Lizards

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Objectives

To measure population changes in lizards that can be correlated with natural and human caused environmental changes.

Introduction

Long-term lizard monitoring will contribute to an understanding of natural ecological processes at OPCNM. Both abiotic (climate, soils, and geology) and biotic (intra- and inter-specific competition, predation pressure, and vegetation) factors are expected to have a strong influence on the vertebrate community, including the lizards. Long-term data on multiple factors may also aid in detecting and understanding natural and human-caused ecosystem effects, and thus assist management needs that may arise.

Lizards are apparently the most numerous vertebrates on the monument (Rosen and Lowe 1996, Petryszyn and Russ 1996), and it is likely that they are of great ecosystem importance as insectivores and as prey for larger vertebrates such as roadrunners, raptors, foxes, and snakes. Lizards are much less mobile than birds and should respond to variation on a smaller spatial scale. Thus, lizards form an important component within the Ecological Monitoring Program (EMP) at OPCNM that is well-suited to detect biotic effects of global climate change, of local human-caused disturbance, and of natural environmental fluctuation. Long-term lizard monitoring should aid managers by providing for early warning of abnormal conditions, data for comparison with other more altered sites, and enhanced understanding of ecological process. Abnormal conditions may be manifested as a sustained decline in one or more species or diversity index, or as a sustained absence of species that were formerly present.

Lizard populations respond to increased rainfall with increased reproduction (Whitford and Creusere 1977, Dunham 1981, Abst 1987, and Anderson 1994). However, lizard population size is not very well correlated with rainfall, and may be strongly influenced by other factors such as predation, as the existing data indicates (Rosen 2000), and as finally suggested by many years of study at the Nevada Test Site (Turner et al. 1970 and 1982). The literature does not contain data-based studies as long as, or with the breadth of information of, the OPCNM lizard, climate, and other species monitoring.

The EMP lizard monitoring protocol is an original, transect-based method (OPCNM, 1995). The most common, and simplest, lizard monitoring method is pitfall trapping (Campbell and Christman 1982, Vogt and Hine 1982, Karns 1986, but see Medica et al. 1971, Gibbons and Semlitch 1982, and Brenner et al. 1992), which requires little skill in the field and is fairly easily standardized. However, it has two major drawbacks for us: (1) it requires that we leave dug-in traps installed, where they may be found by monument visitors, and (2) they cause mortality through predation within the traps even when the system is optimized. Bounds (1996) found that our transect method worked as well, and was less costly, compared to pitfall trap grids.

Any method, short of direct population census, requires the assumption that changes of observed numbers of lizards reflect primarily changes in abundance, rather than changes in individual activity. Rosen and Lowe (1996) provided two years of validation using mark-recapture and line transects showing that the assumption of population changes seems to hold up. The lizard line transect method we have used is designed to minimize the effects of daily, seasonal, and year-to-year flux in activity level on the result. It requires some skill and care in the field, but

has the absolute minimum effect possible on the monitored individuals and populations. Further, the data we are gathering might later be utilized within the distance-sampling methodology (Buckland et al. 1995), and can be used to estimate actual lizard population density with some limited additional research to determine proportion of lizards that are active during surveys.

Monitoring was initiated during a 4-year (1987–1991) study of OPCNM herpetofauna. During 1990 and 1991, project research personnel worked with and trained OPCNM Resources Management field workers on performance of the lizard line protocol. Most of the 1991 work, and all subsequent monitoring, was done by monument staff. In the beginning, only the Core I sites were visited due to constraints of time and personnel, but by 1993 all sites were visited during both activity seasons. This consistency greatly facilitates analysis and interpretation of the data. This report presents results through 2005.

Methods

Study sites

This project was carried out at 19 study sites, with 1 to 4 transects each (Table 6-1, Figure 6-1). Two of the sites, utilized only for lizard monitoring, include a pair of lines (LIZG1 and LIZG2) just east of the East Armenta EMP site and a single line (CREO1) in the creosotebush community east of Armenta Ranch. The LIZG transects are located in the middle of the snake monitoring site, and were designed to yield data for a direct correlative evaluation against the voluminous lizard data extracted from the snake traps and other work on that site. The CREO1 line was established to complete a comprehensive landscape transect from Ajo Mountain rock slope, to upper bajada, middle bajada, lower bajada, and valley floor. The most recent additions are two transects, ALAM2 and BULL1, which were added in summer 2001 to obtain more data on the sensitive species, *Aspidoscelis burti*.

The sampling design suggested by Rosen and Lowe (1996) called for monitoring in rocky slope, bajada, and valley floor to capture the soil texture gradient. Both the mesic eastern and xeric western portions were represented. Ideally, they included sites with both a xeroriparian line and an upland (i.e., non-xeroriparian) line, although they compromised on some sites for efficiency reasons and some sites have 2 xeroriparian or 2 upland lines (see Table 6-1).

Transect methods

The methods, which are summarized briefly here, have followed the monitoring protocols set forth in detail by the principal investigators (OPCNM, 1995; Rosen and Lowe, 1996). Lizard monitoring was conducted during the spring maximum of lizard activity, late April through May, and again during the summer maximum, late-July through late-September, once the summer monsoon rains had commenced. Lizards were censused on line transects for which the transect centerline, varying in length from 100 to 300 meters, was walked repeatedly during peak lizard activity time and temperature during morning on warm (or hot), sunny, and fairly calm, days. Care is taken with timing and observer behavior on-transect to minimize the probability that lizards may be frightened off the transect. All lizards seen within 7.5 meters of the centerline were included on the monitoring data sheet. The following data were recorded: species, time, distance along transect, lizard distance from centerline at first sighting, and size/age class. Gender was recorded if it could be determined. Eight sites have just 1 line (200-300 m long), while 9 sites have 2 lines each (100-200 m long). Each of these sites can be monitored in one morning by one field worker. The Pozo Nuevo EMP site, which has 4 100-m lines covering the breadth of habitats, requires 2 people or 2 mornings to complete. The design of the protocol is such that a person can walk 2 lines alternately on a single morning.

Generally, each line was walked beginning at the east end so lizards could be readily seen basking in the morning sun, and all lines were

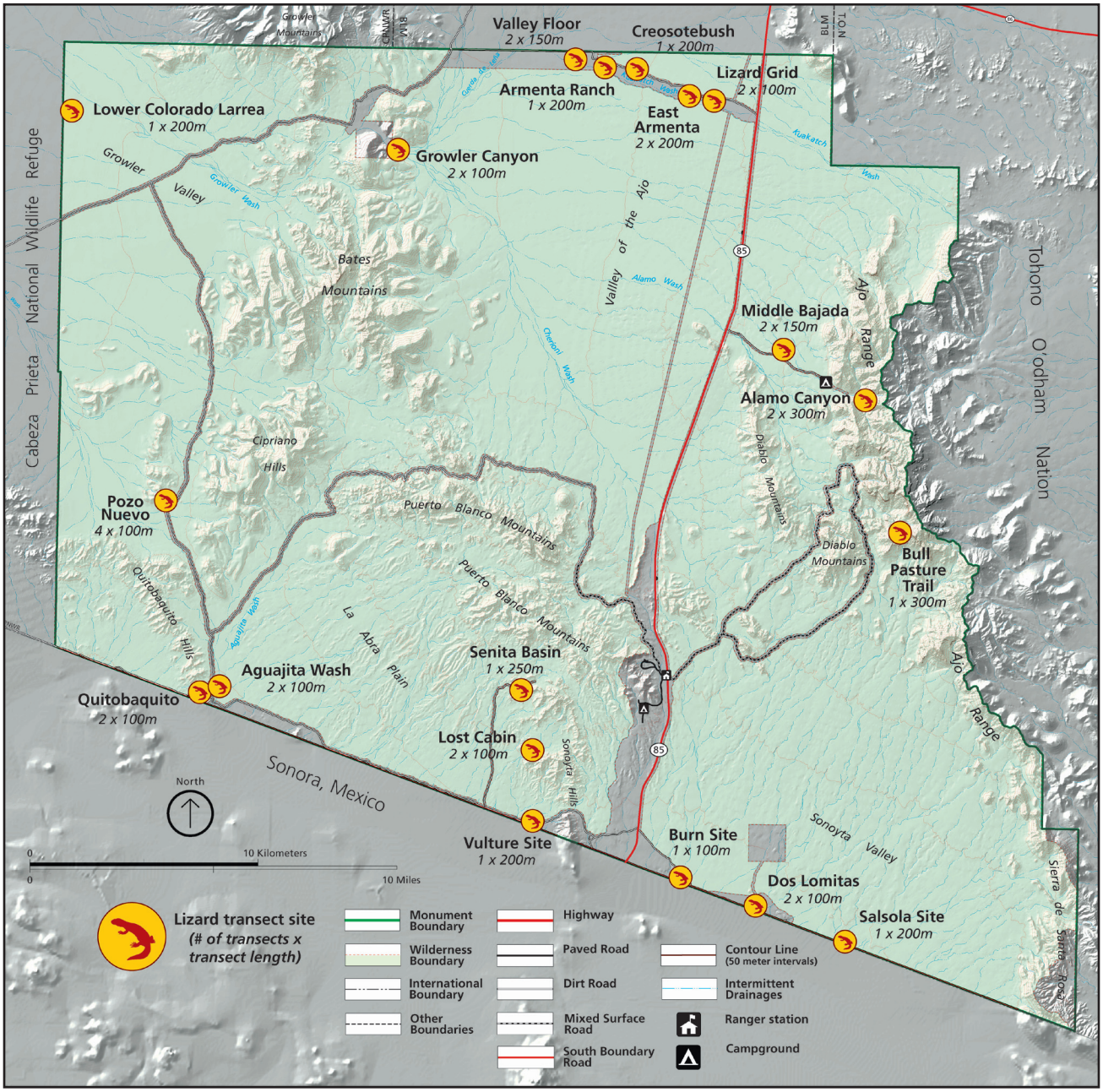

Figure 6-1. Lizard transect sites at Organ Pipe Cactus N.M.

Table 6-1. Classification of lizard lines according to hydrologic regime and soil texture at Organ Pipe Cactus N.M.

Site	Transect	Code	Length (m)	Hydrologic regime	Soil texture	Transect alias
Aguajita Wash	1	AGUA1	100	upland	bajada	Saltbush
Aguajita Wash	2	AGUA2	100	xeroriparian	bajada	Bosque
Alamo Canyon	1	ALAM1	300	xeroriparian	rocky slope	Canyon Bottom
Alamo Canyon	2	ALAM2	300	upland	rocky slope	
Armenta Ranch	1	ARMR1	200	xeroriparian	valley floor	
Bull Pasture	1	BULL1	300	upland	rocky slope	
Burn Site	1	BURN1	100	xeroriparian	valley floor	
Creosotebush	1	CREO1	200	upland	valley floor	
Dos Lomitas	1	DOLO1	100	xeroriparian	valley floor	Inside Exclosure
Dos Lomitas	2	DOLO2	100	xeroriparian	valley floor	Outside Exclosure
East Armenta	1	EARM1	200	upland	bajada	Desertscrub
East Armenta	2	EARM2	200	xeroriparian	bajada	Kuakatch Wash
Growler Canyon	1	GROW1	100	xeroriparian	valley floor	Wash Bed
Growler Canyon	2	GROW2	100	xeroriparian	valley floor	Bosque
Lizard Grid	1	LIZG1	100	upland	bajada	North
Lizard Grid	2	LIZG2	100	upland	bajada	South
Lost Cabin	1	LOST1	100	upland	bajada	Wash Flats
Lost Cabin	2	LOST2	100	upland	rocky slope	Rocky Draw
Lower Colorado Larrea	1	LOWE1	200	upland	valley floor	
Middle Bajada	1	MIDB1	150	xeroriparian	bajada	Wash
Middle Bajada	2	MIDB2	150	upland	bajada	Flats
Pozo Nuevo	1	POZO1	100	upland	rocky slope	Hill Base
Pozo Nuevo	2	POZO2	100	xeroriparian	valley floor	Wash
Pozo Nuevo	3	POZO3	100	upland	valley floor	dumosa Bursage
Pozo Nuevo	4	POZO4	100	upland	valley floor	deltoidea Bursage
Quitobaquito	1	QBQT1	100	upland	rocky slope	Hill
Quitobaquito	2	QBQT2	100	xeroriparian	bajada	Bosque
Salsola Site	1	SALS1	200	xeroriparian	valley floor	
Senita Basin	1	SENI1	250	upland	bajada	
Valley Floor	1	VALL1	150	upland	valley floor	Flats
Valley Floor	2	VALL2	150	xeroriparian	valley floor	Wash
Vulture Site	1	VULT1	200	mixed	bajada	

Table 6-2. Lizard species recorded on transect lines at Organ Pipe Cactus N.M.

Family	Scientific name	Common name	Code
Iguanidae	*Dispsosaurus dorsalis*	desert iguana	DIDO
Crotaphytidae	*Crotaphytus nebrius*	Sonoran collared lizard	CRNE
	Gambelia wislizenii	longnose leopard lizard	GAWI
Phrynosomatidae	*Callisaurus draconoides*	zebratail lizard	CADR
	Phrynosoma platyrhinos	desert horned lizard	PHPL
	Phrynosoma solare	regal horned lizard	PHSO
	Sceloporus clarkii	Clark's spiny lizard	SCCL
	Sceloporus magister	desert spiny lizard	SCMA
	Urosaurus graciosus	brush lizard	URGR
	Urosaurus ornatus	tree lizard	UROR
	Uta stansburniana	side-blotched lizard	UTST
Teiidae	*Aspidoscelis burti*	canyon spotted whiptail	ASBU
	Aspidoscelis tigris	western whiptail	ASTI
Helodermatidae	*Heloderma suspectum*	Gila monster	HESU

walked beginning with first warmth, shortly after sunrise. Air and soil surface temperatures were recorded at the beginning of each walk. Transect walks were timed to coincide with the peaks of activity of each of the various species of lizards present, with particular attention being given to the "indicator species", usually whiptail lizards (genus *Aspidoscelis*--until recently called *Cnemidophorus*), around which the timing and duration of each session are generally determined. This was accomplished by continuous awareness of lizard activity in the area, including away from the transects. Once the number of individuals observed of the indicator species had peaked and was diminishing for 1 or 2 more walks, the transect monitoring session was complete, unless there was reason to suspect that an anomalous event (wind, clouds, small number random events) underlay the result. If so, the transect might be run again; or the data might be abandoned, and the transect re-run on another day to ensure a suitable environmental context for all results accepted. Generally, lizard activity diminished significantly once surface temperatures exceeded 50°C. As usual, the day-to-day weather, especially during the summer monsoon season, necessitated attentiveness, patience, and flexibility in scheduling the monitoring.

This protocol did not sample for nocturnal species such as the western banded gecko (*Coleonyx variegatus*). Also, some species that were more active during the hottest part of the day, such as the desert iguana (*Dipsosaurus dorsalis*), were likely under represented, along with the cryptic and less active horned lizards (*Phrynosoma solare* and *P. platyrhinos*). The chuckwalla (*Sauromalus ater*) has never been recorded on a transect, due to its very specialized habitat of rocky areas with large boulders.

The ability to detect lizards on a transect in a consistent, repeatable manner matching the described protocol is principally a matter of observer experience, especially keeping in mind that morning behavior is dictated principally by thermoregulation. There are other considerations as well. Heavily vegetated sites present a challenge for visual detection, but the timing of walks for basking and activity in the open, along with auditory cues, can overcome these situations. The first detection of a lizard on a transect is frequently by sound, and then it is seen, either running to cover or rustling under a shrub or tree. With experience, the observer will correlate these

sounds with the eventual visual identification of the lizard to the point where it is most often possible to identify the lizard by sound alone, using cues such as location and time of day. Each species of lizard has its own "signature" method of locomotion, much as birds can be identified by the way they fly. All of these cues help in the identification of a lizard, frequently by a combination of locomotion style, sound, and time and location. The large majority of detections and identifications are by simple clear sighting of the lizard, however. Certainly, a fleeting glimpse or auditory detection cannot lead to any determination of gender, although size class can usually be determined. In 1997 for instance, 3 out of 1228 lizard detections were recorded as heard.

Data analysis

In this report, relative abundance is equivalent to the peak value obtained for a species per 100 meters of transect. A species' peak value is the maximum count obtained among all walks of a transect in a given morning. The relative abundance or peak for (all) lizards is the sum of peak values for all species per 100 meters. Species richness is the number of species (sometimes called species diversity). Diversity was calculated using the Shannon function:

$$H' = - \sum (p_i \times \ln(p_i))$$

where p_i is the proportion of the ith species.

To use all sites and compare relative abundance, species richness, and diversity among years, each transect was standardized to zero mean and unit standard deviation. Then all transects were averaged for each season and a standard error computed. To provide some insight into possible impacts of adjacent land-use, the sites were divided into interior and border groups; mean and standard error were then computed for each group. Border EMP sites include, from west to east, Quitobaquito, Aguajita Wash, Vulture Site, Burn Site, Dos Lomitas, and Salsola Site; all other sites are interior (Figure 6-1).

Trend analysis was conducted for each species to determine if there was any change in relative abundance. For each species, the peak value for each season at each transect was used. All of the 1988-2005 data were used. Trends were modeled independently for each species by using a generalized linear mixed model (PROC GLIMMIX; SAS) with a year covariate to estimate trend, a season factor (spring or summer) to control for seasonal variation, a random transect effect, and a random year effect. The random year effect captures annual variation that cannot be explained by linear trend alone. A log link function based on a Poisson distribution with overdispersion was specified for the model.

Results

The most commonly observed species, based on the sum of peak values, was *Aspidoscelis tigris* (Figure 6-2). Other common species, in descending order of relative abundance, were *Uta stansburiana*, *Urosaurus ornatus*, *Callisaurus draconoides*, and *Sceloporus magister*.

Data for peak numbers of lizards observed are presented as graphs for each transect in Appendix A. Between 1997 to 2005, 2 transects, VALL1 and GROW1, had zero lizards recorded in spring 2002 and spring 2005, respectively. The highest peak recorded was 22 lizards per 100m at the Burn 1 transect in summer 2000. Most transects exhibited a maximum relative abundance of lizards in summer 1998 and a minimum in spring 2003. This pattern is also apparent in the combined graph (Figure 6-3).

Trend analysis indicated changes in some species during the period 1988-2005 (Table 6-3). The most significant change was a 4.8% average annual increase in *U. stansburiana* ($P<0.001$). That translates to a doubling in abundance in 16 years. The most common species, *A. tigris*, exhibited a 2.5% average annual decrease ($P=0.051$).

Plots of mean, standardized values for border and interior sites does not reveal any sustained departure between the two groups for relative

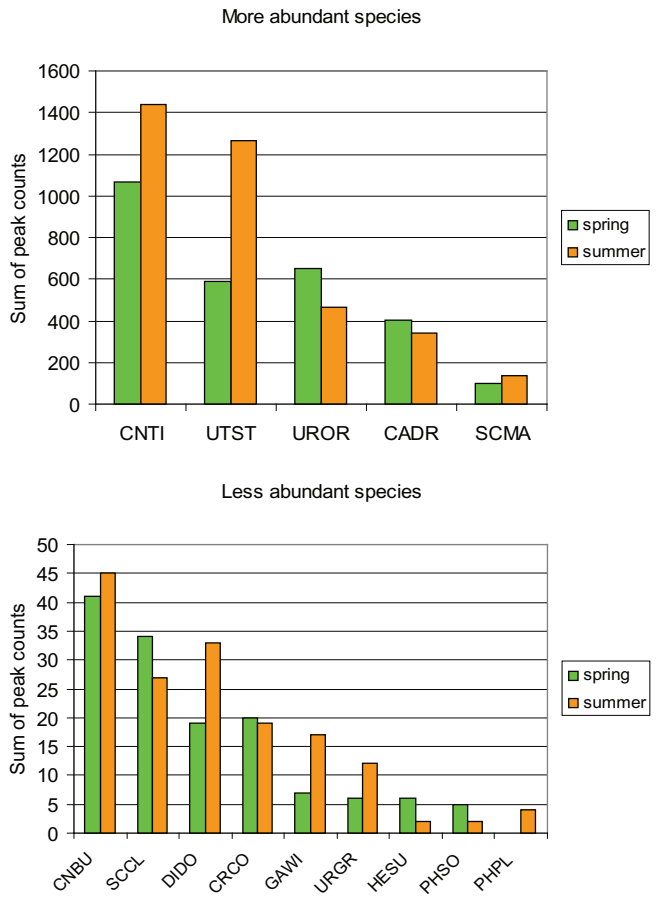

Figure 6-2. Sum of peak counts for lizards on all transects at Organ Pipe Cactus N.M., 1988-2005.

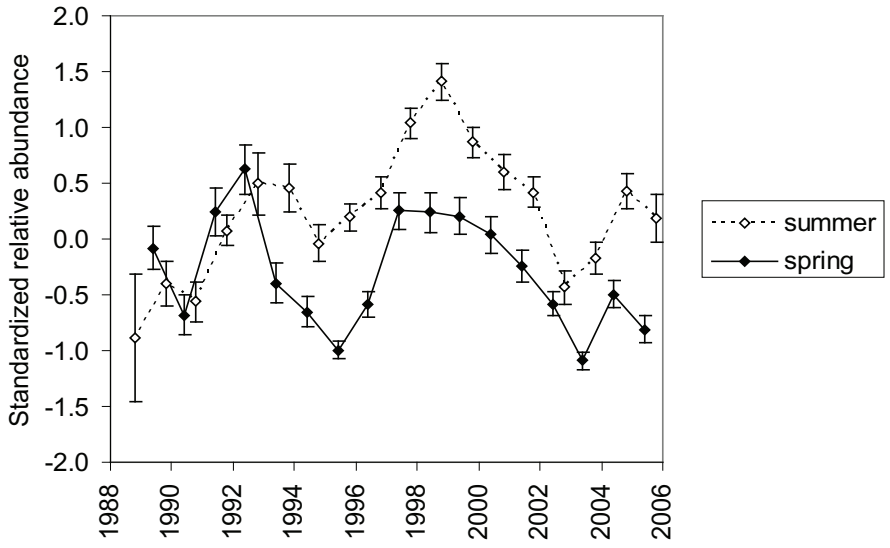

Figure 6-3. Relative abundance of all lizards, standardized for each transect at Organ Pipe Cactus N.M., 1988-2005. Mean and standard error derived from all transects pooled for a given season.

Table 6-3. Estimated annual change, based on trend model, for lizard species on transect lines at Organ Pipe Cactus N.M., 1988-2005.

Species	% Annual Change	Standard Error	95% CI	Significance
Aspidoscelis burti		insufficient data		
Aspidoscelis tigris	-2.5	1.3	(-4.9 to 0.0)	0.051
Callisaurus draconoides	-2.5	2.0	(-6.2 to 1.5)	0.214
Crotaphytus nebrius		insufficient data		
Dispsosaurus dorsalis	-6.9	3.9	(-14.2 to 1.1)	0.088
Gambelia wislizenii	5.4	6.5	(-6.7 to 19.1)	0.394
Heloderma suspectum	6.0	13.6	(-17.7 to 36.4)	0.652
Phrynosoma platyrhinos		insufficient data		
Phrynosoma solare	0.9	15.7	(-25.6 to 36.9)	0.954
Sceloporus clarkii		insufficient data		
Sceloporus magister	-2.1	2.1	(-6.1 to 2.1)	0.320
Urosaurus graciosus	8.4	16.4	(-19.5 to 45.9)	0.594
Urosaurus ornatus	0.3	2.2	(-3.9 to 4.8)	0.884
Uta stansburniana	4.8	1.2	(2.4 to 7.1)	<.001

abundance, diversity, or species richness (Figure 6-4).

Discussion

At most sites, lizards peaked in 1997-1998, fell off dramatically in 2002-2003, and recovered in 2004-2005 (Appendix A and Figure 6-3). This pattern follows the general pattern seen for rainfall in 1997-2005. Since 1996, OPCNM has experienced one wet year (1998), several mediocre rainfall years, and one record-setting dry year in 2002. Monsoon rains have been spotty at best, and there have been long dry spells in the winter and spring. Field workers have reported that insect activity has been relatively low, with many sites being eerily quiet, and there were fewer roadrunners, snakes, and other predators seen as well. Some of this can be quantitatively evaluated using the snake and bird monitoring data.

In the longer-term view (1988-2005), lizards appear to have gone through three cycles with peaks occurring in 1992, 1998, and 2004 (Figure 6-3). Interestingly, the peak in 1998 is greater despite the 1992 peak being associated with a wetter and more prolonged El Niño event. Following 1992, lizards actually declined markedly well before the rainy era ended; Rosen (2000) attributed this to high observed predator activity. Rosen (2000) reported a dramatic and consistent annual increase in predator activity (observed abundance) starting from 1990, and peaking in 1995, and decreasing after 1996. We hypothesize that the magnitude and time-lag of responses to climatic events is modified by other biotic interactions. This is novel in a field that has been largely dominated by ideas of interspecific competition and climate as determinants of lizard community function and population fluctuations.

The results of trend analyses are interesting because it is a terrestrial, small-bodied species, U. stansburiana, that has increased, while the terrestrial, larger-bodied species, A. tigris, appears to have decreased during the period 1988-2005 (Table 6-3). Many small-bodied lizards, including U. stansburiana, mature early (less than one year), produce multiple clutches, and have a short life expectancy. An examination of trends within habitat categories might reveal differences between them with respect to species with different life history strategies.

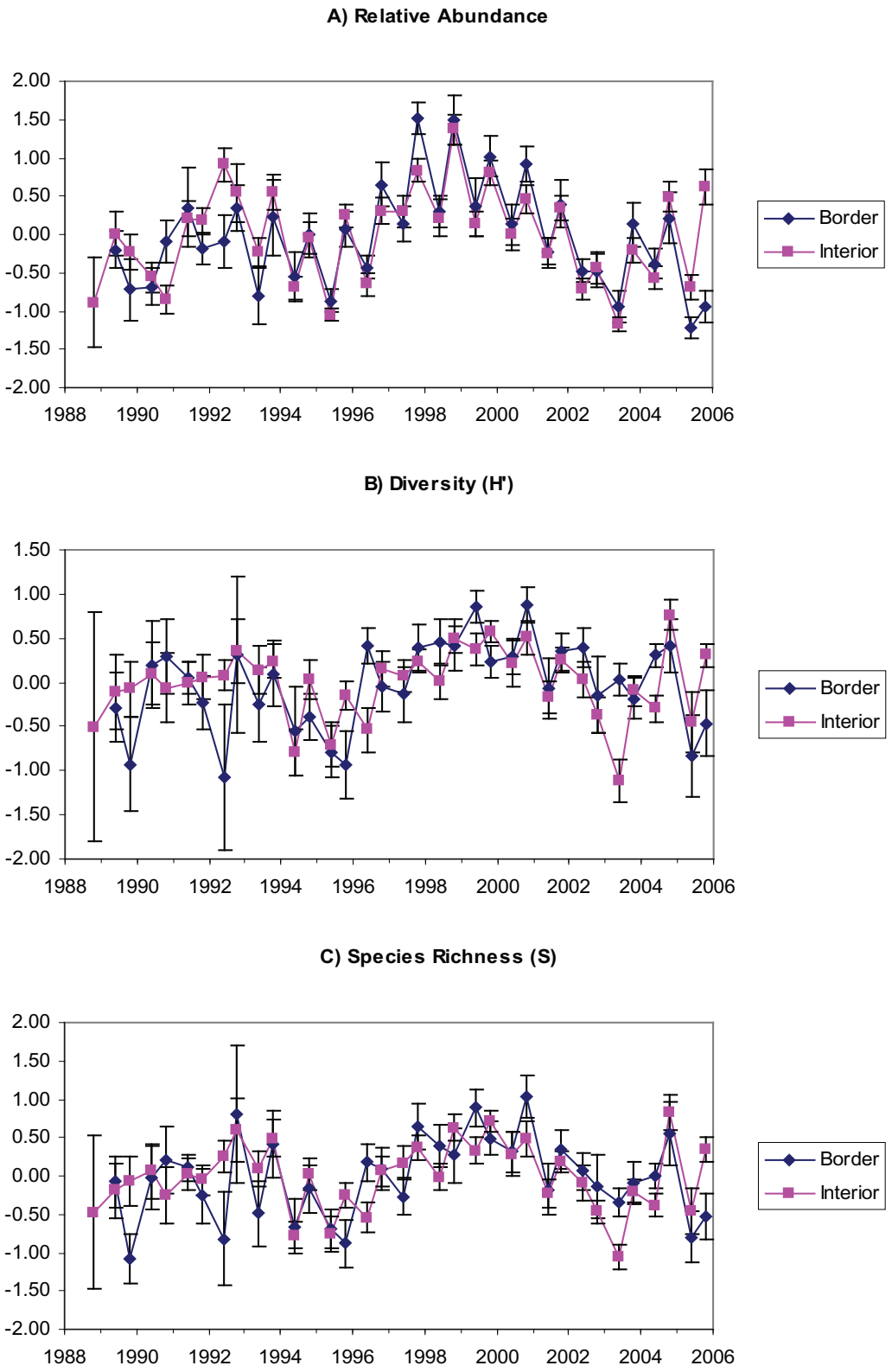

Figure 6-4. Comparison of lizard transect results from 9 border and 21 interior sites at Organ Pipe Cactus N.M. Mean and standard error for A) relative abundance, B) diversity, and C) species richness. Each site standardized to zero mean and unit variance.

Several lizard species at OPCNM are considered as sensitive from a management perspective. The U.S. Fish and Wildlife Service lists *A. burti* and *Sauromalus ater* (chuckwalla) as species of concern; BLM also lists them as sensitive species (AGFD 2006). Rosen and Lowe (1996) recommended four lizard species for the OPCNM Red List, including *A. burti*, *Sceloporus clarkii*, *U. graciosus*, and *Phrynosoma platyrhinos*. Each is at its climatically determined range limit and would be vulnerable to climate change. *A. burti* and *S. clarkii* are characteristic of deep canyons and rocky slopes of the Arizona Upland subdivision of the Sonoran Desert, whereas *U. graciosus* and *P. platyrhinos* are characteristic of valley floor environments in the Lower Colorado Valley subdivision.

While the objective of lizard monitoring at OPCNM is "to measure population changes in lizards that can be correlated with natural and human caused environmental changes," no standard has been set for the desired level of precision. A reasonable goal for detecting trends would be to be able to detect a 10% annual increase or decrease in relative abundance on study sites over a ten year time span, with α=0.10 (Type 1 error) and β=0.20 (Type 2 error). Preliminary analyses by the EMP coordinator (unpublished) suggested that 5 of the 14 species detected on lizard transects have sufficient power to detect change. These 5 species are *A. tigris*, *C. draconoides*, *S. magister*, *U. ornatus*, and *U. stansburiana*. These are common and widespread species. One common species, *C. draconoides*, prefers open ground with loose soil such as washes, dirt roads, and clearings; it may be good indicators of frequent disturbance, especially if combined with low overall lizard diversity. *Uta stansburniana* is capable of 100% annual turnover and would also be expected in recently disturbed sites that are in early stages of recovery.

This simple power analysis indicates that several key indicator species may be efficiently studied using the OPCNM EMP lizard monitoring protocol, although some less abundant species may require more effort. However, this power analysis is preliminary, and does not account for variance that can be explained by covariates of lizard abundance, such as climate and predation, for example, which will add statistical efficiency and ecological realism to the trend analyses, increasing power in both the narrow and broad sense.

Lizard species that are at their climatically determined distributional limits would be good indicators of climate change, except that they tend to be less common. To detect trends in *A. burti* and *S. clarkii,* 10 lizard lines would be needed in the Ajo Range. However, only 3 lines currently exist there. The Lower Colorado Valley species, *U. graciosus* and *P. platyrhinos,* are too uncommon to be monitored with current protocols without a large increase in effort. *Sauromalus ater* is not recorded on any of the current lizard lines and would likely require a different technique.

Recommendations

- Consider shifting some of the current lizard monitoring effort to focus more on sensitive species such as *Aspidoscelis burti* and *Sceloporus clarkii* in the Ajo Range. Develop interpretive materials for these and other species characteristic of mesic communities in larger desert mountain ranges. Educate the public about the vulnerability of these small and isolated communities to climate change.

- Lizards are a conspicuous part of the Sonoran Desert and play an important role in many food chains. Although the current protocol appears to provide a good, unbiased indicator of status and trends in lizard communities, lizards do not play as wide a range of ecological roles as do rodents or birds. In addition to being consumers and prey, rodents excavate burrows affecting soils, vegetation, and diverse wildlife habitat and they are important for seed dispersal. Birds serve as consumers (at multiple trophic levels), prey, agents of dispersal, and pollinators. The full utility of lizard data needs to be examined to determine

to what extent one can correlate changes in the lizard communities with natural and human caused environmental changes and help address current monument and regional natural resource issues.

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