herpetofauna is discussed. It is essential to definitively stop habitat alteration and destruction to ensure the survival of these species in the wild.

The anthropocene, a new reality?

One word that frequently defines Mexico is diversity. This is probably a general assumption, based on the extraordinary mosaic of languages, cultures, landscapes, and organisms living within the same territory. The biological diversity in particular is in danger of disappearing. At present, Mexican biological diversity is facing an extreme risk of extinction, numerous groups of species have been declining since the beginning of last century or even earlier, similar to other parts of the world. The loss of wild populations and species in Mexico, as in other megadiverse countries, has increased recently as a consequence of human growth and activities in such magnitude that we refer to the present time not as the Holocene, but as the Anthropocene (Bradshaw et al., 2021; Dirzo et al., 2014). Vertebrates, probably the best-known group of organisms, are frequently used as a model to establish population status and trends and to design conservation strategies (March et al., 2009). Human activities have a severe impact on natural systems, to the point of probably causing a sixth mass extinction (Barnosky et al., 2011). What will we do in the next decade to counterbalance our excessive negative impact? Efforts to preserve and restore nature will be fundamental to avoid species extinctions worldwide.

Mexican threatened amphibians and reptiles: An overview

Amphibians and reptiles, together, are an important group of vertebrates in terms of the biomass they contribute to an ecosystem. Amphibians are frequently selected as indicators of ecosystems conditions, they are a fundamental part of the trophic paths, and they represent an ancient vertebrate history by being the first tetrapods to invade the land. Reptiles are well known for controlling populations of other vertebrates, like small mammals, and helping to naturally control insect plagues. Both groups have been studied by early European naturalists since the 17th century and formally studied since the 18th century, although they belong to different taxonomic classes and have different biological and ecological traits.

With some gaps in terms of systematics and natural history studies, both groups were known from the 17th century and intensively studied from the 20th century in Mexico. To date, 419 species of amphibians and 937 of reptiles have been documented in Mexico (Frost, 2021; Uetz et al., 2020). A considerable number of species have been discovered in the last 20 years. Amphibian diversity includes 255 species of frogs and toads (Order Anura), 161 species of salamanders, (Order Caudata) and three species of

cecilians (Order Gymnophiona) (Frost, 2021; Amphibiaweb, 2021). In contrast, Reptile diversity in Mexico includes 937 species. There are 891 are snakes and lizards (Order Squamata), 43 turtles and tortoises (Order Testudines), and three crocodilians (Order Crocodylia). This amazing fauna is distributed across the country occupying different types of habitats, such as temperate and tropical forests, grasslands, and deserts and mangroves, among other biomes. This article deals only with Mexican amphibian and reptile species under risk categories defined by IUCN Red List (2020): Vulnerable (VU), Endangered (EN) and Critically Endangered (CR), and Mexican Red List (NOM 059, 2019): Under Special Protection, (PR), Threatened (A) and In Danger of extinction (P). The number of threatened species amounts to 344, as we discuss below (see Appendix 1).

Conservation issues

According to the current red list of IUCN (2020), 243 amphibian and 101 reptile species are at risk, classified as VU, EN, or CR (Table 1). This equates to 58% of Mexican amphibian and 11% of reptile species from the entire herpetofauna are currently at risk. More than half of the amphibian species have serious conservation problems: 97 species CR, 97 species EN, and 49 species VU. Indeed, 202 (83%) of the 243 at-risk species are endemic to Mexico.

Many Mexican salamander species (122 of 161 species, or 77.8%) have been classified at risk of extinction. Most of the Mexican threatened salamanders belong to the families Plethodontidae (lungless salamanders) and Ambystomatidae (Mole salamanders), and both families are threatened even though they occur in extreme different habitats. For example, *Ambystoma taylori*, (Taylor's salamander, Fig. 1), a neotenic species is listed as CR. Its single population is restricted to a brackish water lake in the state of Puebla (Alchichica) where the water levels have recently decreased, and water pollution has increased (Fig. 2). Another threatened salamander is *Pseudoeurycea mystax*, (Mustache False Brook Salamander), a lungless (Plethodontid) species inhabiting temperate forests in Oaxaca (Fig. 3). This species is listed as CR because its habitat has been constantly impacted by deforestation and its geographic distribution significantly reduced (Fig. 4). Both cases represent extremely threatened endemic species whose habitats and ecological requirements are totally distinct.

Table 1 Mexican threatened amphibians and reptiles and conservation status according to the IUCN Red List (2020) and the Norma Official Mexicana (Government of Mexico red list) (2019).

Taxa	*Mexican Diversity*	*No. Spp.*	*Mexican endemics*	*IUCN (2020)*			*NOM-059 (DOF, 2019)*			*NPAs (%)*	*Total spp. threatened*
				Vu	*En*	*Cr*	*Pr*	*A*	*P*	*No/Yes*	*% From whole Mexican herpetofauna*
Amphibia											
Anura	255	121	93	35	46	40	47	14	6	72/49	121/255 (23.9%)
Caudata	161	122	108	14	51	57	43	17	7	68/54	122/161 (75.8%)
Gymnophiona	3	0	2	0	0	0	0	0	0	NA	NA
TOTAL	419	243	203	49	97	97	90	31	13		243/419 (58.0%)
Reptilia											
Crocodylia	3	1	0	1	0	0	1	0	0	0/1	1/3 (33.3%)
Testudines	43	18	5	11	3	4	29	25	8	2/15	18/43 41.83%
Squamata	891	82	74	41	37	4	2	1	4	29/50	82/891 (9.2%)
TOTAL	937	101	79	53	40	8	32	26	12		101/937 (10.8%)

Fig. 1 *Ambystoma taylori*, (Taylor's salamander), a microendemic mole salamander from Laguna Alchichica, Puebla, Mexico.

Fig. 2 Laguna Alchichica, a brackish lagoon at the Mexican state of Puebla, the only place where the Taylor's salamander *Ambystoma taylori* inhabits.

Fig. 3 *Pseudoeurycea mystax*, (Mustache False Brook Salamander) from Ayutla, Oaxaca, Mexico.

Fig. 4 Habitat of *Pseudoeurycea mystax*, (Mustache False Brook Salamander) near Ayutla, Oaxaca, Mexico.

Moreover, according to the IUCN Red List (2020), 198 species show decreasing population trend, only nine are considered as stable and 36 have unknown population trend. Consequently, amphibians should have priority over other vertebrate species, due to the identified threats affecting especially the 194 EN and CR species (Table 2). The Mexican Red List from the government of Mexico (Norma Official Mexicana 059, in Spanish, Diario Oficial de la Federación, 2010) is an administrative and legal document which aims to identify and classify Mexican species that could be in risk of extinction. The latest version published includes 109 species of amphibians and reptiles, 31 are defined as threatened (A, amenazada, in Spanish), 13 are in Critical danger of extinction (P, en peligro de extinción) and 90 are considered under special protection (Pr, bajo protección especial). Due to the administrative process by which species are evaluated, it does not always coincide with the IUCN Red List, however, the methods of assessment are similar by evaluating habitat, geographic distribution, and the intrinsic vulnerability of species to human activities.

Reptiles have a harder situation. From the 101 species listed in IUCN (2020) in any risk category, 79 (78%) are endemic to Mexico. In terms of conservation, 53 species are listed as VU, 40 are EN, and eight are classified as CR (Table 1). Reptile population trends show that 72 imperiled species (71.28%) are decreasing, seven are stable, 19 have an unknown population trend, and two cannot be specified. In contrast, Mexican red list, NOM 059 (Diario Oficial de la Federación, 2010) consider 32 species as under special protection (Pr), 26 as Threatened (A), and 12 in Danger of Extinction (P) (Table 2).

There are several causes for this Mexican herpetofauna severe conservation situation (Table 2). When we focused on the widespread threats measured and available in the IUCN Red List (2020), we found that extensive agriculture affected 198 species (81.5%), changes in land use affected 194 species (79.8%), deforestation affected 161 species (66.2%), and the presence of emergent infectious diseases affected 122 species (50.2%). Concerning emergent infectious diseases, chytridiomycosis, a disease caused by the microscopic chytrid fungi *Batrachochytrium dendrobatidis* (Bd) and *B. salamandrivorans* (Bsal) that caused amphibian population declines and extinctions worldwide. Recently, Mexican studies have demonstrated that Bd is highly dispersed throughout Mexico affecting 76 species to date, predominantly those inhabiting tropical cloud forests (Basanta et al., 2019; López-Velázquez, 2018). Bsal, currently a major threat for European salamanders, is confined to Asia and Europa, and however, because of international legal and illegal wildlife pet traffic, it represents an important peril to western hemisphere amphibian species (Basanta et al., 2019). A recent study on potential risk of Bsal for Mexico shows that in particular, Mexican salamanders could be in a severe danger if this fungus arrives, suitable areas of preference of the fungus coincide with the areas of concentration of salamander diversity (30%) at central and southern forests (Basanta et al., 2019). Other factors such as urban development, climate change, and illegal or legal wildlife traffic have also impacted the conservation of amphibian populations during the last decades (Dirzo et al., 2014).

The establishment of natural protected areas (NPAs) is an important conservation strategy aimed to preserve ecosystems and species and can be valuable when combined with other conservation strategies like red lists or specific conservation or restoration programs. For instance, an accurate analysis of range extensions of amphibian species (see below) shows that 129 species inhabit unprotected areas, and the ones inhabiting any NPA have low % of their distribution under protection (Fig. 5). For only 17 species the NPAs do include about 90–100% their geographic range. For other species the situation is variable, 34 have 10%; 15 have 10–20% (Fig. 6). This aspect is obviously related with the presence of federal or state NPAs, for example, 126 species inhabit in a NPA, 65 species occur in at least one NPA, 19 in two, six in three and so on, with just two species ranging in five to 12 NPAs (Fig. 6). It is important to highlight that 18 recently described amphibian species, mostly Mexican endemics with a very restricted distribution, have not been evaluated in any red list. The IUCN assessment efforts have increased in recent years, with more than 100 Mexican species evaluated in 2019. As a final point, 19 species are still classified as data deficient (DD) in the IUCN Red List (2020), likely underestimating a more severe conservation situation for Mexican amphibians. A summary of threats to Mexican amphibians can be seen in Table 2.

The proportion of reptile species without assessments is higher than amphibians, probably because Mexico is the 2nd highest country in reptile diversity (Flores-Villela and García Vázquez, 2014). The main factors affecting their populations are, in order of importance: change in land use, affecting 81 species (80.2%), deforestation for 36 species (35.6%), leading primarily to urban development for 30 species (29.7%), extensive agriculture with 27 species (26.7%), invasive exotic species with 16 species (15.8%), and climate change with 14 species (13.8%). Other factors seem to have a less impact, however, like in the case of amphibians, but this issue deserves a more scrutiny since 130 species in the IUCN Red List (2020) could not be evaluated and remain DD. In addition, numerous species have been recently described and remain unassessed.

NPAs appear to be more efficient in protecting reptiles since 66 species inhabit at least in one of them (Fig. 7). However, 23 species have only 10% of their range under protection, seven from 20 to 30%, 5 from 40% to 50% and only 13 from 90% to 100% (Fig. 8). A summary of reptile threats in Mexico can be seen in Table 2.

Table 2 Main threats for Mexican amphibians and reptiles according to the IUCN Red List (2020).

Taxa	*No. Spp.*	*Pop. trend (No. Spp.)*	*Habitat alteration*				*Invasive alien spp.*	*Climate change*	*Diseases*	*Traffic*	*Hunting*	*Contamination*
		Decreasing/stable/unknown	*Agriculture*	*Land change use*	*Deforestation*	*Urbanization*				*Legal/Illegal/unknown*		
Amphibia												
Anura	121	93/5/22	108	94	92	50	8	15	58	1/1/0	4	25
Caudata	122	105/2/13	104	112	103	77	10	8	63	0/0/1	6	20
Reptilia												
Crocodylia	1	0/–/1	0	0	0	0	1	0	0	1/0/0	1	0
Squamata	82	59/7/16	23	65	36	18	12	5	0	?/4/6	17	2
Testudines	18	13/0/5	4	16	0	11	3	9	0	1/4/7	11	8

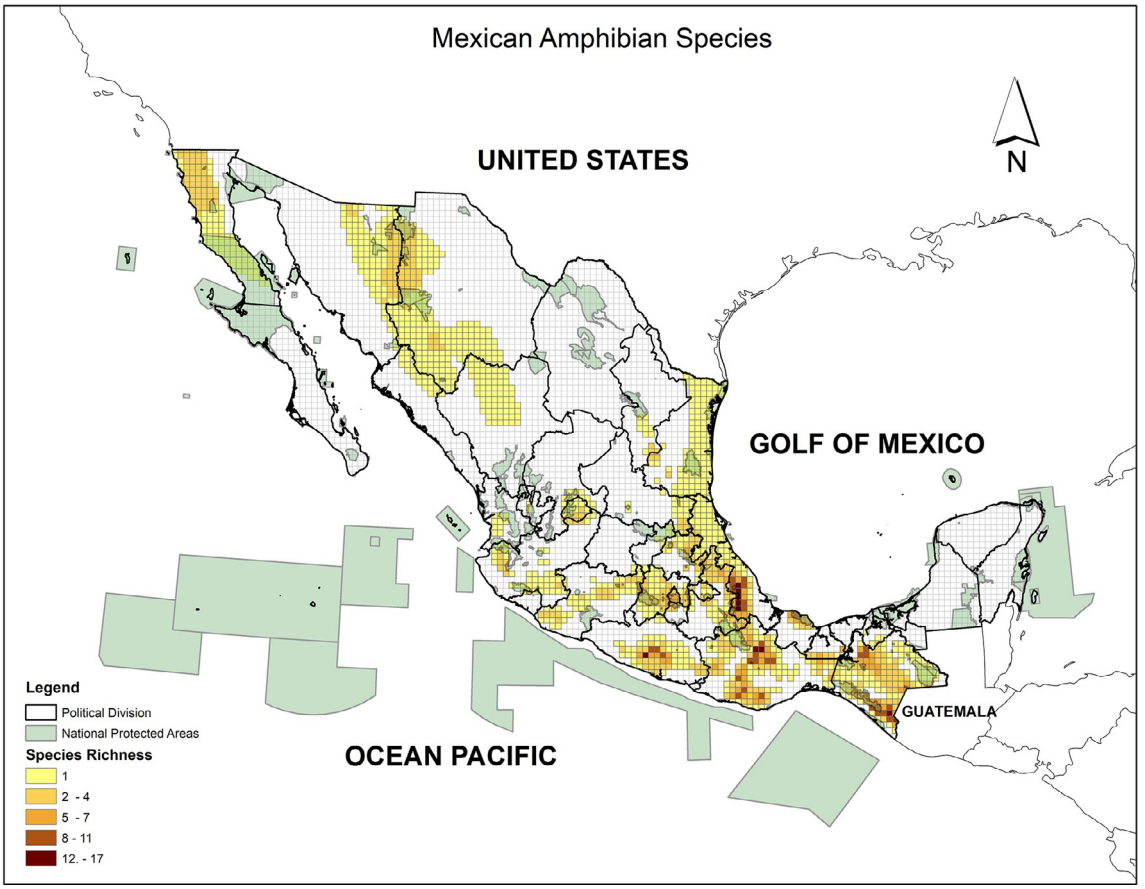

Fig. 5 Distribution of Mexican threatened amphibians in relation to the Federal Natural Protected Areas (NPAs) of Mexico.

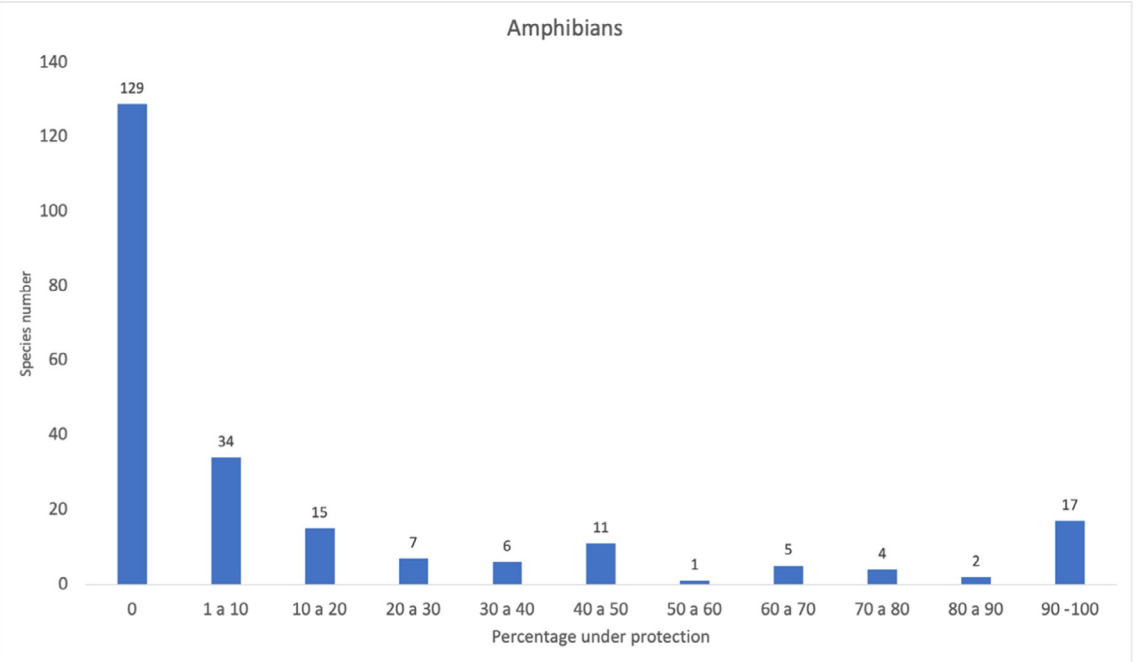

Fig. 6 Proportion of protected and unprotected habitat extension for Mexican amphibians.

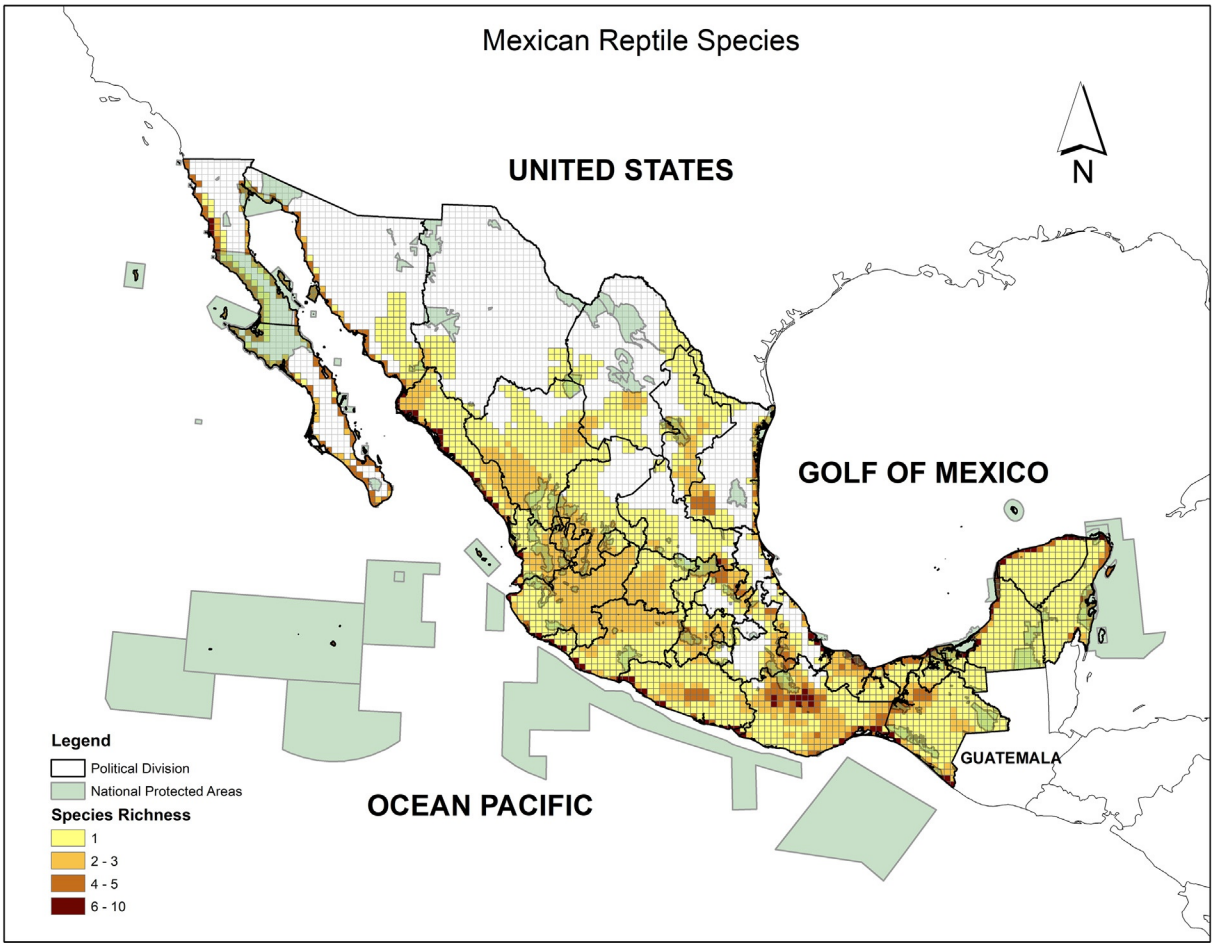

Fig. 7 Distribution of Mexican threatened reptiles in relation to the Federal Natural Protected Areas (NPAs) of Mexico.

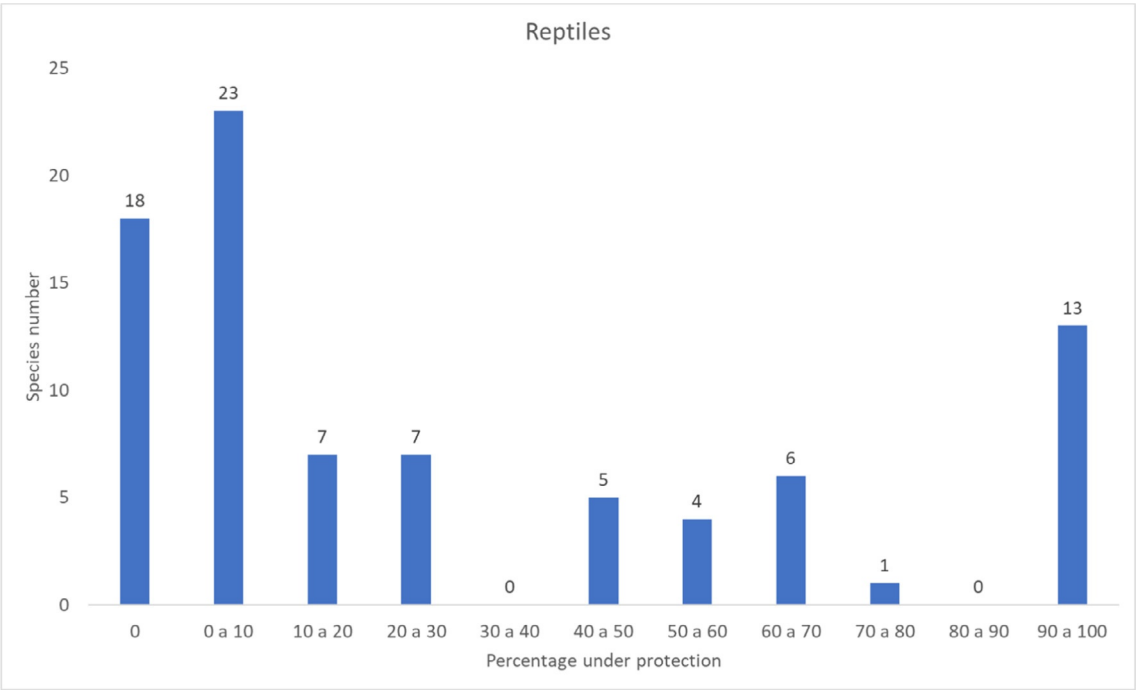

Fig. 8 Proportion of protected and unprotected habitat extension for Mexican reptiles.

Mexican threatened amphibians and reptiles, where are they located?

Threatened herpetofauna are dispersed throughout Mexico, however, as will be seen later, there are some areas where numerous amphibian and reptile species are concentrated. These areas congregate up to 17 threatened species, hereafter named "centers of concentration of threatened species" (CCTS) and will be discussed ahead. To delimit these CCTS, a geographic analysis was performed over the following criteria: Mexican herpetofauna species considered by IUCN within one of the risk categories (e.g., CR, EN, VU) were compiled, these included 101 reptiles and 243 amphibians. Spatial patterns of species endangerment were based on contour maps provided via IUCN shapefiles. Using ArcGis 10.5® (ESRI, 2016), we clipped digital maps to the Mexico boundaries for further analysis. We used the Hawthtools® within the ArcMap environment to create the spatial distribution patterns of endangerment, we first created a fishnet of 400 km^2 (4000 ha) quadrants within Mexico and then established centroids. We enumerated intersecting species distribution polygons to the centroids and estimated species richness and composition associated with each grid-cell centroid. Intersecting species numbers by grid were reclassified into five reptile categories and four amphibian categories. We measured the geographic extension of each species and natural protected areas in km^2 and analyzed the spatial concordance of their polygons to determine the % of the total geographic distribution area of each species under protection by the natural protected areas system as well as the number of natural protected areas where each species is included. To determine land use and the conservation status of each vegetation type within each grid (400 km^2) we overlaid the fishnet on the vector data sets at 1:250,000 scale obtained by photo interpretation and selected 2014 Landsat TM 8 satellite images of the most recent national forest inventory (INEGI, 2016) in order to subtract the polygons of the land use and vegetation type for each grid. We then reclassified land use and vegetation categories into three new ones based on the landscape integrity that included, transformed (urban, cultivated, etc.), secondary (natural vegetation with secondary growth), and primary (natural vegetation). We measured the coverage by each of these three categories with respect to surface area within each grid to determine the percentage of primary vegetation within a grid as a proxy of conservation status of the ecosystems with respect to the number of endangered species included in each grid. Finally, we analyzed endangerment by vegetation type.

A rapid examination on the distribution of threatened amphibians revealed that most amphibian species have a restricted geographic range, with an estimated area less than 400 km^2 (Fig. 9). Restricted distribution is one of the main causes of their fragility. Mapping across 20 × 20 km grids showed that the vast majority of threatened amphibians congregate in the mountains of the Sierra Madre del Sur of Guerrero, Oaxaca and Chiapas, at western Mexico, and alongside the state of Veracruz in the Gulf of Mexico versant. In these areas, 16–17 species are sympatric in areas of no more of 400 km^2. This pattern is not a surprise, the four

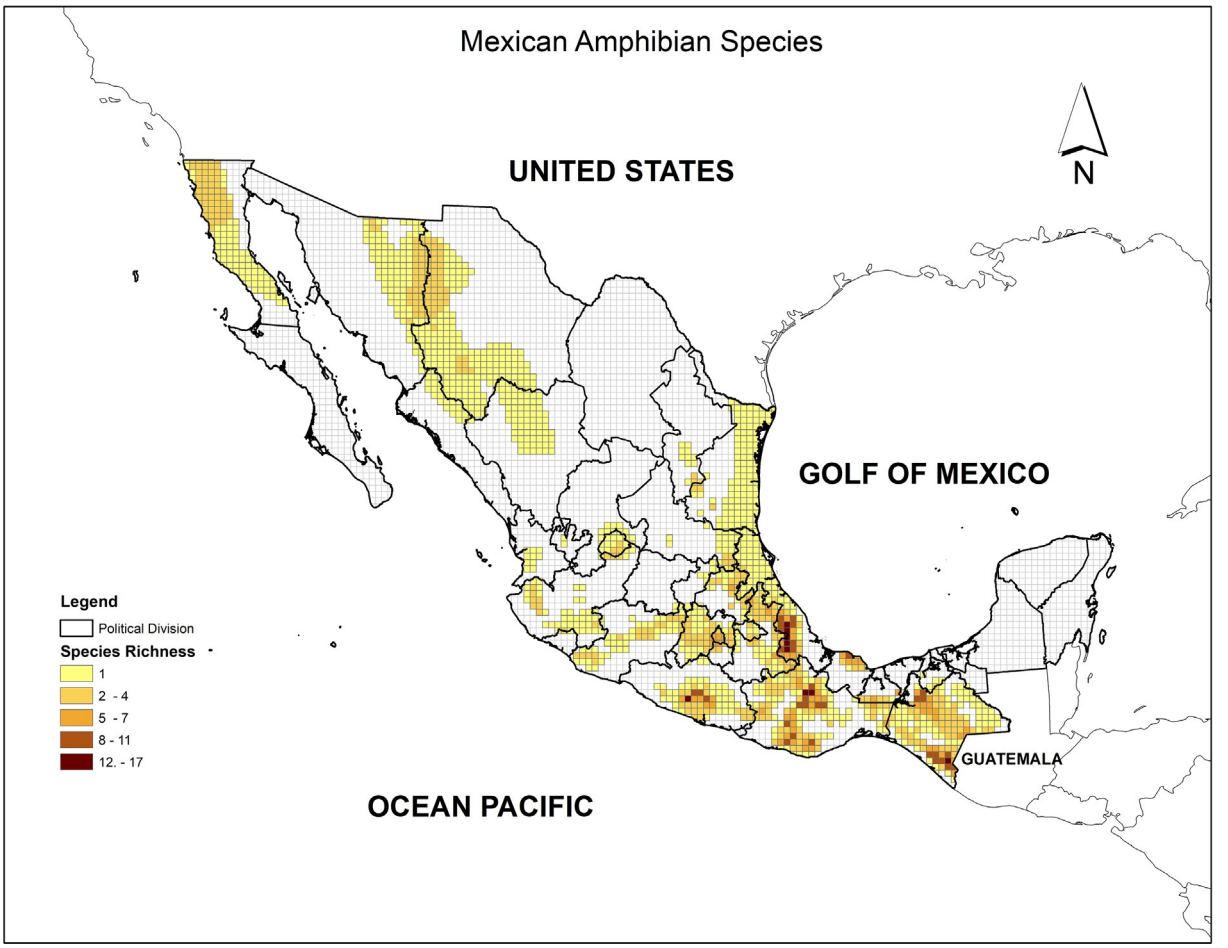

Fig. 9 Centers of concentration of threatened amphibian species (CCTS) in Mexico.

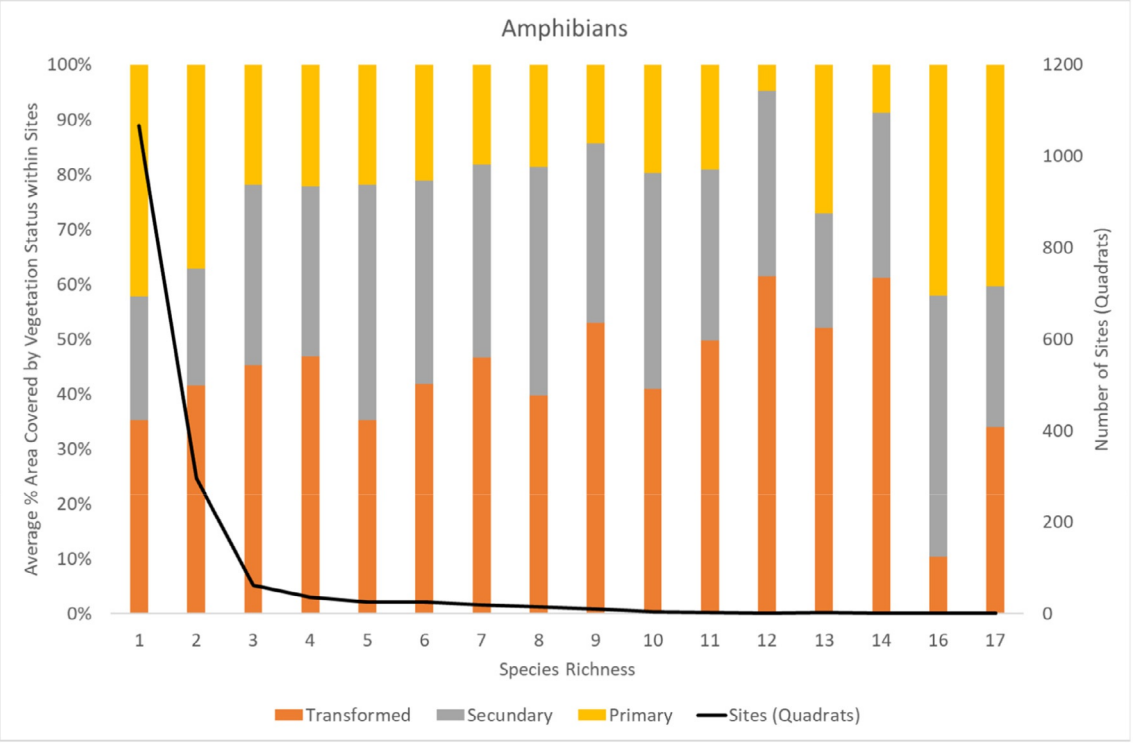

Fig. 10 Proportion of land occupied by threatened amphibian species in Mexico.

states are the most diverse in Mexico: the more diversity, the more threatened species. These species inhabit areas south of the Mexican Transvolcanic belt, confirming the historic fact of complex evolution and diversification of several vertebrate groups in this portion of Mexico. In this assessment, quadrants with a concentration greater than 10 species are considered as critical areas for the conservation of Mexican amphibians. Those areas represent natural threatened ecosystems, areas covered by tropical cloud forest, pine, and pine-oak forests. Factors affecting those areas come from habitat transformation and loss, frequently areas designated for the development of agriculture and human settlements. At the rest of the country, only one or up to six species can be identified (Fig. 9).

To illustrate the compromised survivorship of Mexican amphibians, the proportion of transformed land in relation to species richness was measured (Fig. 10). The great majority of sites (shown as quadrats) hold amphibian species in transformed areas or areas with secondary growth. Proportion of pristine or primary forests is less than 50% in numerous sites (yellow fragment of the bars in Fig. 10). Only few locations support up to 17 threatened species, these areas have a mixture of disturbed and relatively well-preserved areas, hence demonstrating that by preserving native forest elements it is possible to maintain local species richness. Nevertheless, these changes might vary depending on the natural communities, biogeographic history and of course, human intervention.

The distribution pattern of threatened reptile species is entirely different. The areas of higher reptile species concentration run throughout the Pacific coast, from Sinaloa to southern Chiapas and include northwestern Baja California. The Gulf of Mexico versant also congregates up to 6–10 species along the coastline. Continental lands that are also important centers of threatened reptile concentration are located in northern Oaxaca (mountains) and an isolated quadrant at the Querétaro-San Luis Potosí border (Fig. 11). This group of organisms prefers areas of desert and scrub lowlands, it is notorious that northern sites are mostly inhabited by just one species per quadrant. Reptiles seem to be more tolerant than amphibians to human disturbance, they can survive in areas impacted or transformed (Fig. 12).

Fig. 11 Centers of concentration of threatened reptile species (CCTS) in Mexico.

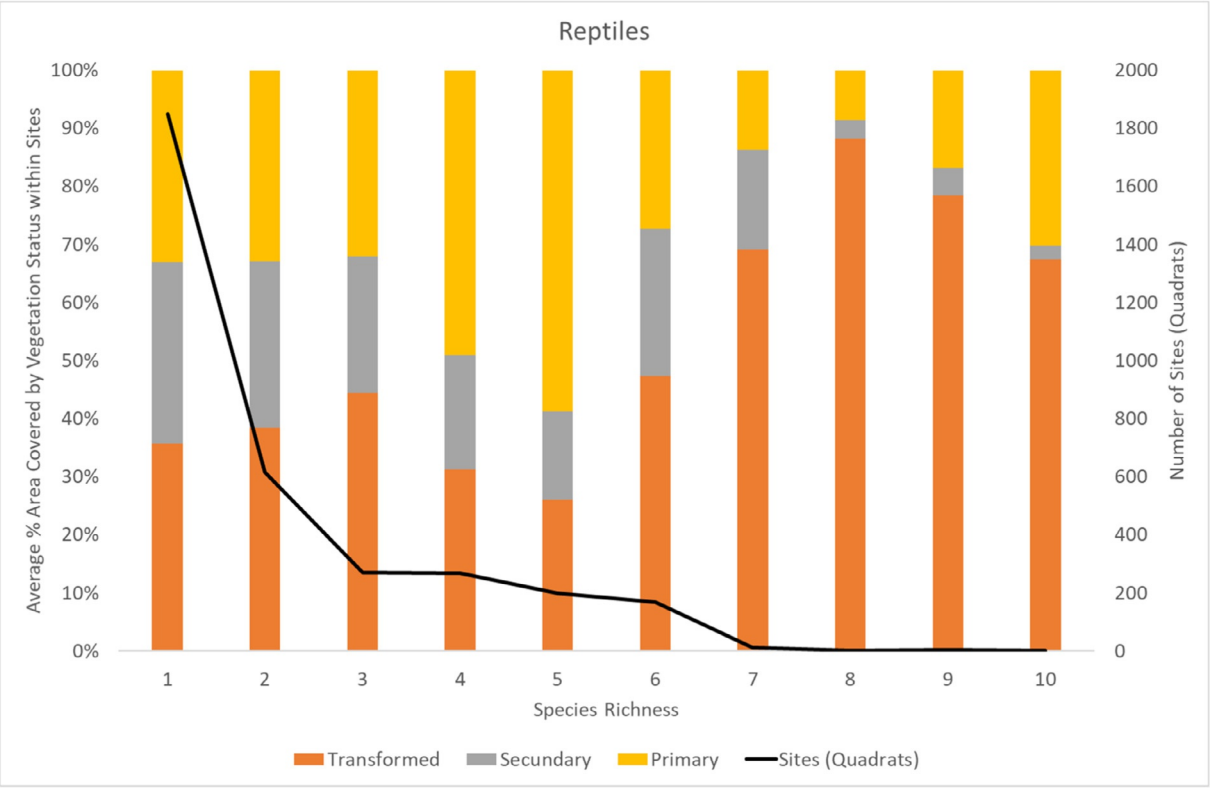

Fig. 12 Proportion of land occupied by threatened reptile species in Mexico.

Critical areas and likelihoods for restoration

Mexico's natural habitats are well known worldwide because of their diversity and beauty. These habitats are recognized also for the contribution to the world's biological diversity, although they also exhibit extremely high rates of disturbance. Due to the nature of Mexican herpetofauna, and the complex physiography of the country, efforts to preserve the natural areas of greatest diversity become an intricate paradox, making the protection efforts scarce or even nonexistent, or on the other hand, they are focused on species individually (Urbina-Cardona & Flores-Villela, 2010). Severe signs of degradation and even destruction have been reported along Mexican ecosystems.

Large-scale restoration programs are required for several sites, they must be focused on the ecological requirements of amphibians and reptiles. For example, the absence of stumps and tree branches on the forest floor deprives shelter to salamanders (the most imperiled group in amphibians) even when reforestation has been completed. The most jeopardized ecosystems for the Mexican herpetofauna are the tropical cloud forest and rainforest in central and southern Mexico (Gual-Díaz and Rendón-Correa, 2014). In some regions of southern Mexico, introduction of fruit trees has replaced native forests but failed due to poor planning. The use of native species is the key to a successful reforestation program.

The identified CCTS with provisional names are (Fig. 9):

- Sierra Madre del Sur de Guerrero. This transect runs along the southern mountains of Guerrero. This CCTS concentrates 13 species in one square, adjacent squares have from five to eight species. The area is covered with pine and oak forests with small areas of mountain cloud forest at the hills. Small human settlements as well as small agricultural practices occur in these areas which have been transformed from forested areas to grasslands and crops or in a better case, a secondary forested area. Nevertheless, endemic species inhabit there, like Savage's Robber frog (*Craugastor uno*, Fig. 13) and Pine wood tree frog (*Charadrahyla pinorum*, Fig. 14). In addition, the region in general is not completely studied.
- Northern Oaxaca. This area is located at north Sierra Juarez, here, two centers congregate 16 and 17 threatened species and surrounded areas from 7 to 10. The centers are concentrated along the Sierra Juarez mountainous system, it is covered by mountain cloud forest and pine and pine-oak forests at temperate elevation and tropical deciduous forests at lowlands. These centers have been severely impacted by human transformation. At present, just a few patches of mountain cloud forest persist. Logging and tourism are the main factors of impact.

Fig. 13 *Craugastor uno* (Savage's Robber frog) from Sierra Madre del sur in Guerrero, Mexico.

Fig. 14 Pine wood tree frog (*Charadrahyla pinorum*) from, Guerrero, Mexico.

- Central Veracruz and adjacent Puebla. This CCTS is situated at the mountainous part of Veracruz at the border of state of Puebla. Like the other centers, this area is covered with pine and fir forests. This is probably the most impacted area of all these four areas of concentration. Human settlements and accompanied logging and grazing have led to a marked deterioration in the area.
- Northern and southwestern Chiapas. This CCTS is located north to the city of Tuxtla Gutiérrez and corresponds to the highlands of Chiapas, covered with mountain cloud forest and conifer forests, 11 threatened species inhabit here and from three to six in surrounding squares. Urbanization, a significant traffic of people and land use changes are the main threats to this important center. The second CCTS is situated at southwestern Chiapas, close to the Guatemala border, the area is highly forested with small but numerous human settlements. The highest center has 14 threatened species whilst the surrounding squares range from 7 to 10. Salamanders are well represented here, like Franklin's Mushroom tongue salamander (*Bolitoglossa franklini*, Fig. 15).

Mexico's threatened reptile species are mostly concentrated in coastal lands, with the exception of central Oaxaca and less significant Guerrero mountains. A rapid inspection of the threatened species distribution shows that this pattern is the result of sea turtle nesting beach distribution (Fig. 11). Six of the seven sea turtle species in the world spawn on Mexican beaches. This ranges coincides with the two species of Mexican crocodiles, *Crocodylus acutus* in the Pacific and *C. moreletii* in the Atlantic. Delimitation of two CCTS for reptiles is as follows:

- Northern Baja California. This area is located at the northern Baja California peninsula. These lowlands areas are mostly covered with xerophytic shrubs and the typical beach and dune vegetation. Besides sea turtle species, Mexican endemic lizards like *Anniella geronimensis* (Fig. 16) and *Aspidoscelis labialis* can be found here.
- Northern Oaxaca. This center coincides with the one identified for amphibians at the Sierra Juarez mountains. Seven squares are located along this region and surrounding areas, where Mexican endemics like the Mount Zempoaltepec arboreal alligator lizard (*Abronia fuscolabialis*), or the Oaxacan cat-eyed snake (*Tantalophis discolor*) range (Figs. 14 and 15, respectively). Other squares can harbor up to five threatened species.

Fig. 15 Franklin's Mushroom tongue salamander (*Bolitoglossa franklini*).

Fig. 16 *Anniella geronimensis* (Baja California Legless Lizard).

Fig. 17 *Mixcoatlus barbouri* (Barbour's Montane Pit Viper) from Guerrero, Mexico.

In summary, CCTS for threatened amphibians are highly populated areas and coincide with regions of poverty and social conflicts. The causes of disturbance are human related, transformation of habitat for small-scale but persistent agriculture, as well as cattle and logging, are the most frequently observed. A remote possibility of protection via the NPAs disappears when the location of the NPAs and the CCTS's do not overlap geographically (Fig. 5). None of these centers have federal protection, they are private lands with "ejidal" or common ownership. As can be seen, amphibians, in general, do not tolerate high rates of habitat disturbance (Fig. 10). For this reason, survival means stopping habitat destruction. In addition, some species are hunted for human consumption, like the frog *Lithobates sierramadrensis* well known as a food in western Mexico.

Reptiles inhabit the most imperiled habitats in Mexico. Sea turtles and alligator lizards (*Abronia* spp.) are subject to intense illegal commercial wildlife for pet traffic or are hunted for consumption (sea turtle eggs, *Ctenosaura* iguanas). There are some real needs to stop illegal wildlife trafficking and protect habitats. Imperiled venomous snakes deserve special attention because they are frequently killed out of fear, like Barbour's montane pitviver (*Mixcoatlus barbouri*, Fig. 17). The cloud forests of central Mexico, where numerous reptile species occur, represent a small fraction of Mexico's territory (I,828,205 ha), and are located in Mexico's most threatened habitats (Sánchez-Colón et al., 2009; Gual-Díaz and Rendón-Correa, 2014). Finally, only few critical CCTS's are located in protected areas, but they are dispersed across Mexico. As with amphibians, reptiles still are present even when up to 90% of the land is altered (Fig. 12). Reptiles are more tolerant to disturbances than amphibians and are found in primary, secondary, and transformed areas. Some areas with a higher proportion of primary forests, up to 60%, support just five species, whilst other more disturbed, up to 10 species. Furthermore, the analysis shows that species are concentrated in only few sites, mostly covered with tropical deciduous forests, mangroves, and tropical rain forests.

Conclusions: It is now or never to preserve the Mexican herpetofauna

The CCTS's identified here are logical to predict because they coincide with areas of high diversity that have gained recognition with other programs like the Zero Extinction Alliance (Ceballos et al., 2009). The Mexican government, though the natural protected agency, CONANP, Comisión Nacional de Áreas Naturales Protegidas, has made important efforts to protect numerous areas representing Mexican ecosystem diversity (CONANP, 2020). Other official forest programs have failed to aid in conservation efforts. The CCTS's here defined should be of top priority for the conservation of amphibian and reptile species, well managed can serve as a model of conservation.

The basis of a successful program in conservation biology is education, it is an imperative for conservation purposes to reconcile human requirements with conservation interests (Primack and Vidal, 2019). People should realize that the current state of the planet is a consequence of human society's actions. In Mexico, the nearest opportunity for conservation of the herpetofauna is the social initiatives for land protection (Áreas Destinadas Voluntariamente a la Conservación, ADVCs in Spanish). The potential for conservation of these areas grows with the increasing number of stakeholders and community owners that visualize the environmental problem. CONANP has certified 518 of these sites, including 182 with federal protection and 336 as ADVCs, and surprisingly this last number is continuously increasing. These areas, although not 100% effective in protection of Mexican herpetofauna, can harbor rare or restricted species that range outside an NPA, even in small areas (Ochoa Ochoa et al., 2009). In the ADVCs, local people actively participate in the conservation of their own lands, create a better future. The support of local and federal governments is required to offer alternatives for people to completely stop habitat transformation and destruction, then programs of production can be established to restore forest cover and reintroduce native species. Nothing can be achieved without creating and strengthening working alliances between academics, local communities, and government agencies. Above all, a change in (a reduction of) people's consumption habits will truly make a difference, in essence, a change of mind.

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