

Preliminary Assessment of Changes in a Lizard Assemblage at an Ecotone in Southeastern Arizona

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Abstract—The Madrean Archipelago and its associated valleys have the highest diversity of lizards in the United States. This is due to a convergence of ecoregions in an area that provides excellent environmental conditions for life history needs of terrestrial ectotherms. The study area, near Safford, Arizona, is known to have about 20 species of sympatric lizards, although only about one-half are common. The lizard community is represented by species of the Sonoran and Chihuahuan deserts, semi-desert grasslands, and lower Madrean and boreal woodlands. It has recently been suggested that lizard species are expected to decline globally due to climate change and other reasons. A study site representing an ecotone between desert and grassland/montane/riparian vegetation types in a foothills situation was chosen, as ecotones are marginal habitats that are expected to be sensitive to environmental change. Study objectives were to assess the baseline lizard community and detect changes in the lizard assemblage over time due to climate change and other factors. During systematic road transects, a total of 3,889 lizards representing 13 species were recorded during 60 visits in 2003 ($n = 8$ visits), 2010 ($n = 12$), and 2011 ($n = 40$). Although this represents the early stages of a long-term monitoring program, preliminary observations show differences in the lizard assemblage between years consistent with climate change predictions.

Introduction

The Madrean Archipelago's "sky island" mountain ranges and valleys have the highest diversity of lizards in the United States of America; nearly one-third of all U.S. species (about 37-39/120) are found in southeastern Arizona and adjacent New Mexico (Jones and Lovich 2009). There can be about 15-20 sympatric species in a small area, where the mountains meet the valleys (Degenhardt and others, 1996 [p. 208]; Jones 2009; Lazaroff and others, 2006).

Literature suggests lizards are declining for a variety of reasons including habitat loss, invasive species, and competition with other species (Gibbons and others, 2000; Olson 2012). Sinervo and others (2010) documented local extinctions of lizards from study plots in Mexico, making a cause-and-effects case for the decline in diversity due to climate change. They went on to describe how the life history attributes of lizards are such that increased spring temperatures and other factors made lizards, as a group, susceptible to extirpation and extinction. They predicted that by 2080 about 40% of lizard species would become locally extinct and 20% would become globally extinct.

When the Sinervo and others (2010) paper was published, I reinitiated surveys from 2003 (Jones 2009) to identify potential changes in the local lizard assemblage since that time, as well as qualitative changes since the Nickerson and Mays (1969) inventory of the Pinaleno

Mountains. In this paper I document some changes in the lizard assemblage, although surveys to date are only the beginning of what is intended to be a long-term monitoring project. Thus, results reported here are preliminary or observational, but do help establish a baseline of distribution and relative abundance of commonly encountered species, as well as highlighting some inter-year trends.

Study Area

The study area is about 10 mi S of Safford, Graham County, Arizona, along a 2.7-mi stretch of road (Forest Road 57) from its junction with Swift Trail (Highway 366). This dirt road is usually termed Marijilda Road, because it accesses Marijilda Creek. Elevation ranges from about 3,810 to 4,010 ft above mean sea level. Adjacent vegetation is primarily semi-desert grassland, but the area is situated at an ecotone between two deserts (Sonoran and Chihuahuan) in the San Simon Valley and semi-desert grasslands and Madrean encinal (oak) woodlands in the foothills of the Pinaleno Mountains (Brown 1994). Vegetation is primarily composed of grasses, shrubs, cacti, and small trees. Lehmann Lovegrass (*Eragrostis lehmanniana*, a non-native bunchgrass), Velvet Mesquite (*Prosopis velutina*), Engelmann Prickly Pear (*Opuntia engelmannii*), and Soaptree Yucca (*Yucca elata*) are among the common plant species, but desert scrub, riparian, and encinal woodland species are also present (Jones 2009, unpublished data). Because the area is rocky, sections of the shoulders of Marijilda Road are replete with boulders and boulder piles, partially an artifact of road construction. The first 0.4 miles of road approach the foothills from the desert valley, then the road turns to parallel the lower slopes of the mountains. The transect ends at Marijilda Creek, a perennial stream with deciduous riparian vegetation.

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Methods

In 2003, 2010, and 2011, I conducted a road-transect tally of lizards along Marijilda Road, according to a protocol; the method is discussed in greater detail elsewhere (Jones 2009). Basically, the observer drove very slowly along Marijilda Road, and stopped when a lizard was seen. The lizard was then viewed through binoculars and identified to species and age class (hatchling, juvenile, subadult, adult), and the 0.1 mi segment of road was recorded. Only the driver tallied lizards seen; passengers (if present) were not allowed to point out lizards. Lizards in the Desert Spiny Lizard complex (*Sceloporus magister* and *S. bimaculosus*) were recorded simply as “*Sceloporus magister* complex” because both species are sometimes difficult to distinguish and likely hybridize in the area (Jones and Schwalbe 2009; Phelan and Brattstrom 1955). Lizards of the *Aspidoscelis sonorae* complex are recorded as *A. flagellicauda*. Without genetic confirmation, I consider *A. flagellicauda* to be the only species in the *A. sonorae* complex present, although HerpNet (an online resource of museum records) reports *A. sonorae*, *A. flagellicauda*, and *A. exsanguis* from the immediate vicinity. All species in the complex are similar and there are taxonomic uncertainties (Jones and Lovich 2009).

Starting in June 2010, surveys were conducted year-round. There was a minimum of one survey per month during November through February, and one survey per week March through October. Surveys

were conducted when temperature, sunlight, wind, and cloud cover were conducive to surface activity of lizards (temperatures between 75 and 95 °F, with mid-80's being optimal, plus low wind and low cloud cover). Starting time was as early as 0700 in the summer and as late as 1400 in the winter.

Age class data were recorded differently between 2010 and 2011 (not at all in 2003), and there was apparent observer bias in 2011. In order to compare results of reproductive output between 2010 and 2011, I limited observations to my own and transformed age class codes to make them comparable. Age classes reported here are classified as Young (= hatchlings and young-of-year juveniles) or Adult (= subadult or adult). The distinction is based on species-specific phenotypic attributes (e.g., size, coloration, pattern, and secondary sexual characters) and the appearance of young-of-year.

Results

Jones (2009) reported that 19 species have been documented along the Marijilda Road and adjacent lower Swift Trail, but presently I consider the total to be 20 (table 1), counting both species of the *Sceloporus magister* complex. *Elgaria kingii* is a cryptic species that may be present in the riparian area, but has not been detected from Marijilda Creek, although it has been documented from nearby Noon Creek (Nickerson and Mays 1969). Interestingly, *Holbrookia*

Table 1—Lizards of Marijilda study site and adjacent lower Swift Trail. Detections (counts) are for all systematic road-transect surveys in 2003, 2010, and 2011. Species not detected during surveys were opportunistic or had been documented in the literature. *Sceloporus magister* complex includes *S. magister*, *S. bimaculosus*, and presumptive hybrids. See Jones and Lovich (2009) for a discussion of taxonomy and nomenclature, which is recognized here.

Standard English Name	Scientific Name	Code	Count	Percent
Ornate Tree Lizard	<i>Urosaurus ornatus</i>	UROR	1560	40
Common Side-blotched Lizard	<i>Uta stansburiana</i>	UTST	809	21
Desert Spiny Lizard complex	<i>Sceloporus magister</i> complex	SCMC	611	16
Tiger Whiptail	<i>Aspidoscelis tigris</i>	ASTI	277	7
Eastern Collared Lizard	<i>Crotaphytus collaris</i>	CRCO	191	5
Greater Earless Lizard	<i>Cophosaurus texanus</i>	COTE	187	5
Clark's Spiny Lizard	<i>S. clarkii</i>	SCCL	94	2
Desert Grassland Whiptail	<i>A. uniparens</i>	ASUN	37	1
Regal Horned Lizard	<i>Phrynosoma solare</i>	PHSO	6	<1
Round-tailed Horned Lizard	<i>P. modestum</i>	PHMO	3	<1
Long-nosed Leopard Lizard	<i>Gambelia wislizenii</i>	GAWI	2	<1
Gila Spotted Whiptail	<i>A. flagellicauda</i>	ASFL	2	<1
Zebra-tailed Lizard	<i>Callisaurus draconoides</i>	CADR	1	<1
Hybrid horned lizard	<i>P. solare</i> × <i>P. modestum</i>	PHHY	1	<1
Unidentified lizards		UNKN	108	3
Western Banded Gecko	<i>Coleonyx variegatus</i>	COVA	0	0
Gila Monster	<i>Heloderma suspectum</i>	HESU	0	0
Texas Horned Lizard	<i>P. cornutum</i>	PHCO	0	0
Greater Short-horned Lizard	<i>P. hernandesi</i>	PHHE	0	0
Great Plains Skink	<i>Plestiodon obsoletus</i>	PLOB	0	0
Yarrow's Spiny Lizard	<i>S. jarrovi</i>	SCJA	0	0
Total	20 species		3,889	100

maculata and *Sceloporus undulatus* complex seem to be absent, but they have been documented from the vicinity (Nickerson and Mays 1969).

A total of 60 surveys were completed: 8 in 2003 (1 June to 3 August), 12 in 2010 (26 June to 11 December), and 40 in 2011 (all months). The only complete calendar-year survey was 2011 because that was the first complete year when long-term monitoring was an objective. There were a total of 3,889 lizard detections (range 0 - 179 detections per visit, mean = 64.8 sd = 38.2) during the 3 survey years. Thirteen species were recorded during road tallies (table 1). The most commonly detected species (at least 5% of detections) were Ornate Tree Lizard (*Urosaurus ornatus*), Common Side-blotched Lizard (*Uta stansburiana*), Desert Spiny Lizard complex, Tiger Whiptail (*Aspidozelis tigris*), Eastern Collared Lizard (*Crotaphytus collaris*), and Greater Earless Lizard (*Cophosaurus texanus*). Species not detected during transects were assumed to be rare in the study area, nocturnal, or cryptic. Some species, such as *U. ornatus*, *U. stansburiana*, and parthenogenetic whiptails are known to frequent disturbed areas, such as the road margin (Jones and Lovich 2009; Wright and Lowe 1968).

Lizards were detected year-round, in a generally bimodal distribution reflecting spring and summer (monsoonal) peaks of activity (fig. 1). In 2011 (the complete year), seasonal activity varied by species. Only *U. stansburiana* (especially) and *U. ornatus* were active during the winter, and only then on warm days (generally in the 60's). *Sceloporus clarkii* (n = 58) also had a long period of activity (March through November). *Aspidozelis uniparens* (n = 26) had the narrowest peak of activity, with 65% of the detections in July, immediately following the onset of summer rains. *Aspidozelis tigris* was only active during hot periods, with 88% (n = 203) being active June through August. The other species showed a generally normal curve from spring through fall, although there was a profound increase in surface activity for some species with the onset of summer rains. This spike was apparent for *A. uniparens*, *U. ornatus*, *U. stansburiana*, and *S. magister* complex. Horned lizards (*Phrynosoma solare*, *P. modestum*, and a hybrid [Jones and Winsor, in press]) also were mostly detected after the onset of the monsoon (71% [5/7] detections). Although sample size was low for horned lizards, monsoonal peak activity was noted in other years and from opportunistic observations on the adjacent

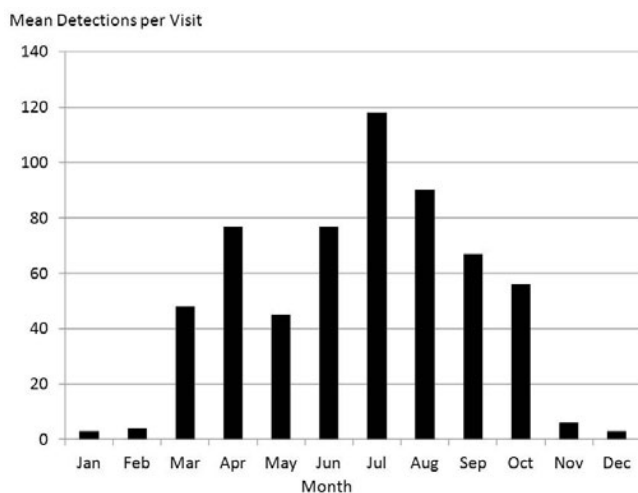


Figure 1—Mean detections of lizards (Y-axis) by month in 2011, showing the bimodal pattern of spring and monsoon peaks of surface activity. In 2010, there was another peak in late summer and early fall due to the emergence of young-of-year.

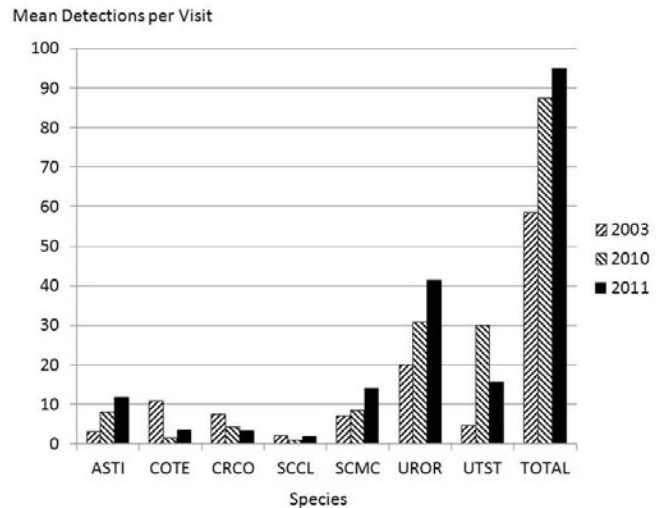


Figure 2—Mean detections per visit of common species by year for June through August, the only months surveyed in all 3 years. Species codes are shown in Table 1.

paved Swift Trail. There was no apparent monsoonal spike for *A. tigris*, *C. collaris*, or *C. texanus*.

A comparison of differences between years had to be limited to June, July, and August, the only months that were sampled in all 3 years. Figure 2 shows the differences in the relative detections of common species. There were observed decreases over time (2003 vs. 2010/2011) in *C. texanus* and *C. collaris* and an increase in *A. tigris* and *U. stansburiana*. In fact, *U. stansburiana* was considered extremely rare on Maricopa road in the 1960's despite extensive searches for it (Nickerson and Mays 1969), but it is now extremely abundant.

Figure 3 shows differences in age-class distribution for common species between 2010 and 2011. The data clearly show a higher proportion of Young to Adult categories in 2010 than 2011, with the exception of *U. stansburiana*. This observation is consistent with the expectations from the winter drought pattern between years (e.g., Vitt and others, 1978).

One of the ways I tracked changes in the lizard assemblage was by comparing distribution of detections by species along the transect. Overall, the first mile or so of the transect had the highest detection rate and presumably the highest density of surface-active lizards (fig. 4). This pattern was similar in all years. The detection rate dropped with increasing distance from the start, although there was an increase in detections at the end of the road, which corresponds to the Maricopa Creek riparian area. Most of the species were not evenly distributed. The large number of detections in the first part of the transect was primarily due to the three most common species, *U. ornatus*, *U. stansburiana*, and *S. magister* complex. *Urosaurus ornatus*, *C. texanus*, and *S. clarkii* were responsible for most observations at the creek. *Aspidozelis tigris* (2003-2011) and *C. texanus* (2003 only, fig. 5) were fairly evenly distributed along the transect. *Crotaphytus collaris* and *A. uniparens*, were most abundant in the upper one-half of the transect. *Sceloporus clarkii* was usually found in distinct segments. According to data, *C. texanus* was much more abundant in 2003, but it is interesting to note that the distribution along the transect also changed. In 2003, the species was common and widely distributed, while in 2010 and 2011, there were far fewer detections and the species was mostly detected in two or three distinct road segments (fig. 5).

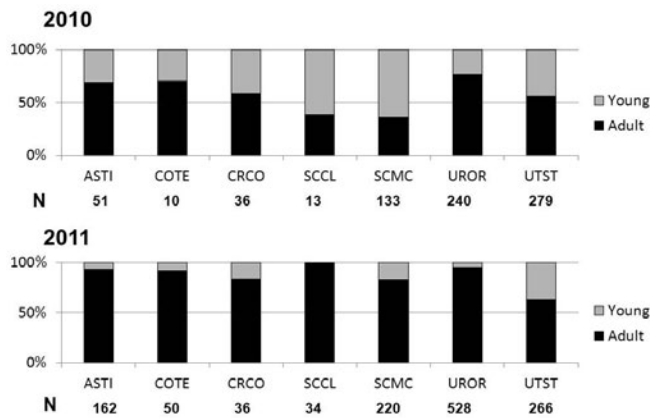


Figure 3—A coarse comparison of relative reproductive output between 2010 and 2011 (see text for explanation), June through October. There was good winter precipitation in 2009-2010, which translated to a good year for annuals and flowering perennials (hence, abundant insect prey), whereas 2010-2011 was a dry winter with few annuals (hence, reduced insect prey). Decreases in reproductive output due to frequent winter drought years could result in population declines and possibly extirpation for some species. However, the role of monsoonal moisture and reproductive success is poorly understood. Species codes are shown in Table 1.

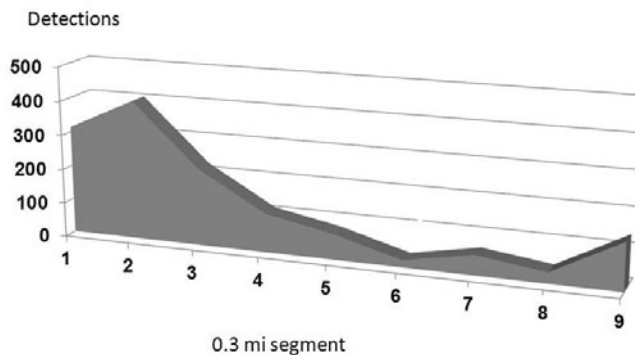


Figure 4—Total detections of all species of lizards by road segments for a 1-year subset in 2010-2011 ($n = 1,380$ detections). Lizards are recorded by 0.1-mi segments, but are combined here in 0.3-mi segments for display. Segment 6 (mile 1.3-1.6) is the area treated for invasive weeds, but notice that lizards are not particularly abundant in either side of the area.

Discussion

This study is attempting to answer three major questions: (1) which lizard species compose the assemblage, (2) how they are distributed spatially and temporally, and (3) how the assemblage will change over time. The third part requires a cause-and-effect explanation, especially as it relates to climate change.

For the first question, I reviewed the literature and HerpNet, conducted surveys, and spent many opportunistic hours in the study area between 2003 and 2011. The lizard assemblage should be accurate now, although other rare or cryptic species could be detected in the future. Jones (2009) reported that the study area has the highest diversity of lizard species (for such a small area) documented anywhere in the United States. Other areas of southeastern Arizona or adjacent New

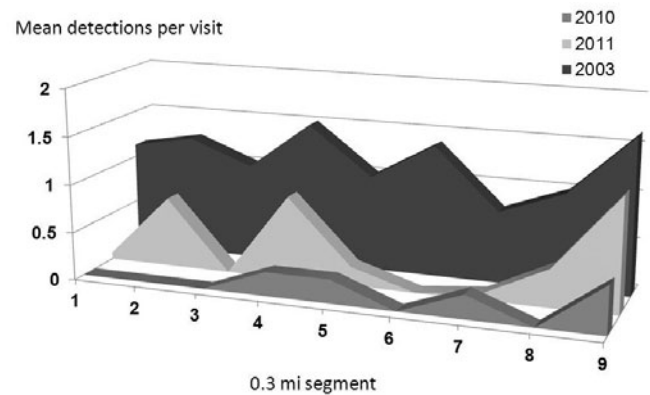


Figure 5—Mean detections of *Cophosaurus texanus* by 0.3-mi segment by year. In 2003 this species was the second most abundant species (18.4% of detections) and was widespread across the study area. In 2010 and 2011 there were considerably fewer observations (1.2% and 3.2%, respectively) and the lizards were in discrete areas (usually near washes and Marijilda Creek riparian area).

Mexico likely have a similar level of diversity, but clearly the Madrean Archipelago and surrounding valleys have the highest diversity in the country. The explanation for the high diversity was reported by Jones (2009): the area is a convergence zone of physiographic provinces that each has a high diversity of lizard species.

The second question—how lizards are distributed along the transect—is starting to unfold. Distribution of most species is not random and patterns are emerging. I am currently engaged in an intensive habitat characterization study component along the transect to determine why lizards are distributed as they are. Observations suggest certain variables will likely help explain abundance, such as distribution and type of rock, vegetation community, topography, and topographic features (e.g., desert approach, foothill, stream). Another observation is that the segment of road from about milepost 1.3-1.6 has the least number of detections, despite having the best visibility of the entire transect. This area was treated for invasive weeds and regrowth is sparse. However, treatment of invasive weeds in a small area to abate spread may be a very important conservation measure that is best evaluated at a larger scale.

The third question is the crux of the study. The Sinervo and others (2010) prediction of large-scale lizard declines was the impetus to re-initiate surveys. Marijilda was selected because of the high diversity and apparent high abundance of lizards, and its setting in an ecotone. Because ecotones are at the edge of vegetation communities, they are expected to have sensitivity to show change from altered climate patterns or other factors (Allen and Breshears 1998, Loehle 2000, Noble 1993). Unfortunately, when the study was initiated in 2003, that was not a goal, so the 2003 data are limited, and the Nickerson and Mays (1969) paper was qualitative. However, these provide the only information we have on the area before 2010. The observations from then to now are generally consistent with climate change predictions. *Cophosaurus texanus*, a foothill species in the Marijilda area, has gone from being extremely abundant and widespread to uncommon with a disjunct distribution. *Uta stansburiana*, a desert species, has gone from being “extremely rare” (Nickerson and Mays 1969) to extremely abundant.

It is well established in the literature that lizard populations are known to be naturally dynamic between years (e.g., Dunham 1982; Ferguson and Fox 1984; Vitt and others, 1978); there are many factors

that influence population dynamics, including temperature, moisture, and resource availability. Nevertheless, the difference seen between years is a red flag that suggests there may be a changing lizard assemblage concomitant with the frequent droughts and increased mean annual temperature in the past decade. The species that have shown increases in this study are desert species, while some grassland/foothill species have been stable or showing decreases. Of course, there are factors besides climate change that can influence lizard distribution. Another hypothesis for a changing lizard assemblage is the weed-species hypothesis for all-female whiptails (Wright and Lowe 1968). There are three species (at least) of whiptails (*Aspidoscelis*) in the study area, including two parthenogenetic species, but only the gonochoristic species (*A. tigris*, a desert associate) is common and well-distributed along the transect, unlike *A. uniparens* and *A. flagellicauda*, which are typical of grasslands and woodlands.

This study is not limited to understanding lizard biology, as there are inferred management implications. Lizards may function as a “canary in a coal mine,” warning of impending vegetation change or identifying other environmental parameters. Even with increased temperature and decreased precipitation, some plants may be temporarily resilient (e.g., many seeds or shrubs can endure droughts, then capitalize on occasional wet years). Tracking vegetation change itself in an ecotone may be problematic (Noble 1993). Because of natural history attributes of lizards (e.g., a rapid drop in fecundity due to drought), it seems logical there will be changes in lizard populations before dramatic shifts in vegetation are seen. Such an early warning system can help land managers assess habitat vulnerabilities, so they can adjust management strategies for programs such as range or fire management (USFS 2011). Also, there are inherent uncertainties in models that predict the outcome of a changing environment on species assemblages. This study should help support or refute these predictions, refine variables and outputs, identify other factors contributing to population shifts, and contribute to adaptive management of habitat for lizards and other organisms.

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