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Amphibian & Reptile Conservation
19(2): 41–58 (e350).

Biological connections: The uncertain future of the threatened U.S.–Mexico border region herpetofauna

[1]*Vicente Mata-Silva, [2]Ana Bertha Gatica-Colima, [3]Dominic L. DeSantis, [1]Arturo Rocha, [4]Uriel Hernández-Salinas, [5]Manuel Nevárez-de los Reyes, [6]Jorge H. Valdez-Villavicencio, [7]Louis W. Porras, [1]Anna F. Tipton, [1]Matthew Montoya, David Lazcano, and Larry David Wilson****

[1]*Department of Biological Sciences, The University of Texas at El Paso, El Paso, Texas 79968-0500, USA* [2]*Laboratorio de Ecología y Biodiversidad Animal, Programa de Biología, Universidad Autónoma de Ciudad Juárez, Juárez, Chihuahua, MEXICO.* [3]*Department of Biological & Environmental Sciences, Georgia College & State University, Milledgeville, Georgia 31061, USA* [4]*Instituto Politécnico Nacional, CIIDIR Unidad Durango, Sigma 119, Fraccionamiento 20 de Noviembre II, Durango 34220, México* [5]*Vivero "Proyecto Digitostigma," General Escobedo, Nuevo León, Mexico* [6]*Conservación de Fauna del Noroeste, A.C., Ensenada, Baja California 22800, Mexico* [7]*7705 Wyatt Earp Avenue, Eagle Mountain, Utah, 84005, USA*
**correspondign author*
***Deceased*

***Abstract.*—In light of critical environmental crises, this study emphasizes the urgent need for the U.S. and Mexico to protect 231 shared herpetofaunal species (amphibians and reptiles) distributed along their border. Key findings indicate that Texas and Chihuahua have the highest number of these cross-border species, with the Chihuahuan Desert ecoregion being particularly rich in diversity. Alarmingly, 62 species (26.8%) are classified as highly vulnerable, predominantly reptiles, and 90 species are narrowly distributed across just a few states and ecoregions, primarily in the California-Baja California, Texas-Tamaulipas, and Arizona-Sonora border areas. This study highlights how the border wall severely harms wildlife by sidestepping environmental laws, destroying habitats, and undermining crucial conservation and research efforts. Consequently, our research strongly advocates for increased binational cooperation between both nations, urging governmental bodies to base their policies on sound scientific knowledge and adopt a biocentric approach to ensure the continued survival of these vulnerable species and their habitats.**

Keywords. Anurans, conservation status, environment, global crises, national boundaries, salamanders, squamates, turtles

Citation: Mata-Silva V, Gatica-Colima AB, DeSantis DL, Rocha A, Hernández-Salinas U, Nevárez-de los Reyes M, Valdez-Villavicencio JH, Porras LW, Tipton AF, Montoya M, Lazcano D, Wilson LD. 2025. Biological connections: The uncertain future of the threatened U.S.–Mexico border region herpetofauna. *Amphibian & Reptile Conservation* 19(2): 41–58 (e350).

Accepted: 22 July 2025; **Published:** 15 December 2025

***Resumen.*—Ante las graves crisis ambientales globales, este trabajo subraya la necesidad urgente de que México y Estados Unidos protejan las 231 especies de anfibios y reptiles que comparten a lo largo de su frontera. Los resultados indican que Texas y Chihuahua albergan el mayor número de estas especies transfronterizas, siendo la ecorregión del Desierto Chihuahuense particularmente rica en diversidad. De manera alarmante, 62 especies (26.8%) se clasifican como altamente vulnerables, predominando los reptiles, y 90 especies tienen una distribución restringida a solo unos pocos estados y ecorregiones, principalmente en las áreas fronterizas de California-Baja California, Texas-Tamaulipas y Arizona-Sonora. Nuestro estudio resalta como el muro fronterizo afecta gravemente la vida silvestre al evadir leyes ambientales, destruir hábitats y socavar esfuerzos cruciales de conservación e investigación. En consecuencia, la investigación aboga firmemente por una mayor cooperación binacional entre ambas naciones, instando a los organismos gubernamentales a basar sus políticas en un sólido conocimiento científico y a adoptar un enfoque biocéntrico para asegurar la supervivencia continua de estas especies vulnerables y sus hábitats.**

Palabras Claves. Anuros, estatus de conservación, medio ambiente, crisis globales, fronteras nacionales, salamandras, escamosos, tortugas

Correspondence. **vmata@utep.edu*

"Investigations of the links between human infrastructure and ecological damage have provided eye-opening insights into humanity's environmental impacts and contributed to global environmental policies. Fences are globally ubiquitous, yet they are often omitted from discussions of anthropogenic impacts."

McInturff *et al.* (2020)

Introduction

Political borders share only a few characteristics with biological borders, since they are established by people for reasons other than creating and maintaining biological borders through natural processes. The border between the countries of Mexico and the United States of America, however, is one drawn by humans based on both political and biological (physiographic) criteria. The western portion of the border was drawn based on political and historical criteria, and essentially consists of "lines drawn in the sand." The eastern portion coincides with the course of the Rio Grande (or Río Bravo) from the point where it meets the border at El Paso to where it enters the Gulf of Mexico at Brownsville, Texas, and Matamoros, Tamaulipas. This border is the 10th longest continuous border in the world, and extends for 3,145 km from the Pacific Ocean at Border Field State Park in San Diego County, California, USA, and Playas de Tijuana in the municipality of Tijuana in Baja California, Mexico, to the Gulf of Mexico near Boca Chica State Park in Cameron County, Texas, USA, and Playa de Bagdad in the municipality of Matamoros in Tamaulipas, Mexico (worldatlas.com; accessed 19 June 2024).

Six states in Mexico and four in the United States are arrayed along the lengthy U.S.–Mexico border (worldatlas.com; accessed 19 June 2024). The six Mexican states, from west to east, are Baja California, Sonora, Chihuahua, Coahuila, Nuevo León, and Tamaulipas; the four US states, in the same direction, are California, Arizona, New Mexico, and Texas (Rand McNally Road Atlas 1998). Given the disparity in the number of states on either side of the border, one would think that each US border state would overlap with more than one Mexican state, which is true but for one exception. The southern border of California overlaps the northern borders of Baja California and Sonora, although only for a few kilometers in the latter state. The situation with an overlap in the remaining states is as follows: Arizona with Sonora (the exception noted above); New Mexico with Sonora (only a few kilometers) and Chihuahua; and Texas with Chihuahua, Coahuila, Nuevo León, and Tamaulipas (Pan American Health Organization 2013).

Biological borders are not simply "lines drawn in the sand," but instead are transitional areas between one vegetation type and an adjacent one, or between one physiographic region and another. They constitute areas of biological significance, and often coincide with physiographic borders that reflect major geological events of the past. The vegetation often adapts to the physiographic distinctions, with the animals following behind. The same is true for the amphibians and reptiles found in given regions, as they also adapt to vegetational and physiographic separations (Brown and Lomolino 1998).

Given the myriad of local, regional, and global threats currently confronting the herpetofauna, scientists around the globe are racing not only to describe unknown species before they become extinct, but also to assess the conservation status of those already known and to identify possible solutions in response to these threats. The implementation of such plans, however, will not be an easy task as a result of the widespread existence of usually opposing and short-term political agendas. This serious issue threatens the survival of herpetofaunal species whose distributions encompass more than a single nation, such as those found both in the United States and Mexico (Lemos-Espinal 2015; Lemos-Espinal et al. 2015a,b; 2016a,b; 2017, 2019). This border crosses several ecoregions that contain an important component of biodiversity (LaDuc et al. 2019; González-Saucedo et al. 2021). Most of all, the current physical barrier and the possibility of continued expansion will only negatively impact these species (McCallum et al. 2014; Jakes et al. 2018). The scientific community and a number of professional organizations have recently expressed this opinion (Fowler et al. 2017; LaDuc et al. 2019). In 2018, more than 2,500 scientists voiced their concern about the effects that fences and a border wall will have on biodiversity (Peters et al. 2018). Their conclusions were that the wall could disconnect 346 (more than 34%) of the nonflying native terrestrial species, and consequently elevate their risk of extirpation within the United States, according to IUCN Red List criteria.

During the past several years, a growing number of important wildlife, conservation, and nature studies have been conducted along the U.S.–Mexico border. For example, Lasky et al. (2011) studied human land use along ~600 km of pedestrian fence as current barriers; one of their main conclusions was that new barriers would increase the number of species at risk, and they identified herpetofaunal and non-volant mammal species that were prone to local or global extinction. Fowler et al. (2017) and LaDuc et al. (2019) noted that the negative impacts on wildlife could be lessened by limiting the extent of physical barriers and associated roads. In addressing a gap through a systematic literature review of the ecological effects of fences, McInturff et al. (2020) indicated that by highlighting past research and offering frameworks for the future, their aim was to formalize the nascent field of fence ecology. More recently, Ragan et al. (2021) explained the damage that the U.S.–Mexico border is having on four species of endangered mammals (the Jaguar, Ocelot, Beaver, and Black Bear). Furthermore, Liu et al. (2019, 2020) wrote that the borders between countries often coincide with important landscape features such as mountains, ridges, and rivers, since they are strong ecological gradients that support high biodiversity (exactly as seen along the U.S.–Mexico border region). Importantly, although a number of

Table 1. Current composition of the native herpetofauna of the US-Mexico border.

Orders	Families	Genera	Species
Anura	9	18	39
Caudata	4	6	7
Subtotals	**13**	**24**	**46**
Squamata	19	58	172
Testudines	4	8	13
Subtotals	**23**	**66**	**185**
Totals	**36**	**90**	**231**

herpetofaunal studies have been conducted in both sides of the border with some emphasizing the implications of physical barriers in natives species (Lemos-Espinal 2015; Lemos-Espinal et al. 2017; Lemos-Espinal and Rorabaugh 2015; Lemos-Espinal and Smith, 2015a,b; Lemos-Espinal and Smith, 2016a,b; Lemos Espinal et al. 2019), most studies looking at transboundary conservation have focused on large mammals (Thorton et al. 2018; Liu et al. 2020). Because the increasing urbanization along the U.S.-Mexico border and expected drier conditions from climate change, binational efforts to conserve the natural ecosystems and their native species are an imperative (Lemos-Espinal and Smith 2015). Consequently, further empirical studies on the effects of changes along the United States-Mexico border on amphibians and reptiles are needed to fully understand the consequences and to develop potential remedial efforts. Given the ongoing political circumstances surrounding the United States-Mexico border, our main objective was to determine the herpetofauna currently present on both sides of this border and the potential impact of shifting border policies for the conservation of these species.

Methods

For this analysis, we identified the number of native species found along the border region in both the United States and Mexico, and documented their current occurrence by state and ecoregion (Fig. 1). Using a combination of these two data sets, we devised a simple scheme to indicate the relative susceptibility of the border species to the presence of a border barrier. For determining their conservation status, we used the Environmental Vulnerability Score (EVS) system. This system was implemented by Wilson et al. (2013a, b) to assess the conservation status of the amphibians and reptiles native to Mexico (except for marine species). Based on these approaches, we identified the species most vulnerable to existing human-made barriers along the U.S.–Mexico border. Our taxonomic species list comes from the review of numerous sources including our previous work pertaining to this region (Degenhart et al. 2005; Wilson et al. 2013a,b; Wilson et al. 2017; Lemos-Espinal 2015 and chapters therein; Lemos-Espinal and Rorabaugh (2015); Lemos-Espinal and Smith 2015ab; Lemos-Espinal et al. 2016a,b; 2017, 2019;Nevárez-de los Reyes et al. 2016; Terán-Juarez et al. 2016; Lazcano et al. 2019; Peralta-Garcia et al. 2023; Ramirez-Bautista et al. 2023; Gatica-Colima et al. 2024). We also reviewed the taxonomic list of *Mesoamerican Herpetology* for taxonomic updates (https://mesoamericanherpetology.com/index.html; accessed on 30 May 2024).

Composition of the U.S.–Mexico Border Herpetofauna

Currently, the herpetofauna of the U.S.–Mexico border consists of 231 species (Table 1), including 39 anurans, seven salamanders, 172 squamates, and 13 turtles. These 231 species are classified in four orders, 36 families, and 90 genera (Table 1). The 231 species constitute 16.4% of the 1,405 species occurring in Mexico (Ramírez-Bautista et al. 2023) and 33.7% of the 685 species found in the United States (Powell et al, 2019).

Distribution of the U.S.–Mexico Border Herpetofauna by State

Herein, we document the distribution of the U.S.–Mexico herpetofaunal species along the 10 border states (see Table A1). As much as possible, we organized the state distributional data in Table 2 so that the states along the border of the United States and Mexico lie opposite one another. For example, we placed Baja California next to California, since the former state lies to the south of the latter. This placement allows the patterns of distribution of the border species to be more easily seen. We organized the ecoregional distributional data in this table from west to east.

The members of the border herpetofauna occupy as few as two states (one on the Mexican side and the other on the US side) to as many as 10 states (i.e., all of the states along the U.S.–Mexico border), as follows: two (69, 30.0%); three (27, 11.7%); four (51, 22.1%); five (26, 11.3%); six (22, 9.5%); seven (11, 4.8%); eight (12, 5.2%); nine (five, 2.2%); and 10 (eight, 3.5%). The mean occupancy level is 4.3, meaning that the typical herpetofaunal species occupies less than one-half of the states distributed along the border. Only eight out of the 231 total species are distributed across all 10 of the border states, including *Anaxyrus cognatus*, *Urosaurus ornatus*, *Arizona elegans*, *Masticophis flagellum*, *Pituophis catenifer*, *Rhinocheilus lecontei*, *Thamnophis marcianus*, and *Crotalus atrox*. All of these species are

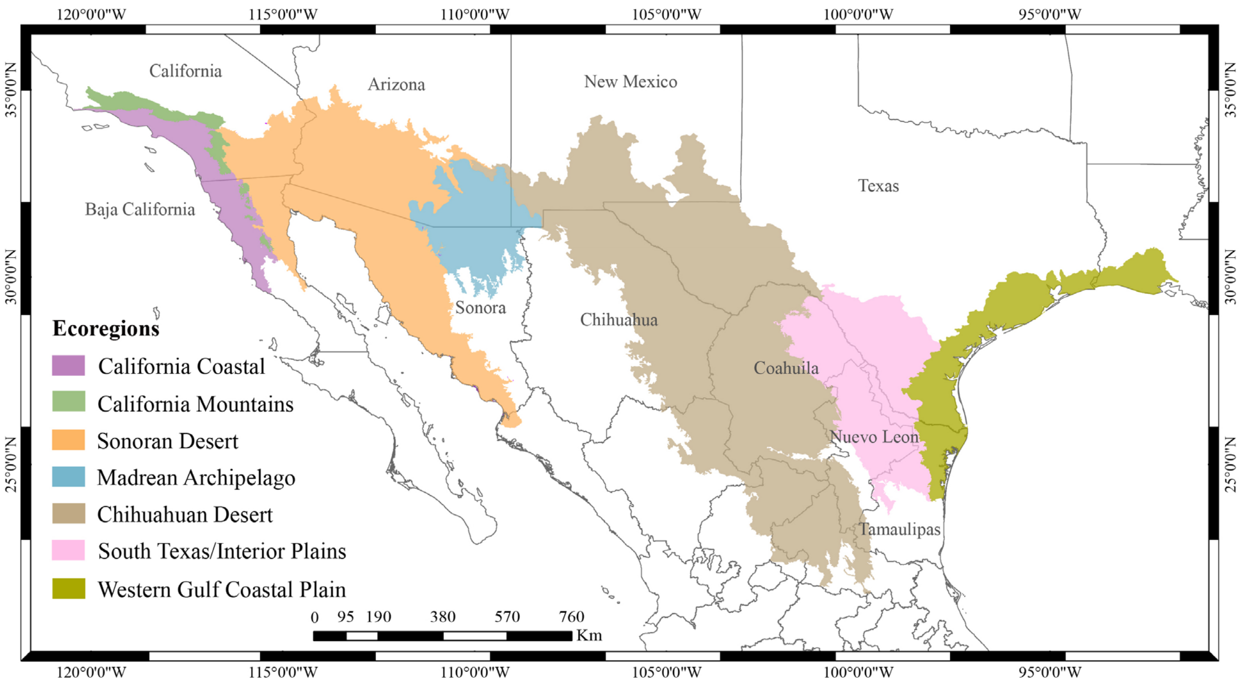

Fig 1. Depiction of the United States-Mexico border states and their ecoregions (CEC, 1997).

snakes, except for one anuran (*A. cognatus*) and one lizard (*U. ornatus*); four of the snakes are colubrids, one is a natricid, and one is a crotalid.

The number of species per state ranges from 74 in Baja California to 129 in Texas ($\bar{x}$ = 98.3). The number and percentage of the total border herpetofauna distributed in each of the 10 border states are as follows (in order of placement in Table 2): CA= 79 (34.2%); BC = 74 (32.0%); AZ = 111 (48.1%); SO = 103 (44.6%); NM = 100 (43.3%); CH = 113 (48.9%); TX = 129 (55.8%); CO = 101 (43.7%); NL = 80 (34.6%); and TM = 93 (40.3%). The percentage representation by state ranges from 32.0 to 55.8 ($\bar{x}$ = 42.5%). As expected, in all the ordinal-level taxa the largest number of species is found in Texas, since it is the state with the longest border, with the exception of Chihuahua, which has the same number of turtle species (Table 2).

The number of anurans in the 10 border states ranges from six in Nuevo León to 23 in Texas, the number of salamanders from none in New Mexico, Coahuila, and Nuevo León and one in Arizona, Sonora, and Chihuahua to four in Texas, and the total number of amphibians from six in Nuevo León (where there are no salamanders) to 27 in Texas. The number of squamates ranges from 58 in Baja California to 94 in Texas, the number of turtles from one in California and Baja California to eight in Chihuahua and Texas, and the total number of reptiles from 59 in Baja California to 102 in Texas (Table 2).

Based on the country distributional data in Table A1, we constructed a Coefficient of Biogeographic Resemblance (CBR) matrix for the herpetofaunal species shared between 45 two-state pairs (Duellman, 1990), and we placed these values in Table A2. The formula for this metric is CBR = 2C/N1 + N2, where C is the number of species in common to both states, N1 is the number of species in the first state, and N2 is the number of species in the second state. The number of species shared among all the regional pairings ranges from 10 between the states of Baja California and Nuevo León, and Baja California and Tamaulipas, to 98 between Arizona and Sonora. As indicated above, eight species occupy all 10 states along the border, so only two more are common to Baja California and Nuevo León, and Baja California and Tamaulipas. These states lie at almost opposite ends of the

Table 2. Summary of the numbers of herpetofaunal species at the ordinal and class levels that occur in states along the U.S.–Mexico border. The abbreviations are as follows: CA = California; BC = Baja California; AZ = Arizona; SO = Sonora; NM = New Mexico; CH = Chihuahua; TX = Texas; CO = Coahuila; NL = Nuevo León; and TM = Tamaulipas.

Taxa	States									
	CA	BC	AZ	SO	NM	CH	TX	CO	NL	TM
Anura	12	12	16	17	16	18	23	14	6	21
Caudata	3	3	1	1	—	1	4	—	—	3
Amphibia	15	15	17	18	16	19	27	14	6	24
Squamata	63	58	88	80	76	85	94	80	69	64
Testudines	1	1	5	4	7	8	8	7	5	5
Reptilia	64	59	94	85	84	94	102	87	74	69
Totals	**79**	**74**	**111**	**103**	**100**	**113**	**129**	**101**	**80**	**93**

border. The mean value of the species shared among all 10 states is 47.8. The average number of shared species for each of the 10 border states, arranged in ascending order, is as follows: Baja California = 25.8; California = 29.2; Nuevo León = 43.4; Tamaulipas = 44.9; Sonora = 49.9; Arizona = 53.6; Coahuila = 54.8; New Mexico = 55.3; Chihuahua = 60.1; and Texas = 60.6.

The CBR values in Table A2 range from 0.12 to 0.95. As expected, the lowest value is that between the states of Tamaulipas with both California and Baja California (Table A2). This value is between states that lie at opposite extremes of the border. Again, as expected, the highest value is between Baja California and California, which lie adjacent to one another at the western extreme of the border. The mean value for the collective CBR figures for each state, in ascending order, is as follows: Baja California = 0.30; California = 0.33; Tamaulipas = 0.46; Nuevo León = 0.47; Sonora = 0.49; Arizona = 0.51; Texas = 0.54; Coahuila = 0.54; New Mexico = .55; and Chihuahua = 0.56.

We used the CBR data in Table A2 to construct a UPGMA dendrogram (Fig. 2) to illustrate the herpetofaunal relationships among the 10 states along the U.S.–Mexico border. The data in this dendrogram indicate what one would expect, i.e., that the states are arranged in relation to one another from left to right, as they exist geographically from west to east. In addition, the states in the dendrogram are arranged in pairs that reflect their north-to-south geographic relationships, i.e., that the US states are paired with the Mexican states that lie to their south, e.g., California paired with Baja California, Arizona with Sonora, New Mexico with Chihuahua, and Texas with Coahuila. Only Nuevo León and Tamaulipas are not paired with the US states, but rather are paired with one another. The dendrogram is comprised of two principal clusters, one composed of two states (California and Baja California) and the other with the remaining eight border states joined at the 0.24 level. California and Baja California are joined at the 0.95 level, which is the highest level in the dendrogram. The other main cluster consists of two subclusters joined to one another at the 0.47 level. One subcluster is comprised of two U.S.–Mexico pairs, including Arizona and Sonora, joined at the 0.92 level, and New Mexico and Chihuahua connected at the 0.84 level (with these two pairs linked at the 0.67 level). The other subcluster is comprised of two state pairs, of which one, the U.S.–Mexico pairing of Texas and Coahuila are attached at the 0.85 level, and the two Mexico-state pairing of Nuevo León and Tamaulipas are connected to one another at the 0.76 level. These last two subclusters are linked at the 0.75 level. The principal conclusion that can be drawn from this dendrogram is that the herpetofauna of the California–Baja California pairing is the most distinctive, when compared to that of the remaining border states. The distinction of next greatest importance is that between the Arizona–Sonora–New Mexico–Chihuahua quadruplet, and the Texas–Coahuila–Nuevo León–Tamaulipas quadruplet.

Distribution of the U.S.–Mexico Border Herpetofauna by Ecoregion

We adopted the same system of ecoregions used by Lasky *et al*. (2011), including from west to east, the California Coastal region (CC), the California/Baja California Mountains (CM), the Sonoran Desert (SD), the Madrean Archipelago (MA), the Chihuahuan Desert (CD), the South Texas/Interior Plains (ST), and the Western Gulf Coastal Plain (GC). We document the distribution of the U.S.–Mexico border herpetofaunal species among these seven ecoregions in Table A1 and provide a summary in Table 3.

The number of these ecoregions occupied by the given species (Table A1) ranges from one to seven (of a total of seven), as follows: one (93; 40.3%); two (76; 33.0%); three (42; 18.2%); four (11; 4.8%); five (six; 2.6%); six (two; 0.9%); and seven (one; 0.4%). Only a single species (the snake *Pituophis catenifer*) occupies all seven ecoregions, and two species (the snakes *Arizona elegans* and *Rhinocheilus lecontei*) are found in six of the seven ecoregions. The mean occupancy level is 2.0, indicating that only a little more than a quarter of the ecoregions are inhabited by the typical border species.

The number of species per ecoregion (Table 3) ranges from 40 in the California/Baja California mountains to 100 in the Chihuahuan Desert ($\bar{x}$ = 66.3). The numbers and percentages of the total border herpetofauna distributed in each of the seven border ecoregions are as

Table 3. Summary of the numbers of herpetofaunal species, at the ordinal and class levels, occupying the ecoregions along the U.S.–Mexico border. The abbreviations are as follows: CC = California Coastal; CM = California/Baja California Mountains; SD = Sonoran Desert; MA = Madrean Archipelago; CD = Chihuahuan Desert; ST = Southern Texas Plains; and GC = Western Gulf Coastal Plain.

Taxa	Ecoregions						
	CC	CM	SD	MA	CD	ST	GC
Anura	6	7	12	13	17	11	15
Caudata	3	2	1	1	1	—	3
Amphibia	**9**	**9**	**13**	**14**	**18**	**11**	**18**
Squamata	38	30	63	55	73	44	41
Testudines	1	1	3	3	9	4	6
Reptilia	**39**	**31**	**66**	**59**	**82**	**48**	**47**
Totals	**48**	**40**	**79**	**73**	**100**	**59**	**65**

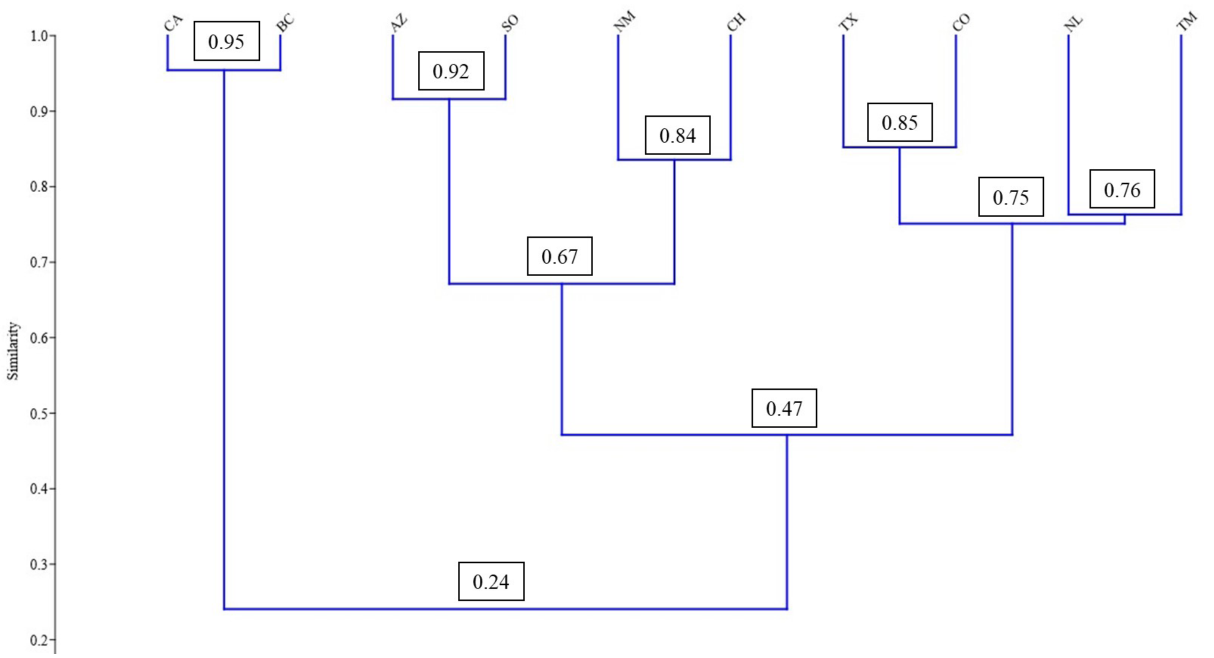

Fig 2. UPGMA generated dendrogram illustrating the similarity relationships of species richness among the herpetofaunal components in the 10 states along the United Sates–Mexico border (based on the data in Table 4; Sokal and Michener 1958). We calculated the similarity values using Duellman's (1990) Coefficient of Biogeographic Resemblance (CBR).

follows (in order of placement in Table A5): CC = 48 (20.8%); CM = 40 (17.3%); SD = 79 (34.2%); MA = 73 (31.6%); CD = 100 (43.3%); ST = 59 (25.5%); and GC = 65 (28.1%). The percentage representation ranges from 17.3 to 43.3 ($\bar{x}$ = 28.7%). In almost all the taxa, except for the salamanders, the greatest numbers of species are found in the Chihuahuan Desert, the ecoregion with the most extensive border coverage of the seven represented.

Based on the ecoregional distribution data in Table A1, we devised a Coefficient of Biogeographic Resemblance (CBR) matrix for the herpetofaunal species shared between 21 two-state pairs, and we placed these values in Table A3. The number of species shared among all the regional pairings ranges from three between the regions of CC and ST, CM and ST, CM and GC, to 46 between CD and ST. Since two species occupy six ecoregions and one seven, we expected that three would be the lowest number of species shared among the seven ecoregions. The mean value of the species shared among all seven ecoregions is 18.0. The mean number of shared species for each of the seven border ecoregions, arranged in ascending order, is as follows: CM = 11.2; CC = 12.8; GC = 17.3; MA = 18.5; ST = 19.3; SD = 20.2; and CD = 27.0.

The CBR values in Table A3 range from 0.06 to 0.84. The lowest values are between the ecoregions of CC and ST, CM and ST, and CM and GC. These three values are between the westernmost ecoregion (CC) and the next to the easternmost (ST), and the next to the westernmost (CM) and the next to the easternmost (ST), as well as the easternmost (GC). In ascending order, the mean value for the collective CBR figures for each ecoregion is as follows: CM = 0.23; CC = 0.25; MA = 0.25; GC = 0.25; SD = 0.28; ST = 0.28; and CD = 0.33. These values decrease more or less on either side of the CD ecoregion, toward the west and toward the east.

We also used the data in Table A3 to create a UPGMA dendrogram (Fig. 3), to demonstrate the herpetofaunal relationships among the seven ecoregions distributed along the U.S.–Mexico border. Again, the data in this dendrogram illustrate what one would expect, i.e., that the ecoregions are arranged in the same relationship to one another from left to right as exists geographically from west to east. In a similar manner to the situation relating to the state herpetofaunas, the two westernmost ecoregions, the California Coastal region and the California/Baja California Mountains, are more closely related to one another than either is to any of the other five ecoregions. These two ecoregions are linked to the remaining ecoregion at the 0.11 level. The other five ecoregions are arranged into two major subclusters, one including the Sonoran Desert and the Madrean Archipelago and the other the Chihuahuan Desert, South Texas/Interior Plains, and Western Gulf Coastal Plains. The Sonoran Desert–Madrean Archipelago subcluster is joined to the Chihuahuan Desert–South Texas/Interior Plains–Western Gulf Coastal Plains subcluster at the 0.22 level. The Sonoran Desert and Madrean Archipelago ecoregions are linked to one another at the 0.53 level. And, the Chihuahuan Desert ecoregion is joined to the South Texas Interior Plains–Western Gulf Coastal Plains pairing at the 0.53 level.

Conservation Status of the U.S.–Mexico Border Herpetofauna: the IUCN System

Since the IUCN system of conservation assessment is used globally for all organismic groups, we included the pertinent categorizations in Table A1 and summarize them in Table 4. Of the seven categories recognized in the IUCN system, no border species is allocated to the CR or DD categories (Table 4). Otherwise, only one EN species is included (*Anaxyrus californicus*) and it is distributed on each side of the border in California and Baja California. A maximum of five species are placed in the VU category, and from one to three are found in the 10 border states (Table 4). Thus, one to three species in the border states are allocated to the threat categories (EN, and VU). Two to six species are placed in the NT category. As expected, most of the species in each of the border states are placed in the LC and NE categories, with the majority in the LC category and seven to 12 placed in the NE category. The numbers and proportions of the herpetofauna assigned to the LC category per state is as follows (Table 4): California, 63 of 79 (79.7%); Baja California, 58 of 74 (78.4%); Arizona, 95 of 111 (85.6%); Sonora, 89 of 103 (79.7%); New Mexico, 87 of 100 (87.0%); Chihuahua, 99 of 113 (87.6%); Texas, 111 of 129 (86.1%); Coahuila, 85 of 101 (84.2%); Nuevo León, 70 of 80 (87.5%); and Tamaulipas, 82 of 93 (88.2%). Thus, the proportions range from 79.2 to 88.8 ($\bar{x}$ = 84.4). Based on these evaluations, from a conservation perspective, the U.S.–Mexico border herpetofauna apparently is in good shape; these data are similar to those reported in entries of the MCS series that have appeared in *Amphibian & Reptile Conservation* and the journal *Mesoamerican Herpetology*. An analysis of the status of the same species using the EVS system, however, leads to other conclusions (see below).

Conservation Status of the U.S.–Mexico Border Herpetofauna: the EVS System

We used the Environmental Vulnerability Score (EVS) to gauge the level of environmental impact posed by an impassable barrier at the U.S.–Mexico border. We placed the EVS for the 231 border species in Table A1 and provide a summary in Table A4. These scores range from 3 to 18, two fewer than the total theoretical range of 3 to 20 (Wilson et al. 2013a, b).

Table 4. Summary of the numbers of species allocated to the IUCN categories, arranged by states.

States	CR	EN	VU	NT	LC	DD	NE	Totals
California	—	1	—	6	63	—	9	**79**
Baja California	—	1	—	5	58	—	10	**74**
Arizona	—	—	2	5	95	—	9	**111**
Sonora	—	—	2	5	89	—	7	**103**
New Mexico	—	—	2	4	87	—	7	**100**
Chihuahua	—	—	3	3	99	—	8	**113**
Texas	—	—	3	3	111	—	12	**129**
Coahuila	—	—	2	3	85	—	11	**101**
Nuevo León	—	—	1	2	70	—	7	**80**
Tamaulipas	—	—	2	2	82	—	7	**93**

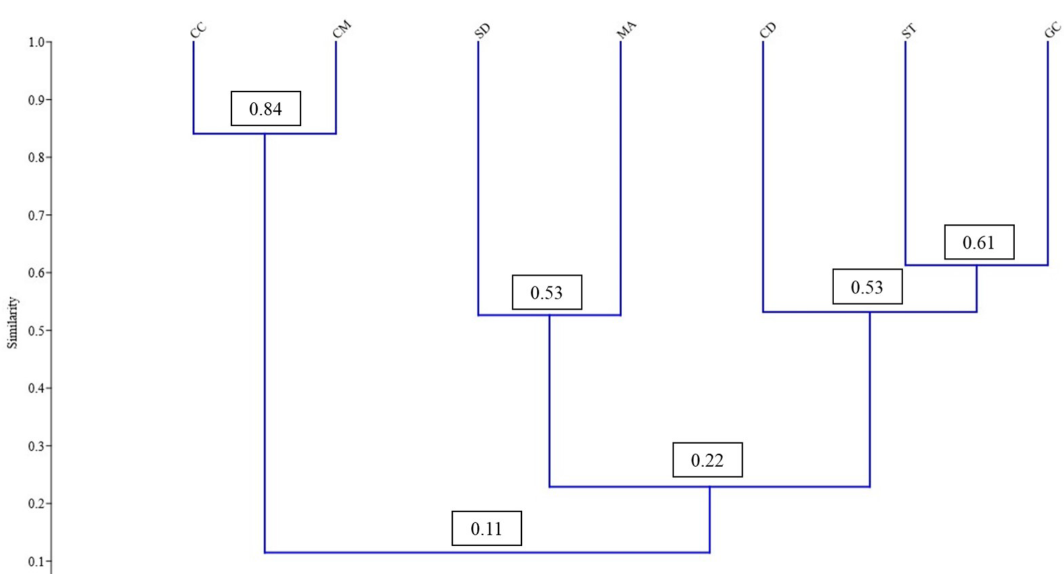

Fig. 3. UPGMA generated dendrogram illustrating the similarity relationships of species richness among the herpetofaunal components in the seven ecoregions along the United States–Mexico border (based on the data in Table 6; Sokal and Michener 1958). We calculated the similarity values using Duellman's (1990) Coefficient of Biogeographic Resemblance (CBR).

In Table A4 we calculated the numbers of species associated with each of the various EVS values, organized by states. Generally speaking, the EVS values for the 10 states range from 3 or 4 to 16 or 18 (Table A1). We found a range of 3 to 18 in the states of Chihuahua, Texas, Coahuila, and Tamaulipas, a range of 3 to 16 in the states of California, Baja California, Arizona, and Sonora, and a range of 4 to 18 in the states of New Mexico and Nuevo León. None of the species in the border states was assessed an EVS of 17 (Tables A1 and A4).

We also determined the numbers of species for each state allocated to the low, medium, and high vulnerability categories; we placed this information in Table A1 and present a summary in Table A4. These data indicate that the number of species in each state increases from the low to the medium categories, and then decreases in the high category to a number below those in the low category. The percentage of the herpetofauna with an EVS in the low category for the 10 states ranges from 27.0 to 35.5 ($\bar{x}$ = 29.8); for the medium category from 44.1 to 49.5 ($\bar{x}$ = 47.7); for the high category from 20.3 to 25.0 ($\bar{x}$ = 22.4). Thus, we found that the EVS for close to one-half of the border species (48.9%) falls into the medium category and close to the remaining half (51.1%) in either the low or the high category.

We also calculated column sums for each of the EVS values to indicate the total numbers of species in the 10 border states allocated to these values 3 through 18 (with the exception of 17). These data indicate that the values increase from a low of 8 species (for an EVS of 18) to a peak of 128 species (for an EVS of 11). Based on this analysis, we conclude that the largest portion of species in the 10 border states were allocated EVS values ranging from 10 to 14.

We determined the numbers of species associated with each of the various EVS values, organized by ecoregions. In general, the EVS values for the seven ecoregions ranges from 3 or 4 to 15, 16, or 18 (Table A5). The range of 3 to 18 is for the CD, ST, and GC regions; the range of 3 to 16 is for the SD region; the range of 4 to 16 is for the MA region; the range of 4 to 15 is for the CC region; and the range of 5 to 15 is for the CM region (Table A5).

In Table A1 we established the numbers of species for each ecoregion placed in the low, medium, and high vulnerability categories, and we present a summary of these data in Table A5. These data demonstrate that the number of species in each ecoregion increases from the low to the medium category, and then decreases in the high category to a number below those in the low category, which is the same pattern seen among the border states. The percentage of the herpetofauna with an EVS in the low category for the seven ecoregions ranges from 29.0 to 40.0 ($\bar{x}$ =33.6); for the medium category from 41.5 to 47.9 ($\bar{x}$ = 45.7); and for the high category, from 16.7 to 25.3 ($\bar{x}$ = 20.7). Thus, slightly less than one-half of the ecoregional species fall into the medium category, the same situation seen among the border states, and slightly more than half into the low and high categories.

Distributional Status of the U.S–Mexico Border Species

In an effort to determine the potential susceptibility of the U.S.–Mexico border herpetofauna to damage from politically determined border fencing, we devised a simple measure by adding the number of states inhabited (from two to 10) to the number of ecoregions inhabited (from one to seven). We indicate the measure by placing the number of states involved preceded by the letter S, and then added the number of ecoregions involved preceded by the letter E. The most restrictive value would be that for two states (the minimum for a border species) added to a single ecoregion (the minimum inhabitable) or S2E1. The most expansive value would be that for 10 states plus seven ecoregions or S10E7. We tabulated the numbers of species for the various distributional values and indicate them below:

S2E1 = 38	S6E3 = 9
S2E2 = 28	S6E4 = 1
S2E3 = 3	S7E2 = 4
S3E1 = 20	S7E3 = 4
S3E2 = 5	S7E4 = 2
S3E3 = 1	S7E5 = 1
S4E1 = 21	S8E2 = 2
S4E2 = 20	S8E3 = 7
S4E3 = 6	S8E4 = 3
S5E1 = 10	S9E4 = 4
S5E2 = 7	S9E5 = 1
S5E3 = 8	S10E3 = 2
S5E5 = 1	S10E5 = 3
S6E1 = 3	S10E6 = 2
S6E2 = 9	S10E7 = 1

These figures indicate that the largest number of border species (142 of 231; 61.5%) occupy from two to four states and from one to three ecoregions. The remaining 89 species (38.5%) range more broadly in five to 10 states and one to seven ecoregions. As recent history has shown, decisions about the positioning and extent of the fencing along the U.S.–Mexico border have been made on a political basis, with the most recent Republican administration having replaced or erected 452 miles of border fencing (ca. 80 miles of new fencing where no barriers stood previously) (cpb.gov; accessed 10 April 2024). Meanwhile, the current Democratic administration has proposed no plans for continued border barrier construction. Much of the recent border barrier is described as "bollard fencing," which is composed of vertical metal bars that range from ca. six to 10 m in height (cpb.gov; accessed 10 April 2024). In a vacuum, this type of barrier might serve as a permeable or semi-permeable barrier to most of the smaller-bodied border herpetofauna. However, these fences coincide with significant adjacent land cover changes (land clearing and road construction) and elevated border patrol activities (namely, vehicle patrol of border fencing), that undoubtedly have direct and indirect negative impacts on herpetofauna and other wildlife (Thornton et al. 2018; LaDuc et al. 2019). In this context, our identified border species with narrow distributions are more likely to be adversely affected by such border barriers and associated activities. If absolutely necessary, such physical barriers should be constructed with the aim of maintaining landscape connectivity for wildlife, and built in a "wildlife-friendly" manner (Linnell et al. 2016). We can assume that the inherently political dimensions of this conservation challenge will continue for the foreseeable future, if current rhetoric is any indication. We consider the construction of physical barriers to prevent illegal crossings as a last resort, and only should be done when more humane solutions have proven ineffective. Alternatively, if decisions about the positioning and amount of fencing were to be made on biological rather than political criteria, then steps should be taken to ensure that the more narrowly distributed species are allowed freer access across the border than ones that are more broadly distributed. From a purely biological and conservation perspective, however, it would be more desirable to have no fencing that would restrict the free movement of border species across the border.

The most narrowly distributed taxa along the U.S.–Mexico border comprise 90 species, which range in two or three states and one or two ecoregions (Table A1). These species are as follows (we indicate their distribution score parenthetically):

Anaxyrus boreas (S2E2)
Anaxyrus californicus (S2E2)
Anaxyrus retiformis (S2E1)
Eleutherodactylus campi (S3E2)
Eleutherodactylus marnockii (S3E2)
Acris blanchardi (S3E1)
Hyliola cadaverina (S2E2)
Hyliola hypochondriaca (S3E2)
Pseudacris clarkii (S2E1)
Smilisca baudinii (S2E1)
Smilisca fodiens (S2E1)
Leptodactylus fragilis (S2E1)
Hypopachus variolosus (S2E1)
Lithobates catesbeianus (S2E2)
Lithobates tarahumarae (S3E1)
Rana boylii (S2E1)
Rana draytonii (S2E2)
Rhinophrynus dorsalis (S2E1)
Spea hammondii (S2E2)
Aneides lugubris (S2E1)
Batrachoseps major (S2E2)
Ensatina eschscholtzii (S2E2)
Notophthalmus meridionalis (S2E1)
Siren intermedia (S2E1)
Siren lacertina (S2E1)
Elgaria multicarinata (S2E2)
Anniella stebbinsi (S2E1)
Crotaphytus nebrius (S2E1)
Crotaphytus vestigium (S2E2)
Coleonyx reticulatus (S2E1)
Coleonyx switaki (S2E1)
Holbrookia propinqua (S2E1)
Petrosaurus mearnsi (S2E1)
Phrynosoma blainvillii (S2E2)
Phrynosoma goodei (S2E1)
Phrynosoma platyrhinos (S3E1)
Sceloporus occidentalis (S2E2)
Sceloporus orcutti (S2E2)
Sceloporus slevini (S3E1)
Sceloporus vandenburgianus (S2E2)
Uma notata (S2E1)
Uma rufopunctata (S2E1)
Urosaurus nigricaudus (S2E2)
Phyllodactylus nocticolus (S2E1)
Plestiodon callicephalus (S3E1)
Plestiodon gilberti (S3E2)
Plestiodon skiltonianus (S2E2)
Scincella lateralis (S3E1)
Aspidoscelis burti (S2E1)
Aspidoscelis hyperythra (S3E1)
Aspidoscelis laredoensis (S2E1)
Aspidoscelis neomexicana (S3E1)
Aspidoscelis sexlineata (S3E1)
Aspidoscelis stictogramma (S2E1)
Aspidoscelis xanthonota (S2E1)
Xantusia henshawi (S2E2)
Xantusia vigilis (S3E1)
Bogertophis rosaliae (S2E1)
Drymobius margaritiferus (S2E1)
Ficimia streckeri (S3E1)
Gyalopion quadrangulare (S3E1)
Lampropeltis knoblochi (S3E1)
Lampropeltis multifasciata (S2E1)
Masticophis fuliginosus (S2E2)
Masticophis lateralis (S2E2)
Opheodrys vernalis (S2E1)
Phyllorhynchus browni (S2E1)
Sonora annulata (S3E1)
Sonora cincta (S3E1)
Sonora episcopa (S2E1)
Sonora palarostris (S2E1)
Sonora taylori (S2E1)
Tantilla cucullata (S3E1)
Tantilla gracilis (S2E1)
Tantilla planiceps (S2E2)
Trimorphodon lambda (S3E2)
Trimorphodon lyrophanes (S2E2)
Coniophanes imperialis (S3E1)
Hypsiglena ochrorhyncha (S2E2)
Storeria dekayi (S3E1)
Thamnophis hammondii (E2E2)
Agkistrodon laticinctus (S3E1)
Crotalus helleri (S2E2)
Crotalus tigris (S2E2)
Sistrurus miliarius (S2E1)
Actinemys pallida (S2E2)
Chrysemys picta (S2E1)
Kinosternon arizonense (S2E1)
Kinosternon hirtipes (S3E1)
Gopherus morafkai (S2E2)

At the other extreme, *Pituophis catenifer* is the most broadly distributed species, as it occurs in all 10 of the border states and the seven ecoregions.

The 90 most-narrowly distributed species listed above occur to some extent in all 10 of the border states. To qualify as a border species, it must occur in at least one state on each side of the border, but then the question arises as to how many of the most-narrowly distributed species occur in each of the 16 border states combinations. The answer is as follows:

CA–BC = 35	TX-NL = 1
TX–TM = 13	NM–TX–CO = 1
AZ–-SO = 13	TX–CO–NL = 1
AZ–SO–CH = 6	CA–BC–NM = 1
CA–BC–AZ = 3	NM–TX–TM = 1
TX–CO = 3	CA–AZ–SO = 1
CH–TX–CO = 3	NM–CH = 2
TX–NL–TM = 6	BC-AZ-SO = 1

Perusal of the data indicates that 61 of the 90 species (68.0%) are distributed in three cross-border pairings, viz., California–Baja California, Texas–Tamaulipas, and Arizona–Sonora. We suggest that these 61 species should be established as focal taxa for examining the effects of the U.S.–Mexico cross-border fence populations of these species. These border areas also contain significant urbanization associated with the San Diego–Tijuana, Nogales, AZ–Nogales, SO, and the Brownsville–Matamoros city pairings. Obviously, however, the existence of the border fencing in these areas is not the only factor adversely impacting the integrity of the populations of these species in these regions.

The 90 most narrowly distributed species occupy one or two ecoregions, as follows:

California Coastal Region = 28
Chihuahuan Desert = 41
California/Baja California Mountains = 23
South Texas Plains = 20
Sonoran Desert = 42
Western Gulf Coastal Plain = 27
Madrean Archipelago = 35

Thus, the most significant ecoregion relative to the ecoregional distribution of the most narrowly distributed species is the Sonoran Desert, followed by the Chihuahuan Desert, and the Madrean Archipelago.

Discussion

Although we are aware that the world is going through a significant period of human population growth rate decline, with some exceptions (Ceballos et al. 2017), it is still increasing in absolute numbers and various governments persist in implementing policies that are diametrically opposed to the reasoning of the scientific community, thereby jeopardizing our own existence, along with that of the rest of life on the planet. This governmental resistance to the advice of the world's scientists applies to the fashion in which political decisions are made at the border between the United States of America and Mexico.

In the October 2018 issue of *BioScience*, a huge compendium of 2,556 scientists from 43 countries in the world (including 1,472 from the United States and 616 from Mexico) signed on to an article entitled "Nature divided, scientists united: US–Mexico border wall threatens biodiversity and binational conservation." These authors and the signatories (Peters et al. 2018: 740) maintained that "fences and walls erected along international boundaries in the name of national security have unintended but significant consequences for biodiversity." These individuals point out three ways in which border infrastructure and security operations (hereafter "the border wall") threaten biodiversity and discuss actions designed to minimize such threats.

• "The border wall bypasses environmental laws." These authors note that "In 2005, the US Congress passed the Real ID Act, which gives the Department of Homeland Security (DHS) authority to waive any laws that slow the wall's construction, including the Endangered Species Act (ESA) and the National Environmental Policy Act (NEPA)." What this means is that the US Congress gave the authority to whatever four- or eight-year executive administration the voters place in office to supersede whatever laws have been established to protect species the world's biologists have decided that need such protections from humanity's depredations. Thus, an immigration-friendly administration conceivably can have the same impact as one that is immigration-opposed, since the laws enacted over the years to protect vulnerable species, no matter where they might sit on the "extinction spectrum," can be waived with the stroke of a pen. The data we present on EVS categorizations (Table A4) demonstrate that the proportion of the species of highest environmental vulnerability ranges from 20.3%–25.0% ($\bar{x}$ = 22.4) per state, indicating that more than one-fifth of the border species can be expected to be disproportionately impacted by across-the-board political decisions.

• "The border wall harms wildlife populations by eliminating, degrading, and fragmenting habitats." As Lasky et al. (2018) pointed out, there are seven ecoregions of varying dimensions arrayed on either side of the US–Mexico border (Figure 1). We documented the occurrence of the 231 border species among these seven ecoregions (Table 3), indicating that the total number of species resident in these ecoregions ranges from a low of 40 in the California/Baja California Mountains region to a high of 100 in the Chihuahuan Desert region. These data implicate that no one ecoregion contains more than 43.3% of the total of the border species (100 species in the Chihuahuan Desert ecoregion/231 total border species). The least speciose and smallest ecoregion located along the border is the California/Baja California Mountains with only 40 species or 17.3% of the total number of the 231 border species.

The data concerning ecoregion distribution placed in Table A1 indicate that the 231 border species are distributed among the seven ecoregions arrayed along the border, as follows: one ecoregion—93 species

(40.3%); two ecoregions—76 species (33.0%); three ecoregions—42 species (18.2%); four ecoregions—11 species (4.8%); five ecoregions—six species (2.6%); six ecoregions—two species (0.9%); and seven ecoregions—one species (0.4%). The average ecoregion occupancy is 2.0. Consequently, we can expect that indiscriminate habitat destruction and degradation along the border will have serious consequences for these relatively narrowly distributed herpetofaunal border species. However, by implementing a set of strategies such as key placement and design of wildlife crossings, restauration of habitats and connectivity, policy and management adjustments, and research and monitoring (among others), it may be possible to mitigate some of the severe impacts along the border towards ensuring the long-term connectivity and conservation of native amphibian and reptile populations in this vital transboundary region.

The 93 species limited in distribution to a single ecoregion are found as follows: CC ecoregion—four species (4.3%); CM ecoregion—two species (2.2%); SD ecoregion—24 species (25.8%); MA ecoregion—19 (20.4%); CD ecoregion—22 (23.6%); ST ecoregion—six species (6.5%); and GC ecoregion—16 species (17.2%). As a result, from a conservation perspective, each of the border ecoregions is of interest, especially the SD, CD, and MA ecoregions.

• "The border wall devalues conservation investment and scientific research." Since the border wall exists to regulate (and retard) movement of individuals from the south into the United States, this regulation is a political consideration and not one that involves conservation and science. Since the federal government is charged with maintaining the integrity of the border as a means of controlling the movement of migrants, the amount of investment in conservation and scientific research is considered immaterial. Given that all the authors of this paper are scientists and conservationists, we believe that the money spent on determining the impact of the border wall might be better spent by searching for ways to protect these organisms, while at the same time regulating the flow of humans across the border (see recommendations below).

Conclusions

1. The herpetofauna of the border region between the U.S. and Mexico is comprised of 231 species, including 39 anurans, seven salamanders, 172 squamates, and 13 turtles.
2. The 231 species are distributed among 10 states, four on the U.S side of the border, and six on the Mexican side. The number of species per state are as follows, from west to east: California, 79; Baja California, 74; Arizona, 111; Sonora, 103; New Mexico, 100; Chihuahua, 113; Texas, 129; Coahuila, 101; Nuevo León, 80; and Tamaulipas, 93.
3. The number of species shared among the border states ranges from 11 between Baja California and Nuevo León, and Baja California and Tamaulipas, to 98 between Arizona and Sonora, and Texas and Coahuila. The Coefficient of Biogeographic Resemblance values range from 0.12 between the states of Baja California and Tamaulipas, and California and Tamaulipas, to 0.95 between the states of Baja California and California.
4. The 231 border species are distributed among seven ecoregions arrayed along the border. The number of species per ecoregion, arranged from west to east, are as follows: California Coastal (CC), 48; California/Baja California Mountains (CM), 40; Sonoran Desert (SD), 79; Madrean Archipelago (MA), 73; Chihuahuan Desert (CD), 100; Southern Texas Plains (ST), 59; and Western Gulf Coastal Plain (GC), 65.
5. The number of species shared among the ecoregions along the border range from 3 between the CC and ST, CM and ST, and CM and GC to 46 between the CD and ST. The Coefficient of Biogeographic Resemblance values range from 0.06 between the CC and ST, the CM and ST, and the CM and GC, to 0.84 between the CC and CM.
6. By applying the IUCN system of conservation status to the U.S.–Mexico border herpetofauna, we attained the following results (by category, number, and proportion): EN (one; 0.4%); VU (five; 2.2%); NT (12; 5.2%); LC (188; 81.4%); and NE (25; 10.8%).
7. The EVS system provided a greater value in assessing the conservation status of the U.S.–Mexico border herpetofauna, through which we allocated the resulting scores to the low, medium, and high vulnerability categories, and determined that the values increase from low (56) to medium (113) and then decrease to high (62). Thus, about one-half of the border species (48.9%) are in the medium EVS category (scores 10–13).
8. We determined the numbers of species for each state and each ecoregion and placed them in the low, medium, and high vulnerability categories; we then established that in each state and ecoregion the number of species increases from those in the low category to the medium category, and then decreases in the high category to a number below those in the low category.
9. In attempting to determine the relative susceptibility of the members of the U.S.–Mexico border herpetofauna to damage from the politically positioned border fencing, we devised a simple measure by adding the number of occupied states to the number of occupied ecoregions. We recorded the measure by using the notation S for the state and E for the ecoregion followed by the number of states and ecoregions inhabited; for example, we used S2E1 to signify a species that occupies two states and a single ecoregion (the most restricted distribution possible), and S10E7 to indicate a species that occupies all 10 states and all seven ecoregions (the most expansive distribution possible). When categorized in this manner, 142 or 61.5% of the 231 border species

occupy from two to four states and from one to three ecoregions.

10. We assume that future border fencing will be added depending on the political leaning of the U.S. administration in power. We can only hope that politicians will come together to resolve these issues in the future, including more humane solutions to illegal border crossings.
11. Ninety taxa are the most narrowly distributed along the border, the ones ranging from two to three states and from one to two ecoregions. These species comprise 19 anurans, six salamanders, 60 squamates, and five turtles. The majority of these species (61 or 68.0%) are distributed in three cross-border pairings, i.e., California–Baja California, Texas–Tamaulipas, and Arizona–Sonora.
12. The ecoregions inhabited by the 90 most narrowly distributed species in order of significance are the Sonoran Desert, Chihuahuan Desert, and the Madrean Archipelago.
13. The major concerns with the impact of border policy on the organisms that are distributed on both sides of the border are that: (a) the border wall bypasses environmental laws; (b) the border wall harms wildlife populations by eliminating, degrading, and fragmenting habitats; and (c) the border wall devalues conservation investment and scientific research.

Recommendations

1. Our most fundamental recommendation, the one we would give for all of humanity's actions on our planet, is to base important decisions on the best scientific knowledge available. All too often, decisions are made on opinion, and over time they have given rise to a plethora of problems that involve global environmental issues, including climate change, biodiversity decline, and atmospheric and water pollution.
2. Given that we are currently undergoing the sixth mass extinction event in Earth's history, a subsidiary recommendation is that we work to understand the implications that biodiversity decline holds for humanity, which will require adopting a new paradigm for human existence, one based on biocentrism rather than anthropocentrism. Such a paradigm shift will require inventing a new approach to education based on critical thinking, empathic promotion, and ecological consciousness. Continuation of the *status quo* in education will continue to exacerbate the self-inflicted problems humanity faces.
3. The approach we take in dealing with the border issues between the United States and Mexico exemplifies our continuous clashes with the remainder of the biosphere. The border between the United States and Mexico has shifted back and forth over time since the two countries have been in existence. The placement of the border, however, had nothing to do with the ranges of organisms along the border or their biological needs, but instead with political decisions and differences. The position of the border between the two nations actually dates to the outcome of the Mexican-American War of 1846–1848 (Intervención Estadounidense en México) and the Gadsden Purchase of 1854 (Tratado de La Mesilla), which accounted for major losses of Mexican terrain ceded to the United States.
4. Based on the results of our study, we recommend that the impact of the existing fence and any additional planned fencing should be studied with reference to the 90 species of the total of 231 herpetofaunal border species that are most narrowly distributed, i.e., that range into two or three states and one or two ecoregions. This evaluation should also include species distribution modeling. The majority of these 90 species occur in the following pairings: CA—BC (35 species); TX—TM (13); and AZ—SO (13). This number (61) is 68.0% of the total. Such a study could center on three focal points, i.e., the San Diego-Tijuana connection, that of the Nogales AZ—Nogales SO connection, and that of the Brownsville—Matamoros—connection, and extend outward to encompass the remainder of the borders between California and Baja California, Arizona and Sonora, and, finally, Texas and Tamaulipas. Such a study logically should involve collaborators on both sides of the border at these three locations. Further, we recommend that the results of these studies be combined into a single published report, to be shared with the Chief of the U.S. Border Patrol, the Commissioner of the U.S. Customs and Border Protection, and the Secretary of the U.S. Department of Homeland Security, as well as their Mexican counterparts.
5. Our final recommendation is that we would like to see the initiation of a new era in US—Mexican relations, one that is based on cooperation and collaboration, rather than competition and discord.

"Ultimately, a robust field of fence ecology will be well positioned to provide the science to manage and mitigate one of humankind's most pervasive alterations of our planet."

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Acknowledgments.—We acknowledge all the scientists, environmentalists, and institutions on both sides of the US/Mexico border for their numerous and continued efforts on many fronts, but especially with the goal of protecting the rich biodiversity found across this boundary. Our work is dedicated to all these people and their institutions. VMS, ABGC, AR, and AFT were funded by a UTEP University Research Institute award. Lastly, we are very grateful to two anonymous reviewers for their insightful comments to the manuscript.

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Vicente Mata-Silva is a herpetologist originally from Río Grande, Oaxaca, Mexico, with a strong focus on the ecology, conservation, natural history, and biogeography of herpetofaunas in Mexico, Central America, and the southwestern United States. He earned his bachelor's degree from the Universidad Nacional Autónoma de México (UNAM), and both his master's and Ph.D. from the University of Texas at El Paso (UTEP). Currently, Vicente is an Associate Professor of Instruction of Biological Sciences at UTEP within the Ecology and Evolutionary Biology Program, and Director of UTEP's 41,200-acre Indio Mountains Research Station, located in the Chihuahuan Desert of Trans-Pecos, Texas. To date, Vicente has authored or co-authored over 190 peer-reviewed scientific publications. He also serves as an Associate Editor for the journal *Herpetological Review*, and is a Taxonomic Board member for the website *Mesoamerican Herpetology.*

Ana Bertha Gatica-Colima was born in Tijuana, Baja California, Mexico, and is a biologist with an M.S. in Management of Arid Zones from the Universidad Autónoma de Baja California, and a Ph.D. in Natural Resources from the Universidad Autónoma de Chihuahua. She was awarded a Diploma in Herpetology by the Sociedad Herpetológica Mexicana AC, and is a founding teacher of the Biology Program at the Universidad Autónoma de Ciudad Juárez. She is a researcher responsible for the Animal Ecology and Biodiversity Laboratory, where the scientific collection is maintained. This collection contains specimens of vertebrates mostly from the Chihuahuan Desert in the state of Chihuahua, Mexico. Ana has taught undergraduate students (in courses on chordate biology, fieldwork biology, and management of arid zones), and has been working with reptiles and amphibians for about 30 years. Her main interests are rattlesnakes of the genus *Crotalus* from the Sonoran and Chihuahuan deserts, although she also has worked with other colleagues on various aspects of vertebrate research. Ana has directed about 100 theses (undergraduate and graduate students), and has received grants for several projects, including three from CONABIO. She has participated in revising amphibian and reptile species proposals to be included, excluded, or have their categories changed in the SEMARNAT Norm. About 45 of her publications have appeared in refereed journals, and she has participated in national and international academic meetings. Ana is an active member of the Sociedad Herpetológica Mexicana AC, the Society for the Study of Amphibians and Reptiles, and the Southwestern Association of Naturalists. She also likes hiking and taking photos for Naturalista.

Dominic DeSantis, Ph.D., is an Associate Professor of Vertebrate Biology at Georgia College & State University, in Milledgeville, Georgia USA. He earned his B.S. in Wildlife Biology from Texas State University in 2013 and his Ph.D. in Ecology and Evolutionary Biology from the University of Texas at El Paso (UTEP) in 2019. While at UTEP, Dr. DeSantis was a National Science Foundation-Graduate Research Fellow from 2016–2019. Dr. DeSantis' research interests include the behavioral ecology and conservation biology of herpetofauna, and his work in these areas has produced 79 peer-reviewed publications (32 journal articles, one book chapter, and 46 research notes).

Arturo Rocha is a Ph.D. student in the Ecology and Evolutionary Biology program at the University of Texas at El Paso. His interests include the study of biogeography, physiology, and ecology of amphibians and reptiles in the southwestern United States and Mexico. A graduate of the University of Texas at El Paso, his thesis centered on the spatial ecology of the Trans- Pecos Rat Snake (*Bogertophis subocularis*) in the northern Chihuahuan Desert. To date, he has authored or co-authored over 20 peer-reviewed scientific publications.

Uriel Hernández-Salinas is a herpetologist and co-author of three books: Herpetofauna del Valle de México: Diversidad y Conservación, Lista Anotada de los Anfibios y Reptiles del Estado de Hidalgo, México, and Los Anfibios y Reptiles del Estado de Hidalgo: Diversidad, Biogeografía y Conservación. He is a full-time professor and curator of the scientific collection of amphibians and reptiles at CIIDIR Durango-IPN. His main topics of interest are biodiversity, species richness, biogeography, and evolution of life histories of various species of the amphibians and reptiles of Mexico.

Manuel Nevárez-de los Reyes is a biologist who graduated from the Universidad Autónoma de Nuevo León in San Nicolás de los Garza, Mexico. His initial interest was in the study of amphibians and reptiles, but his professional life led him to investigate other areas, such as environmental impact and the study of cacti. From 1997 to 2007 he served as head of Environmental Protection in the Residencia Regional de Construcción Noreste of the Federal Electricity Commission. Manuel has been involved with numerous workshops and conferences, and has authored both popular science and peer-reviewed articles on herpetology and cacti. Among his accomplishments, he discovered a new genus and species of cactus, *Digitostigma caput-medusae*, and in 2002 co-authored its original description. The following year he created "Proyecto Digitostigma," a nursery dedicated to the commercial propagation of this and other cacti species, which contributes to their knowledge and conservation. In 2016, Manuel obtained a Ph.D. in Wildlife Management and Sustainable Development at the Universidad Autónoma de Nuevo León, with a thesis entitled "Ecological distribution of the herpetofauna of the Sierra de Gomas in northern Nuevo León," under a grant from the National Council of Science and Technology. For some years now, he has been collaborating with a consulting firm in the preparation of environmental impact studies and supervision of projects, mainly within the renewable energy sector.

Jorge H. Valdez-Villavicencio is a herpetologist from Baja California, Mexico. He obtained his Bachelor's degree at the Universidad Autónoma de Baja California (UABC), and his Master's degree in management and conservation of natural resources at the Centro de Investigaciones Biológicas del Noroeste in La Paz, Baja California Sur. He has collaborated on various projects related to the monitoring, research, and conservation of wildlife, mainly amphibians and reptiles in the Baja California peninsula, and is an Associated Curator of the Herpetological Collection of the UABC. Currently, he is the Research Coordinator and founding member of Fauna del Noroeste, a non-profit organization that seeks to promote local biodiversity conservation based on scientific research. His main research interest is focused on the ecology and conservation of amphibians and reptiles.

Louis W. Porras received an AA degree in Biology in 1971 from what today is called Miami-Dade College, where he studied under the late Albert Schwartz. Over the years he has authored or co-authored over 60 academic publications, including the descriptions of two new species, and two taxa have been named in his honor. Louis developed an interest in amphibians and reptiles at an early age in his native Costa Rica, and in 1955 his family relocated to the United States. Throughout his career a passion for the field has led him to travel to many remote areas, including throughout the Bahamas, the United States, Mexico, and Central America, as well as to parts of South America and Asia. As a teenager Louis regularly attended meetings of the South Florida Herpetological Society, and eventually served as President of the group. In 1968 he worked at the Houston Zoological Gardens, under the tutelage of the late John E. Werler, and from 1982 to 1984 he was employed at Utah's Hogle Zoo, in close association with the late James L. Glenn and the VA Venom Research Laboratory. In 1976 he attended the inaugural meeting of the International Herpetological Symposium (IHS), and for many years served the group in various capacities, including as Vice-President and President. In 1993, along with Gordon W. Schuett, he conceptualized and helped launch the journal *Herpetological Natural History*, and for IHS' 20th anniversary three former Presidents dedicated a special publication, *Advances in Herpetoculture*, in recognition of his contributions. More recently, in honor of his lifelong achievements IHS initiated the "Louie Porras Award," which is presented to the speaker at the annual meeting whose work represents exceptional accomplishments that benefit herpetological conservation. Louis' career in publishing started in 1995, when as a member of Canyonlands Publishing Group he served as Managing Director and Editorial Director of *Fauna* magazine. In 2002 he founded Eagle Mountain Publishing, LC, which to date has published such herpetological titles as *Biology of the Vipers* (2002), *Biology of the Boas and Pythons* (2007)*, Amphibians, Reptiles, and Turtles in Kansas* (2010), *Conservation of Mesoamerican Amphibians and Reptiles* (2010), and *Amphibians and Reptiles of San Luis Potosí* (2013); from 2014 to 2019 Louis was the Publisher and Managing Editor of the electronic journal *Mesoamerican Herpetology*, and recently he was the publisher and co-editor of the book *Advances in Coralsnake Biology*: *with an Emphasis on South America.*

Anna F. Tipton is currently a PhD student at the University of Texas at El Paso and completed her MS in biology at Georgia College & State University. Her research thus far has centered on the impacts of anthropogenic influences on rattlesnake behavior, and she is broadly interested in the behavioral ecology, natural history, and conservation biology of herpetofauna. She has collaborated on projects involving disease ecology and the application of novel biologging techniques and hopes to expand the focus of her research into the social behavior of herpetofauna. Anna is an active member herpetological societies including the Herpetologists' League, the Society for the Study of Amphibians and Reptiles, and Partners in Amphibian and Reptile Conservation, and has authored or co-authored numerous publications in the field of herpetology.

Matthew Montoya is a graduate student in the Environmental Science program at the University of Texas at El Paso, and a current employee of Texas Parks and Wildlife. He has been involved in various projects such as pronghorn restoration, capture and collaring of mule deer and aoudad, and the recent translocation of bighorn sheep to the Franklin Mountains. His interests include the behavior and ecology of mammals and squamates in the Chihuahuan Desert, as well as outreach in the Trans-Pecos region of Texas. Matthew is a park ranger at the Franklin Mountains State Park in El Paso, Texas and actively monitors rattlesnake and bighorn populations using telemetry and remote sensing.

David Lazcano was a distinguished herpetologist and a dedicated professor at the Universidad Autónoma de Nuevo León (UANL). He held multiple degrees from UANL's Facultad de Ciencias Biológicas, including a Bachelor of Chemical Science (1980), a Bachleor of Biology (1982), a Master's in Wildlife Management (1999), and a PhD in Biological Science with a specialization in Wildlife Management (2005). David was a full-time professor at UANL, where he taught courses such as animal behavior, biogeography, biology of chordates, and wildlife management. He also served as the head of the Laboratorio de Herpetología and the Coordinación de Intercambio Académico within the Facultad de Ciencias Biológicas. Since 1979, he had actively contributed to both undergraduate and graduate programs. David's research primatily focused on the herpetofaunal diversity of northeastern Mexico, and his broader interests encompassed ecology, herpetology, biology of chordates, biogeography, animal behavior, and population maintenance techniques of montane herpetofauna.

Larry David Wilson was a renowned herpetologist with lengthy experience in Mesoamerica who passed away from leukemia on 28 April 2024. He was born in Taylorsville, Illinois, USA, and received his university education at the University of Illinois at Champaign-Urbana (B.S. degree) and at Louisiana State University in Baton Rouge (M.S. and Ph.D. degrees). He authored or co-authored 488 peer-reviewed papers and books on herpetology. Larry was the senior editor of *Conservation of Mesoamerican Amphibians and Reptiles* (2010) and a co-author of seven of its chapters. His other books include *The Snakes of Honduras* (1985), *Middle American Herpetology* (1988), *The Amphibians of Honduras* (2002), *Amphibians & Reptiles of the Bay Islands and Cayos Cochinos, Honduras* (2005), *The Amphibians and Reptiles of the Honduran Mosquitia* (2006), and *Guide to the Amphibians & Reptiles of Cusuco National Park, Honduras* (2008). He was also the co-author of 16 entries in the Mexican Conservation series, which dealt with the herpetofauna of the states of Michoacán, Oaxaca, Chiapas, Tamaulipas, Nayarit, Nuevo León, Jalisco, Puebla Coahuila, Hidalgo, Veracruz, Querétaro, Tabasco, Guanajuato, and the Baja California Peninsula, as well as the tri-state Mexican Yucatan Peninsula. In addition, he was a co-author of several significant publications on the development and extensive application of the EVS measure and on conservation issues related to the Mexican and Central American herpetofaunas. He authored or co-authored the descriptions of 76 currently recognized herpetofaunal species, and six species have been named in his honor, including the anuran *Craugastor lauraster*, the lizard *Norops wilsoni*, as well as coccidian parasite *Isospora wilsoni.* In 2005 he was designated a Distinguished Scholar in the Field of Herpetology at the Kendall Campus of Miami-Dade College by the then-campus president Dr. Wasim Shomar. Larry also served as a Co-chair of the Taxonomic Board for the website Mesoamerican Herpetology.

Table A2. Pair-wise comparison matrix of Coefficient of Resemblance (CR) data of herpetofaunal relationships for the 10 states lying along the U.S.–Mexico. Underlined values = number of species in each region; upper triangular matrix values = species in common between two regions; and the lower triangular matrix values = the CBR values. The formula for this algorithm is CBR = $2C/N_1 + N_2$ (Duellman, 1990), where C is the number of species in common to both regions, N_1 is the number of species in the first region, and N_2 is the number of species in the second region. See Table 3 for an explanation of the abbreviations and Fig 1 for the UPGMA dendrogram produced from the CR data.

	CA	BC	AZ	SO	NM	CH	TX	CO	NL	TM
CA	**79**	73	41	36	26	24	20	18	14	11
BC	0.95	**74**	36	32	21	20	16	14	10	10
AZ	0.43	0.39	**111**	98	71	78	49	44	32	33
SO	0.40	0.36	0.92	**103**	65	73	45	40	30	30
NM	0.29	0.24	0.67	0.64	**100**	89	72	65	44	45
CH	0.25	0.21	0.69	0.68	0.84	**113**	81	75	50	51
TX	0.19	0.16	0.41	0.39	0.63	0.67	**129**	98	75	89
CO	0.20	0.16	0.42	0.39	0.65	0.70	0.85	**101**	70	69
NL	0.18	0.13	0.34	0.33	0.49	0.52	0.72	0.77	**80**	66
TM	0.12	0.12	0.32	0.31	0.47	0.50	0.80	0.71	0.76	**93**

Table A3. Pair-wise comparison matrix of Coefficient of Resemblance (CR) data of herpetofaunal relationships for the seven ecoregions lying along each side of the U.S.–Mexico border. Underlined values = number of species in each region; upper triangular matrix values = species in common between two regions; and lower triangular matrix values = CBR values. The formula for this algorithm is CBR = $2C/N_1 + N_2$ (Duellman, 1990), where C is the number of species in common to both regions, N_1 is the number of species in the first region, and N_2 is the number of species in the second region. See Table 2 for explanation of abbreviations and Fig 2 for the UPGMA dendrogram produced from the CR data.

	CC	CM	SD	MA	CD	ST	GC
CC	**48**	37	19	7	7	3	4
CM	0.84	**40**	12	6	6	3	3
SD	0.30	0.20	**79**	40	28	13	9
MA	0.12	0.11	0.53	**73**	35	13	10
CD	0.09	0.09	0.31	0.40	**100**	46	40
ST	0.06	0.06	0.19	0.20	0.58	**59**	38
GC	0.07	0.06	0.13	0.15	0.48	0.61	**65**

Table A4. EVS values and categorizations for the U.S.–Mexico border herpetofauna, arranged by states. The EVS categories are as follows: L = low vulnerability; M = medium vulnerability; and H = high vulnerability.

States	EVS Values and Categorizations																			
	3	**4**	**5**	**6**	**7**	**8**	**9**	**L**	**10**	**11**	**12**	**13**	**M**	**14**	**15**	**16**	**17**	**18**	**H**	**Total**
California	1	1	3	—	2	8	9	**24**	13	9	11	6	**39**	10	5	1	—	—	**16**	**79**
Baja California	1	1	2	—	2	8	9	**23**	12	7	10	6	**35**	11	4	1	—	—	**16**	**74**
Arizona	1	1	3	3	4	12	6	**30**	15	15	12	13	**55**	13	11	2	—	—	**26**	**111**
Sonora	2	1	3	2	4	11	6	**29**	13	16	10	12	**51**	11	10	2	—	—	**23**	**103**
New Mexico	—	1	3	3	6	8	8	**29**	12	13	10	11	**46**	15	8	1	—	1	**25**	**100**
Chihuahua	1	1	3	3	5	10	9	**32**	15	17	11	13	**56**	15	8	1	—	1	**25**	**113**
Texas	3	2	4	5	6	9	9	**38**	13	13	16	17	**59**	16	10	4	—	2	**32**	**129**
Coahuila	1	1	3	4	6	6	9	**30**	10	12	11	16	**49**	12	6	2	—	2	**22**	**101**
Nuevo León	—	1	2	4	4	6	7	**24**	6	13	8	11	**38**	10	3	4	—	1	**18**	**80**
Tamaulipas	3	1	4	6	5	7	7	**33**	7	13	11	10	**41**	10	4	4	—	1	**19**	**93**
Totals	**13**	**11**	**30**	**30**	**44**	**85**	**79**	**—**	**116**	**128**	**110**	**115**	**—**	**123**	**69**	**22**	**—**	**8**	**—**	**—**

Table A5. EVS values and categorizations for the U.S.–Mexico border herpetofauna, arranged by ecoregions. See Table 2 for explanation of abbreviations. EVS categories as follows: L = low vulnerability; M = medium vulnerability; and H = high vulnerability.

Ecoregions	EVS Values and Categorizations																			
	3	**4**	**5**	**6**	**7**	**8**	**9**	**L**	**10**	**11**	**12**	**13**	**M**	**14**	**15**	**16**	**17**	**18**	**H**	**Total**
CC	—	1	2	—	2	6	6	**17**	8	4	8	3	**23**	7	1	—	—	—	**8**	**48**
CM	—	—	1	—	2	5	5	**13**	6	3	8	2	**19**	7	1	—	—	—	**8**	**40**
SD	1	1	3	1	4	9	6	**25**	11	8	6	9	**34**	10	8	2	—	—	**20**	**79**
MA	—	1	2	2	4	9	6	**24**	12	11	5	7	**35**	7	6	1	—	—	**14**	**73**
CD	2	1	2	2	6	7	9	**29**	12	12	8	14	**46**	11	9	3	—	2	**25**	**100**
ST	2	—	2	4	3	2	7	**20**	2	10	9	6	**27**	6	1	4	—	1	**12**	**59**
GC	3	1	3	4	4	5	6	**26**	4	7	10	6	**27**	3	4	4	—	1	**12**	**65**
Totals	**8**	**5**	**15**	**13**	**25**	**43**	**45**	**—**	**55**	**54**	**54**	**47**	**—**	**51**	**30**	**14**	**—**	**4**	**—**	**—**