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Landscape change and conservation priorities: Mexican herpetofaunal perspectives at local and regional scales

Cambios en el paisaje y prioridades de conservación: una perspectiva herpetofaunística mexicana a escalas local y regional

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Abstract. Few studies have demonstrated historical human impact on biodiversity at local and regional scales, largely due to lack of baseline information and long term monitoring for most taxa. In 1958 and 1959 researchers from the Museum of Vertebrate Zoology (MVZ) visited the Mexican state of Aguascalientes and increased its documented amphibian and reptile fauna from 21 to 30 species. Using MVZ collections, field notes, and landscape photographs taken during that expedition, we resurveyed those same localities in 2004 to document herpetofaunal changes coincident with greatly increased human activities. Despite its small area, Aguascalientes encompasses several biogeographic regions and the threat of local extinction at species' distributional limits has broader implications for regional biotas. New discoveries raise to 71 the number of species known for that state, but our comparisons suggest a gloomy future for amphibians and reptiles in Aguascalientes. Paradoxically, human impact is managed primarily at state and municipal levels, often devoid of locally relevant context. Our findings illustrate the conservation value of intensive small-scale studies, focused on the natural history of particular species and localities, as complements to large-scale biodiversity assessments on country wide and continental scales.

Key words: Aguascalientes, reptiles, amphibians, landscape history, conservation.

Resumen. Pocos estudios han demostrado el impacto humano histórico en la biodiversidad a escalas local y regional debido a la carencia de monitoreo para la mayoría de los grupos taxonómicos. En 1958 y 1959 investigadores del Museum of Vertebrate Zoology (MVZ) visitaron Aguascalientes, México y elevaron de 21 hasta 30 el número de especies de anfibios y reptiles para el estado. Usando la colección, notas de campo y fotografías de paisaje tomadas durante esas expediciones, visitamos esas localidades en 2004 para documentar cambios en la herpetofauna asociados con el incremento en actividades humanas. En Aguascalientes se encuentran varias regiones biogeográficas, y la posibilidad de extinciones locales en los límites de distribución de especies tiene implicaciones importantes para la fauna regional. Nuevos descubrimientos elevan a 71 el número de especies, pero nuestras comparaciones sugieren un futuro pesimista para la herpetofauna. Paradójicamente, aunque el impacto humano principalmente tiene un manejo estatal y municipal, frecuentemente se hace sin un contexto local relevante. Nuestros hallazgos ilustran el valor complementario para la conservación de estudios locales e intensivos con foco en la historia natural de especies, en conjunción con evaluaciones de biodiversidad a nivel de país y de continente.

Palabras clave: Aguascalientes, reptiles, anfibios, historia de paisaje, conservación.

Introduction

Biological conservation is fundamentally concerned with human impacts on species and their environments; however, few studies have shown in detail how we have historically affected the persistence of vertebrates in natural habitats, due in large part to lack of long term monitoring. Most temporal comparisons of diversity span less than 1 generation of the organisms under study (Willis et al., 2005) and we generally lack baselines with which to evaluate biotic changes. Repetitions of historical surveys thus provide excellent opportunities to assess long-term changes due to anthropomorphic effects, especially if collecting efforts and techniques can be replicated. Re-censusing can supply information on presence and absence of species, as well as document changes in population size and distribution, promote the discovery of new species, and guide management of natural areas (Knight, 2003).

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Projects that evaluate landscape change with historical information are scarce and their results contradictory: some have increased the number of species known for a surveyed region, others reported persistence of species, and still others documented species extinctions and colonizations (Lannoo et al., 1994; Robinson, 1999; Mendoza-Quijano et al., 2001; Gibbs et al., 2005; Hossack et al., 2005). Although frequently qualitative rather than quantitative, and only rarely repeatable in a consistent and statistically comparable fashion, historical databases have nonetheless been important because they are the only standard we have with which to estimate diversity, population trends, and suggest factors responsible for species declines and colonizations (Lannoo et al., 1994; Robinson, 1999; Brodman et al., 2002; Gibbs et al., 2005). Historical studies of landscape changes have been used to document the effects of human activities (Mendoza-Quijano et al., 2001), assess extinction risks for songbirds (Schrott et al., 2005), and evaluate changes in species richness and population sizes (Robinson, 1999).

Most studies of historical ecological change have focused on temperate regions and conservation assessments have increasingly emphasized large spatial scales. The recent publication of a country-wide analysis of distributional patterns in México's herpetofauna (Ochoa Ochoa and Flores Villela, 2006) is an invaluable contribution to tropical conservation planning and underscores the need for complementary, fine scale studies. We chose the central Mexican state of Aguascalientes for analysis of landscape change and conservation of amphibians and reptiles for several reasons: 1) historical information from expeditions by personnel from the University of California Museum of Vertebrate Zoology (MVZ) almost 50 years ago is available as a baseline; 2) Aguascalientes has an area of 5,589 km^2 (INEGI, 1995), making it the fifth smallest state in México and suitable for rapid, yet thorough assessment; 3) Aguascalientes is positioned at the intersection of several biogeographically interesting faunal components: Sierra Madrean and Trans-Volcanic Belt forests, arid Mexican Plateau deserts, and subtropical vegetation dividing the 2 main forested areas, Sierra Fría and Sierra del Laurel (INEGI, 2005).

Using the MVZ records and documented collection localities, we resurveyed amphibians and reptiles across Aguascalientes, with the goal of assessing faunal changes concomitant with almost a half century of continuing human impact. Our results show that the herpetofauna remains substantially intact but is widely threatened by extensive land conversion. We also pinpoint specific taxa and ecosystems for emphasis in management planning, and highlight the importance of natural history research in local and regional conservation activities (Greene, 2005).

Material and methods

The amphibians and reptiles of Aguascalientes began to receive attention early in the past century, and intensive collecting efforts commenced more recently when W. Z. Lidicker and colleagues at the MVZ surveyed the state in 1958 and 1959 (Anderson and Lidicker, 1963). This expedition was the most important zoological collecting effort up to that time, in both number of species newly reported for the state and geographic coverage. The MVZ expedition sampled almost every major physiographic region and increased from 21 to 30 the known number of species of amphibians and reptiles in the state. Several publications since then dealt exclusively with the state's reptiles and amphibians, and thus the herpetofauna is becoming well known. As of 2008, 71 species of amphibians and reptiles were recorded for Aguascalientes, representing the 6% of the species reported for the country and making it 1 of the states with the lowest number of species of amphibians and reptiles (Flores Villela and Gerez, 1994; Flores-Villela and Canseco, 2004). The rate of species discovery has been constant since 1945 and shows no sign of an asymptote (Fig. 1), with all species being native but *Hemidactylus turcicus* (Mediterranean Gecko) and *Ramphotyphlops braminus* (Braminy Blind Snake).

We used the baseline information from the MVZ (Anderson and Lidicker, 1963) to compare the status of several collection localities for amphibians and reptiles over a period of ca. 45 years. We examined all relevant field notes and specimens, and interviewed W. Z. Lidicker Jr. regarding details of the expedition. For brevity, we sometimes refer to the 1958-1959 expeditions as *original* or *MVZ* and to our 2004 surveys as *recent*.

The original expeditions included an exploratory/non-collecting trip in 1956 and periods of intensive fieldwork in July of 1958 and 1959. Eighteen collecting localities were mentioned by Anderson and Lidicker (1963) and 6 localities were photographed with recognizable landscape features. After checking field notes and visiting the actual collecting localities we determined that 2 were the same site visited on 2 separate occasions, 5 were geographically too close to recognize individually (making them effectively 2 localities), and 2 did not yield herpetological material. The final number of collecting localities in 2004 was thus reduced to 12 (Fig. 2, Table 2), and field work was planned such that roughly the same amount of time was spent at each locality. The MVZ expeditions spent a total of 36 days in the field between July 8-28 in 1958 and 1959, whereas we worked for 26 field days between July 6 and August 20 in 2004.

The number of people participating in fieldwork was

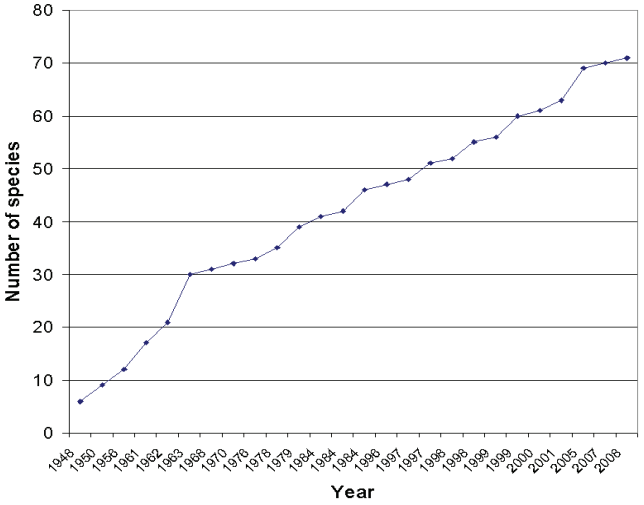

Figure 1. Increase in the number of species of amphibians and reptiles reported from Aguascalientes, México. Years on the X axis correspond to dates of publications that added species (based on Burt, 1931; Smith and Taylor, 1945; Smith and Taylor, 1948; Smith and Taylor, 1950; Chrapliwy, 1956; Chrapliwy et al., 1961; Banta, 1962; Anderson and Lidicker, 1963; Zweifel, 1968; McDiarmid and Scott, 1970; Thomas and Dixon, 1976; Harris and Simmons, 1978; Smith and Smith, 1979; Wilson and McCranie, 1979; McCranie and Wilson, 1984; Camper, 1996; Sigala Rodríguez and Vázquez-Díaz, 1996; Vázquez-Díaz and Quintero-Díaz, 1997; Ramírez-Bautista et al., 1998; Vázquez-Díaz et al., 1998a; Vázquez-Díaz et al., 1998b; Vázquez-Díaz et al., 1998c; Quintero-Díaz et al., 1999b; Quintero-Díaz et al., 1999a; Vázquez-Díaz and Quintero-Díaz, 1999; Vázquez-Díaz et al., 1999a; Vázquez-Díaz et al., 1999b; Quintero-Díaz et al., 2001; Vázquez-Díaz and Quintero-Díaz, 2005; Quintero-Díaz et al., 2007; Sigala Rodríguez et al., 2008).

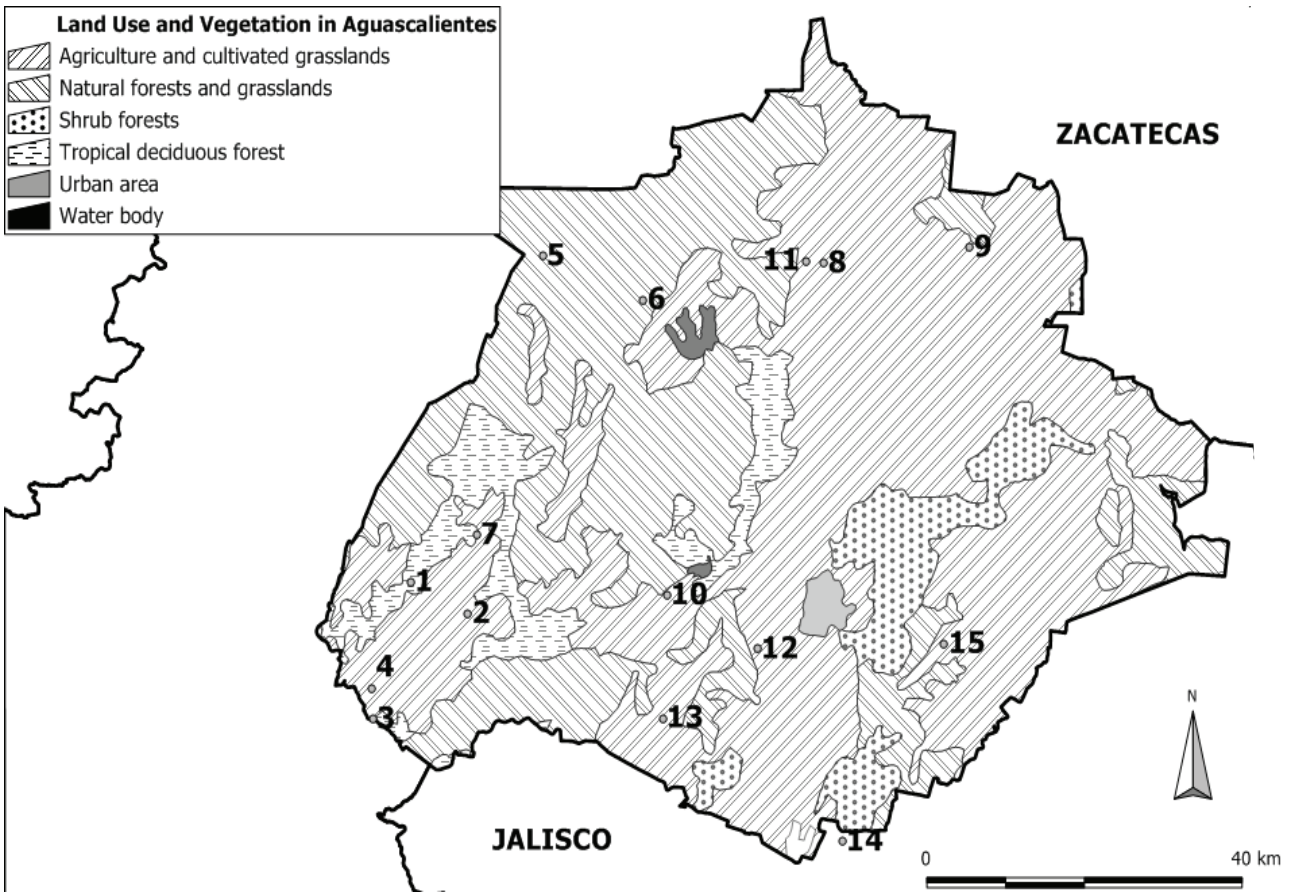

Figure 2. Major vegetation types and current land use patterns in Aguascalientes, México (Modified from CONABIO, 1998). Numbers correspond to localities that were surveyed and/or photographed, locality details can be seen in Table 1.

Table 1. Details for the surveyed localities. For each site the following information is given: Site ID refers to the numbers in map in Figure 2, locality, general locality as originally stated in Anderson and Lidicker (1963), latitude and longitude in decimal degrees, and whether the site was collecting locality, photographed locality, or both

Site 1: El Tigre, Calvillo, Ags., "4½ miles northwest of Calvillo", 21.901167, -102.76737 , Collecting locality, landscape photographs available.
Site 2: El Chiquihuitero, Calvillo, Ags., "2 miles north of Calvillo", 21.8697, -102.70212, Collecting locality.
Site 3: Road Calvillo-Jalpa, east of state boundary with Jalisco, Ags., "¼ mile east of the state boundary", "8 miles southwest of Calvillo" and "7½ miles west-southwest of Calvillo", 21.764883, -102.81018, Collecting locality.
Site 4: Presa Media Luna, Calvillo, Ags., "5½ miles west of Calvillo", 21.79595, -102.81152, Collecting locality.
Site 5: North of Presa de la Araña, Sierra Fría, Ags., "3 miles north of Cerro del Jaguey", 22.224033, -102.61683, Collecting locality, landscape photographs available.
Site 6: Barranca Ventanillas, San José de Gracia, Ags., two visits to "8 miles west-northwest of Col. Pres. Calles", 22.180533, -102.50197, Collecting locality, landscape photographs available.
Site 7: La Labor, Calvillo, Ags., "1 km. south of La Labor" and "½ mi. south of La Labor", 21.947533, -102.69243, Collecting locality.
Site 8: East of Rincón de Romos, Ags., "1¼ miles east of town" Rincón de Romos, 22.219454, -102.31677, Collecting locality.
Site 9: East of Tepezalá, Ags., "2 mi. east of Tepezalá" 22.232833, -102.12987, Collecting locality.
Site 10: Venaderos, west of the city of Aguascalientes, Ags. "Venadero (sic)… 13 miles west of Aguascalientes", 21.887967, -102.47555, Collecting locality.
Site 11: South of Rincón de Romos, Ags., "1/3 mile south" of Rincón de Romos, 22.216917, -102.29598, Collecting locality. Surveyed in 1958 but just briefly in 2004 because it is composed of small inhabited properties.
Site 12: Ciudad de los Niños, Ags., "Ciudad de los Niños (1/3 mile west)", 21.834591, -102.37258, Collecting locality, this place was being used as an extended cattle enclosure when we visited in 2004.
Site 13: Los Caños, Aguascalientes, not mentioned in the article, 21.765883, -102.48033, non-collecting locality, landscape photographs available.
Site 14: Road 45, junction to Teocaltiche, not mentioned in the article, 21.643407, -102.27553, non-collecting locality, landscape photographs available.
Site 15: Road 70 to San Luis Potosí, not mentioned in the article, 21.839749, -102.15906, non-collecting locality, landscape photographs available.

the same in both surveys. We sampled opportunistically, walking in the areas surrounding the localities and paying attention to suitable microhabitats (Casas-Andreu et al., 1991; Simmons, 2002), such that 579 person-hours were spent searching, looking for original locations, and questioning local residents about photographs when it was difficult to find the original photographed locality. We also re-photographed 6 sites that had recognizable features in the 1956 to 1959 images, insofar as possible from the same vantage points, to evaluate historical changes at the landscape level. Finally, shared ecological characteristics of species have proved important for identifying causes of populations declines and extinctions (Kotiaho et al., 2005), and we therefore used natural history data for the Aguascalientes herpetofauna to identify species especially prone to conservation threats.

Results

The total number of specimens encountered in the surveys was 99 in 1958-1959 and 114 in 2004. We documented 37 species in 2004, compared to 18 in the original surveys. We found 16 out of the 18 species found in 1958-1959 and 21 additional species (Table 2). Among those found in 2004, the colubrid snakes *Coluber taeniatus* (Striped Whipsnake) and *Tantilla wilcoxi* (Chihuahuan Black-headed Snake), both from the poorly studied northeastern portion, were new records for Aguascalientes (see references in caption for Figure 1). In addition, reports in progress on *Pseudoeurycea bellii* (Bell's Salamander), the gecko *Hemydactylus turcicus*, and the snakes *Pituophis catenifer* (Gopher Snake) and *Storeria storerioides* (Mexican Brown Snake) will bring the total number of species of amphibians and reptiles to 71 (Vázquez-Díaz and Quintero-Díaz, 2005). We did not find 2 species that were recorded in 1958-1959, *Craugastor augusti* (Barking Frog) and *Holbrookia maculata* (Lesser Earless Lizard).

The 6 localities photographed in the original surveys represent a diverse array of environments and regions in Aguascalientes, encompassing the more xeric eastern portion of the state, high elevation oak forest in the west, and mid-elevation thorn shrub in central and southern parts of the state (Fig. 3 for a selection of photographs). Comparison between the original and the new photographs reveal several patterns: all of them show signs of human disturbance in one way or another; 5 of the 6 photographs show agricultural crops replacing almost completely the natural vegetation; 3 have drastic changes in vegetation composition that are not due to agricultural crops, but only

Table 2. Species found in the original (1958-1959) and the recent surveys, common names following Crother (2008), Liner (1997), and relative abundances as considered by Vázquez-Díaz and Quintero-Díaz (2005): AB=Abundant, CO=common, RA=rare

Species	*English common name*	*Found 1958-1959*	*Found in 2004*	*Relative abundance*
Anaxyrus compactilis	Plateau Toad		X	CO
A. punctatus	Red-spotted Toad	X	X	AB
Craugastor augusti	Barking Frog	X		CO
Hyla arenicolor	Canyon Treefrog	X	X	AB
H. eximia	Mountain Treefrog		X	AB
Hypopachus variolosus	Sheep Frog		X	CO
Lithobates montezumae	Montezuma Leopard Frog		X	AB
L. pipiens	Northern Leopar Frog	X	X	RA
Spea multiplicata	Mexican Spadefoot	X	X	CO
Kinosternon integrum	Mexican Mud Turtle	X	X	AB
Anolis nebulosus	Clouded Anole	X	X	CO
Aspidoscelis gularis	Common Spotted Whiptail	X	X	CO
Barisia ciliaris	Imbricate Alligator Lizard	X	X	CO
Holbrookia maculata	Lesser Earless Lizard	X		?
Plestiodon lynxe	Oak Forest Skink		X	CO
Phrynosoma orbiculare	Mountain Horned Lizard	X	X	CO
Sceloporus grammicus	Mesquite Lizard	X	X	AB
S. horridus	Horrible Spiny Lizard	X	X	AB
S. jarrovii	Yarrow's Spiny Lizard		X	AB
S. scalaris	Bunch Grass Lizard		X	CO
S. spinosus	Spiny Lizard	X	X	CO
Sceloporus torquatus	Crevice Swift	X	X	AB
Urosaurus bicarinatus	Tropical Tree Lizard		X	CO
Coluber bilineatus	Sonoran Whipsnake		X	RA
C. mentovarius	Neotropical Whipsnake		X	RA
C. taeniatus	Striped Whipsnake		X	RA
Conopsis nasus	Large Nose Earthsnake		X	AB
Crotalus lepidus	Rock Rattlesnake	X	X	AB
C. molossus	Black-tailed Rattlesnake	X	X	CO
Hypsiglena torquata	Night Snake		X	RA
Oxybelis aeneus	Brown Vinesnake		X	RA
Pituophis deppei	Mexican Bullsnake		X	RA
Salvadora bairdi	Baird's patchnose snake		X	RA
Senticolis triaspis	Green Ratsnake		X	CO
Tantilla bocourti	Boucort's Blackhead Snake		X	RA
T. wilcoxi	Chihuahuan black-headed Snake		X	RA
Thamnophis cyrtopsis	Black-necked Gartersnake			CO
T. eques	Mexican Gartersnake	X		CO
T. melanogaster	Mexican Blackbelly Watersnake		X	RA

1 displays favorable changes in the sense of an increase in oaks, while in the other 2 oaks and grasses were replaced by *Dodonaea viscosa*, a plant indicative of habitat degradation. Four photographs have bigger or new roads in them and 1 shows the increase in size of Calvillo, the most populous human settlement in western Aguascalientes.

Figure 3. Selected original and recent landscape photographs. They correspond to Site 1 El Tigre (top), Site 5 Sierra Fría (middle), and Site 13 Los Caños (bottom). Recurrent issues in these and other photographs are evident: growth of populated places, replacement of natural vegetation by agricultural fields, appearance of roads and urban vegetation (top and bottom), and the recovery of the oak forests in Sierra Fría (middle).

Discussion

Our study evaluated changes in the herpetofauna of Aguascalientes over a period of almost 50 years, by using historical data and landscape photographs in the context of intensive re-sampling. Of the only 2 species missing in our recent surveys, *Craugastor augusti* is a frog with cryptic behavior and ecology (Goldberg and Schwalbe, 2004), and we have found it in previous years in the Sierra Fría, so it is still present in the state. The first specimen of *Holbrookia maculata* in Aguascalientes was collected in 1959, several individuals were observed and 1 collected in 1971 (Anderson and Lidicker, 1963; McCranie and Wilson, 2001), and its absence in our recent surveys is puzzling, especially because this is a conspicuous species in other localities where it does occur (Stebbins, 2003). The *H. maculata* locality is in the middle of the first irrigation district in México, and its establishment, with the subsequent increase in agricultural activities and change in land use, might explain the absence of *H. maculata*. Perhaps this species is more vulnerable than previously thought, as elsewhere it has disappeared even where it was abundant as recently as 1982 (Taggart, 2006). Although we can not confidently assert that the species is eradicated from Aguascalientes, we encourage studies focused on this species to determine with certainty its status in the state.

The taxonomic status of the several species of *Lithobates* (Frost et al., 2006) in the southern part of the Mexican Plateau has been historically in flux, and older references to *L. pipiens* may have pertained to several species in the *L. pipiens* complex (Hillis, 1988). The specimens found in Aguascalientes in 1958 and 1959 seem to be part of what is now known as the *Stertirana* complex (Hillis and Wilcox, 2005) and most similar to *L. montezumae*, a species common throughout the state and that we found in 2004.

Several new records of amphibians and reptiles for Aguascalientes resulted from our 2004 and other recent surveys, and clearly, the rate of species discovery has not yet reached a plateau. That we encountered more species in 2004 than were found in 1958-1959 cannot be attributed to the improvement of habitat conditions in subsequent decades, and invasions seem unlikely. Instead, we think the differences reflect the MVZ expeditions' preoccupation with mammals and birds, whereas we focused exclusively on amphibians and reptiles; they recorded 40 species of birds and 39 species of mammals, and contemporary studies might well document changes in those groups relative to the MVZ baseline collections.

A common criticism of comparative studies of survey data is that they could easily be biased by high environmental variability among years. This problem is especially relevant for amphibians and reptiles because their daily and seasonal activities are heavily influenced by environmental conditions. In Aguascalientes, as in many other regions, the number of species found in dry years is typically small compared to those with high precipitation. Fortunately for our comparisons, both 1959 and 2004 were years with high levels of precipitation following a period of drier years in Aguascalientes (Sosa-Ramírez, 1998).

The original and new landscape photographs provide a glimpse of historical changes at a geographically and ecologically diverse set of localities, and have important implications for conservation planning. Our findings reveal extensive corn plantations replacing thorn shrub vegetation, guava fruit plantations displacing large areas in the southwestern portion of the state that were formerly tropical deciduous forest, and widespread urbanization. These habitat modifications undoubtedly diminish the likelihood that many species of vertebrates can persist in

the long term. Photographs from Sierra Fría, the largest remaining forests in Aguascalientes, show an increase in oak (*Quercus sp.*) coverage, with much of the change visible as young trees. This corroborates previous research comparing aerial photographs that revealed a replacement of pines and pine-oak forests by *Juniperus deppeana* and other arbustive species after the intensive logging extraction in Sierra Fría between 1920 and 1950 (Minnich et al., 1994). The consequences of these changes for faunal communities remain to be explored.

Tropical deciduous forest hosts high levels of biological endemicity, is globally endangered (Flores-Villela and Gerez, 1994), and its persistence in Aguascalientes might be threatened. This vegetation type covers a small area in the southwestern part of the state, harbors elements of the humid Pacific Coast biota, and unfortunately, as shown in the photographs, has recently been extensively displaced by fruit plantations. Otherwise widely distributed species that reach Aguascalientes only in tropical deciduous forest, like the colubrid snakes *Drymarchon melanurus* (Central American Indigo Snake)*, Oxybelis aeneus* (Brown Vinesnake)*,* and *Senticolis triaspis* (Green Ratsnake) will likely become locally extinct when this habitat type disappears.

Ecological and natural history data suggest that certain species are particularly vulnerable to extinction in Aguascalientes. Among amphibians, *Smilisca dentata* (Upland Burrowing Treefrog) has a highly restricted distribution and is present only in the southern tip of the state and nearby areas in northern Jalisco; the Aguascalientes locality is heavily used by cattle and there are plans to subdivide and sell the land (Quintero Díaz, pers. comm.). The plethodontid salamander *Pseudoeurycea bellii*, was only discovered in Aguascalientes in 2003 in the Sierra Fría after being missed in previous years of work; its presence was predicted (McCranie and Wilson, 2001), and perhaps this species is particularly secretive or unusually rare there. Most Mexican ambystomatids are declining due to pollution, habitat modification, loss of preferred habitats, and widespread introduction of exotic fishes for human consumption (Huacuz-Elías, 2001). While pollution and intense farming don't seem to threaten *Ambystoma tigrinum* (Tiger Salamander) in New México, USA (Degenhardt et al., 1996), the effects of those impacts and non-native predators have not been evaluated in Aguascalientes.

Among reptiles in Aguascalientes, *Phrynosoma modestum* (Round-tailed Horned Lizard) is at the southernmost limit of its distribution (Sherbrooke, 2003) and known from a single specimen (McCranie and Wilson, 2001) in the northeastern part of the state; several attempts to locate additional specimens have been unsuccessful. *Drymarchon melanurus* is large, active and in Aguascalientes associated with humid environments in tropical deciduous forest; the first specimen dates to 1980 (McCranie, 1980) and a second one was captured in 2005 (Quintero-Díaz, pers. comm.). *Crotalus pricei* (Twin Spotted Rattlesnake) is known for the state from only 3 specimens, reaches the southern tip of its distribution there, and although it occurs widely in the Sierra Madre Occidental and Sierra Madre Oriental, the population in Aguascalientes is isolated and has proven elusive despite intensive efforts in the last decade. Similarly, the distribution of *C. aquilus* (Queretaran Dusky Rattlesnake) barely reaches Aguascalientes through the Sierra del Laurel in the southwestern part of the state; this species is primarily associated with the Trans-volcanic belt in central México.

Those species of amphibians and reptiles recorded by at most a few specimens emphasize that Aguascalientes, despite its small size, encompasses the distributional limits of several species due to the junction of several diverse physiographical regions. The study of peripheral populations and comparison with those in the core of the distribution ranges are critical in the conservation efforts of endangered species (Channell and Lomolino, 2000), and emphasizes the importance of the state for the biogeography and conservation of Mexican herpetofauna.

Aguascalientes has between 60% and 80% of its surface altered by human activity (Flores-Villela and Gerez, 1994), and unfortunately this mirrors the global environmental crisis. Our results call attention to high rates of change as natural environments are displaced by anthropogenic activities, as well as a key way that scientific collections, given their intrinsically historical nature, can aid in conservation. More than a century ago, Joseph Grinnell at the MVZ envisioned this role for natural history museums (Shaffer et al., 1998), and we urge increased support for field research in the service of protecting nature (Greene, 2005).

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