RESULTS FOR FIRST-YEAR HERPETOFAUNA INVENTORIES

OF SOUTHERN COLORADO PLATEAU NATIONAL PARKS

Immature Coachwhip eating New Mexico Whiptail at Petroglyph National Monument

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Erika Nowak, Trevor Persons, and Shawn Knox

USGS Biological Resources Division
Forest and Rangeland Ecosystem Science Center
Colorado Plateau Field Station
Northern Arizona University, Flagstaff, Arizona

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INTRODUCTION

In fiscal year 2000, the Park Service received a substantial budget increase for inventory and monitoring studies, and a nationwide program to inventory vertebrates and vascular plants within the national parks was begun in earnest. As part of this new inventory effort led by the Inventory and Monitoring office, a total of 265 National Park units (parks, monuments, recreation areas, historic sites, etc.) were identified as having significant natural resources, and these were divided into 32 groups or "networks" based on geographical proximity and similar habitat types. The many NPS areas on the Colorado Plateau of Utah, northern Arizona, northwestern New Mexico, and western Colorado were divided into a northern and a southern network. An inventory plan ("Biological Inventory of National Park Areas on the Southern Colorado Plateau") was developed in 2000 for the 19 park units in the southern Colorado Plateau (SCP) network (Stuart 2000).

Long-term biological inventory goals for each park are to provide: (1) complete bibliographies of studies pertinent to biological inventory of network parks; (2) detailed summaries of biological survey and natural history specimen data for the network parks; (3) species lists for each taxonomic group in relational database and hard copy format; (4) relative abundance estimates for selected species of concern in each vertebrate and vascular plant taxonomic group; (5) spatially located data for species of interest or concern; (6) spatial data on sampling site locations for GIS and a GIS data browser; (7) pertinent herbarium and museum vouchers databases; and, (8) recommendations for long-term monitoring within the network.

In the first year of reptile and amphibian inventories in the SCP network, we surveyed the following park units: Aztec Ruins National Monument (AZRU), El Morro National Monument (ELMO), Petroglyph National Monument (PETR), Salinas Pueblo Missions National Monument (SAPU), Sunset Crater Volcano National Monument (SUCR), Walnut Canyon National Monument (WACA), Wupatki National Monument (WUPA), and Yucca House National Monument (YUHO). In addition, Hovenweep National Monument (HOVE) was transferred from the NCP to the SCP network due to its close proximity to several SCP parks being surveyed. Most of these parks have little or no information available on the reptile and amphibian species that occur within them, and species presence/absence has not been adequately determined. With such a lack of baseline information, the parks have no ability to develop management policies for the herpetofauna, and also no knowledge of the occurrence of rare or sensitive species. These parks have the highest priority needs for herpetofauna inventories.

Objectives

The overall goals of our inventory are to: 1) provide each park with a baseline inventory of reptiles and amphibian in major habitats within the park with the goal of documenting 90% of the species present; 2) identify park-specific species of special concern (which could become part of future "vital signs" monitoring); and 3) based on the inventory, recommend an effective monitoring program so that Resource Management staff at each park can assess the condition of amphibian and reptile populations over time, and detect significant changes in those populations.

STUDY AREA DESCRIPTION

Our study area covered both the southern Colorado Plateau. Figure 1 shows the location of each park surveyed on the SCP network Stuart (2000) gives more precise descriptions of the habitat and other features of each park unit.

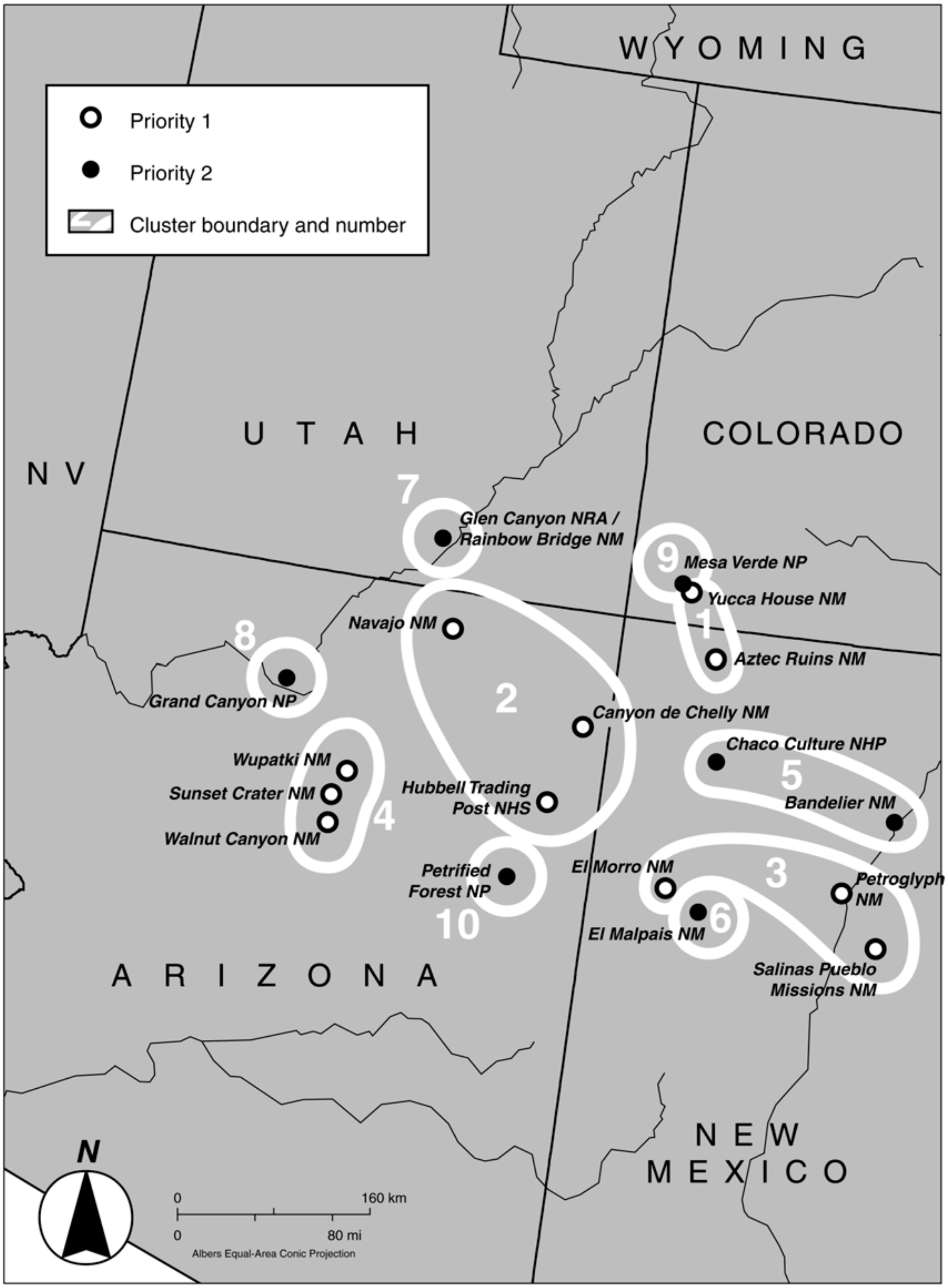


Figure 1. Location of National Park Service units in the SCP network. See Stuart (2000) for a description of park clusters (outlined in white and identified by number). Eight parks were inventoried for reptiles and amphibians in 2001: AZRU, ELMO, PETR, SAPU, SUCR, WACA, WUPA, and YUHO. HOVE was also included in Cluster 1 for reptile and amphibian surveys. See text for abbreviations.

METHODS

We conducted reptile and amphibian inventories at nine national monuments on the southern Colorado Plateau between May and September 2001 using standard herpetological techniques. These included visual survey methods (divided into time-area constrained searches, general surveys, nocturnal general surveys, and random encounters) and night road driving. Each time a survey was conducted, we recorded weather conditions, location, time, observers, and other pertinent information (Appendix A). For each species detected at each park, we photographed representative animals and collected information on age, sex, length, weight, and reproductive condition. We also collected voucher specimens of most species at each park except ELMO.

Visual Survey Methods

Time-area constrained searches (TACS) are a version of visual encounter surveys defined by Crump and Scott (1994) in which not only the amount of time spent searching, but also the area covered, are standardized. TACS consist of walking systematically through each habitat within the sampling area for a specified amount of time, searching all reasonable areas within that habitat, and recording reptiles and amphibians encountered (Drost and Nowak 1997, Scott 1994). This method yields a number of individuals and species collected or observed per person-hour.

Using one or two people, we conducted one-hour time-constrained searches within randomly-generated or non-randomly selected one-ha plots. In larger parks, i.e. ELMO, PETR, SUCR, WACA, and WUPA, our TACS plots were primarily randomly generated. These sites were a subset of those determined using GIS to stratify parks by habitat (see Stuart 2000). In smaller parks, i.e. AZRU, HOVE, SAPU, and YUHO), we did not have randomly generated plots, but instead used non-randomly selected plots. These plots covered same area as the randomly-generated plots, but their location was based on a subjective appraisal of habitat quality for herpetofauna and uniqueness. For comparison purposes, we also conducted non-random TACS in several parks with random plots, including ELMO and PETR.

When possible, we tried to keep plot dimensions at $100m^{2,}$ centered on the randomly-generated point coordinates. In some areas, we were forced to move the plot center or change its shape to stay within a given habitat type. In at least once case (at PETR), the randomly generated point fell well outside the park boundaries, requiring us to move the plot center over 100 m. For each plot, we recorded the location of center point in UTMs using a global positioning system (GPS) unit, as well as plot dimensions and orientation if different from cardinal bearings (N, S, E, W). We also photographed and described the topography, elevation, slope, aspect, vegetation, and non-vegetative cover of each plot using data sheets developed in conjunction with the database manager for the Southern Colorado Plateau I&M Network (Appendix A).

We conducted visual encounter surveys that were not time or area-limited. In these "general surveys," we sampled habitats that appeared to be of high quality for reptiles or amphibians, were otherwise unique, and/or not represented by TACS plots. The focus of this method was to search selected microhabitats opportunistically without necessarily covering a given area thoroughly.

Most of these general surveys were conducted during the day, but we also conducted some at night. Nocturnal general surveys were used primarily to search amphibian breeding areas and document calling and/or larvae. Usually these surveys were conducted by walking, but at YUHO, where amphibian breeding habitats are scattered over a large area, we drove between sites.

Amphibians and reptiles seen incidental to other fieldwork by us or seen by park staff were referred to as "random encounters." As with the amphibians and reptiles seen or captured by the different sampling methods described above, we recorded standard data on random encounters, including date, time, location, species, and size measurements and sex (if the animal was captured).

Road or Night Driving Surveys

Driving slowly on roads at night and carefully scanning the road in the headlights of the vehicle is recognized as an excellent method for surveying some groups of reptiles, particularly snakes (e.g., Klauber 1939, Mendelson and Jennings 1992, Rosen and Lowe 1994, Sullivan 1981). This method is also effective for surveying amphibians (Shaffer and Juterbock 1994), particularly in the arid southwest where many anuran species are seldom active during daytime, but can often be found crossing roads on warm, rainy nights. Although suitable paved or hard-packed dirt roads within or adjacent to the parks we surveyed were minimal, we conducted limited road driving on warm, rainy summer nights. Half of the parks contained at least a few hundred consecutive meters of paved roads within their boundaries (ELMO, SAPU, SUCR, WACA, WUPA), while the rest had sections of paved or dirt roads adjacent to their boundaries (AZRU, HOVE, PETR, and YUHO). We did not conduct road driving at SUCR, WACA, or YUHO.

We standardized night driving surveys by driving a vehicle at slow speeds (30-40 km per hour) on park roads, identifying all amphibians and reptiles encountered to species and recorded if they were either alive on the road (AOR) or dead on the road (DOR), sexing and aging all individuals, as possible, and recording locations to the nearest 0.1 mi using calibrated vehicle odometers.

Voucher Specimens

We documented the presence of each species at each park using high-quality, close-up 35-mm color slides. We also attempted to collect at least one individual of each species at each park. Though many individuals were taken alive and humanely euthanized, we also salvaged many animals that were found dead on roads in or near the parks. Specimens were injected with and immersed in 10% formalin for fixing, then transferred to 55% isopropyl alcohol for preservation using standard techniques (Pisani 1973). At the conclusion of the study, these specimens will be deposited primarily in the herpetological collections at the Museum of Southwestern Biology (MSB), University of New Mexico, and some will be deposited in the Flagstaff Area National Monuments vertebrate collection. Each specimen will have a National Park Service issue specimen tag containing information on species, collector, date of collection, collection site, and National Park Service (ANCS+) catalog numbers.

Data Analyses

Sampling site locations and selected capture locations of individual animals were recorded using either a GARMIN® GPSIII Plus or Garmin 12 GPS unit in the datum NAD 27. These data will be mapped at a later date by the database manager for the Southern Colorado Plateau I&M Network.

The effectiveness of the different sampling methods was estimated by determining overall species diversity and capture rate per unit effort for each of the sampling methods. The number of species or individuals captured per unit effort was estimated by dividing the number captured or sighted by the total effort for that method or time period. The amount of sampling effort was measured as number of hours spent on each survey multiplied by the number of people per survey (person-hours). To compare the efficacy of different methods in detecting individuals per unit effort, data were analyzed using the statistical computer program SPSS ver. 10.1 (2000). For all parametric data analysis, we used Levene's test of homogeneity of variance to verify that variances between groups were homogenous (Neter et al. 1990). Comparisons between methods were made using t-tests, and among methods using the non-parametric Kruskal-Wallis H-test (Sokal and Rohlf 1981). Significance was determined at the $p \leq 0.05$ level.

To estimate inventory completeness, we first compared our results with master lists of potentially occurring species. Development of the preliminary master list of potentially occurring species was based on consultation of selected literature sources (e.g. Degenhardt et al. 1996, Hammerson 1999), extensive personal knowledge of the distribution and habitats of southwestern amphibians and reptiles, preliminary (unanalyzed) data from selected museum collections, and results of fieldwork from the 2001 season.

In addition to master lists, we used species accumulation curves (e.g. Scott 1994) and mark-recapture based models (e.g. Burnham and Overton 1979) to estimate inventory completeness. Species accumulation curves were generated for all parks using Microsoft Excel. Because mark-recapture models require the use of random (i.e. plot survey) data, results can only reasonably be applied to lizards, the group best suited to daytime, visual encounter survey techniques. Because of the limited dataset after only one year, we will wait until the completion of fieldwork at each park to perform mark-recapture analyses.

Finally, we analyzed inventory completeness in relation to effort (total person hours of field survey time) across all SCP park areas surveyed in 2001. These analyses were designed to determine if relatively lower (or higher) inventory success at some parks was simply a function of amount of time spent in the field, or if other park-specific factors were more important in determining our success rates. Scatter diagrams were plotted and linear regression analyses performed (95% confidence intervals) using SPSS SigmaPlot 5.0 graphing software.

RESULTS AND DISCUSSION

Overview of Inventory Results

During herpetological inventories at nine national monuments in the Southern Colorado Plateau Network from May to September 2001, we documented 38 amphibian and reptile species, including one salamander species, seven anuran species, 17 lizard species, and 13 snake species (Appendix B). Scientific (Latin) names for these and other species mentioned in the report are found in Appendix E. Several parks, including AZRU, ELMO, SAPU, and YUHO, did not have previous herpetological surveys, so all species discovered in them were "new." Of the remaining five parks that had some previous herpetological fieldwork, we discovered two new species at PETR, one new species at WACA, and one new species at WUPA. Overall, we estimate our inventory completeness for all parks surveyed to be 51%. Estimated inventory completeness for individual parks varied from a low of 36% for SUCR to a high of 69% for WUPA.

Sampling Effort and Efficacy of Methods

We spent approximately 511 person-hours (i.e., the number of people conducting any given survey multiplied by the number of hours per survey) on inventories for amphibians and reptiles between May and September 2001 at the nine different parks. The total amount of time, in person-hours, spent on each sampling method and at each park is summarized in Table 1.

Table 1. Sampling time in person-hours for amphibian and reptile survey methods during inventories of nine Southern Colorado Plateau National Park areas, May-September 2001. The total sampling time is summarized for each park and each method in bold type.

METHOD	AZRU	ELMO	HOVE	PETR	SAPU	SUCR	WACA	WUPA	YUHO	TOTAL
RANDOM PLOTS	-	2.05	-	22.24	-	6	8	13.76	-	**52.05**
NON-RANDOM PLOTS	9.55	3.27	25.15	9.57	18.44	-	-	-	12.55	**78.53**
TOTAL PLOTS	**9.55**	**5.32**	**25.15**	**31.81**	**18.44**	**6**	**8**	**13.76**	**12.55**	**130.58**
GENERAL SURVEYS	29.13	15.7	40.02	64.54	46.66	1.18	26.1	38.95	28.33	**290.61**
NOCTURNAL GENERAL SURVEYS	13.99	6	12.26	4.25	16.99	-	-		17.12	**70.61**
TOTAL GS	**43.12**	**21.7**	**52.28**	**68.79**	**63.65**	**1.18**	**26.1**	**38.95**	**45.45**	**361.22**
NIGHT DRIVES	0.22	1.21	10.13	0.53	6.04	-	--	1.62	-	**19.75**

TOTAL	**52.89**	**28.23**	**87.56**	**101.13**	**88.13**	**7.18**	**34.1**	**54.33**	**58.0**	**511.55**

We spent the most time sampling at PETR, the largest park. Parks with separate units (SAPU and HOVE) also received a larger share of sampling effort, in part because the habitats in each unit tended to differ from each other. SUCR received the least amount of sampling effort due to its small size, its high elevation, and to the paucity of suitable habitat there for reptile and especially amphibian species. The sampling effort at ELMO was abruptly cut short due to administrative factors beyond our control in June, so the effort there is disproportionately low compared to other parks of its size.

We spent the greatest amount of sampling time in all parks except SUCR on general surveys. This was not accidental, as we have seen in previous studies in the region that this method consistently tends to detect greater numbers of both species and individuals per unit effort than other methods (e.g. Drost et al. 2001). We then focused on random and non-random plots to provide repeatable and quantifiable sampling. Most of the parks we inventoried were less than 1000 acres, so the majority of plots we did were non-random. We spent the least amount of time conducting night road driving, as most of the parks had only short stretches of paved roads within their boundaries. We attempted to make up for the lack of night surveys via roads through walking surveys, or nocturnal general surveys. Some of these surveys involved driving between amphibian breeding ponds but we did not consider these to be bona fide night drives as we were not attempting to detect species during this time.

The amount of time spent on each method was not necessarily correlated with either the total number of individuals or species detected by that method nor the rate at which individuals were detected. Appendix C lists the numbers of individuals and species detected by each method for each park. For initial ease of comparison, these numbers were tallied across all parks and the number of individuals detected per unit effort was calculated for each taxa (Table 2). If needed, we will examine the efficacy of different methods in each park after a second season of data collection to make park-specific monitoring method recommendations.

Table 2. Total number of individuals, individual detection rate per unit effort, and number of species detected by different methods during a herpetological inventory of nine southern Colorado Plateau National Parks, May-September 2001. The total number of individuals and species detected by each method is given, as well as the detection rate (number of individuals divided by effort). Amount of effort was measured in person-hours. The total number of individual amphibians does not include larvae, but larvae are included in the total number of species.

	Random Plots	**Non-Random Plots**	**All Plots**	**General Surveys**	**Nocturnal General Surveys**	**Night Driving**	**Random Encounters**
AMPHIBIANS							
Individuals	-	-	1	64	50	20	5
Individuals / Effort	-	-	0.012	0.22	0.71	1.01	-
Species	-	-	1	6	6	5	2
LIZARDS							
Individuals	140	252	392	923	-	2	86
Individuals / Effort	2.69	3.21	3.00	3.18	-	0.10	-
Species	10	13	16	17	-	1	13
SNAKES							
Individuals	3	24	27	58	1	17	13
Individuals / Effort	0.06	0.30	0.21	0.20	0.014	0.86	-
Species	3	6	8	10	2	5	6
TOTAL							
Individuals	**143**	**276**	**420**	**1045**	**51**	**39**	**117**
Individuals / Effort	**2.75**	**3.51**	**3.22**	**3.59**	**0.72**	**1.97**	**-**
Species	**13**	**19**	**25**	**33**	**8**	**11**	**21**

While we spent the most time (effort) conducting general surveys, when corrected for the amount of effort, they were still the most productive method overall in detecting individuals of all taxa (H= 32.36; d.f.= 4; p= 0.000). General surveys were the most effective by far in detecting species. These results are consistent with those from inventories at Petrified Forest National Park (Drost et al. 2001) and those of the Northern Colorado Plateau I&M Network (Graham and Platenberg 2001 unpubl.). In fact, general survey techniques have been documented to be the best herpetological detection method for compilation of species lists (e.g. Campbell and Christman 1982, Scott 1994). General surveys were particularly effective in detecting diurnal reptiles, and slightly less effective at detecting more nocturnal amphibians. Most amphibians detected using this method were neotenic salamanders and anuran larvae living in pools of water.

The next most effective method in detecting individuals was non-random plots. While these plots were both time and area-constrained, they were not randomly selected. Instead, habitats that looked suitable for reptiles and amphibians and/or unique habitats were chosen. In this way, they were perhaps more similar to general surveys than to random plots. Drost and Nowak (1997) noted that this method was more effective in detecting individual reptiles at Montezuma Castle National Monument than either pitfall trapping or road driving. However, non-random plots were not useful for detecting amphibians in either that study or in our surveys.

Random plots were best at detecting common diurnal lizards. They tended to detected fewer individuals and species than non-random plots, but this difference was not statistically significant ($t= 0.55$, d.f.= 80, $p= 0.32$). One new species was detected on a random plot at PETR (Ringneck Snake), but this is likely due to the amount of time spent on the plots at that park, optimal weather conditions for activity, and to good luck. The poor success of randomly-selected plots in detecting both individuals and species is consistent with results from both the Northern Colorado Plateau (Graham and Platenberg 2001 unpubl.) and the Sonoran Desert I&M Networks (M. Goode, USGS Sonoran Field Station, pers. comm.), and from reptile and amphibian inventories at Olympic National Park (M. Adams, USGS Forest and Rangeland Ecosystem Science Center, pers. comm.). This is likely due to lack of focus on taxa-specific habitat quality in GIS-generated stratification layers. Many of the randomly-selected plots in our study were poor reptile habitat, and as no plots contained more than ephemeral drainages, they were also very poor amphibian habitat.

When the detection rate of individuals and species was compared between random and non-random plots with the same park (e.g. at PETR and ELMO), there was little difference in the number of species detected between the plots, but individual detection rates were mixed. At ELMO, more lizards were detected per unit effort on random plots despite less time being spent on this method. At PETR, non-random plots detected two to three times the number of both lizards (4.18 per person-hour) and snakes (0.31 per person-hour) than the random plots did (2.24 lizards and 0.09 snakes per person-hour). The results for PETR were not statistically significant ($U= 24.5$, $p= 0.951$), likely due to a low amount of effort (i.e. sample size) (see Table 1).

When the number of individuals detected per unit effort were compared between general surveys and all random and non-random plots combined, the results were statistically significant ($t= -2.28$, d.f.= 190.743, $p=0.024$). These tests were run using pooled variances (i.e., not assuming equal variances). The variances were likely not homogenous because general surveys detected much higher numbers of individuals per unit effort than either plot type ($F= 8.915$, $p= 0.005$).

Based on our first-year results, we would strongly advise against using randomly-selected plots for future inventories, and for monitoring anything other than common diurnal species. If randomly-generated plots must be used to satisfy statistical requirements and issues of repeatability, we would advise using them only on a very limited basis and instead spend the majority of effort on other methods. Rather than using a mix of non-random and random plots, we would advocate using non-random plots and documenting the shape and estimated size of the area covered in relation to the center of the plot (coordinates documented using a GPS unit).

Nocturnal general surveys were fairly effective in detecting amphibian individuals and species, but they did not work well for other taxa. These results are also consistent with those of the Northern Colorado Plateau I&M Network (Graham and Platenberg 2001 unpubl.), but they are not consistent with those of the Sonoran Desert I&M Network, where nighttime temperatures are warmer and all herpetofauna are much more likely to be nocturnally active. The parks where nocturnal general surveys were particularly effective are located at lower elevations (e.g. SAPU). We would recommend this method only for targeting known or suspected amphibian breeding areas.

Night road driving does not look to be particularly effective overall in detecting individuals or species in the parks we surveyed, although it was the most effective method in detecting individual amphibians. The low numbers for night driving in Table 3 are misleading, however. Several of the species detected during road driving were not seen using any other method, e.g. amphibians at PETR, Glossy Snake at SAPU and HOVE, and Woodhouse's Toad at SAPU. When paved roads (and occasionally hard-packed dirt roads) are available, they are well known as a herpetological technique of choice for detecting snakes and amphibians (e.g. Campbell and Christman 1982, Fitch 1987, Shafer and Juterbock 1994). On the southern Colorado Plateau, Drost and Nowak (1997), Drost et al. (2001), and Persons (2001) all found road driving to be an important method for detecting snakes and amphibians. While road driving may never be a primary sampling method in the parks we surveyed due to the paucity of suitable roads within or adjacent to park boundaries, it should be utilized on particularly favorable warm and rainy summer nights as a targeted method to detect rarer taxa.

Random encounters are hard to quantify as a sampling technique, but are very important in detecting rare taxa. These encounters commonly occurred while we were en route to conduct one of the other sampling methods. We have also included verified species observations by park staff in this category, e.g. Longnose Snake seen at PETR by Mike Medrano of the Resource Management staff. This species was not detected by any other method at PETR. We also found a young Coachwhip eating a New Mexico Whiptail in a random encounter at PETR (cover photograph).

Estimates of Inventory Completeness

Master List. To estimate inventory completeness, we primarily compared our results with master lists of potentially occurring species. These lists will evolve over the course of the study as we uncover more information from ongoing literature and museum searches, as well as refine our knowledge of species occurrence and habitats as fieldwork progresses. Although we have fragmentary data for a few parks on known occurrence of other species (from previous studies or museum specimens), these species are only ranked as highly probable, rather than as known to occur. This is because the present analyses are primarily designed to assess the efficacy of our field methods in attempting to conduct a complete species inventory, with the knowledge that other sources of information will ultimately enhance our totals of documented species in some parks.

Development of the preliminary master list of potentially occurring species (Table 3) was based on consultation of selected literature sources (e.g. Degenhardt et al. 1996, Hammerson 1999), extensive personal knowledge of the distribution and habitats of southwestern amphibians and reptiles, preliminary (unanalyzed) data from selected museum collections, and results of fieldwork from the 2001 season. Probability of species occurrence was ranked as low, medium, or high, i.e. 0-33%, 34-67%, and 68-100%. In Table 3 these three rankings are coded as 1, 2, and 3, respectively. For quantitative analysis, these rankings were converted to the midpoint of their percentage range, i.e. 0.17, 0.50, and 0.83. These values were used as weighting factors for species not found by us in 2001. For example, two species with rankings of medium probability of occurrence would combine to equal one full expected species (0.50 x 2=1.00 species), whereas six species of low probability of occurrence would be required to equal one full expected species (0.17 x 6=1.02 species). Species found by us in 2001 (coded as X in Table 3) are weighted 1.00.

Using the weighted master list approach, we estimated an overall inventory completeness of 51% for the nine SCP parks (including HOVE) surveyed in 2001 (Table 3). Values for individual parks ranged from a low of 36% for SUCR to a high of 69% for WUPA. As discussed above, these figures only represent species found during the 2001 field season, and do not include our *a priori* knowledge of museum collection holdings of other species from these parks. We expect that the ultimate documented species lists will be enhanced by the addition of museum specimen data for some parks, especially at PETR (proximity to Albuquerque) and WUPA (Persons 2001). Unfortunately, very little work has been done at the other parks, and we are unlikely to add many species by examination of museum collections and more thorough review of the literature.

Table 3. All amphibian and reptile species found or expected to occur in the nine SCP park areas surveyed in 2001. Ranking of probability of species occurrences is as follows: 1 = low probability, 2 = medium probability, and 3 = high probability). X = a species found by us in 2001. Weighted total is equivalent to the total number of species expected to occur in each park, and estimated inventory completeness is simply the number found by us in 2001divided by the weighted total.

SPECIES	AZRU	ELMO	HOVE	PETR	SAPU	SUCR	WACA	WUPA	YUHO
Amphibians									
Tiger Salamander	3	X	X	3	X	3	3	3	X
Great Plains Toad				3	1			X	
Red-spotted Toad	1	1	3	3	X		2	3	1
Woodhouse's Toad	X	1	3	3	2		1	X	X
Canyon Treefrog			1				X		
Mountain Treefrog							1		
Striped Chorus Frog	X	3	3		1		2		X
Couch's Spadefoot				3					
Plains Spadefoot	3		3	3	X			3	
New Mexico Spadefoot	3	3	3	X	X	1	3	X	3
Bullfrog	1				1				1
Northern Leopard Frog	1				1				1
Turtles and Tortoises									
Snapping Turtle				1					
Painted Turtle				1					
Slider	2			1					
Western Box Turtle				3	1				
Spiny Softshell				1					
Lizards									
Madrean Alligator Lizard							2		
Common Collared Lizard	X	2	X	X	X	1	2	X	1
Longnose Leopard Lizard	1		X	X	1			X	
Lesser Earless Lizard	3	1	2	X	X	1	1	X	
Texas Horned Lizard					1				
Short-horned Lizard	3	3	3	X	3	X	3	X	3
Roundtail Horned Lizard				X	X				
Sagebrush Lizard	X		X			1	2	3	X
Desert Spiny Lizard			X					X	
Eastern Fence Lizard	X	X	X	X	X	X	X	X	X
Tree Lizard	3	X	X	3	X	X	X	X	2
Side-blotched Lizard	3		X	X	1	1	1	X	X
Many-lined Skink	2	X	3	2	3	3	3	1	3
Great Plains Skink				X	2		2		
Chihuahuan Spotted Whiptail				1	X				
Little Striped Whiptail	2			X	X		X	X	
New Mexican Whiptail				X					
Checkered Whiptail				1	1				
Western Whiptail	X		X	3				X	
Desert Grassland Whiptail				1					
Plateau Striped Whiptail	X	X	3		1	X	X	X	X
Desert Night Lizard			1						

Table 3, continued.

SPECIES	AZRU	ELMO	HOVE	PETR	SAPU	SUCR	WACA	WUPA	YUHO
Snakes									
Glossy Snake	3		3	3	X		1	3	
Racer	1			3					
Ringneck Snake	1	1	1	X	3		3		1
Corn Snake				3					
Chihuhuan Hook-nosed Snake				3					
Western Hognose Snake	2			3	3				
Night Snake	3	3	3	3	3	3	3	X	3
Common Kingsnake	2		3	3				3	
Sonoran Mountain Kingsnake						3	X		
Milk Snake	2	3	3	1	3		1	3	2
Smooth Green Snake			2						1
Coachwhip				X					
Striped Whipsnake	X	3	X	X	X	3	3	X	X
Gopher Snake	X	X	X	3	X	3	3	X	X
Long-nosed Snake			1	X	1				
Graham Patchnose Snake		1		1	3				
Western Patchnose Snake							3	X	
Ground Snake			1					3	
Southwestern Black-headed Snake	1		2				1	1	
Plains Black-headed Snake				3	3				
Black-necked Garter Snake	1		1	1	X		2	1	1
Western Terrestrial Garter Snake	X	3	2	1	X	1	X	1	X
Checkered Garter Snake				1					
Common Garter Snake				3					
Lyre Snake							1		
Lined Snake					3				
Western Diamondback Rattlesnake				X	3				
Black-tailed Rattlesnake				2	2	1	3		
Western Rattlesnake	X	3	X	X	X	3	X	3	X
Massasauga				3	2				
Texas Blind Snake				3	1				
TOTAL RANK 1	**8**	**5**	**6**	**12**	**12**	**7**	**8**	**4**	**7**
TOTAL RANK 2	**6**	**1**	**4**	**2**	**4**	**0**	**7**	**0**	**2**
TOTAL RANK 3	**9**	**8**	**12**	**21**	**10**	**7**	**10**	**9**	**4**
TOTAL FOUND (X)	**11**	**6**	**12**	**17**	**17**	**4**	**8**	**18**	**11**
WEIGHTED TOTAL	**22.8**	**14.0**	**25.0**	**37.4**	**29.3**	**11.0**	**21.1**	**26.1**	**16.5**
ESTIMATED INVENTORY COMPLETENESS	**48%**	**43%**	**48%**	**46%**	**58%**	**36%**	**38%**	**69%**	**67%**

Species Accumulation. Species accumulation curves (plotted per survey day) for the nine SCP parks surveyed in 2001 are shown in Figure 2a-i.

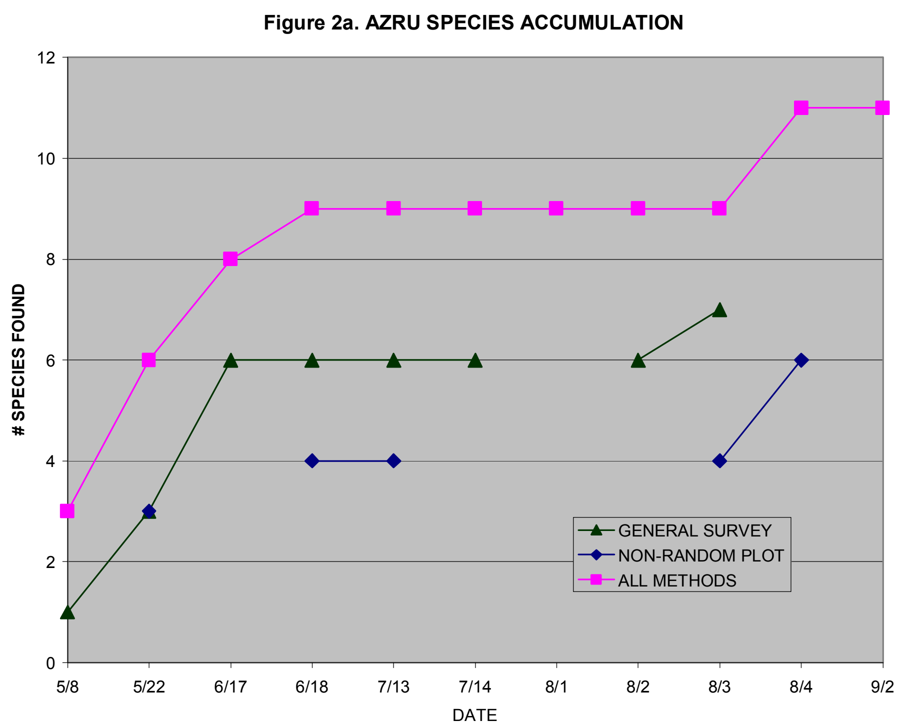


Figure 2a. AZRU SPECIES ACCUMULATION
SPECIES FOUND
DATE
0
2
4
6
8
10
12
5/8
5/22
6/17
6/18
7/13
7/14
8/1
8/2
8/3
8/4
9/2
GENERAL SURVEY
NON-RANDOM PLOT
ALL METHODS

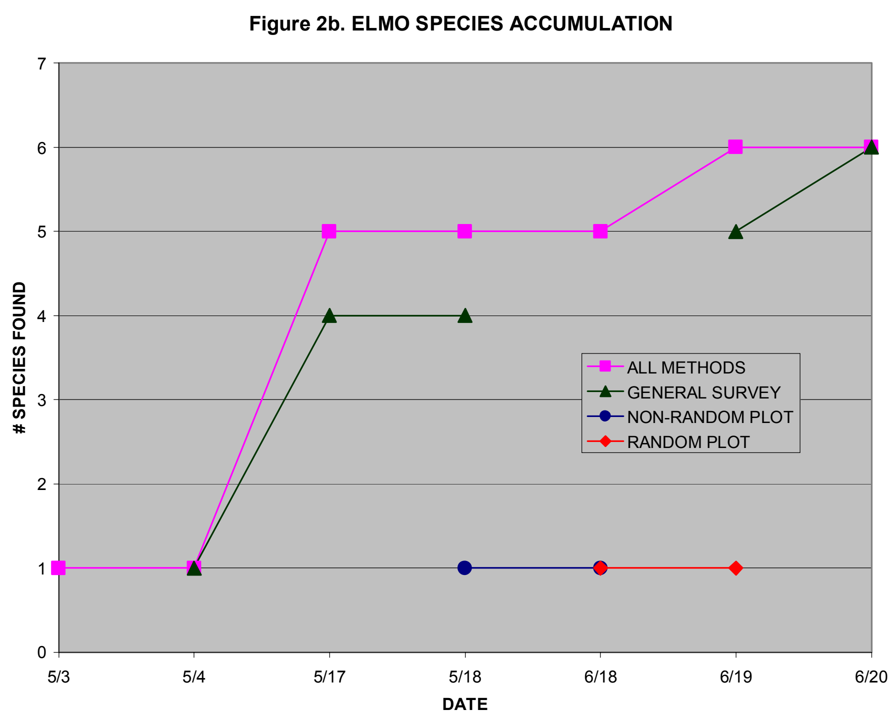


Figure 2b. ELMO SPECIES ACCUMULATION
SPECIES FOUND
DATE
0
1
2
3
4
5
6
7
5/3
5/4
5/17
5/18
6/18
6/19
6/20
ALL METHODS
GENERAL SURVEY
NON-RANDOM PLOT
RANDOM PLOT

Figure 2c. HOVE SPECIES ACCUMULATION

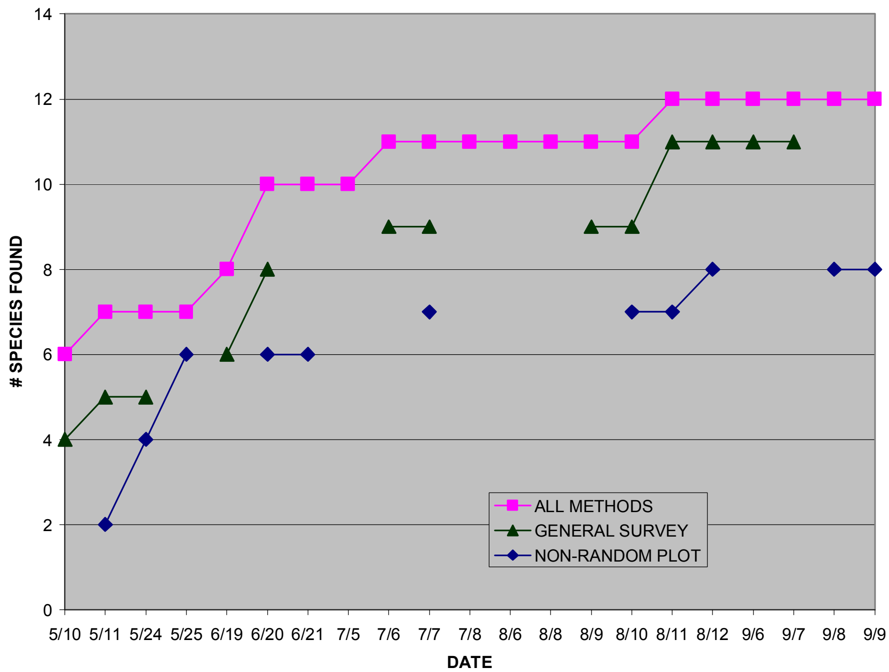


Figure 2d. PETR SPECIES ACCUMULATION

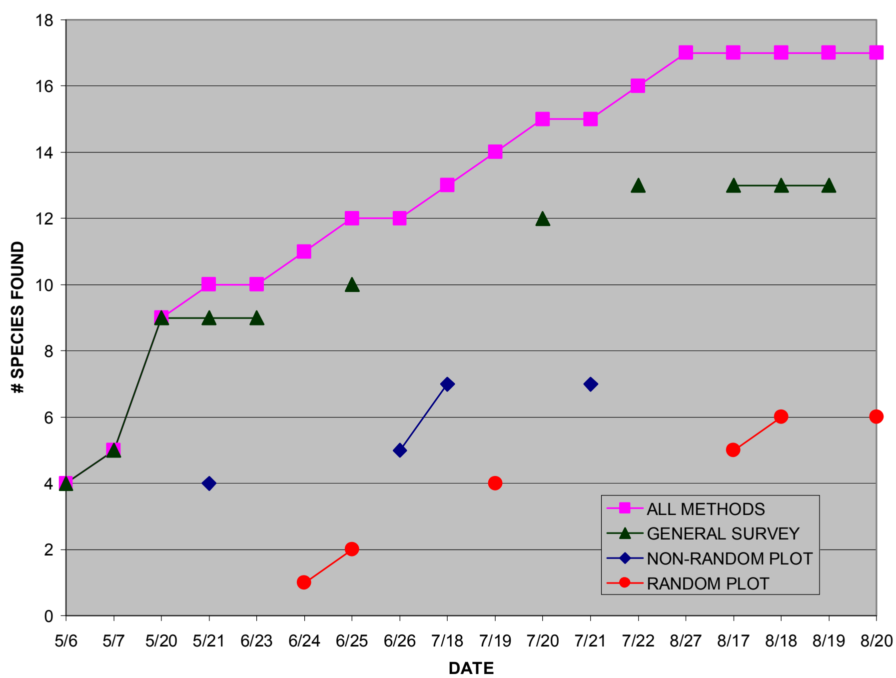


Figure 2e. SAPU SPECIES ACCUMULATION

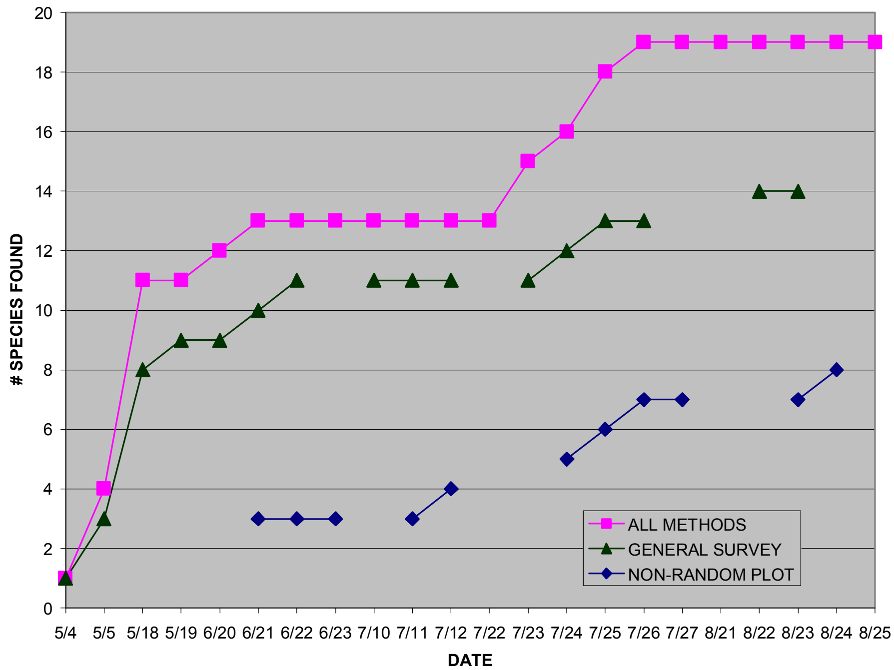


Figure 2f. SUCR SPECIES ACCUMULATION

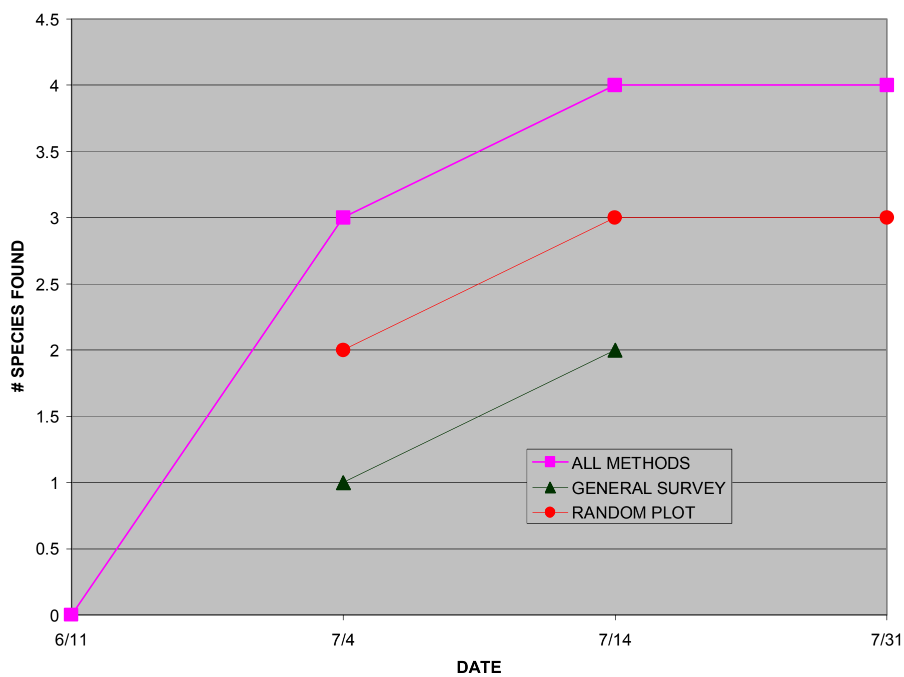


Figure 2g. WACA SPECIES ACCUMULATION

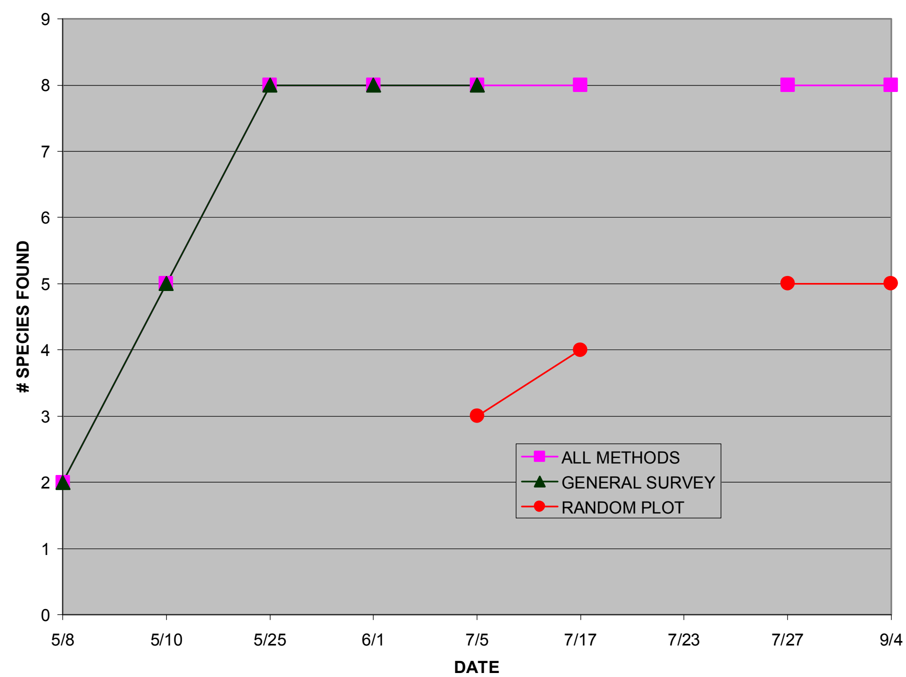
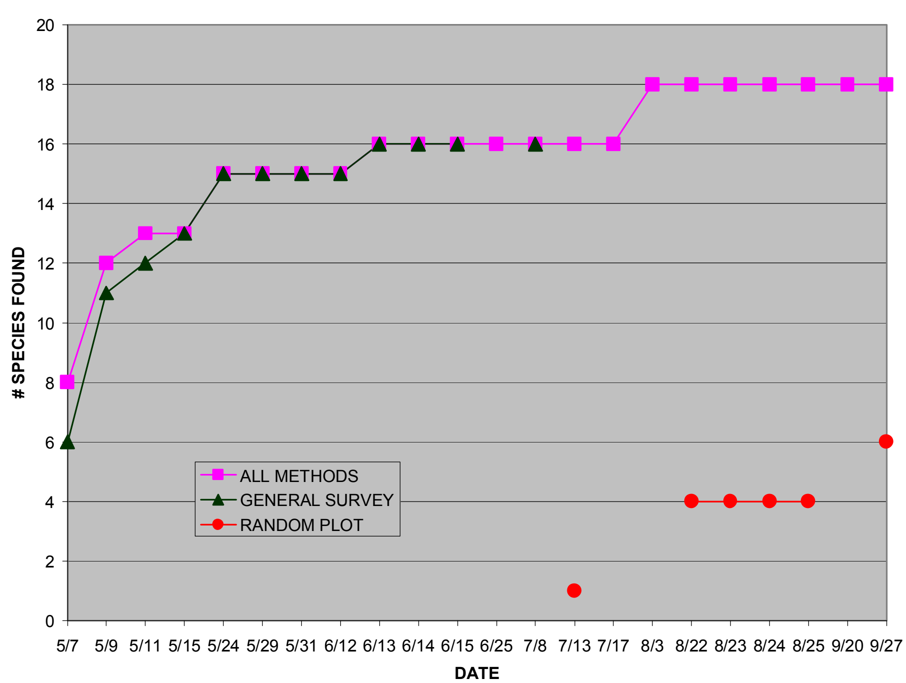


Figure 2h. WUPA SPECIES ACCUMULATION



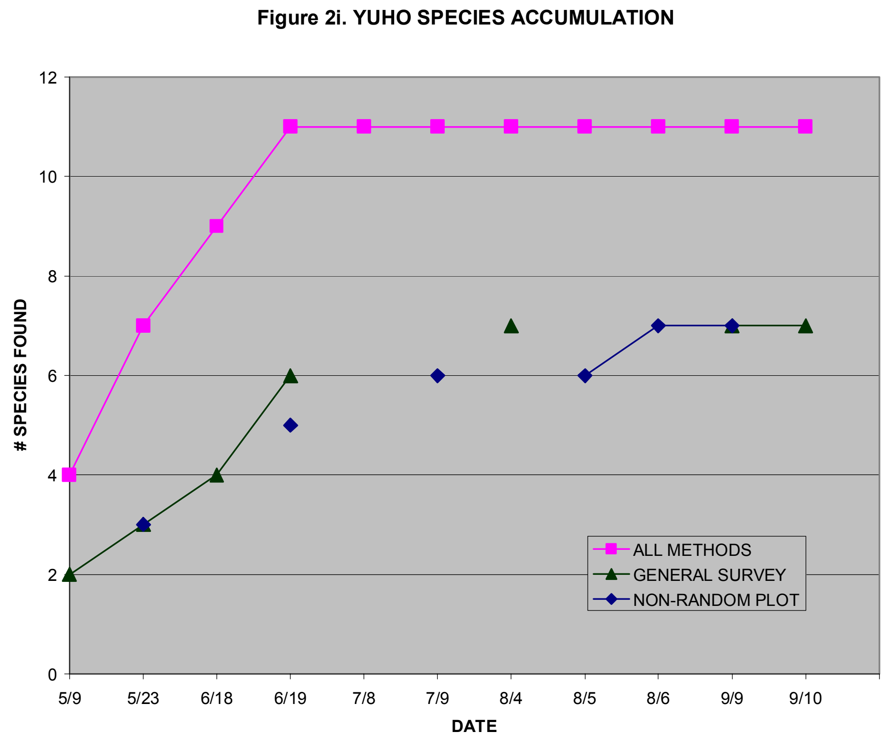


Figure 2a-i. Species accumulation curves for amphibians and reptiles from surveys conducted in 2001 at nine National Park Service areas on the southern Colorado Plateau.

Although a few parks we did not survey repeatedly do not show a sharp decline in species accumulation (e.g. ELMO, SUCR), it is obvious from examining the graphs for most parks that species accumulation rates slowed down by the end of the season, dramatically for some (e.g. WACA, YUHO). Because species accumulation rates in parks in both networks are generally slowing down even after only one year of fieldwork, we feel that are reaching a point of lower return on our investment of time (and money) using current methods.

Because estimated inventory completeness is overall only about 50%, and is in no park even 70%, the asymptotic nature of the species accumulation curve for many parks (e.g. YUHO) is misleading: we are in fact not close to detecting 90% of the species at any given park. This false asymptote tells us only that we are close to detecting most of the common species using our current methods. We are not using a variety of methods that adequately sample across taxa. Our methods thus far have largely been daytime surveys, particularly random plot searches. While random TACS provide a basis for statistical comparison among parks or habitats, they commonly detect only diurnal lizards, a group of species easily found by general surveying or VES methods. The most important factor in reducing success in 2001 was the relative unavailability of night driving as a method for detecting amphibians and snakes. Most areas surveyed in 2001 are small parks with few paved roads.

When a variety of field methods are used over a long span of time, species accumulation curves can give a reliable estimate of degree of inventory completeness, i.e., a strongly asymptotic curve suggests that you are at or near 100% completeness (Scott 1994). In a two year amphibian and reptile inventory at Petrified Forest National Park, Drost et al. (1999) plotted a strongly asymptotic species accumulation curve, and comparison with master lists of expected species produced an estimated inventory completeness of >90%. This high success rate was due to the combination of field methods that adequately sampled across taxa. In particular, nighttime road driving was extremely effective at sampling amphibians and snakes, including many species not detected by any other method.

Inventory Completeness in Relation to Effort. Across the nine SCP parks there is only a weak, non-significant relationship between effort and inventory completeness, when using total person hours as a measure of effort (Figure 3; $r^2=0.046$, df=7, $p>0.05$).

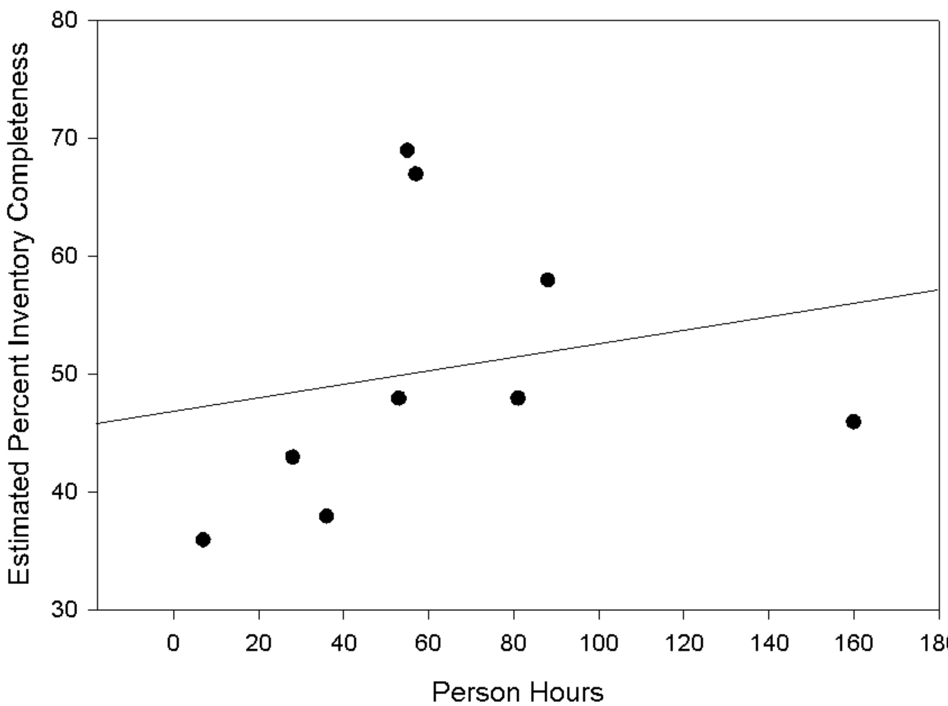


Figure 3. Scatter diagram of estimated inventory completeness in relation to effort for the nine SCP park areas surveyed for amphibians and reptiles in 2001.

The parks with the highest estimated completeness, WUPA (69%) and YUHO (67%), received only moderate amounts of effort (55 and 57 person-hours, respectively), whereas the park receiving by far the most effort (PETR, 160 person-hours) had a relatively low estimated completeness (46%). These results indicate that park-specific differences in habitats or herpetofauna greatly affect our ability to detect all, or most, species in a given area. If inventory completeness is our primary goal, we will need to tailor our efforts, both in terms of methods and field time, to individual parks.

Inventory Completeness of Different Taxa Groups. Using the same weighting methods and data from Table 3, we calculated that overall our estimated inventory completeness for amphibians was 41%, for lizards was 71%, and for snakes was 38%. The relatively high success rate for lizards is likely because most lizard species are diurnal and conspicuous, and our efforts were biased towards daytime searches (both plots and general surveys) that easily detect such species. Most amphibians on the southern Colorado Plateau (especially spadefoot toads) breed during the summer monsoon season, and are often active on only a few nights a year, making them difficult to locate. In addition, 2001was a poor monsoon year at some parks (personal observation), as temporary pools were not found at all in some areas, much less the amphibians that may use them for breeding. As with amphibians, many snake species are primarily nocturnal, and many are extremely secretive in their habits, so a low success rate for snakes is not surprising.

For both amphibians and snakes, however, the single most important factor limiting our success rate is the lack of extensive networks of roads in most of the SCP parks surveyed in 2001. Based on data from our own studies in the region (Drost et al. 1999, 2001, Persons 2001), nighttime road surveys are by far the most effective method for detecting both amphibians and snakes. At Petrified Forest National Park (Drost et al. 1999, 2001) the combination of general daytime foot surveys for lizards and nighttime road surveys resulted in an overall estimated inventory completeness of >90%.

LITERATURE REVIEW AND MUSEUM SEARCHES

Although we have just begun the process of reviewing literature relevant to herpetology in the SCP parks, we have drawn on a number of sources in compiling our list (Table 3) of species expected to occur at each park (Bateman 1976, 1980, Bleakly et al. 1996, Bury 1977, Davenport 1998, Degenhardt et al. 1996, Fowlie 1965, Hammerson 1999, Harris 1963, Persons 1999, 2001, Persons and Bradley 2000, Scott 1979, Stebbins 1985). In addition, we have begun reviewing park species lists and natural history observation cards. Although these seldom have associated documentation (e.g., photographs) that would allow us to accept a record as proof of occurrence, they frequently alert us to the possibility or probability of a species occurring in a particular park. For example, a species list for HOVE (Rado 1975) lists Smooth Green Snake as occurring in the monument. Due to marginal habitat, we would not *a priori* expect this species to occur at HOVE, but because this list is otherwise sound we must consider it as a real possibility.

Thorough museum searches will be conducted throughout the study period, and every effort will be made to locate specimens of species that remain undocumented by us at the end of each park's field inventory. Although fragmentary, knowledge of selected museum collection holdings (e.g. Museum of Northern Arizona, University of Arizona, Flagstaff Area National Monuments) has helped us in constructing our preliminary lists of hypothetical species at many parks (Table 3). For parks in New Mexico and Colorado, we will rely heavily on excellent, recent books (Degenhardt et al. 1996, Hammerson 1999) and associated databases to be made available to us (C. Painter, New Mexico Game and Fish Department, pers. comm.), which include locality data for specimens from virtually every major U.S. museum with holdings from those states.

SPECIMENS COLLECTED

We collected 99 amphibian and reptile specimens in 2001 at the nine SCP park areas surveyed (including HOVE). A complete list of these specimens is found in Appendix D. Included are a number of whiptail lizard specimens collected at WUPA as part of a separate study being conducted concurrently by TBP. Upon completion of the inventories, these 99 specimens, and others to be collected subsequently, will be deposited primarily in the herpetological collections at the Museum of Southwestern Biology (MSB), University of New Mexico, and will be assigned both MSB and National Park Service (ANCS+) catalog numbers. Some of the specimens collected from SUCR, WACA, and WUPA will be deposited in the Flagstaff Area National Monuments vertebrate collection.

RECOMMENDATIONS FOR FUTURE INVENTORY WORK

Clearly, given an overall estimated inventory completeness of only 51% and a trend in most parks of slowing of species accumulation over time, reaching the goal of 90% inventory completeness at the end of one or two years seems unrealistic without a shift in methodology. Although random plots have advantages for performing replicable statistical analyses, they are not a cost-effective means of conducting complete species inventories. Although a large enough dataset based upon randomly-located plots may be able to generate a statistically valid estimate of how complete a species inventory is (e.g. Burnham and Overton 1979), such an approach will likely not document many uncommon or rare species. It is well known that general (non random) herpetological collecting techniques are far superior if compilation of a species list is the primary goal of a project (e.g. Campbell and Christman 1982, Scott 1994). With that in mind, our recommendations for conducting fieldwork in 2002 follow.

Abandon random time/area constrained search plots. These plots, which primarily detect diurnal lizards, take a large amount of field time (locating and establishing boundaries of plots, surveying for animals, and recording of habitat data), and are unlikely to produce many new species. In addition, because most plots were conducted during peak morning lizard activity times, the brief morning window of maximum lizard activity is generally used up conducting a single survey. In order to maximize our chances of finding new species, peak activity times should be spent searching for animals across a variety of habitats. If some sort of TACS sampling method is desired, we would recommend a limited number of non-random one-hour one-hectare plots.

Conduct targeted searches for uncommon species. A general knowledge of the distribution and abundance of the more common amphibian and reptile species, (identified as a secondary goal of these inventories) comes naturally as a byproduct of fieldwork, regardless of the specific methods employed. To realistically attempt an inventory completeness of 90%, most sampling effort in

2002 should be directed towards locating uncommon or secretive species not yet detected. In particular, targeted searches should be conducted for amphibians, especially in early spring for spring-breeding species (e.g. Striped Chorus Frog) and during the summer monsoon season, when many true toads and spadefoot toads breed explosively. The largest number of undetected species are snakes, and to find them more general surveys should be conducted during optimum activity times (often evening, especially after the onset of summer monsoon rains in July and August). At other times of the day, likely microhabitats (e.g. under rocks and logs) where animals may be resting should be targeted. Where possible, night driving should also be continued during the monsoon season.

Use passive trapping methods. Although logistical constraints and limited budgets make implementation of elaborate pitfall trap or drift fence arrays (e.g. Campbell and Christman 1982) unrealistic, we should consider the limited use of trapping methods as a supplemental approach to detect some species in some habitats. Although pitfall traps can sometimes be effective at trapping small fossorial snakes and lizards (e.g. skinks, alligator lizards, Ground Snake), the need for archaeological clearance and high post-installation maintenance requirements make casual, temporary placement of pitfalls undesirable. However, small funnel traps, made from aluminum window screening, can be effective at capturing many of the same species, if placed strategically within the habitat (Fitch 1987). These funnel traps could easily be placed in convenient locations during the course of a field visit, or even left in place on a longer term basis if NPS personnel or volunteers would be willing to check them periodically.

Increase involvement of National Park Service staff and volunteers. Observations and/or collections by Park Service staff can be invaluable in an inventory effort such as this, especially for uncommon or secretive species that are generally undetected during periodic, short duration visits to the parks. Now that baseline data exists on species occurrence in most parks, help of interested staff and volunteers can more easily be solicited by distributing “want lists” of species still undetected, along with instructions on salvaging road killed animals and even capturing live animals and holding them until they could be picked up by researchers. While people’s willingness to handle amphibians and reptiles varies greatly, a number of staff at SCP parks surveyed in 2001 showed an interest in this project, and a general enthusiasm for the animals.

Observation cards held at park units have been very helpful in highlighting appropriate survey locations, but these frequently date back pre-1980’s. The staff at several parks recorded herpetofauna observations all summer, and this proved to be a valuable resource. It is recommended that all parks units be supplied with observation cards and staff encouraged to use them. We could provide training in species identification if desired.

RECOMMENDATIONS FOR LONG TERM MONITORING

Although limited data after only one year of inventory work preclude us from making detailed recommendations for monitoring of amphibians and reptiles, a few ideas are worth mentioning at this point. Clearly, more work is needed at most parks in order to reach a satisfactory level of inventory completeness, which should precede any serious long term monitoring efforts. One compromise approach could be to conduct periodic (e.g. every ten years) complete species inventories (D. Swann, Saguaro National Park, pers. comm.), which would aid in the ultimate goal of completion or near completion of species lists, and simultaneously serve as a general monitoring of overall diversity.

It is also clear from our preliminary data from 2001 that monitoring of uncommon or rare species (e.g. Milk Snake), which are often of interest as potential "vital signs" of ecosystem health, will be extremely difficult in most cases, simply because they are so difficult to locate at all. Instead, monitoring should focus on common species or groups of species (e.g., diurnal lizards). An exception would probably be small, highly localized populations of some amphibian species or known amphibian breeding areas (e.g. the Animas River at AZRU).

Based on the preliminary data from 2001, the random one-hectare plot searches do not appear to be a very effective means of detecting large numbers of individuals across taxa, and are therefore not an ideal method for long term monitoring of diversity. They may have some limited value in monitoring common diurnal lizard species. Rigorous transect-based monitoring of lizard communities has been underway at Organ Pipe Cactus National Monument for over a decade (e.g. Rosen and Lowe 1996), and such a method may be applicable to many areas on the Colorado Plateau as well. More baseline inventory data is needed in order to make specific recommendations on long term monitoring for both special concern species and overall amphibian and reptile biodiversity.

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Appendix A. Data form for herpetofauna TACS at random and non-random 1-ha plots in the Southern Colorado Plateau I&M Network. There are two pages, meant to be photocopied back to back.

Southern Colorado Plateau Herpetofauna Surveys

Date _______________ **Observers** ____________________________ **Location** ________________________________

GPS Unit ____________________ **Datum / Zone** ________________ **UTMs: N** _________________ **EPE** ____________

E __________________

Elevation ___________ **USGS Quad** _______________________________________ **Slope** __________ **Aspect** __________

Description of Plot

____

____

Photo #s __________ **Description of Photo Shots**____

Landform Class ______________________ **Soil Type** ____________________ **Surface Water Type** ___________________

Cover Stratum	Species	% Cover	Height
Tree Total %			
Shrub Total %			
Herbaceous Total %			
Unvegetated Total %	Bedrock		

	Large Rocks (>10 cm)		
	Small Rocks (0.2 - 10 cm)		
	Sand / Bare Soil		
	Litter / Duff		
	Woody Debris (> 1 cm)		
	Biotic Crust		

Southern Colorado Plateau Herpetofauna Surveys (p 2)

Date ________________ **Observers** ______________________________ **Location** ___________________________________

	Time	% Cloud Cover	Sun Condition	Ta ‘C	Ts ‘C	Wind m/s Max.	Wind m/s Av.	rH %
Begin								
End								

HERPETOFAUNA OBSERVATIONS

Species	Time	Sex	Age Class	Notes

Notes

Appendix B. Amphibians and reptiles detected at nine national parks and monuments on the Southern Colorado Plateau during herpetological surveys in 2001.

Amphibians

Tiger Salamander *(Ambystoma tigrinum*)
Great Plains Toad (*Bufo cognatus*)
Red-spotted Toad (*Bufo punctatus*)
Woodhouse's Toad (*Bufo woodhousii)*
Canyon Treefrog (*Hyla arenicolor*)
Striped Chorus Frog (*Pseudacris triseriata*)
Plains Spadefoot (*Spea bombifrons*)
New Mexico Spadefoot (*Spea multiplicata*)

Lizards

Common Collared Lizard (*Crotaphytus collaris*)
Longnose Leopard Lizard (*Gambelia wislizenii*)
Lesser Earless Lizard (*Holbrookia maculata*)
Short-horned Lizard (*Phrynosoma douglassii*)
Roundtail Horned Lizard (*Phrynosoma modestum*)
Sagebrush Lizard (*Sceloporus graciosus*)
Desert Spiny Lizard (*Sceloporus magister*)
Eastern Fence Lizard (*Sceloporus undulatus*)
Tree Lizard (*Urosaurus ornatus*)
Side-blotched Lizard (*Uta stansburiana*)
Many-lined Skink (*Eumeces multivirgatus*)
Great Plains Skink (*Eumeces obsoletus*)
Chihuahuan Spotted Whiptail (*Cnemidophorus exsanguis*)
Little Striped Whiptail (*Cnemidophorus inornatus*)
New Mexican Whiptail (*Cnemidophorus neomexicanus*)
Western Whiptail (*Cnemidophorus tigris*)
Plateau Striped Whiptail (*Cnemidophorus velox*)

Snakes

Glossy Snake (*Arizona elegans*)
Ringneck Snake (*Diadophis punctatus*)
Night Snake (*Hypsiglena torquata*)
Sonoran Mountain Kingsnake (*Lampropeltis pyromelana*)
Coachwhip (*Masticophis flagellum*)
Striped Whipsnake (*Masticophis taeniatus*)
Gopher Snake (*Pituphis catenifer*)
Long-nosed Snake (*Rhinocheilus lecontei*)
Western Patchnose Snake (*Salvadora hexalepis*)

Black-necked Garter Snake (*Thamnophis cyrtopsis*)
Western Terrestrial Garter Snake (*Thamnophis elegans*)
Western Diamondback Rattlesnake (*Crotalus atrox*)
Western Rattlesnake (*Crotalus viridis*)

Appendix C. Individual Park Accounts of Species Detected.

The following nine individual park accounts (a-i) contain summaries of our findings, number of individuals and species detected by different methods, estimated inventory completeness after the first year of fieldwork, and notes on new species, rare species, or other species of special interest. In addition, we briefly summarize where effort will be directed in 2002 in order to complete our species inventories.

a. Aztec Ruins National Monument (AZRU)

We recorded eleven species at AZRU in 2001 (Table a1), for an estimated inventory completeness of 48% (Table 3).

Table a1. Amphibian and reptile species observed at AZRU in 2001. An asterisk (*) denotes a species where a voucher specimen was collected.

*Woodhouse's Toad
*Striped Chorus Frog
*Common Collared Lizard
*Sagebrush Lizard
*Eastern Fence Lizard
*Western Whiptail
*Plateau Striped Whiptail
Striped Whipsnake
Gopher Snake
*Western Terrestrial Garter Snake
Western Rattlesnake

Table a2. Number of individuals and species detected by different methods at AZRU in 2001. An "X" in a column indicates that the method was not used at that park.

AZRU	Random Plots	Non-Random Plots	General Surveys	Nocturnal General Surveys	Night Driving	Random Encounters	TOTAL
Amphibians							
Individuals	X	-	2	7	1	2	**12**
Species	X	-	1	2	1	1	**2**
Lizards							
Individuals	X	52	35	-	-	3	**90**
Species	X	4	4	-	-	1	**5**
Snakes							
Individuals	X	2	4	1	1	-	**8**
Species	X	2	2	1	1	-	**4**
Total							
Individuals	**X**	**54**	**41**	**8**	**2**	**5**	**110**
Species	**X**	**6**	**7**	**3**	**2**	**2**	**11**

Although no previous studies have been published on the herpetofauna of AZRU, none of the species we found in 2001 were unexpected based on collections from the region (Degenhardt et al. 1996). We expect AZRU to have a fairly diverse herpetofauna for its small size, based on the diversity of habitats found in the monument. In particular, the recently added undisturbed uplands north of the main irrigation ditch likely harbor a number of snake species (e.g., Night Snake, Hognose Snake, Common Kingsnake, Glossy Snake) not yet found by us. This is also the only area in the monument where we observed Common Collared Lizards and Western Whiptails. Second year efforts will focus heavily on this habitat type in an effort to locate these species. In addition, effort will be directed toward finding a number of amphibians that likely occur (particularly Tiger Salamanders and spadefoot toads). Of special interest is the all-female Plateau Striped Whiptail, which appears to be represented at AZRU by two distinct morphological types. It is possible that these two morphological types represent two distinct species of separate hybrid origin. More observations and collections of Plateau Striped Whiptails will be made in 2002 in an effort to understand this observed variation.

b. El Morro National Monument (ELMO)

We recorded six species at ELMO in 2001 (Table b1), for an estimated inventory completeness of 43% (Table 3).

Table b1. Amphibian and reptile species observed at ELMO in 2001. An asterisk (*) denotes a species where a voucher specimen was collected.

Tiger Salamander
Eastern Fence Lizard
Tree Lizard
Many-lined Skink
Plateau Striped Whiptail
Gopher Snake

Table b2. Number of individuals and species detected by different methods at ELMO in 2001.

ELMO	Random Plots	Non-Random Plots	General Surveys	Nocturnal General Surveys	Night Driving	Random Encounters	TOTAL
Amphibians							
Individuals	-	-	14	14	-	-	**28**
Species	-	-	1	1	-	-	**1**
Lizards							
Individuals	4	3	17	-	1	3	**28**
Species	1	1	4	-	1	1	**4**
Snakes							
Individuals	-	-	1	-	-	1	**2**
Species	-	-	1	-	-	1	**1**
Total							
Individuals	**4**	**3**	**32**	**14**	**1**	**4**	**58**
Species	**1**	**1**	**6**	**1**	**1**	**2**	**6**

None of the species we found at ELMO in 2001 were unexpected based upon habitat or collections from the region (Degenhardt et al. 1996). Due to the abrupt discontinuation of field efforts midway through the summer because of perceived National Environmental Policy Act (NEPA) compliance problems, we were unable to adequately survey the monument during the summer monsoon season when spadefoot toads and some snakes were likely most active. We expect to resume surveys in spring of 2002, pending resolution of NEPA compliance issues.

c. Hovenweep National Monument (HOVE)

We recorded 12 species at HOVE in 2001 (Table c1), for an estimated inventory completeness of 48% (Table 3).

Table c1. Amphibian and reptile species observed at HOVE in 2001. An asterisk (*) denotes a species where a voucher specimen was collected. Locations in parentheses indicate park units where the species was observed. ST=Square Tower unit, H&H=Hackberry & Horseshoe unit, HOL=Holly unit, CC=Cutthroat Castle unit, CAJ=Cajon unit, and GP=Goodman Point unit.

*Tiger Salamander (H&H)
Common Collared Lizard (ST, CC, CAJ)
*Longnose Leopard Lizard (ST, CAJ)
*Sagebrush Lizard (ST, GP)
*Desert Spiny Lizard (HOL, CAJ)
*Eastern Fence Lizard (all six units)
*Side-blotched Lizard (ST, H&H, CC, CAJ)
*Tree Lizard (ST, H&H, HOL, CC, CAJ)
*Western Whiptail (ST, HOL, CC, CAJ)
Striped Whipsnake (ST)
*Gopher Snake (ST)
Western Rattlesnake (ST)

Table c2. Number of individuals and species detected by different methods at HOVE in 2001.An "X" in a column indicates that the method was not used at that park.

HOVE	Random Plots	Non-Random Plots	General Surveys	Nocturnal General Surveys	Night Driving	Random Encounters	TOTAL
Amphibians							
Individuals	X	-	1	2	-	-	**15**
Species	X	-	1	1	-	-	**1**
Lizards							
Individuals	X	65	191	-	-	20	**276**
Species	X	7	8	-	-	5	**8**
Snakes							
Individuals	X	1	2	-	9	1	**13**
Species	X	1	2	-	4	1	**3**
Total							
Individuals	**X**	**66**	**194**	**2**	**21**	**21**	**304**
Species	**X**	**8**	**11**	**1**	**8**	**6**	**12**

Because of a poor monsoon season at HOVE in 2001, a number of amphibians suspected to occur in the monument probably did not breed, thus we could not locate them by listening for breeding choruses. We did locate a number of these species (New Mexico Spadefoot, Red-spotted Toad, Woodhouse Toad) nearby while driving the main paved road outside the monument, suggesting they almost certainly occur nearby within the monument units themselves. Aside from amphibians, the other group underrepresented in our 2001 surveys were snakes. A number of uncommon, secretive snake species are known (but unvouchered) or suspected to occur at HOVE (Table 3), and targeted searches will be required to greatly increase our chances of finding these.

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d. Petroglyph National Monument (PETR)

We recorded 17 species at PETR in 2001 (Table d1), for an estimated inventory completeness of 46% (Table 3).

Table d1. Amphibian and reptile species observed at PETR in 2001. An asterisk (*) denotes a species where a voucher specimen was collected.

New Mexico Spadefoot
Common Collared Lizard
Longnose Leopard Lizard
Lesser Earless Lizard
Short-horned Lizard
*Roundtail Horned Lizard
*Eastern Fence Lizard
*Side-blotched Lizard
*Great Plains Skink
*Little Striped Whiptail
New Mexican Whiptail
*Ringneck Snake
Coachwhip
*Striped Whipsnake
Long-nosed Snake
Western Diamondback Rattlesnake
Western Rattlesnake

Table d2. Number of individuals and species detected by different methods at PETR in 2001.

PETR	Random Plots	Non-Random Plots	General Surveys	Nocturnal General Surveys	Night Driving	Random Encounters	TOTAL
Amphibians							
Individuals	-	-	-	1	1	-	**2**
Species	-	-	-	1	1	-	**1**
Lizards							
Individuals	51	40	194	-	-	19	**304**
Species	4	5	9	-	-	4	**10**
Snakes							
Individuals	2	3	6	-	-	4	**15**
Species	2	2	4	-	-	1	**6**
Total							
Individuals	**53**	**43**	**200**	**1**	**-**	**24**	**321**
Species	**6**	**7**	**13**	**1**	**-**	**6**	**17**

Although no species we found at PETR in 2001 were new for the region (Degenhardt et al. 1996), two species (Little Striped Whiptail and Ringneck Snake) are new for the monument, based on a list compiled in Bleakly et al. (1996). Both of these species were found in grasslands in the Volcanoes region of the monument. One species (Long-nosed Snake) was not found directly by us, but was photographed by Mike Medrano (PETR resource management specialist). Observations and/or collections by Park Service staff are invaluable in an inventory effort such as this, especially for uncommon or secretive species that are generally undetected during periodic, short duration visits to an area. Future efforts will be directed towards finding amphibians and snakes by increasing surveys during the summer monsoon season. In addition, many species listed as hypothetical in Table 3 (mostly turtles) are only likely in the small, disjunct section of the monument along the Rio Grande, an area we did not survey in 2001.

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e. Salinas Pueblo Missions National Monument (SAPU)

We recorded 17 species at SAPU in 2001 (Table e1). Although our inventory completeness at any given unit (not calculated) is likely fairly low, the combination of all three units produced an estimated inventory completeness of 58% (Table 3).

Table e1. Amphibian and reptile species observed at SAPU in 2001. An asterisk (*) denotes a species where a voucher specimen was collected. Locations in parenthesis indicate park units in which each species was observed.

*Tiger Salamander (Abo)
*New Mexico Spadefoot (Abo)
*Plains Spadefoot (Gran Quivira, Quarai)
*Red-spotted Toad (Abo)
*Common Collared Lizard (Abo, Quarai)
Lesser Earless Lizard (Gran Quivira)
*Roundtail Horned Lizard (Abo)
*Eastern Fence Lizard (Abo, Gran Quivira, Quarai)
Tree Lizard (Abo)
*Little Striped Whiptail (Abo, Gran Quivira)
*Chihuahuan Spotted Whiptail (Abo, Quarai)
*Glossy Snake (Gran Quivira)
Striped Whipsnake (Gran Quivira)
Gopher Snake (Quarai)
*Black-necked Garter Snake (Abo)
*Western Terrestrial Garter Snake (Abo, Quarai)
Western Rattlesnake (Gran Quivira)

Table e2. Number of individuals and species detected by different methods at SAPU in 2001. An "X" in a column indicates that the method was not used at that park.

SAPU	Random Plots	Non-Random Plots	General Surveys	Nocturnal General Surveys	Night Driving	Random Encounters	TOTAL
Amphibians							
Individuals	X	-	28	-	8	-	**36**
Species	X	-	3	-	3	-	**5**
Lizards							
Individuals	X	49	92	-	1	7	**149**
Species	X	4	7	-	1	3	**7**
Snakes							
Individuals	X	6	21	-	6	4	**37**
Species	X	4	4	-	4	2	**6**
Total							
Individuals	**X**	**55**	**141**	**-**	**15**	**11**	**222**
Species	**X**	**8**	**14**	**-**	**8**	**5**	**19**

Although no previous work has been published on amphibians and reptiles at SAPU, the species we found were not unexpected based upon knowledge of the herpetofauna of the region (Degenhardt et al. 1996). Although not unexpected based on habitat, the Roundtail Horned Lizard collected at Abo is a new record for Torrence County (Degenhardt et al. 1996). Most of the species likely to occur at SAPU that we did not find in 2001 (i.e. those ranked as "3" in Table 3) are snakes (e.g., Ringneck Snake, Hognose Snake, Night Snake, Milk Snake, Graham Patchnose Snake, Lined Snake, Plains Black-headed Snake, Western Diamondback Rattlesnake). Our 2002 efforts will largely be directed at locating these species.

f. Sunset Crater Volcano National Monument (SUCR)

We recorded only four species at SUCR in 2001 (Table f1), for an estimated inventory completeness of 36% (Table 3).

Table f1. Amphibian and reptile species observed at SUCR in 2001. An asterisk (*) denotes a species where a voucher specimen was collected.

*Eastern Fence Lizard
*Tree Lizard
*Short-horned Lizard
Plateau Striped Whiptail

Table f2. Number of individuals and species detected by different methods at SUCR in 2001. An "X" in a column indicates that the method was not used at that park.

SUCR	Random Plots	Non-Random Plots	General Surveys	Nocturnal General Surveys	Night Driving	Random Encounters	TOTAL
Amphibians							
Individuals	-	X	-	X	X	-	**-**
Species	-	X	-	X	X	-	**-**
Lizards							
Individuals	20	X	5	X	X	1	**26**
Species	3	X	2	X	X	1	**4**
Snakes							
Individuals	-	X	-	X	X	-	**-**
Species	-	X	-	-	-	-	**-**
Total							
Individuals	**20**	**X**	**5**	**X**	**X**	**1**	**26**
Species	**3**	**X**	**2**	**X**	**X**	**1**	**4**

Although relatively little field time was spent at SUCR in 2001, the primary reason for the low species total was our focus on conducting random plot surveys, which generally produced only Eastern Fence Lizards and Tree Lizards, which are widespread throughout the ponderosa pine forest (Eastern Fence Lizard) and associated lava flows (Tree Lizards). The one happenstance capture of a Short-horned Lizard did, however, occur on a random plot. Plateau Striped Whiptails were only seen in small area along the roadside near the eastern boundary, and may be restricted to this area based on a lack of suitable habitat elsewhere in the monument (Monica Hansen, personal communication). Most of the species likely to occur at SUCR that we did not find in 2001 (i.e. those ranked as "3" in Table 3) are snakes (e.g., Night Snake, Sonoran Mountain Kingsnake, Striped Whipsnake, Gopher Snake, Western Rattlesnake). Our 2002 efforts should include targeted searches of microhabitats (e.g. under natural cover objects, areas of increased rodent activity) where snakes are more likely to be found.

g. Walnut Canyon National Monument (WACA)

We recorded eight species at WACA in 2001 (Table g1), for an estimated inventory completeness of 38% (Table 3).

Table g1. Amphibian and reptile species observed at WACA in 2001. An asterisk (*) denotes a species where a voucher specimen was collected.

*Canyon Treefrog
Eastern Fence Lizard
Tree Lizard
*Little Striped Whiptail
*Plateau Striped Whiptail
Sonoran Mountain Kingsnake
Western Terrestrial Garter Snake
Western Rattlesnake

Table g2. Number of individuals and species detected by different methods at WACA in 2001. An "X" in a column indicates that the method was not used at that park.

WACA	Random Plots	Non-Random Plots	General Surveys	Nocturnal General Surveys	Night Driving	Random Encounters	TOTAL
Amphibians							
Individuals	-	X	2	X	X	3	**5**
Species	-	X	1	X	X	1	**1**
Lizards							
Individuals	33	X	116	X	X	13	**162**
Species	4	X	4	X	X	2	**4**
Snakes							
Individuals	1	X	3	X	X	-	**4**
Species	1	X	3	X	X	-	**3**
Total							
Individuals	**34**	**X**	**121**	**X**	**X**	16	**171**
Species	**5**	**X**	**8**	**X**	**X**	3	**8**

Although no studies have been published on the herpetofauna of Walnut Canyon, species lists have been produced based on specimens in NPS and other museum collections (unpublished data). Based upon these collections, Canyon Treefrog and both whiptail species are additions to the known herpetofauna of the monument. The Canyon Treefrog was found to be locally abundant in the area of Cherry Canyon that contains permanent rock pools ("tinajas"). One of these pools also produced our only observation of Western Terrestrial Garter Snake, and the habitat appears favorable for Black-necked Garter Snake as well. Although Plateau Striped Whiptails were expected, especially in the more open eastern areas of the canyon bottom, the discovery of Little Striped Whiptails was surprising. The Little Striped Whiptail is generally considered a grassland species, and is locally common in the area from Wupatki southeastward to Meteor Crater, generally between 5000 and 5800 feet elevation (Hahn and May 1972, unpublished data). An isolated chaparral-inhabiting population occurs in the Mazatzal Mountains of central Arizona, as well as near Grand Canyon Village (Hermit Basin) in Grand Canyon National Park (Wright and Lowe 1993). At WACA, Little Striped Whiptails were found in brushy areas in the bottom of Walnut Canyon, as well as in associated side canyons, from the new eastern boundary upstream at least as far as Santa Fe Dam, and at elevations up to 6420 feet. Future surveys both within and outside the monument will determine the relationship of the WACA population to other area populations.

Because WACA has a diversity of habitats, the list of potential amphibian and reptile species is large (Table 3a). Many species associated with Mogollon Rim/central Arizona highland habitats reach the northern limit of their regional distribution near WACA (e.g., Mountain Treefrog, Madrean Alligator Lizard, Great Plains Skink, Lyre Snake, Black-tailed Rattlesnake). Future efforts should be directed towards finding these more elusive species.

h. Wupatki National Monument (WUPA)

We recorded 18 species at WUPA in 2001 (Table h1), for an estimated inventory completeness of 69% (Table 3).

Table h1. Amphibian and reptile species observed at WUPA in 2001. An asterisk (*) denotes a species where a voucher specimen was collected.

Great Plains Toad
Woodhouse's Toad
New Mexico Spadefoot
Common Collared Lizard
*Longnose Leopard Lizard
*Lesser Earless Lizard
Short-horned Lizard
*Desert Spiny Lizard
*Eastern Fence Lizard
*Tree Lizard
*Side-blotched Lizard
*Little Striped Whiptail
*Plateau Striped Whiptail
*Western Whiptail
Night Snake
Striped Whipsnake
Gopher Snake
Western Patchnose Snake

Table h2. Number of individuals and species detected by different methods at WUPA in 2001. An "X" in a column indicates that the method was not used at that park.

WUPA	Random Plots	Non-Random Plots	General Surveys	Nocturnal General Surveys	Night Driving	Random Encounters	TOTAL
Amphibians							
Individuals	-	X	2	X	10	-	**12**
Species	-	X	1	X	2	-	**3**
Lizards							
Individuals	32	X	245	X	-	15	**292**
Species	6	X	11	X	-	7	**11**
Snakes							

Individuals	-	X	4	X	1	2	**7**
Species	-	X	4	X	1	2	**4**
Total							
Individuals	**32**	**X**	**251**	**X**	**11**	**17**	**311**
Species	**6**	**X**	**16**	**X**	**3**	**9**	**18**

Because a recent study of amphibian and reptile road mortality at WUPA recorded large numbers of amphibians and snakes (Persons 2001), we focused most of our 2001 efforts on daytime surveys for lizards. One species found in 2001, the Tree Lizard, was previously unknown from the monument. Also of note was the discovery of an area of sympatry of all three whiptail species in the bottom of Antelope Wash. With the inclusion of specimens collected previously (Persons 2001), WUPA's estimated inventory completeness will be >80% (unpublished data). Efforts in 2002 should be directed towards finding the few remaining species that likely occur (e.g., Tiger Salamander, Sagebrush Lizard, Milk Snake), which would require targeted searches and possibly the use of pitfall or funnel traps.

i. Yucca House National Monument (YUHO)

We recorded eleven species at YUHO in 2001 (Table i1), for an estimated inventory completeness of 67% (Table 3).

Table i1. Amphibian and reptile species observed at YUHO in 2001. An asterisk (*) denotes a species where a voucher specimen was collected.

Tiger Salamander
Woodhouse's Toad
Striped Chorus Frog
*Sagebrush Lizard
*Eastern Fence Lizard
*Side-blotched Lizard
*Plateau Striped Whiptail
Striped Whipsnake
Gopher Snake
*Western Terrestrial Garter Snake
Western Rattlesnake

Table i2. Number of individuals and species detected by different methods at YUHO in 2001. An "X" in a column indicates that the method was not used at that park.

YUHO	Random Plots	Non-Random Plots	General Surveys	Nocturnal General Surveys	Night Driving	Random Encounters	TOTAL
Amphibians							
Individuals	X	-	15	26	X	-	**41**
Species	X	-	1	3	X	-	**3**
Lizards							
Individuals	X	43	28	-	X	5	**76**
Species	X	5	3	-	X	2	**4**
Snakes							
Individuals	X	12	17	2	X	1	**32**
Species	X	2	3	1	X	1	**4**
Total							
Individuals	**X**	**55**	**60**	**27**	**X**	**6**	**149**
Species	**X**	**7**	**7**	**4**	**X**	**3**	**11**

In addition to the monument proper, our surveys in 2001 encompassed surrounding lands soon to be added to the monument. The various ditches and ponds on these surrounding lands account for the three amphibian species we found, and for the relative abundance of Western Terrestrial Garter Snakes in the area. The elimination of the Ute Mountain Ditch begun in 2001 (by enclosing in pipe) and anticipated drying of the various ponds on the property may greatly decrease populations or eliminate some of these species from the monument. Based on our observations, as well as those of others (Marilyn Colyer, personal communication), the rubble mounds on the main monument appear to serve as hibernacula for snakes. We found many shed skins there in 2001, primarily of Striped Whipsnakes, Gopher Snakes, and Western Terrestrial Garter Snakes. We plan on visiting this site in the spring of 2002, in hopes of discovering less common snakes (e.g., Milk Snake, Night Snake) that may share this hibernaculum with the more common species.

Appendix D. Amphibians and reptiles collected at nine southern Colorado Plateau National Park areas (including Hovenweep National Monument) in 2001. Collector abbreviations are EMN = Erika M. Nowak, TBP = Trevor B. Persons, and SCK = Shawn C. Knox. For convenience, all specimens, regardless of collector, were assigned numbers in the field catalog of Trevor B. Persons.

Species	Park	Field Number	Date	Collectors	UTM East	UTM North	Locality	Notes
Tiger Salamander	HOVE	TBP 110	6/19/2001	TBP, SCK			Hackberry unit, pool under ledge at head of main canyon	Regular terrestrial form
Tiger Salamander	SAPU	TBP 073	5/18/2001	TBP, SCK	373484	3812379	Abo unit, in upper of two largest pools in main canyon	Regular terrestrial form
Tiger Salamander	SAPU	TBP 075	5/18/2001	TBP, SCK	373498	3812408	Abo unit, pool above larger pools in main canyon	Neotenic form
Canyon Treefrog	WACA	TBP 085	5/25/2001	TBP	456227	3890159	Cherry Canyon	same as TBP 086/ 087
Canyon Treefrog	WACA	TBP 086	5/25/2001	TBP	456227	3890159	Cherry Canyon	same as TBP 085/ 087
Canyon Treefrog	WACA	TBP 087	5/25/2001	TBP	456227	3890159	Cherry Canyon	same as TBP 085/ 086
New Mexico Spadefoot	SAPU	TBP 151	7/26/2001	EMN	373898	3811801	Abo unit; On US 60 at jct. of SR 513, just south of Abo unit	dying on road
Plains Spadefoot	SAPU	TBP 150	7/23/2001	EMN	400187	3791697	Gran Quivira unit; SR 55, 1.0 mi. e. of turnoff into unit	Just n. of boundary (road runs along it)
Plains Spadefoot	SAPU	TBP 158	8/23/2001	TBP	381402	3828437	Quarai unit, Spanish Corral trail	
Red-spotted Toad	SAPU	TBP 074	5/18/2001	TBP, SCK	373436	3812380	Abo unit, on path beside pool, along main canyon	
Striped Chorus Frog	AZRU	TBP 097	6/17/2001	TBP, SCK	767523	4080521	In irrigation ditch in orchard	
Woodhouse's Toad	AZRU	TBP 098	6/17/2001	TBP, SCK	767495	4080512	In irrigation ditch in orchard	
Roundtail Horned Lizard	PETR	TBP 088	5/21/2001	EMN, SCK	341001	3891623	Southern Geologic Window unit	Collected on 1 Ha plot
Roundtail Horned Lizard	SAPU	TBP 072	5/18/2001	SCK, TBP	373489	3812739	Abo unit, in rocky draw	Same GPS as TBP 071
Common Collared Lizard	AZRU	TBP 101	6/18/2001	TBP, SCK	767344	4080971	Large wash, n. section of mon.	UTM center of 1 Ha plot
Common Collared Lizard	SAPU	TBP 069	5/18/2001	TBP, SCK	373595	3812701	Abo unit, in rocky draw	
Desert Spiny Lizard	HOVE	TBP 132	7/6/2001	EMN	660969	4129395	Cajon unit	
Desert Spiny Lizard	WUPA	TBP 051	5/7/2001	TBP	467621	3927954	Sandstone outcrop w. of FR 545 just n. of monument boundary	SVL 75 mm, VT 114 mm
Desert Spiny Lizard	WUPA	TBP 093	6/12/2001	TBP	464183	3933536	Road along Doney Mountain	Ran over by TBP!
Eastern Fence Lizard	AZRU	TBP 095	6/17/2001	TBP, SCK			Visitor Center	On rock wall outside VC
Eastern Fence Lizard	HOVE	TBP 107	6/19/2001	TBP, SCK	670709	4138803	Square Tower unit, Ruin Canyon	
Eastern Fence Lizard	HOVE	TBP 135	8/9/2001	TBP			Goodman Point unit, in wash ca. 20 m upstream of dropoff	
Eastern Fence Lizard	PETR	TBP 079	5/21/2001	TBP, SCK	343061	3891971	W. of road, in Boca Negra Cyn.	
Eastern Fence Lizard	PETR	TBP 080	5/21/2001	TBP, SCK	343113	3891907	W. of road, in Boca Negra Cyn.	
Eastern Fence Lizard	SAPU	TBP 068	5/18/2001	TBP, SCK	373711	3812729	Abo unit, on wall of main ruins	
Eastern Fence Lizard	SAPU	TBP 153	8/22/2001	TBP	398275	3790928	Gran Quivira; w. end of unit.	

Appendix D, continued.

Eastern Fence Lizard	SAPU	TBP 157	8/23/2001	TBP	381285	3828663	Quarai unit, rocks by foot bridge	
Eastern Fence Lizard	SUCR	TBP 117	7/4/2001	TBP	455409	3913574	south of FR 545 near east boundary	On 1 Ha TACS plot; UTM is center of plot. SVL 60
Eastern Fence Lizard	WUPA	TBP 053	5/7/2001	TBP	467643	3928012	Sandstone outcrop just w. of FR 545, just n. of mon. bdy.	
Eastern Fence Lizard	YUHO	TBP 145	8/5/2001	SCK	708796	4121372	East end of Ismay Draw (southern drainage)	also SCK 002
Great Plains Skink	PETR	TBP 077	5/20/2001	SCK, TBP	342803	3888329	Flats along trail, Rinconada Cyn.	hand caught by SCK
Lesser Earless Lizard	WUPA	TBP 058	5/9/2001	TBP	464353	3935199	East of Antelope Wash	SVL 53, VT 50
Lesser Earless Lizard	WUPA	TBP 094	6/15/2001	TBP	454918	3934235	W. of South Mesa, s. of West Mesa	
Longnose Leopard Lizard	HOVE	TBP 139	8/11/2001	TBP	671009	4139424	Square Tower unit, rim of "Campground Canyon"	
Longnose Leopard Lizard	WUPA	TBP 054	5/7/2001	TBP	469344	3932279	On River Road, 0.73 rd. mi. NE of jct. with Wukoki ruins road	SVL 99, VT 165 (8 of that regenerated)
Sagebrush Lizard	AZRU	TBP 146	8/4/2001	SCK	767158	4081074	On mesa NW of ruins	
Sagebrush Lizard	HOVE	TBP 112	6/20/2001	TBP, SCK	670885	4138987	Square Tower unit, campground	
Sagebrush Lizard	HOVE	TBP 136	8/9/2001	TBP			Goodman Point unit, along trail to rubble mounds, near wash	
Sagebrush Lizard	YUHO	TBP 105	6/18/2001	TBP, SCK	704418	4123921	Along dirt road, Ismay property	
Short-horned Lizard	SUCR	TBP 116	7/4/2001	TBP	455409	3913574	south of FR 545 near e. bdy.	UTM ctr. Ha plot. SVL 87
Side-blotched Lizard	HOVE	TBP 109	6/19/2001	TBP, SCK	669944	4139176	Square Tower unit, head of Ruin Cyn.	
Side-blotched Lizard	PETR	TBP 076	5/20/2001	TBP, SCK	338580	3889584	South of Vulcan Volcano	Near parking area
Side-blotched Lizard	PETR	TBP 133	7/19/2001	EMN, SCK	340694	3890347		Stepped on and killed
Side-blotched Lizard	WUPA	TBP 052	5/7/2001	TBP	467640	3928021	Sanstone outcrop just w. of FR 545, just n. of mon. boundary	SVL 45, VT 73
Side-blotched Lizard	YUHO	TBP 149	8/6/2001	SCK	708868	4122137	N. drainage of Ismay Draw	also SCK 003
Tree Lizard	HOVE	TBP 108	6/19/2001	TBP, SCK	670277	4138979	Square Tower unit, Ruin Canyon	
Tree Lizard	SUCR	TBP 124	7/14/2001	TBP	452788	3912755	SW edge of Bonito Lava Flow east of Lenox Crater	On 1 Ha TACS plot, UTM is center of plot
Tree Lizard	SUCR	TBP 125	7/14/2001	TBP	452788	3912755	SW edge of Bonito Lava Flow east of Lenox Crater	On 1 Ha TACS plot, UTM is center of plot
Tree Lizard	WUPA	TBP 065	5/11/2001	TBP	457483	3933190	NW end Hull's Canyon graben	SVL 51, VT 79
Tree Lizard	WUPA	TBP 066	5/11/2001	TBP	457468	3933189	NW end Hull's Canyon graben	SVL 50, VT 70 (7 regen)
Tree Lizard	WUPA	TBP 123	7/8/2001	TBP	459237	3937275	Basalt outcrop ca. 1 mile ENE of Lomaki Ruins area	
Chihuahuan Spotted Whiptail	SAPU	TBP 070	5/18/2001	TBP, SCK	373604	3812712	Abo unit, in rocky draw	

Appendix D, continued.

Chihuahuan Spotted Whiptail	SAPU	TBP 155	8/22/2001	TBP	373542	3813022	Abo unit, along wash n. of ruins	
Little Striped Whiptail	PETR	TBP 147	7/21/2001	EMN	388610	3892152	On old road between Butte and Vulcan Volcanoes	
Little Striped Whiptail	PETR	TBP 148	7/21/2001	EMN	339135	3892446	Under large double set of power	

							lines on easement road	
Little Striped Whiptail	SAPU	TBP 154	8/22/2001	TBP	399150	3790878	Gran Quivira unit, south of ruins	
Little Striped Whiptail	WACA	TBP 064	5/10/2001	TBP	457594	3891999	Bottom of Walnut Canyon	SVL 69, VT 154 fresh dead
Little Striped Whiptail	WACA	TBP 082	5/25/2001	TBP	457272	3891871	Bottom of Walnut Canyon NE of Santa Fe dam	
Little Striped Whiptail	WACA	TBP 084	5/25/2001	TBP	457595	3892005	Bottom of Wanut Canyon	near TBP 064
Little Striped Whiptail	WACA	TBP 122	7/5/2001	TBP	459070	3892704	Bottom of Walnut Canyon	UTM center of Ha plot; fresh dead SVL 75, VT 132 (95 regenerated)
Little Striped Whiptail	WACA	TBP 127	7/17/2001	TBP	458914	3892391	On rocky slope of side canyon south of Walnut Canyon, ca. 6420 feet elevation	Near NE corner of 1 Ha plot, UTM is center of plot
Little Striped Whiptail	WUPA	TBP 059	5/9/2001	TBP	464266	3935834	Bottom of Antelope Wash	SVL 56, VT 123
Little Striped Whiptail	WUPA	TBP 067	5/15/2001	TBP	453290	3936586	S. of blowhole, s. of FR 545 ca. 1 mile east of US 89	SVL 58, VT 106 (39 regen) near TBP grassland pt. #1
Little Striped Whiptail	WUPA	TBP 130	7/19/2001	TBP	452182	3934748	Ca. 1/4 mi. e. of US 89	UTM is center of 1 Ha plot
Little Striped Whiptail	WUPA	TBP 134	8/5/2001	TBP	461454	3937001	S. of Mesa Well	Antelope Prairie area
Plateau Striped Whiptail	AZRU	TBP 089	5/22/2001	SCK, EMN	232568	4081166	Upland area north of Farmer's Ditch at north boundary	UTM is center of 1 Ha plot
Plateau Striped Whiptail	AZRU	TBP 090	5/22/2001	SCK, EMN	232568	4081166	Upland area north of Farmer's Ditch at north boundary	UTM is center of 1 Ha plot
Plateau Striped Whiptail	AZRU	TBP 099	6/18/2001	TBP, SCK	767344	4080971	Large wash, n. section of mon.	UTM is center of 1 Ha plot
Plateau Striped Whiptail	AZRU	TBP 102	6/18/2001	TBP, SCK	767344	4080971	Large wash, n. section of mon.	UTM is center of 1 Ha plot
Plateau Striped Whiptail	AZRU	TBP 103	6/18/2001	SCK, TBP			Along main irrigation ditch ca. 100 m. east of w. boundary	
Plateau Striped Whiptail	WACA	TBP 063	5/10/2001	TBP	458018	3892334	Bottom of Walnut Canyon	SVL 83, VT 178
Plateau Striped Whiptail	WACA	TBP 083	5/25/2001	TBP	457481	3891941	Bottom of Walnut Canyon, NE of Santa Fe dam	
Plateau Striped Whiptail	WACA	TBP 091	6/7/2001	TBP	459412	3892855	Bottom of Walnut Canyon	SVL 60, VT 137
Plateau Striped Whiptail	WACA	TBP 118	7/5/2001	TBP	459383	3892704	Bottom of Walnut Canyon	UTM is center of 1 Ha plot
Plateau Striped Whiptail	WACA	TBP 119	7/5/2001	TBP	459189	3892627	Bottom of Walnut Canyon	west of TBP 118
Plateau Striped Whiptail	WACA	TBP 120	7/5/2001	TBP	459070	3892704	Bottom of Walnut Canyon	UTM is center of 1 Ha plot
Plateau Striped Whiptail	WACA	TBP 121	7/5/2001	TBP	459070	3892704	Bottom of Walnut Canyon	UTM is center of 1 Ha plot

Appendix D, continued.

Plateau Striped Whiptail	WACA	TBP 128	7/17/2001	TBP	458758	3892704	Bottom of Walnut Canyon	UTM is center of 1 Ha plot
Plateau Striped Whiptail	WACA	TBP 129	7/17/2001	TBP	459415	3892433	Side canyon west of trick tank, s. side of Walnut Canyon	
Plateau Striped Whiptail	WUPA	TBP 057	5/9/2001	TBP	463557	3933387	East of Antelope Wash	SVL 83, VT 182
Plateau Striped Whiptail	WUPA	TBP 060	5/9/2001	TBP	464263	3935765	Bottom of Antelope Wash	SVL 78, VT 167

Plateau Striped Whiptail	WUPA	TBP 114	6/28/2001	TBP	460544	3937515	Below Mesa Well, just s. of n. Wupatki bdy.	
Plateau Striped Whiptail	WUPA	TBP 115	6/28/2001	TBP	460492	3937050	Below Mesa Well, just s. of n. Wupatki boundary	On 1 Ha TACS plot, just south of TBP 114
Plateau Striped Whiptail	YUHO	TBP 106	6/19/2001	TBP, SCK	705222	4124990	Near main ruin mounds	UTM is center of 1 Ha plot
Western Whiptail	AZRU	TBP 100	6/18/2001	TBP, SCK	767344	4080971	Large wash, n. section of mon.	UTM is center of 1 Ha plot
Western Whiptail	HOVE	TBP 111	6/20/2001	TBP, SCK	678571	4145692	Cutthroat Castle unit	upper end of small canyon
Western Whiptail	HOVE	TBP 140	8/12/2001	TBP			Cajon unit, SE corner of unit	
Western Whiptail	WUPA	TBP 055	5/7/2001	TBP	474236	3936257	River Rd., 0.52 mi. w. of cattle-guard, Black Falls Crossing	
Western Whiptail	WUPA	TBP 056	5/7/2001	TBP	468005	3928919	Just below Heiser Spring	SVL 86, VT 208
Western Whiptail	WUPA	TBP 061	5/9/2001	TBP	464067	3935225	Bottom of Antelope Wash	SVL 84, VT 173 (91 regen)
Black-necked Garter Snake	SAPU	TBP 071	5/18/2001	TBP, SCK	373489	3812739	Abo unit, in rocky draw	Palped out half digested *Bufo punctatus* adult
Glossy Snake	SAPU	TBP 143	7/23/2001	EMN	399053	3791090	Gran Quivira unit, by VC gate	
Gopher Snake	HOVE	TBP 113	6/20/2001	SCK, TBP	670987	4139038	Square Tower unit, bouldery hillside of cyn. e. of campground	
Gopher Snake	SAPU	TBP 144	7/23/2001	EMN	382026	3828980	Quarai unit (0.3 mi. east of unit)	dying on road
Ringneck Snake	PETR	TBP 131	7/19/2001	EMN, SCK	340143	3889430	Volcanoes area	SVL 42 cm, VT 9.6, 12.5 g.
Striped Whipsnake	PETR	TBP 078	5/20/2001	TBP, SCK	342304	3888063	In flats of Rinconada Canyon	under garbage (tile board)
W.Terrestrial Garter Snake	AZRU	TBP 096	6/17/2001	SCK, TBP	232981	4080533	Grassy field w. of Animas River	At least 8 embryos
W. Terrestrial Garter Snake	SAPU	TBP 156	8/23/2001	TBP	381603	3828741	Quarai unit, stream at e. bdy.	
W. Terrestrial Garter Snake	YUHO	TBP 104	6/18/2001	SCK, TBP	704997	4125094	By Ute Mountain irrigation ditch	Caught under board

Appendix E. Scientific names of amphibians and reptiles used in the text.

Amphibians

Tiger Salamander (*Ambystoma tigrinum*)
Great Plains Toad (*Bufo cognatus*)
Red-spotted Toad (*Bufo punctatus*)
Woodhouse's Toad (*Bufo woodhousii)*
Canyon Treefrog (*Hyla arenicolor*)
Mountain Treefrog (*Hyla exemia*)
Striped Chorus Frog (*Pseudacris triseriata*)
Couch's Spadefoot (*Scaphiopus couchii*)
Plains Spadefoot (*Spea bombifrons*)
Great Basin Spadefoot (*Spea intermontana*)
New Mexico Spadefoot (*Spea multiplicata*)
Bullfrog (*Rana catesbeiana*)
Northern Leopard Frog (*Rana pipiens*)

Turtles and Tortoises

Snapping Turtle (*Chelydra serpentina*)
Painted Turtle (*Chrysemys picta*)
Slider (*Pseudemys scripta*)
Western Box Turtle (*Terrapene ornata*)
Spiny Softshell (*Trionyx spiniferus*)

Lizards

Madrean Alligator Lizard (*Elgaria kingii*)
Common Collared Lizard (*Crotaphytus collaris*)
Longnose Leopard Lizard (*Gambelia wislizenii*)
Lesser Earless Lizard (*Holbrookia maculata*)
Texas Horned Lizard (*Phrynosoma cornutum*)
Short-horned Lizard (*Phrynosoma douglassii*)
Roundtail Horned Lizard (*Phrynosoma modestum*)
Sagebrush Lizard (*Sceloporus graciosus*)
Desert Spiny Lizard (*Sceloporus magister*)
Eastern Fence Lizard (*Sceloporus undulatus*)
Tree Lizard (*Urosaurus ornatus*)
Side-blotched Lizard (*Uta stansburiana*)
Many-lined Skink (*Eumeces multivirgatus*)
Great Plains Skink (*Eumeces obsoletus*)
Chihuahuan Spotted Whiptail (*Cnemidophorus exsanguis*)
Little Striped Whiptail (*Cnemidophorus inornatus*)
New Mexican Whiptail (*Cnemidophorus neomexicanus*)
Checkered Whiptail (*Cnemidophorus tesselatus*)
Western Whiptail (*Cnemidophorus tigris*)
Desert Grassland Whiptail (*Cnemidophorus uniparens*)
Plateau Striped Whiptail (*Cnemidophorus velox*)
Desert Night Lizard (*Xantusia vigilis*)

Appendix E, continued.

Snakes

Glossy Snake (*Arizona elegans*)
Racer (*Coluber constrictor*)
Ringneck Snake (*Diadophis punctatus*)
Corn Snake (*Elaphe guttata*)
Chihuhuan Hook-nosed Snake (*Gyalopion canum*)
Western Hognose Snake (*Heterodon nasicus*)
Night Snake (*Hypsiglena torquata*)
Common Kingsnake (*Lampropeltis getulus*)
Sonoran Mountain Kingsnake (*Lampropeltis pyromelana*)
Milk Snake (*Lampropeltis triangulum*)
Smooth Green Snake (*Liochlorophis vernalis*)
Coachwhip (*Masticophis flagellum*)
Striped Whipsnake (*Masticophis taeniatus*)
Gopher Snake (*Pituphis catenifer*)
Long-nosed Snake (*Rhinocheilus lecontei*)
Graham Patchnose Snake (*Salvadora grahmii*)
Western Patchnose Snake (*Salvadora hexalepis*)
Ground Snake (*Sonora semiannulata*)
Southwestern Black-headed Snake (*Tantilla hobartsmithi*)
Plains Black-headed Snake (*Tantilla nigriceps*)
Black-necked Garter Snake (*Thamnophis cyrtopsis*)
Western Terrestrial Garter Snake (*Thamnophis elegans*)
Checkered Garter Snake (*Thamnophis marcianus*)
Common Garter Snake (*Thamnophis sirtalis*)
Lyre Snake (*Trimorphodon biscutatus*)
Lined Snake (*Tropidoclonion lineatum*)
Western Diamondback Rattlesnake (*Crotalus atrox*)
Black-tailed Rattlesnake (*Crotalus molossus*)
Western Rattlesnake (*Crotalus viridis*)
Massasauga (*Sistrurus catenatus*)
Texas Blind Snake (*Leptotyphlops dulcis*)