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Patterns of lizard species richness within National Parks and Biosphere Reserves across North America's deserts

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ABSTRACT

Warm deserts world-wide provide habitats for rich lizard species assemblages; North American deserts are no exception, however the desert regions of the US and Mexico are experiencing increasing habitat changes from multiple anthropogenic sources. Our objective here was to document current lizard species richness patterns across the North American deserts within the existing network of conservation areas. We identified 110 lizard species occurring across one or more of the 19 sites we analyzed. Three species richness hot spots were identified; a northern Baja California faunal extension into southern California in the US, and in Mexico, two sites within the state of Coahuila, as well as high endemism in the Cape Region of Baja California Sur. Species richness was associated with sites where desert ecoregions overlap and with insular isolation. Our uncertainty regarding how species will respond to the multifaceted aspects of global change is such that large protected natural areas with complex topography may be the most effective strategy for protecting desert lizards along with overall biodiversity. The 19 sites we analyzed represent the cores of a more robust conservation network that will be needed for the protection of biodiversity across North American Deserts.

1. Introduction

Documenting patterns of species richness across complex landscapes and then fitting those patterns into explanatory frameworks is a foundation of ecology and biogeography. These patterns hold clues to the breadth of habitats occupied by individual species, as well as landscape features that foster species aggregations ranging from rich to depauperate. Additionally, understanding the breadth of habitats and regions a species occupies can provide insights into its resiliency to habitat changes (Broennimann et al., 2006; Reif and Flousek, 2012). Overlaying patterns of biodiversity atop conservation compatible or incompatible land uses enables "gap analyses", focusing limited conservation resources where they can have the largest impact. Current trajectories of global climate change are expected to result in habitat loss and fragmentation. Increasing introductions of invasive species will only increase stresses on biodiversity. These consequences underline the need to assess the efficacy of existing conservation networks at protecting biodiversity "hot spots" in addition to more broadly ranging species.

Many warm deserts world-wide provide habitats for rich lizard species assemblages (Pianka, 1986). Deserts of North America are no exception, however they are experiencing increased habitat loss and fragmentation from urban and agricultural development (Chen et al., 2010; Gadsden et al., 2006b; Rodríguez-Estrella, 2007; Stiles and Scheiner, 2010), wind and solar energy development (Lovich and Ennen, 2011), invasive species (Barrows et al., 2009; Olsson et al., 2012), and levels of climate change with temperatures and precipitation predicted to have a greater departure from current conditions than other temperate regions (Kerr, 2008). Modeled shifts in lizard species' distributions in response to a warming desert have predicted levels of habitat losses corresponding to the breadth of the species' niche (Ballesteros-Barrera et al., 2007; Barrows, 2011; Barrows et al., 2010). Losses of suitable habitat attributed to climate change have already been documented for other lizard species (Barrows et al., 2010; Sinervo et al., 2010). While some lizards have shown resiliency with regard to urban

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development and habitat fragmentation (Kwiatkowski et al., 2008) others have not (Banville and Bateman, 2012; Barrows and Allen, 2009; Barrows et al., 2008). The uncertainty of how species will respond to novel changes resulting from the multifaceted aspects of global change outweighs what we can confidently predict.

With only a narrow ability to foresee the trajectories of species in response to such changes, large protected natural areas with complex topography may be the most effective strategy for protecting desert lizards and overall biodiversity. An important question to consider is whether or not the existing network of protected areas in the deserts of North America is sufficient to protect the current distribution of lizard biodiversity, or do gaps exist that could be the focus of conservation efforts. Our objective here was to document lizard species richness patterns across the North American Deserts in Mexico and the US within the existing network of conservation areas (largely National Parks, National Monuments, and UNESCO Man and the Biosphere Reserves). In reporting these patterns we document near continental-scale patterns in desert lizard biodiversity, develop hypotheses to explain differences in species richness, and provide a coarse-scale assessment of whether the existing conservation areas adequately protect the rich desert saurian fauna of this region.

2. Methods and materials

2.1. Study areas

We compiled lizard species lists of indigenous species for 19 areas that span the Great Basin, Mojave, Sonoran, Chihuahuan and Baja California Deserts of North America (Fig. 1). With one exception, each site included National Parks, National Monuments, State Natural Areas, regional multi-agency conservation programs, or United Nations (UNCESCO) designated Man and the Biosphere Reserves. The one exception was La Comarca Lagunera in Coahuila, Mexico, a site which has received extensive lizard-related research (Castañeda, 2007; Castañeda et al., 2004; Gadsden et al., 2001, 2006a,b, 2012; García-De la Peña et al., 2003, 2004, 2007). While this site has been proposed as a high priority for conservation due to its concentration of endemic species, it has yet to receive broad official protection status (Gadsden et al., 2006b, 2012). *A priori* desert ecoregional affiliations were based on the mapped extents of the North American Deserts in Shreve (1942), Wells and Hunziker (1976) and Wells (1983). These 19 areas, along with a general description of location and management entities, are listed below. The latitude–longitude (lat./long.) coordinates are the loci of the center points for analyzing effectiveness of conserving local lizard species.

2.1.1. Great Basin Desert (GB)

(GB1) Mono Lake Tufa State Natural Area (USA: CA-NV), lat. 37.819125, long. −118.473792, includes State Natural Area lands, Federal Forest Service Scenic Areas and other Federal lands ownerships. Elevation range from 3800 to 2000 m.

(GB2) Great Basin National Park (USA: NV), lat. 38.985595, long. −114.313770, Area 312 km^2, elevation range 3980–1700 m.

2.1.2. Mojave Desert (MD)

(MD1) Death Valley National Park (USA: CA), lat. 36.101752, long. −116.624477, Area 13,470 km^2, elevation range from 2700 to 145 m.

(MD2) Lake Mead National Recreation Area (USA: AZ-NV), lat. 36.143138, long. −114.721882, with elevations from 1500 m to 400 m.

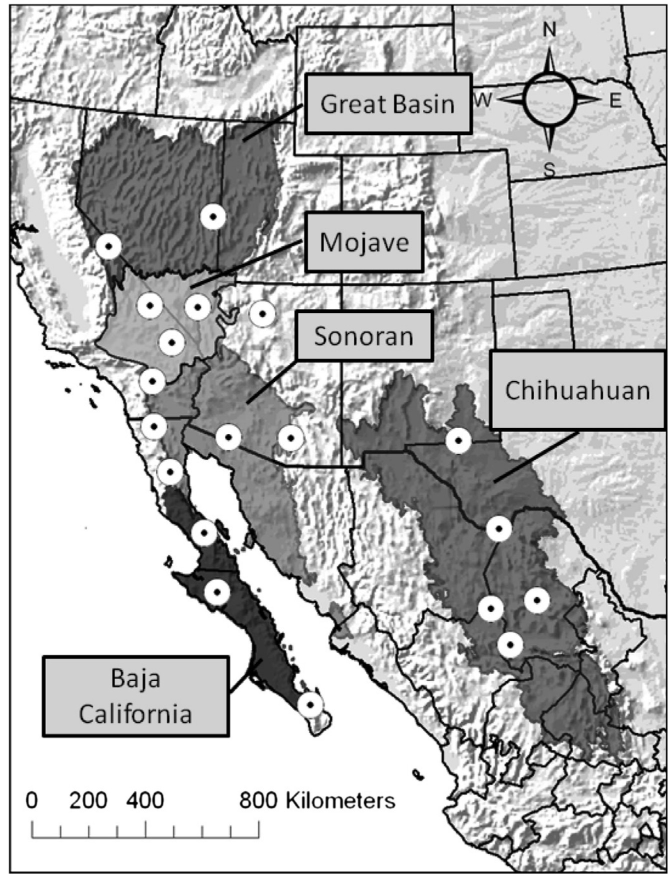

Fig. 1. Distribution of sites included in our assessment of patterns of lizard species richness across five major divisions of North American deserts. The size of the circles (outer diameter) represents the approximate area included in our compilation of lizard species for each site. One site, centered on Grand Canyon National Park (MD3), appears outside the mapped desert distributions; however the lower elevations of the park, along the Colorado River include Mojave Desert vegetation and lizards. See text for site names and descriptions.

(MD3) Grand Canyon National Park (USA: AZ), lat. 36.054604, long. −112.140015. The Park is 4868 km^2 in area, with elevations ranging from 2500 m to 700 m. Although not included in the mapped distribution of the Mojave Desert, the park's lower elevations include an eastward extension of desert flora and fauna.

(MD4) Mojave National Preserve (USA: CA), lat. 35.012601, long. −115.653401, A National Park administered unit of 6400 km^2 in area, elevations ranging from 2500 m to 300 m.

2.1.3. Baja California Desert (BC)

(BC3) Parque Nacional del Desierto Central de Baja California, (MX: BC), lat. 29.156734, long. −114.010397, with elevations ranging from 1249 m to sea level.

(BC4) Reserva de la Biosfera Desierto de El Vizcaíno, (MX: BCS), lat. 27.309302, long. −113.442876, with elevations ranging from 1200 m to sea level.

(BC5) Reserva de la Biosfera Sierra de Laguna, (MX: BCS), lat. 23.841782, long. −110.092806, with elevations from 2000 m to sea level.

2.1.4. Sonoran Desert (SD)

(SD1) Joshua Tree National Park – Santa Rosa and San Jacinto National Monument – Anza Borrego State Park (USA: CA), lat.