

**FIRST-YEAR RESULTS FOR HERPETOFAUNA INVENTORIES
OF SOUTHERN AND NORTHERN COLORADO PLATEAU NATIONAL PARKS**

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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. Inventory plans were developed in 2000 for the 19 park units in the southern Colorado Plateau (SCP) network (Stuart 2000) and the 16 park units of the northern Colorado Plateau (NCP) network (Evenden 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 each 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. In

the NCP network, eight National Parks and Monuments were surveyed: Bryce Canyon National Park (BRCA), Capitol Reef National Park (CARE), Cedar Breaks National Monument (CEBR), Fossil Butte National Monument (FOBU), Golden Spike National Historic Site (GOSP), Pipe Spring National Monument (PISP), Timpanogos Cave National Monument (TICA), and Zion National Park (ZION).

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 park units have no ability to develop management policies for the herpetofauna, and also no knowledge of the occurrence of rare or sensitive species. These park units have the highest priority needs for herpetofauna inventories.

Objectives

The overall goals of our inventories were to: 1) provide each park with a baseline inventory of reptiles and amphibians in major habitats within each 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, to 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 AREAS DESCRIPTION

Our study area covered both the northern and southern Colorado Plateau. Figure 1a shows the location of each park surveyed on the SCP network and Figure 1b. shows the location of NCP network parks. Stuart (2000) and Evenden (2000) give more precise descriptions of the habitat and other features of each park unit for the SCP and NCP networks, respectively.

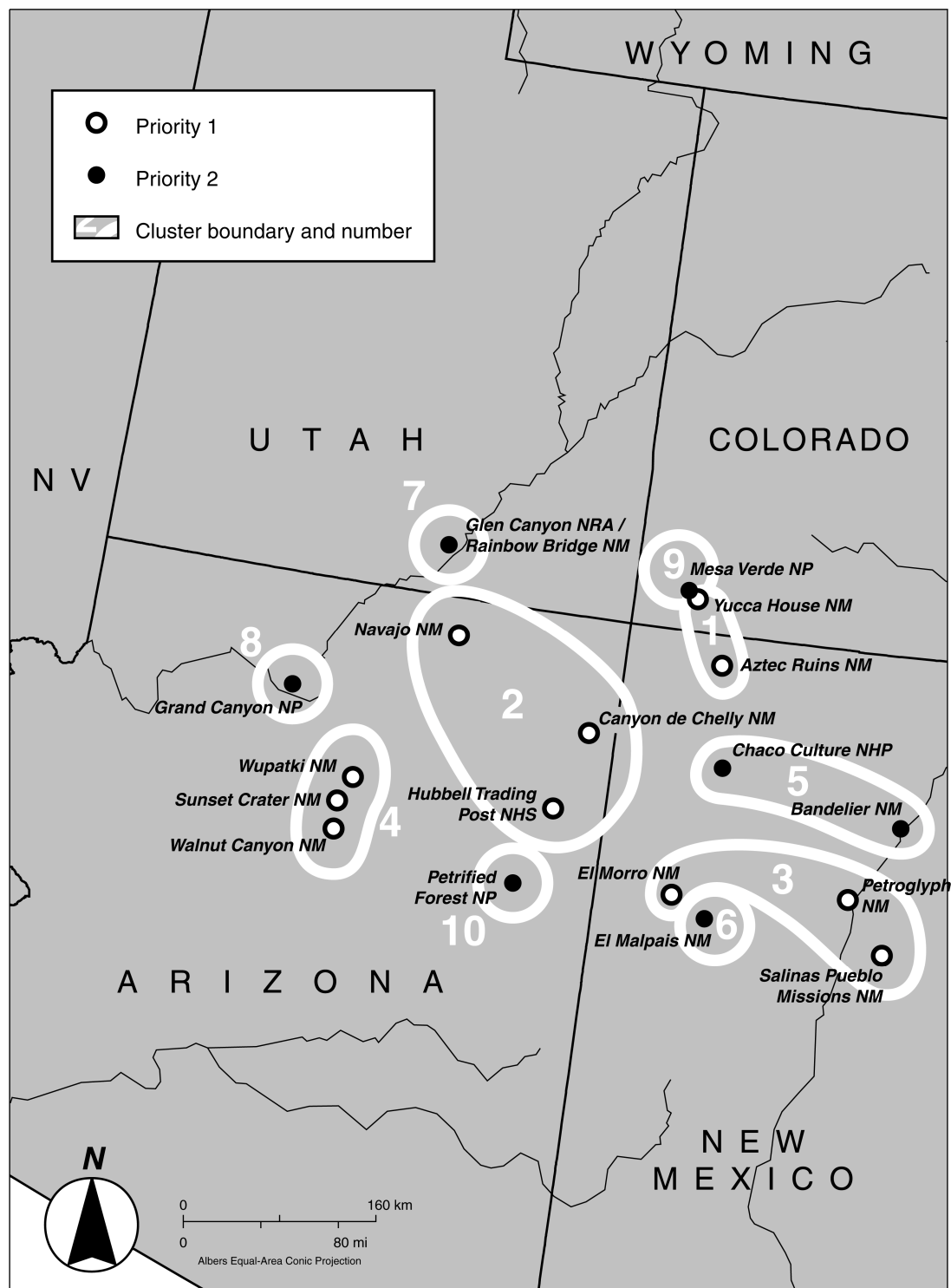


Figure 1a. Location of National Park Service units in the SCP network. See Stuart (2000) for a description of park clusters (outlined in white and identified by number). Eight parks were inventoried for reptiles and amphibians in 2001: AZRU, ELMO, PETR, SAPU, SUCR, WACA, WUPA, and YUHO. HOVE was also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

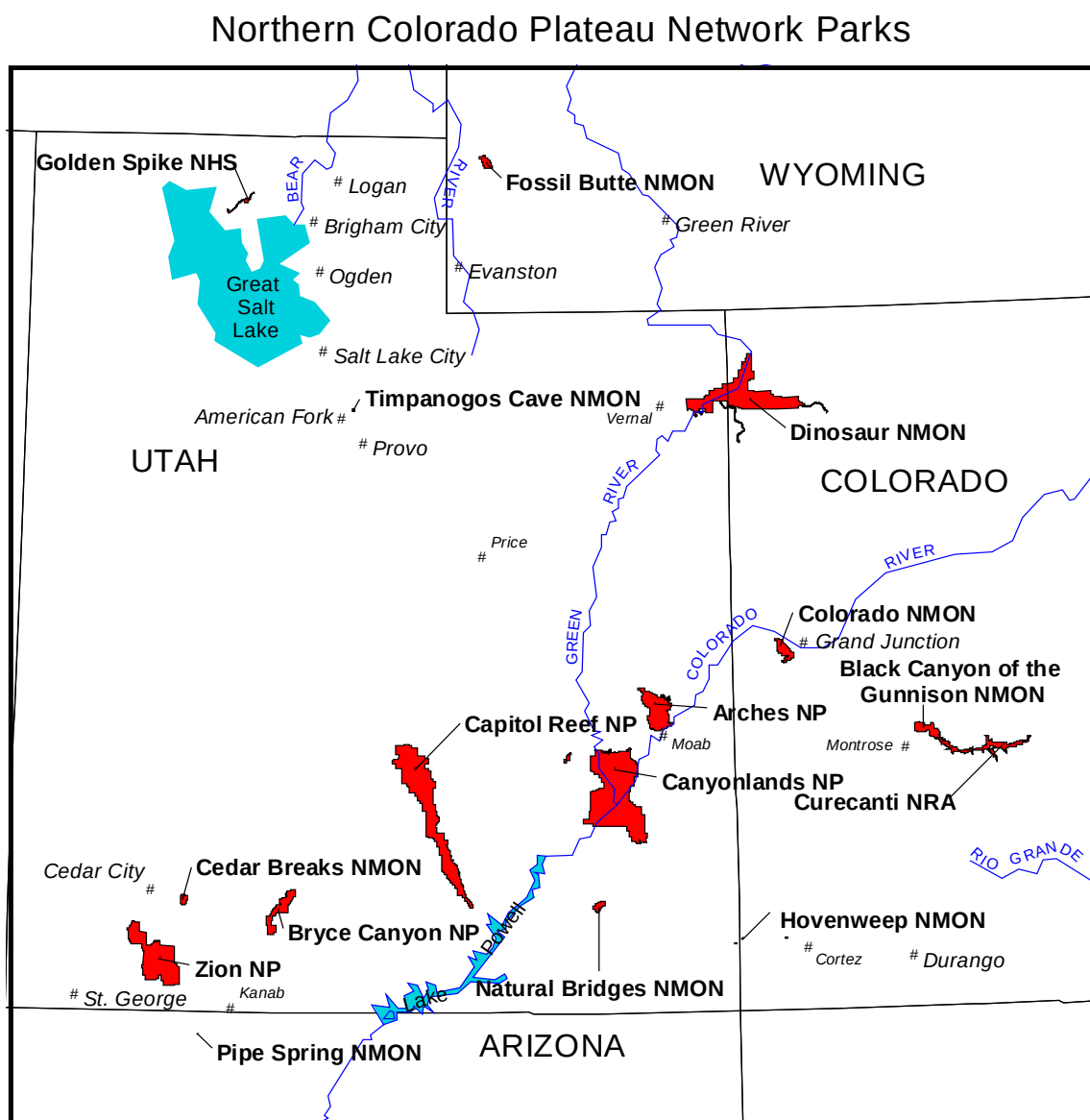


Figure 1b. Location of National Park Service units in the NCP network. Eight parks were inventoried for reptiles and amphibians in 2001: BRCA, CARE, CEBR, FOBU, GOSP, PISP, TICA, and ZION. HOVE was included in the SCP network for reptile and amphibian surveys. See text for abbreviations.

METHODS

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

Visual Survey Methods

Time-area constrained searches (TACS) are a version of VES 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.

We conducted one-hour TACS within randomly generated or non-randomly selected one-hectare plots. In larger parks in both networks, i.e. ELMO, PETR, SUCR, WACA, WUPA, BRCA, CARE, CEBR, GOSP, and ZION, sites for sampling were provided by each GIS data managers. Using GIS, habitat within the park was stratified according to vegetation type (SCP network, Stuart 2000) or slope, elevation and aspect (NCP network, Evenden 2000), and random points were generated within each habitat type. One-hectare square plots were measured out around these points, and surveyed for one to two person-hours for the presence of reptiles and amphibians. Points were selected for survey based on accessibility: those points which fell on a steep, inaccessible slope were moved whenever possible to nearby, contiguous terrain. When possible, we tried to keep plot dimensions at 100m² 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. For each plot, we recorded the location of center point in UTM's 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 standardized data forms developed in conjunction with the network database managers.

In smaller parks in the SCP network, i.e. AZRU, HOVE, SAPU, and YUHO, we did not use randomly generated plots, but instead used plots that were non-randomly selected. These plots covered the 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 conducted non-random TACS in several parks with random plots, including ELMO and PETR.

We also conducted visual encounter surveys that were not time or area-limited. In these “general surveys” (SCP vernacular term) or VES (NCP equivalent term), we sampled habitats that appeared to be diverse and/or of high quality for reptiles or amphibians, were otherwise unique, and/or not represented by TACS plots. Wetlands, creeks, springs and ponds were searched wherever possible for the presence of amphibians, while ridges and rocky outcroppings were productive for locating reptiles. The focus of this method was to search selected microhabitats opportunistically without necessarily covering a given area thoroughly. General surveys or VES were carried out by surveyors walking a route or traversing an area while searching for the presence of herpetofauna by looking under shrubs, within litter, on rocks, logs and branches, and under rocks, logs, etc. Basic habitat information was recorded for each survey, and all herpetofauna encounters were recorded, along with time of observation and microhabitat. In the NCP network, GPS coordinates were measured for the first individual of each species to be observed in an area. Most of these general surveys were conducted during the day, but we also conducted some at night. Nocturnal general surveys or VES 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, morphometric 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). 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. At least half of the parks in both networks contained at least a few hundred consecutive meters of paved roads within their boundaries, 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, YUHO, CEBR, FOBU, PISP, or TICA.

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 mile 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 SCP parks,

and opportunistically in the NCP parks. 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 a GARMIN® GPSIII Plus or 12 GPS unit in the datum NAD 27. These data will be mapped at a later date by the network GIS managers.

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 the number of hours spent on each survey multiplied by the number of people per survey (person-hours).

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. Cox and Tanner 1995, Degenhardt et al. 1996, Hammerson 1999, Stebbins 1985), 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. Preliminary lists of hypothetical species in NCP parks (Graham and Platenberg 2001a) were extensively revised.

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 17 national parks and monuments in the Southern and Northern Colorado Plateau networks from May to September 2001, we documented 48 amphibian and reptile species, including one salamander species, ten anuran species, one tortoise species, 19 lizard species, and 16 snake species. Scientific (Latin) names for these and other species mentioned in the report are found in Appendix E.

In the nine SCP network parks, we documented 38 amphibian and reptile species, including one salamander species, seven anuran species, 17 lizard species, and 13 snake species (Appendix A). 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. We estimate our inventory completeness for SCP parks at 50%. Estimated inventory completeness for individual parks varied from a low of 36% for SUCR to a high of 69% for WUPA.

In the eight NCP network parks, we documented 29 amphibian and reptile species, including one salamander species, six anuran species, one tortoise species, 11 lizard species, and ten snake species (Appendix C). Most parks (CEBR, FOBU, GOSP, PISP, and TICA) did not have previous herpetological surveys, so all species discovered in them were “new.” Of the three remaining parks that had some previous herpetological fieldwork, no new species were discovered. We estimate our inventory completeness for the NCP parks at 51%. Estimated inventory completeness for individual parks varied from a low of 0% for CEBR to a high of 68% for CARE.

Sampling Effort and Efficacy of Methods

We spent a total of 1,480 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 17 different parks in both networks. Approximately 511 person-hours were spent surveying nine parks in the SCP network and approximately 969 person-hours were spent surveying eight parks in the NCP network. The total amount of time, in person-hours, spent on each sampling method and at each park in each network is summarized in Table 1a-b. The sampling methods for the NCP network did not include non-random plots.

Table 1a. 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 (TACS)	-	2.05	-	22.24	-	6	8	13.76	-	52.05
NON-RANDOM PLOTS (TACS)	9.55	3.27	25.15	9.57	18.44	-	-	-	12.55	78.53
TOTAL TACS	9.55	5.32	25.15	31.81	18.44	6	8	13.76	12.55	130.58
GENERAL SURVEYS (VES)	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 VES	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	101.1	88.13	7.18	34.1	54.33	58.0	511.55

Table 1b. Sampling time in person-hours for amphibian and reptile survey methods during inventories of eight Southern Colorado Plateau national park areas, May-September 2001. The total sampling time is summarized for each park and each method in bold type. Five hours of driving at GOSP is actually a day drive.

METHOD	BRCA	CARE	CEBR	FOBU	GOSP	PISP	TICA	ZION	TOTAL
RANDOM PLOTS (TACS)	46.23	42.17	10.0	X	7.83	X	X	50.33	156.56
GENERAL SURVEYS (VES)	93.12	289.5	33.08	65.6	31.33	29.47	30.5	173.6	746.2
NOCTURNAL VES	X	18.84	3.83	X	X	3.8	2.5	11.62	40.59
NIGHT DRIVES	3.6	7.17	X	X	(5.67)	X	X	9.17	25.61
TOTAL	142.9	357.7	46.91	65.6	44.83	33.27	33.0	244.7	968.9

The large difference in the number of person-hours spent surveying for reptiles and amphibians in the different networks primarily reflects a difference in sampling strategy. In the NCP network, the number of surveyors (5) was double that of the SCP crew (3) and each park was to be sampled for only one to one and a half years. In the SCP network, the number of people sampling is lower but each park will be sampled for two to two and a half years. It was originally thought that doubling the number of people but shortening the sampling time would be comparable to a longer sampling time with fewer people.

In both networks, we spent the most time sampling at the largest parks, i.e. PETR, CARE and ZION 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 and TICA received the least amount of sampling effort due to their small size, high elevation at SUCR, and to the paucity of suitable habitat in both parks for reptile and 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 (SCP Network only) to provide repeatable and quantifiable sampling. 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 areas 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 B lists the numbers of individuals and species detected by each method for each SCP park, and Appendix D lists this information for NCP parks. 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 2a-b).

Table 2a. 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 in 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	0	0	1	64	50	20	5
Individuals / Effort	0	0	0.012	0.22	0.71	1.01	-
Species	0	0	1	6	6	5	2
LIZARDS							
Individuals	140	252	392	923	0	2	86
Individuals / Effort	2.69	3.21	3.00	3.18	0	0.10	-
Species	10	13	16	17	0	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	1	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

Table 2b. Total number of individuals, individual detection rate per unit effort, and number of species detected by different methods during a herpetological inventory of eight 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.

	Random Plots	General Surveys	Nocturnal General Surveys	Night Driving	Random Encounters
AMPHIBIANS					
Individuals	7	168	102	0	7
Individuals / Effort	0.04	0.22	2.51	0	-
Species	3	7	5	0	4
LIZARDS					
Individuals	358	1606	0	0	4
Individuals / Effort	2.29	2.15	0	0	-
Species	10	10	0	0	2
SNAKES					
Individuals	5	58	0	4	35
Individuals / Effort	0.03	0.08	0	0.16	-
Species	4	6	0	1	8
TORTOISES					
Individuals	0	3	0	0	0
Individuals / Effort	0	0.008	0	0	-
Species	0	1	0	0	0
TOTAL					
Individuals	370	1835	102	4	46
Individuals / Effort	2.36	2.46	2.51	0.16	-
Species	17	24	5	1	14

We spent the most time (effort) conducting general surveys or visual encounter surveys. In both networks, they detected the most species of any method. In the SCP network, these surveys were also the most effective in detecting individuals per unit effort, while in the NCP group they were the second most effective method in detecting individuals of all taxa. These results are consistent with those from inventories at Petrified Forest National Park (Drost et al. 2001). 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 lizards, slightly less effective at detecting snakes, and least effective in detecting amphibians, which tend to be nocturnal. Most amphibians detected using this method were neotenic salamanders and anuran larvae living in pools of water. General surveys were the only method that detected tortoises in the NCP parks.

In the NCP parks, the most effective method overall for detecting individuals per unit effort was nocturnal general surveys. This method detected only amphibians in NCP parks, and amphibians

and one snake in the SCP parks. While results between the Colorado Plateau networks were consistent for this method, they differ from those of the Sonoran Desert I&M Network, where nighttime temperatures are warmer and all herpetofauna are much more likely to be nocturnally active (M. Goode, USGS Sonoran Field Station, pers. comm.). The parks where nocturnal general surveys were particularly effective are located at lower elevations (e.g. SAPU and ZION). We would recommend this method only for targeting known or suspected amphibian breeding areas.

In the SCP parks, the second most effective method at 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 in detecting common diurnal lizards in both networks, but even then they detected fewer individuals and species than non-random plots in the SCP parks. When the detection rate of individuals and species was compared between random and non-random plots within the same park in the SCP network (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 discrepancy in these results is likely due to a low amount of effort (i.e. sample size) for ELMO compared to PETR (see Table 1).

The poor success of randomly-selected plots in detecting both individuals and species is consistent with results from the Sonoran Desert I&M Networks (M. Goode, USGS Sonoran Field Station, pers. comm.) and 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 studies were poor reptile habitat, and as few plots contained more than ephemeral drainages, they were also very poor amphibian habitat.

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).

Night road driving does not appear to be particularly effective overall in detecting individuals or species in either network, although it was the most effective method in detecting individual

amphibians in the SCP parks. It detected only the relatively common Gopher Snake in the NCP parks. The low numbers for night driving in Table 3a are misleading, however. Several of the species detected during road driving in SCP parks 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, 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 also included verified species observations by park staff in this category, e.g. Longnose Snake at PETR, Western Patchnose snake at ZION, and Short-horned Lizard at CARE. None of these species was detected by any other method in these parks.

Estimating Inventory Completeness

Methods

Our primary method of estimating inventory completeness is comparison of results with master lists of potentially occurring species. These lists will evolve over the course of the studies as we uncover more information from ongoing literature and museum searches, as well as refine our knowledge of species occurrence and habitats. 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 field methods in attempting to conduct a complete species inventory, with the knowledge that other sources of information will ultimately enhance the totals of documented species.

For species not found in 2001, the probability of species occurrence was ranked as low (0-33%), medium (34-67%), or high (68-100%). For quantitative analysis, these rankings were converted to the midpoint of their percentage range, i.e. 0.17, 0.50, and 0.83. In Table 3a-b these three rankings are coded as 1, 2, and 3, respectively, and used as weighting factors. For example, two species with rankings of medium probability of occurrence would combine to equal one full expected species ($0.50 \times 2 = 1.00$ species), whereas six species of low probability of occurrence would be required to equal one full expected species ($0.17 \times 6 = 1.02$ species). Species found in 2001 (coded as X in Table 3a-b) are weighted 1.00.

Given the small numbers of amphibian and reptile species in these parks (compared to plant or invertebrate species), combined with our knowledge of regional herpetology, the master list approach is the most reliable method for estimating inventory completeness for these groups. However, examination of species accumulation rates allows us to evaluate efforts as work progresses. For example, if a curve of species accumulation over time (or effort) becomes

asymptotic at a point we estimate to be only 60% complete, we may decide we need to redirect our efforts at finding the remaining 40% of species by using different field methods.

Overview of Results

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 3a) and 50% for the eight NCP parks surveyed in 2001 (Table 3b). Overall, values for individual parks ranged from a low of 0% for CEBR to a high of 69% for WUPA. In the NCP parks values ranged from 0% (CEBR) to 68% (CARE), and in the SCP parks values ranged from 36% (SUCR) to 69% (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. We expect that the final documented species lists will be enhanced by the addition of museum specimen data for some parks, especially at PETR, WUPA, and ZION. Unfortunately, very little work has been done at other parks, and we are unlikely to add many species by examination of museum collections and more thorough review of the literature.

Table 3a. All amphibian and reptile species found or expected to occur in the nine SCP park areas surveyed in 2001. See text for a discussion of rankings for probability of species occurrences. 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 in 2001 divided 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 3a., 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					
Chihuahuan 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 SCP INVENTORY COMPLETENESS	48%	43%	48%	46%	58%	36%	38%	69%	67%

Table 3b. All amphibian and reptile species found or expected to occur in the eight NCP park areas surveyed in 2001. See text for a discussion of rankings for probability of species occurrences. 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 in 2001 divided by the weighted total.

SPECIES	BRCA	CARE	CEBR	FOBU	GOSP	PISP	TICA	ZION
Amphibians								
Tiger Salamander	3	3	3	X	X	X	3	X
Boreal Toad	2		3	1	1			3
Great Plains Toad		2				2		1
Southwestern Toad								X
Red-spotted Toad	3	X				2		X
Woodhouse's Toad	3	X			X	X	3	3
Canyon Treefrog		X						X
Striped Chorus Frog	3	2	3	3	3		3	3
Great Basin Spadefoot		X		2	X	X	3	X
New Mexico Spadefoot		1						
Bullfrog		1		1	2	1	1	3
Northern Leopard Frog	3	3	3	X	X	1	1	3
Spotted Frog					1		1	
Turtles and Tortoises								
Desert Tortoise								X
Spiny Softshell								1
Lizards								
Great Basin Collared Lizard	1	X			1	X	1	X
Longnose Leopard Lizard	1	X			3	X	1	X
Western Banded Gecko								3
Gila Monster								2
Desert Iguana								1
Common Chuckwalla		1				1		3
Zebra-tailed Lizard								1
Lesser Earless Lizard						2		
Short-horned Lizard	X	X	3	X	3	X	3	X
Desert Horned Lizard		1			2	1		3
Sagebrush Lizard	X	X	2	3	X	X	X	X
Desert Spiny Lizard		X				X		X
Western Fence Lizard							1	1
Eastern Fence Lizard	X	X	2			X	2	X
Tree Lizard	X	X				1	3	X
Side-blotched Lizard	3	X			X	X	2	X
Great Plains Skink						2		
Western Skink	3	2	3		3		3	X
Western Whiptail	3	X			X	X	2	X
Plateau Striped Whiptail	3	X				3		X
Desert Night Lizard		2				1		

Table 3b., continued.

SPECIES	BRCA	CARE	CEBR	FOBU	GOSP	PISP	TICA	ZION
Snakes								
Rubber Boa	3	2	1		2		X	1
Glossy Snake	1					3		1
Racer		2		1	X		3	2
Ringneck Snake	2	1			1		2	X
Night Snake	3	3	2		3	3	3	3
Common Kingsnake		X				3		X
Sonoran Mountain Kingsnake	3	2	3				3	3
Milk Snake	3	2	1		1	1	2	2
Smooth Green Snake				1	1		2	
Coachwhip		1						3
Striped Whipsnake		X			X	X	2	X
Spotted Leaf-nosed Snake								1
Gopher Snake	X	X	2	2	X	X	X	X
Long-nosed Snake		1			1	2	1	3
Western Patchnose Snake		1				3		X
Ground Snake		1				2		X
Southwestern Black-headed Snake		3				2		2
Western Terrestrial Garter Snake	X	X	3	X	3	3	3	X
Common Garter Snake					1		1	
Lyre Snake						1		3
Speckled Rattlesnake								1
Mojave Rattlesnake								1
Western Rattlesnake	3	X	2	1	X	X	X	X
Western Blind Snake								2
TOTAL RANK 1	3	9	2	5	8	8	8	10
TOTAL RANK 2	2	8	5	2	3	7	7	5
TOTAL RANK 3	14	4	8	2	6	6	11	13
TOTAL FOUND (X)	6	19	0	4	11	14	4	25
WEIGHTED TOTAL	19.1	27.8	9.5	7.5	18.8	23.8	18.0	40.0
ESTIMATED NCP INVENTORY COMPLETENESS	31%	68%	0%	53%	59%	59%	22%	63%

Species Accumulation

Species accumulation curves (plotted per survey day) for the nine SCP parks surveyed in 2001 are shown in Figure 2a-i and for seven of the eight NCP parks in Figures 3a-g. Data from CEBR were not plotted because no species were observed. A 25th species was detected at ZION but not recorded on that park's initial accumulation curves. This was a piece of dried up snake discovered by park staff on a maintenance road and identified by one of us (T. Persons) as a Western Patchnose Snake after the field season had ended.

Figure 2a. AZRU SPECIES ACCUMULATION

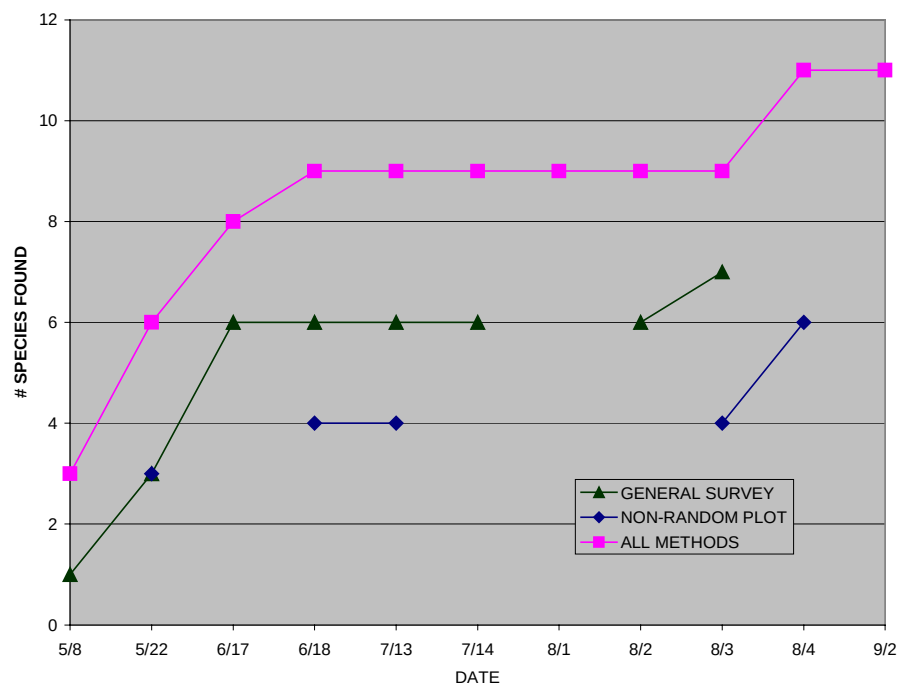


Figure 2b. ELMO SPECIES ACCUMULATION

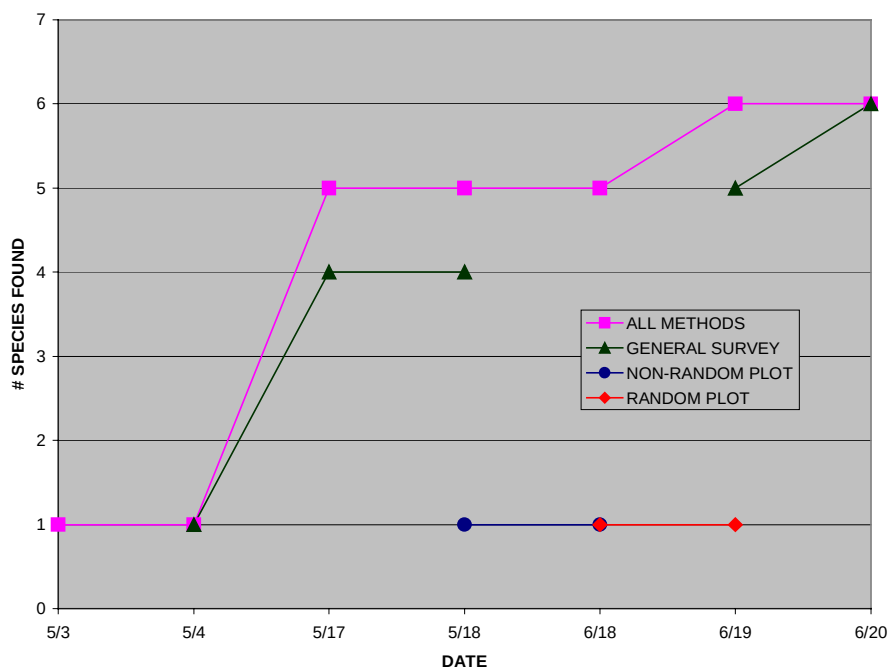


Figure 2c. HOVE SPECIES ACCUMULATION

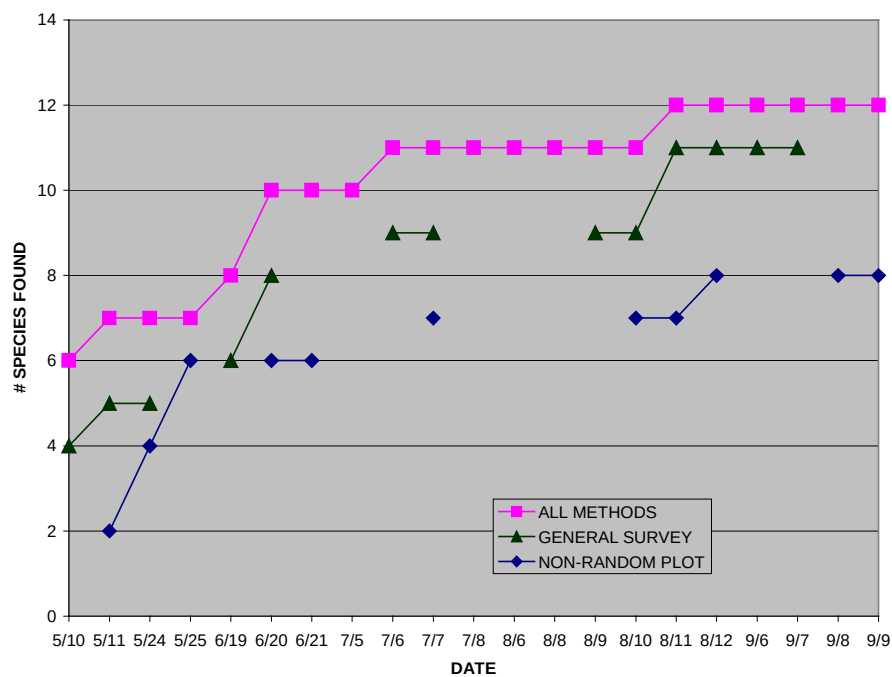


Figure 2d. PETR SPECIES ACCUMULATION

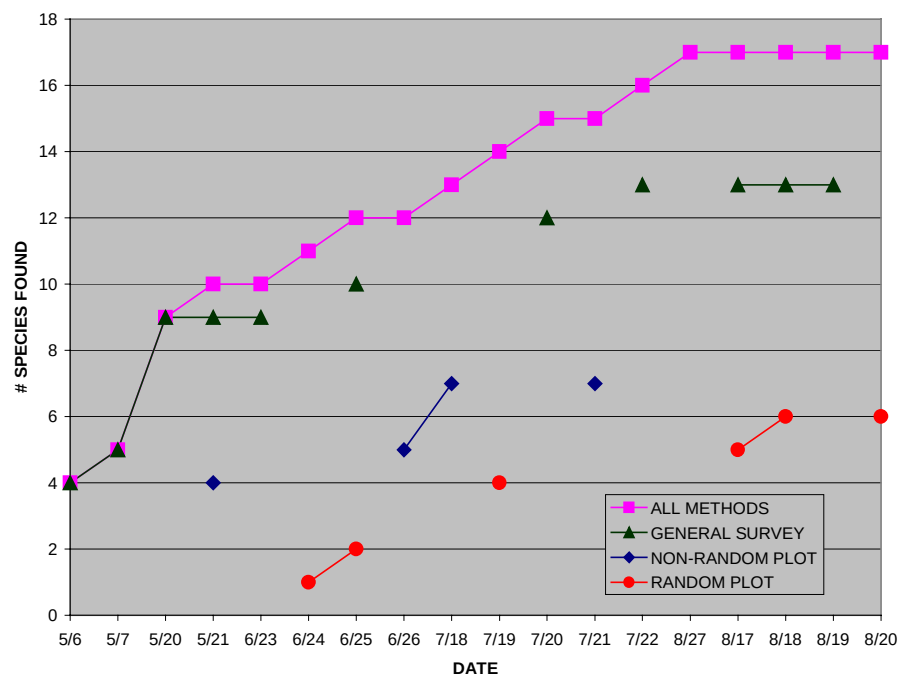


Figure 2e. SAPU SPECIES ACCUMULATION

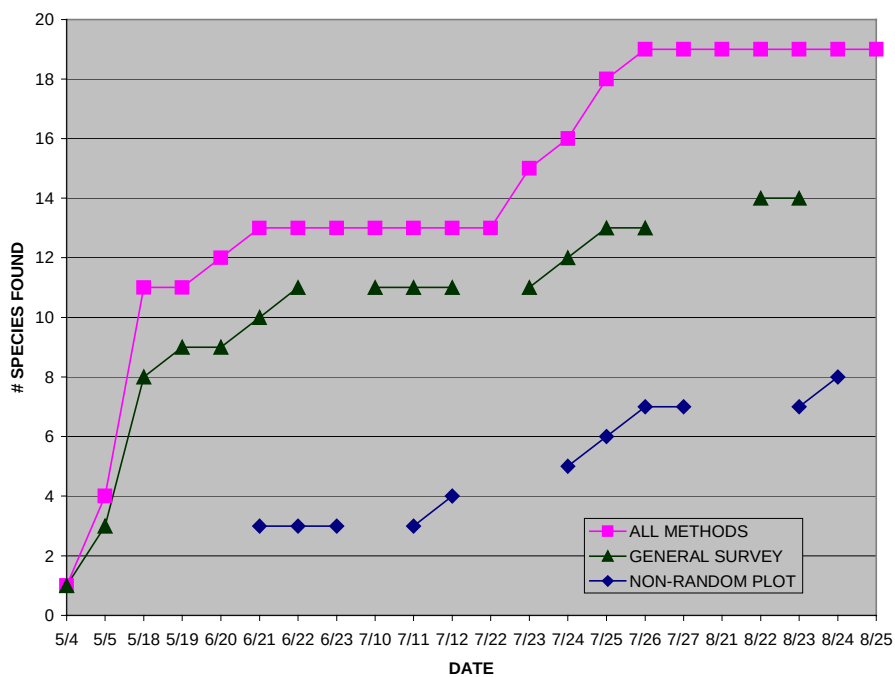


Figure 2f. SUCR SPECIES ACCUMULATION

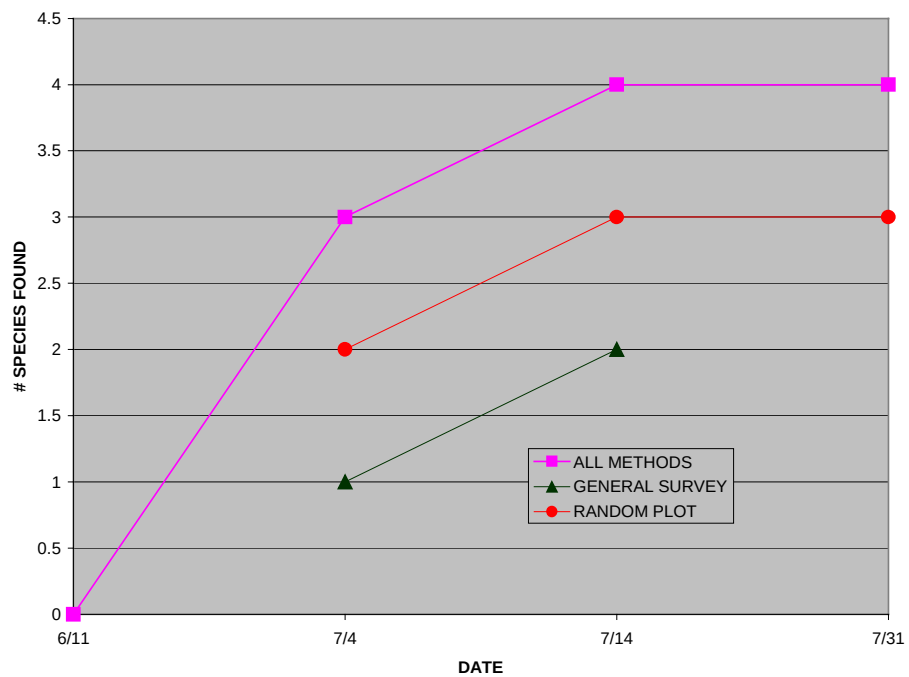


Figure 2g. WACA SPECIES ACCUMULATION

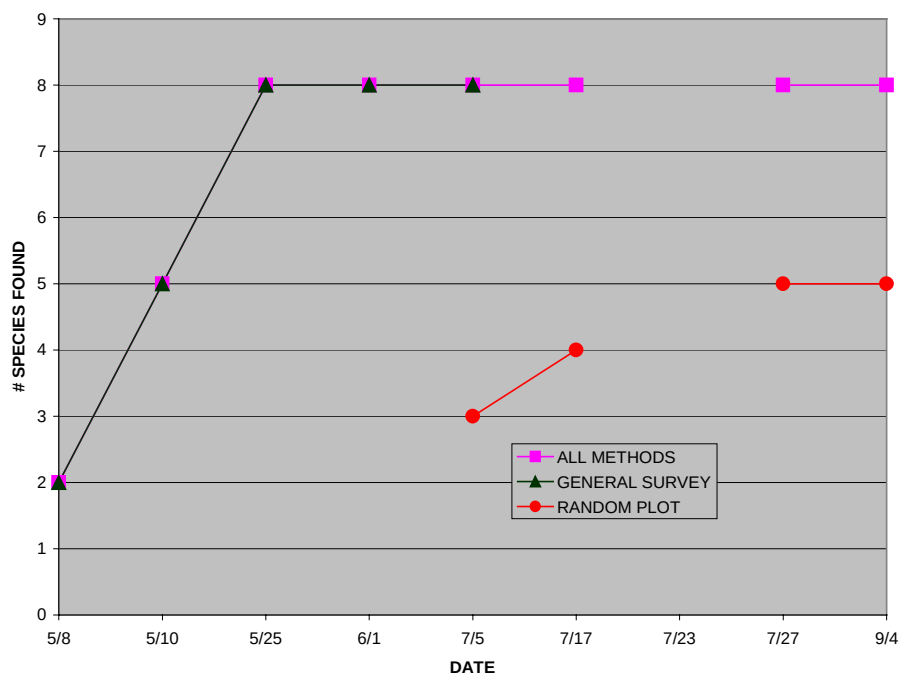


Figure 2h. WUPA SPECIES ACCUMULATION

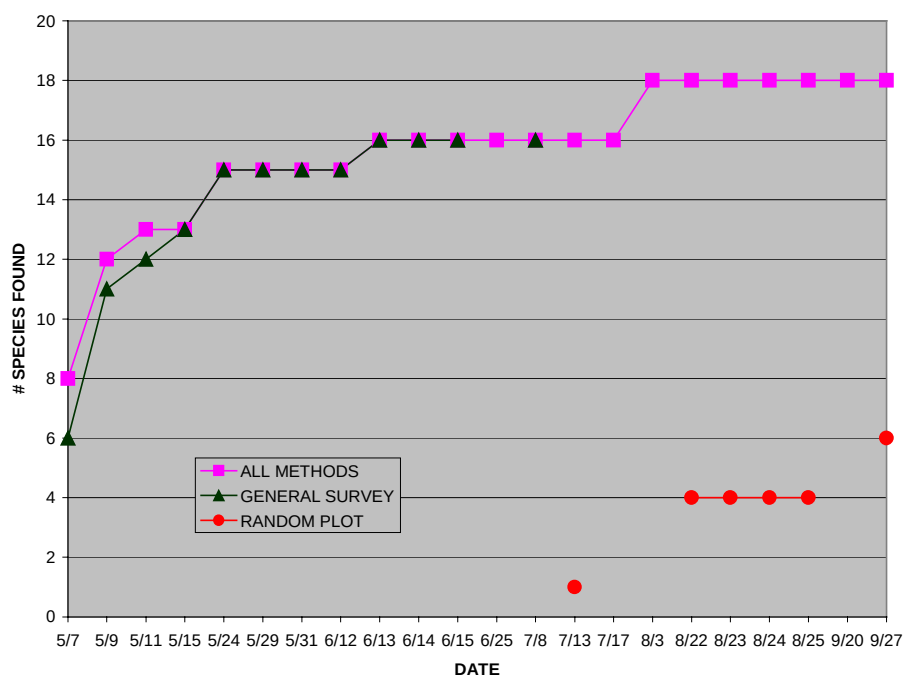


Figure 2i. YUHO SPECIES ACCUMULATION

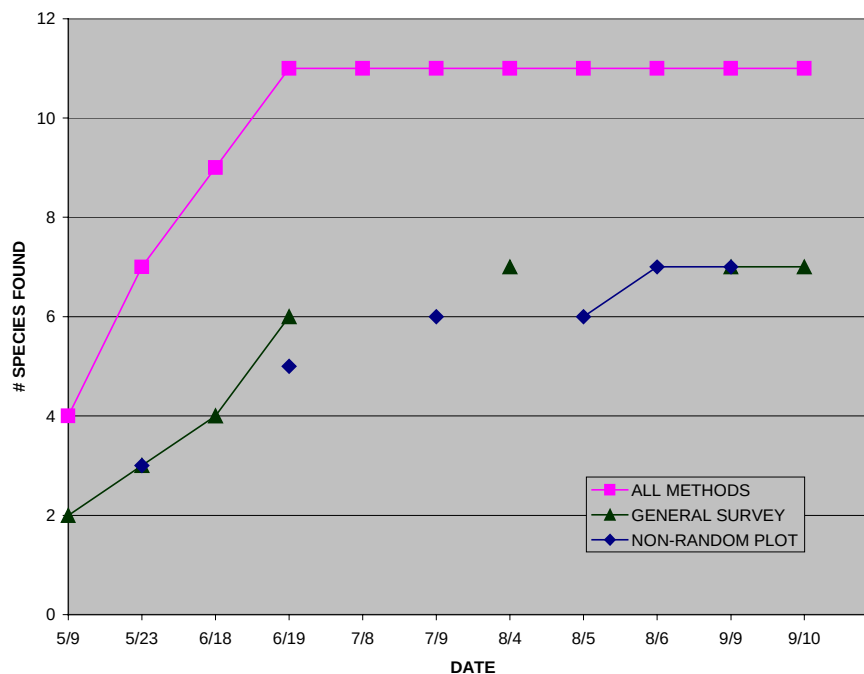


Figure 2a-i. Species accumulation curves for amphibians and reptiles from surveys conducted in 2001 at nine National Park Service areas on the southern Colorado Plateau.

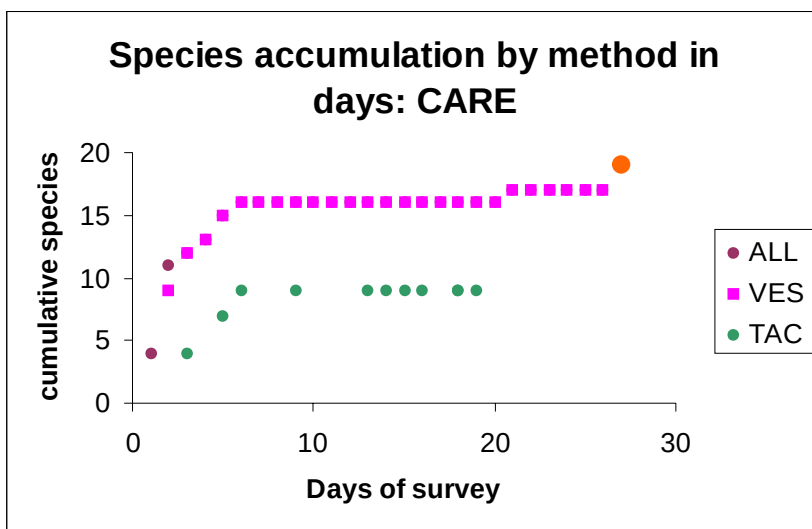


Figure 3a. CARE species accumulation curves. Single dot at upper right of curve is an additional species found by NPS personnel during 2001. TAC = time/area constrained search (random plot); VES = visual encounter survey; ALL = all methods combined.

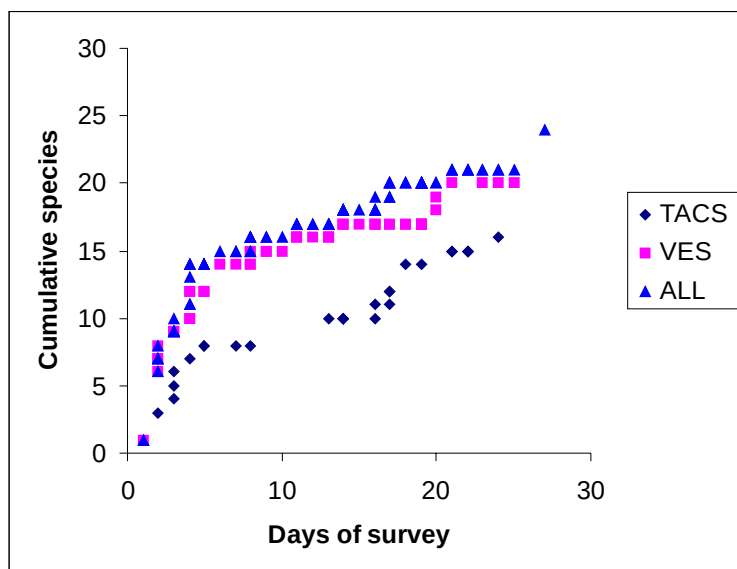


Figure 3b. ZION species accumulation curves. TAC = time/area constrained search (random plot); VES = visual encounter survey; ALL = all methods combined. A 25th species was also discovered by rangers but not reported here (see text).

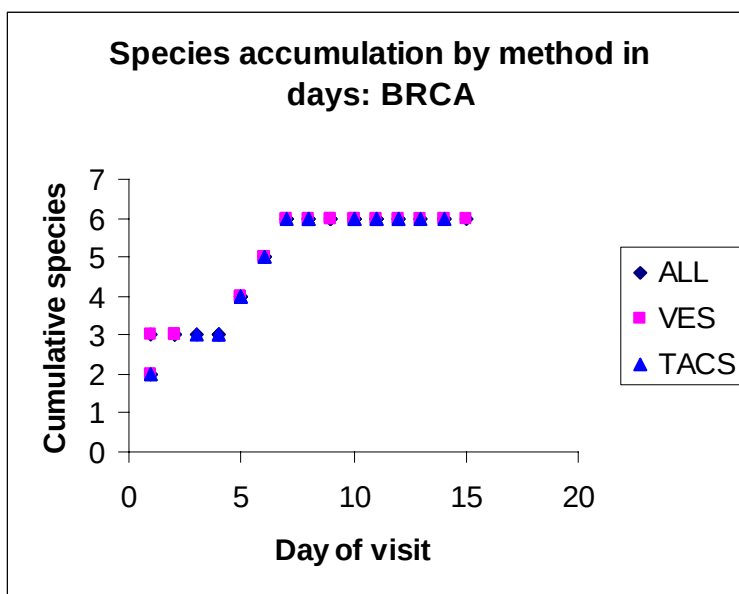


Figure 3c. BRCA species accumulation curves. TAC = time/area constrained search (random plot); VES = visual encounter survey; ALL = all methods combined.

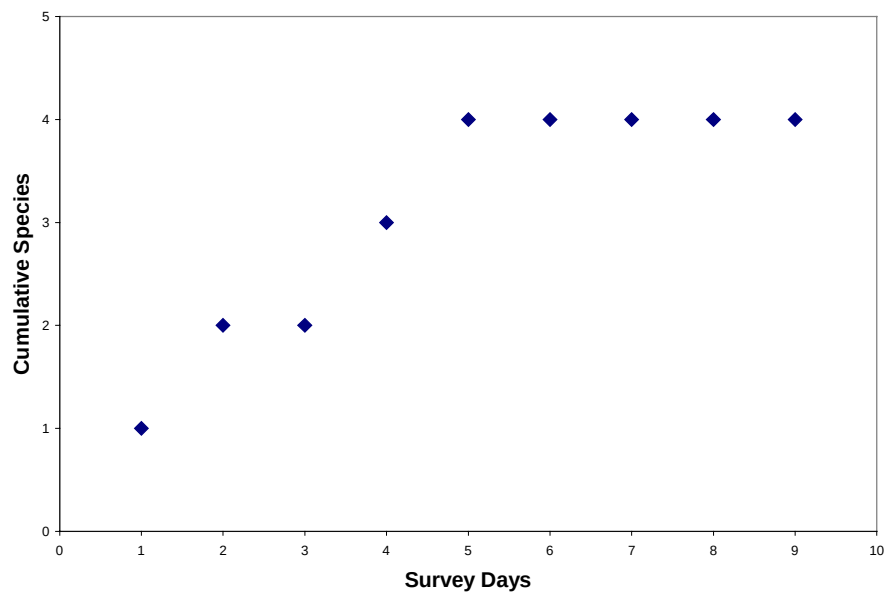


Figure 3d. FOBU species accumulation curve. Data are for all methods combined.

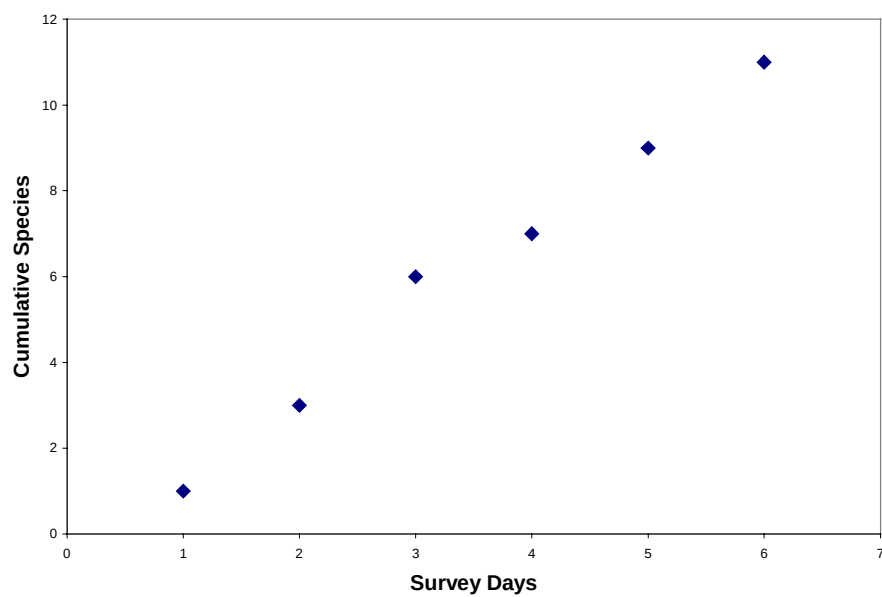


Figure 3e. GOSP species accumulation curve. Data are for all methods combined. Uppermost right hand point represents two additional species found by NPS personnel during 2001.

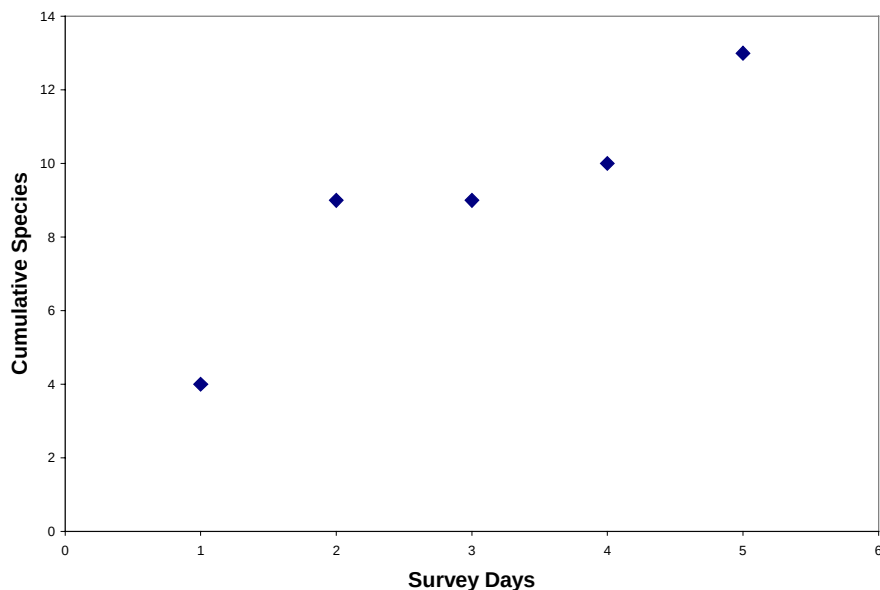


Figure 3f. PISP species accumulation curve. Data are for all methods combined.

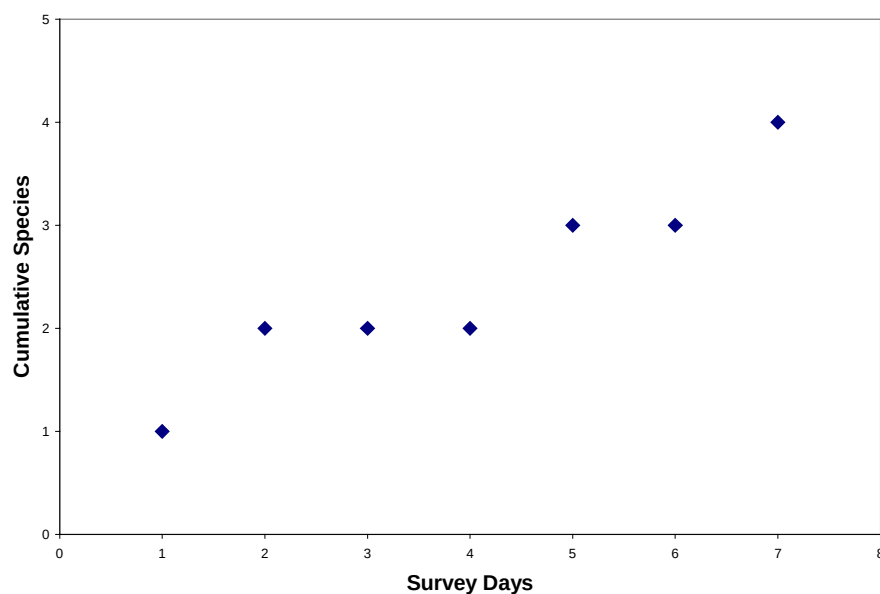


Figure 3g. TICA species accumulation curve. Data are for all methods combined. Uppermost right hand point represents two additional species found by NPS personnel during 2001.

Figure 3a-g. Species accumulation curves for amphibians and reptiles from surveys conducted in 2001 at eight National Park Service areas on the Northern Colorado Plateau. TAC = time/area constrained search (random plot), VES = visual encounter survey, and ALL = all methods combined.

Although a few parks we did not survey repeatedly do not show a sharp decline in species accumulation (e.g. ELMO, GOSP, TICA), 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. CARE, BRCA, FOBU, WUPA, 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., BRCA, CARE, 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 single most important factor in reducing success in 2001, at least in most SCP parks, was the unavailability of night driving as a method for detecting amphibians and snakes. Most areas surveyed in 2001 are small parks with few paved roads. In addition, some of the larger NCP parks (e.g. BRCA, CEBR) are high elevation sites where nighttime temperatures are often too cold for reptile activity, even in midsummer.

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 all NCP and 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 4a; $r^2=0.123$, $df=15$, $p>0.05$). This lack of a significant positive relationship was also true for both the SCP (Figure 4b; $r^2=0.046$, $df=7$, $p>0.05$) and NCP (Figure 4c; $r^2=0.244$, $df=6$, $p>0.05$) and networks separately. These results indicate that park-specific differences in habitats or herpetofauna greatly affect the ability to detect most species in a given area. Simply spending more time in any given park will not guarantee a more complete species list. If inventory completeness is the primary goal, effort will need to be tailored to individual parks and species, both in terms of methods and field time.

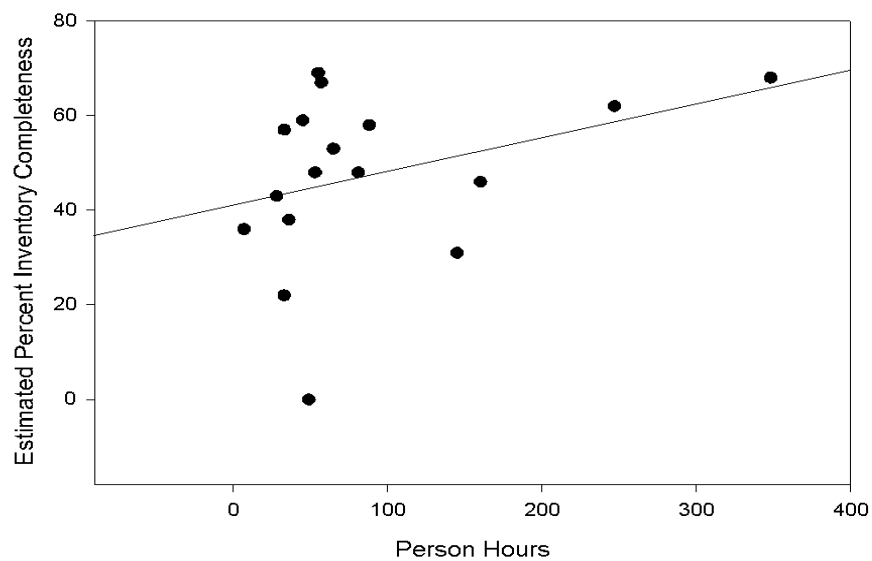


Figure 4a. Scatter diagram of estimated inventory completeness in relation to effort for the 17 NCP and SCP park areas surveyed for amphibians and reptiles in 2001.

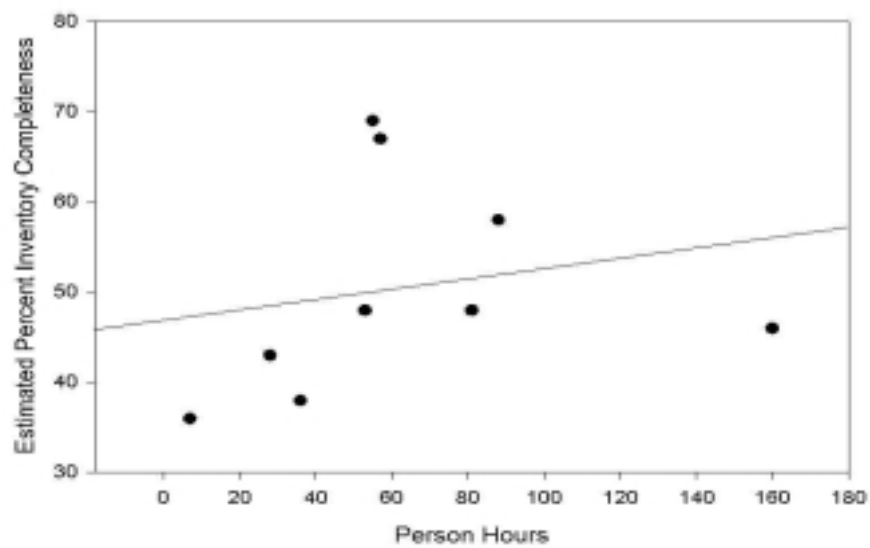


Figure 4b. Scatter diagram of estimated inventory completeness in relation to effort for the nine SCP park areas surveyed for amphibians and reptiles in 2001.

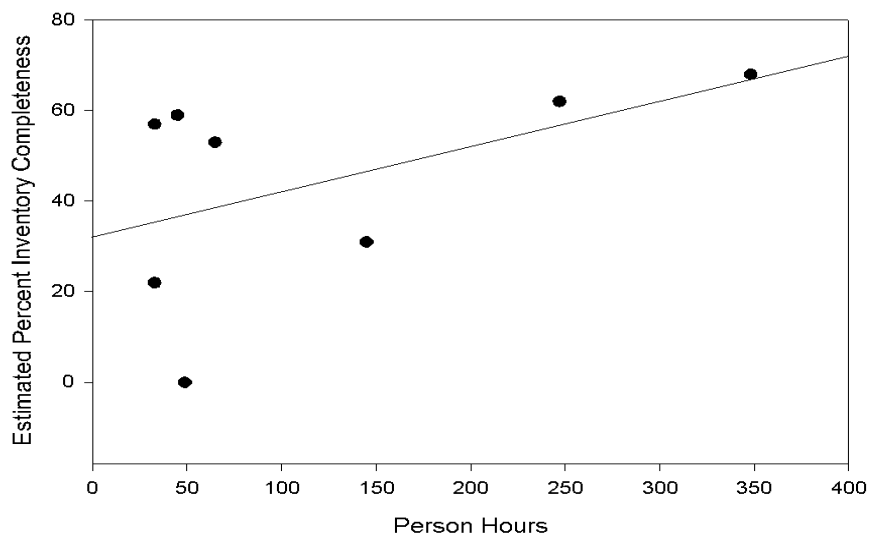


Figure 4c. Scatter diagram of estimated inventory completeness in relation to effort for the eight NCP park areas surveyed for amphibians and reptiles in 2001.

Inventory Completeness of Different Taxa Groups

Using the same weighting methods and data from Tables 3a -b, we calculated that overall (NCP and SCP combined) estimated inventory completeness for amphibians was 41%, for lizards was 65%, and for snakes was 40%. Results were remarkably similar between networks. Inventory completeness for the SCP and NCP was 41% and 42% for amphibians, 71% and 59% for lizards, and 38% and 43% and for snakes, respectively. Data for turtles and tortoises is too minimal to be meaningful, as only one species (Desert Tortoise) was documented from one park (ZION) across both networks.

The relatively high success rate for lizards is due to the fact that most lizard species are diurnal and conspicuous, and our efforts were biased towards daytime searches (both random plots and general surveys) that easily detect most lizard species. Many amphibians on the 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, 2001 was 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, especially in the SCP parks, is the lack of extensive networks of roads in many parks surveyed in 2001. Based on data from our own studies in the region (Drost and Nowak 1997, 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 NCP and SCP parks, we have drawn on a number of sources in compiling our lists (Table 3a-b) X) of species expected to occur at each park (Bateman 1976, 1980, Bleakly et al. 1996, Bury 1977, Cox and Tanner 1995, Davenport 1998, Degenhardt et al. 1996, Douglas 1966, 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. For parks in New Mexico and Colorado, we will rely heavily on 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.

RECOMMENDATIONS FOR FUTURE INVENTORY WORK

Clearly, given an overall estimated inventory completeness of only about 50% for both NCP and SCP clusters, 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 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 many NCP and SCP parks surveyed in 2001 showed an interest in this project, and a general enthusiasm for the animals.

The nature of this project means that a small number of field personnel is stretched across huge expanses: in 2001 four people attempted to cover some 440,000 acres in eight NCP units ranging

from Arizona to Wyoming. Under these circumstances, it is difficult to plan to be in the right locations at the appropriate time and under the appropriate climatic conditions to target certain species, e.g. the explosive breeding amphibians that are only active for a few days each year. Setting up a “hotline” facility for park rangers at all units across each network could maximize survey success for such species. When amphibians are first seen or heard calling, park staff could call us, and we could arrange for a crewmember to arrive within a day. Timing of survey is also important for reptiles, in that many species undergo aestivation during the hot summer months. Searching for anything other than heat-tolerant lizards during these times is unlikely to produce useful results, and can be considered a waste of effort and limited resources. Time should be spent pre-season to research weather patterns and to consult with park staff and local experts to identify those periods of time when survey is unlikely to be productive.

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. Observation record sheets were distributed to the rangers at ZION, although these have not yet been returned. 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 Monument, 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 (e.g., Northern Leopard Frog) 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 populations has been underway at Organ Pipe Cactus National Monument for over a decade (e.g. Rosen and Lowe 1995), 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. Amphibians and reptiles detected at nine national parks and monuments on the Southern Colorado Plateau during herpetological surveys in 2001.

Amphibians

Tiger Salamander
Great Plains Toad
Red-spotted Toad
Woodhouse's Toad
Canyon Treefrog
Striped Chorus Frog
Plains Spadefoot
New Mexico Spadefoot

Lizards

Common Collared Lizard
Longnose Leopard Lizard
Lesser Earless Lizard
Short-horned Lizard
Roundtail Horned Lizard
Sagebrush Lizard
Desert Spiny Lizard
Eastern Fence Lizard
Tree Lizard
Side-blotched Lizard
Many-lined Skink
Great Plains Skink
Chihuahuan Spotted Whiptail
Little Striped Whiptail
New Mexican Whiptail
Western Whiptail
Plateau Striped Whiptail

Snakes

Glossy Snake
Ringneck Snake
Night Snake
Sonoran Mountain Kingsnake
Coachwhip
Striped Whipsnake
Gopher Snake
Long-nosed Snake
Western Patchnose Snake
Black-necked Garter Snake
Western Terrestrial Garter Snake
Western Diamondback Rattlesnake
Western Rattlesnake

Appendix B. Individual park accounts of reptile and amphibian species detected in nine southern Colorado Plateau network parks inventoried in 2001.

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 3a).

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 3a).

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 3a).

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 3a), and targeted searches will be required to greatly increase our chances of finding these.

d. Petroglyph National Monument (PETR)

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

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 3a (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.

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 3a).

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 3a) 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 3a).

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 3a) 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 3a).

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. For sampling effort, grand totals are shown in bold type: at the bottom of each column for the number trapped by each method, and in the far right column for the number of each species captured. The number of individual amphibians includes only adults and terrestrial juveniles; amphibian species include larvae. 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 3a).

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 3a).

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 C. Amphibians and reptiles detected at eight national parks and monuments on the Northern Colorado Plateau during herpetological surveys in 2001.

Amphibians

Tiger Salamander
Southwestern Toad
Red-spotted Toad
Woodhouse's Toad
Canyon Treefrog
Great Basin Spadefoot
Northern Leopard Frog

Turtles and Tortoises

Desert Tortoise

Lizards

Great Basin Collared Lizard
Longnose Leopard Lizard
Short-horned Lizard
Sagebrush Lizard
Desert Spiny Lizard
Eastern Fence Lizard
Tree Lizard
Side-blotched Lizard
Western Skink
Western Whiptail
Plateau Striped Whiptail

Snakes

Rubber Boa
Racer
Ringneck Snake
Common Kingsnake
Striped Whipsnake
Gopher Snake
Ground Snake
Western Patchnose Snake
Western Terrestrial Garter Snake
Western Rattlesnake

Appendix D. Individual park accounts of reptile and amphibian species detected in eight northern Colorado Plateau network parks during inventories in 2001.

The following nine individual park accounts (j-q) 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.

j. Bryce Canyon (BRCA)

We recorded six species at BRCA in 2001 (Table j1), for an estimated inventory completeness of 31 % (Table 3b). Species documented include four lizards and two snakes; no amphibians were observed.

Table j1. Amphibian and reptile species observed at BRCA in 2001.

Short-horned Lizard (*Phrynosoma douglassii*)
 Sagebrush Lizard (*Sceloporus graciosus*)
 Eastern Fence Lizard (*Sceloporus undulatus*)
 Tree Lizard (*Urosaurus ornatus*)
 Gopher Snake (*Pituophis catenifer*)
 Western Terrestrial Garter Snake (*Thamnophis elegans*)

Table j2. Number of individuals and species detected by different methods at BRCA in 2001. An “X” in a column indicates that the method was not used at that park.

BRCA	Random Plots	General Surveys	Nocturnal General Surveys	Night Driving	Random Encounters	TOTAL
Amphibians						
Individuals	0	0	X	0	0	0
Species	0	0	X	0	0	0
Lizards						
Individuals	2	108	X	0	0	110
Species	1	4	X	0	0	4
Snakes						
Individuals	1	3	X	0	0	4
Species	1	2	X	0	0	2
Total						
Individuals	3	111	X	0	0	114
Species	2	6	X	0	0	6

Four visits were made to BRCA, for a total of 17 days in the field. Locations surveyed included Swamp Canyon, Sheep Creek, Pasture Wash, Yellow Creek, Aqua Canyon, Whiteman Bench, Little Henderson Canyon, Mossy Cave, Jolley Hollow, the Fairyland Trail, Yovimpa Pass, Riggs Spring, Corral Hollow, Mutton Hollow, Bullberry Spring and areas along the plateau. Four lizard species and two snake species were documented; no amphibians were observed. No specimen vouchers were collected from BRCA.

Further survey should focus on monsoon-breeding amphibians, usually not easily detectable except during periods of rain. Spring breeding amphibians, such as Striped Chorus Frog and Northern Leopard Frog, may also be present, and should be searched for during the early spring months. Reptile survey at Bryce appears to be most productive during the late summer weeks in August and early September.

k. Capitol Reef National Park (CARE)

We recorded 19 species at CARE in 2001 (Table k1), for an estimated inventory completeness of 68% (Table 3b).

Table k1. Amphibian and reptile species observed at CARE in 2001. An asterisk (*) denotes a species where a voucher specimen was collected.

Red-spotted Toad
 Woodhouse's Toad
 Canyon Treefrog
 Great Basin Spadefoot
 Great Basin Collared Lizard
 Longnose Leopard Lizard
 Short-horned Lizard
 Sagebrush Lizard
 Desert Spiny Lizard
 Eastern Fence Lizard
 Tree Lizard
 Side-blotched Lizard
 Western Whiptail
 Plateau Striped Whiptail
 Common Kingsnake
 Striped Whipsnake*
 Gopher Snake*
 Western Terrestrial Garter Snake
 Western Rattlesnake

Table k2. Number of individuals and species detected by different methods at CARE in 2001.

CARE	Random Plots	General Surveys	Nocturnal General Surveys	Night Driving	Random Encounters	TOTAL
Amphibians						
Individuals	0	58	69	0	1	128
Species	0	4	3	0	1	4
Lizards						
Individuals	116	901	0	0	1	1018
Species	8	9	0	0	1	10
Snakes						
Individuals	0	13	0	1	8	22
Species	0	4	0	1	3	5
Total						
Individuals	116	972	69	1	10	1168
Species	8	17	3	1	5	19

Eight visits were made to CARE, for a total of 30 days in the field. Locations surveyed included Cathedral Valley, Jones Bench, Deep Creek, Temple of the Sun/Moon, Jailhouse Rock and the South Desert, Sulphur Creek, Chimney Rock, Cohab Canyon, Hickman Bridge, Pleasant Creek, Oak Creek, Grand Wash, Capitol Gorge, Old Wagon Trail, Sheets Gulch, Red Canyon, Surprise Canyon, Burr Trail, Onion Beds and Hall's Creek (from the Post to the southern boundary of the park, including the Narrows).

Four amphibian, ten lizard, and five snake species were documented, with over 1100 individual observations recorded. Four road-killed snakes from two species (Striped Whipsnake and Gopher Snake) were collected. In addition to these, ten anuran metamorphs are being maintained in captivity until they reach a stage when they can be positively identified before being euthanized and preserved.

Much of the accessible terrain in CARE was surveyed this season, and more species from the expected list were documented than at any other park. Survey priorities for the next round of visits should concentrate on locating snake species, and to determine distribution and abundance of species already documented. Targeted survey methods, such as funnel and pitfall traps, could be utilized to maximize effort. Time and effort would be better spent gathering more information on other species and in unique habitats. Many of the hypothetical species found in Table 3b might be possible in the extreme southern tip and northwest corners. For example, although it is possible that the Glen Canyon Chuckwalla occurs in the park, the potential distribution of this species is very limited, restricted only to the extreme southern tip of the park.

I. Cedar Breaks National Monument (CEBR)

We recorded 0 species at CEBR in 2001, which gives this park an inventory completeness of 0% (Table 3b).

Three visits were made to CEBR, for a total of seven days in the field. Alpine Pond was dip-netted for larval amphibians. All ponds, springs and wetlands, the plateau, and Ashdown Creek and Rattle Creek below the Breaks were surveyed. No reptiles or amphibians were observed during any visit.

Further survey should concentrate on the explosive spring breeding amphibians during the appropriate time period. It was reported that amphibians were heard calling during the days prior to our first visit in June, but we did not observe any adults, egg masses, or tadpoles. It may be required to access the park in spring, prior to the opening date, to survey the ponds on the plateau. Since CEBR is at 10,000 ft elevation, surveyors may be required to use alternate forms of transportation to reach these ponds, as the road is snow packed and closed all winter. CEBR would be a good place to try out the use of “wanted posters”: posters with illustrations of species the public is likely to encounter on one of the two well-used trails, with the request that sightings be reported to the visitors center. This type of information could provide direction for timing of survey visits. In addition, attempts should be made to locate reptiles in the Ashdown Creek/Rattle Creek areas, although no herpetofauna encounters have ever been reported from this region.

m. Fossil Butte National Monument (FOBU)

We recorded four species at FOBU in 2001 (Table m1), for an estimated inventory completeness of 53% (Table 3b).

Table m1. Amphibian and reptile species observed at FOBU in 2001.

Tiger Salamander
 Northern Leopard Frog
 Short-horned Lizard
 Western Terrestrial Garter Snake

Table m2. Number of individuals and species detected by different methods at FOBU in 2001. An “X” in a column indicates that the method was not used at that park.

FOBU	Random Plots	General Surveys	Nocturnal General Surveys	Night Driving	Random Encounters	TOTAL
Amphibians						
Individuals	X	13	X	X	0	13
Species	X	2	X	X	0	2
Lizards						
Individuals	X	1	X	X	0	1
Species	X	1	X	X	0	1
Snakes						
Individuals	X	13	X	X	2	15
Species	X	1	X	X	1	1
Total						
Individuals	X	27	X	X	2	29
Species	X	4	X	X	1	4

Three visits were made to FOBU, for a total of nine days in the field. Surveys were carried out at the Fossil Lake Trail and adjoining beaver ponds, Moosebone Canyon, Millet Canyon, Murder Hill, Ruby Point, West Dam Site, Chicken Creek, Small Pox Creek, Fossil Butte, and the Historic Quarry Trail. Two amphibian, one lizard and one snake species were observed. No specimen vouchers were collected from FOBU.

Further survey should concentrate on explosive spring breeding amphibians. Striped Chorus Frog has been observed by park staff, and the timing of survey visits is crucial for locating breeding individuals. In addition, more effort should be spent on locating snake species that are likely to occur, such as Gopher Snake, and to understanding patterns of distribution of Short-horned Lizard and dispersal of Tiger Salamander within the park boundary

n. Golden Spike National Monument (GOSP)

We recorded 11 species at GOSP in 2001 (Table n1), for an estimated inventory completeness of 59% (Table 3b).

Table n1. Amphibian and reptile species observed at GOSP in 2001. An asterisk (*) denotes a species where a voucher specimen was collected.

Red-spotted Toad
 Woodhouse's Toad
 Great Basin Spadefoot
 Northern Leopard Frog
 Sagebrush Lizard
 Side-blotched Lizard
 Western Whiptail
 Plateau Striped Whiptail
 Racer*
 Striped Whipsnake
 Western Rattlesnake

Table n2. Number of individuals and species detected by different methods at GOSP in 2001. An "X" in a column indicates that the method was not used at that park.

GOSP	Random Plots	General Surveys	Nocturnal General Surveys	Night Driving	Random Encounters	TOTAL
Amphibians						
Individuals	0	2	X	0	3	5
Species	0	2	X	0	3	3
Lizards						
Individuals	3	1	X	0	0	4
Species	2	1	X	0	0	3
Snakes						
Individuals	0	7	X	1	16	24
Species	0	4	X	1	4	4
Total						
Individuals	3	10	X	1	19	33
Species	2	7	X	1	7	11

Three visits were made to GOSP, for a total of five days in the field. Locations sampled included Blue Creek, the Big Fill Walk, the East and West Tours, the Ravine and the maintenance yard, staff residence, and Visitor Center areas. Three amphibian, three lizard and four snake species were observed. One Racer specimen, found dead and collected by R. Wilson, Head Ranger, has been preserved as a voucher specimen. Further survey priorities include documenting the presence of Short-horned Lizard and the distribution of Great Basin Spadefoot.

o. Pipe Springs National Monument (PISP)

We recorded 14 species at PISP in 2001 (Table o1), for an estimated inventory completeness of 59% (Table 3b).

Table o1. Amphibian and reptile species observed at PISP in 2001.

Tiger Salamander
 Woodhouse's Toad
 Great Basin Spadefoot
 Great Basin Collared Lizard
 Longnose Leopard Lizard
 Short-horned Lizard
 Sagebrush Lizard
 Desert Spiny Lizard
 Eastern Fence Lizard
 Side-blotched Lizard
 Western Whiptail
 Striped Whipsnake
 Gopher Snake
 Western Rattlesnake

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

PISP	Random Plots	General Surveys	Nocturnal General Surveys	Night Driving	Random Encounters	TOTAL
Amphibians						
Individuals	X	2	1	X	4	7
Species	X	2	1	X	2	3
Lizards						
Individuals	X	128	0	X	1	129
Species	X	8	0	X	1	8
Snakes						
Individuals	X	5	0	X	1	6
Species	X	2	0	X	1	3
Total						
Individuals	X	135	1	X	6	142
Species	X	12	1	X	4	14

Three visits were made to PISP, for a total of five days in the field. The entire park unit was surveyed on each of the three visits. Most of the survey effort was focused on the rocky slope and escarpment, and the mixed-sage fields. Three amphibian, eight lizard, and three snake species were observed. No specimen vouchers were collected from BRCA.

Although small, the reptile potential of PISP is great. The staff members are eager to learn and assist in surveys, and they have been keeping records of observations. It may be possible to use targeted methods, such as funnel traps, to determine presence of the less common snake species, and it is likely the staff would be willing to assist in such an undertaking, so long as they are not trapping and handling rattlesnakes. Targeting breeding amphibians should be another priority for this park unit.

p. Timpanogos Cave National Monument (TICA)

We recorded four species at TICA in 2001 (Table p1), for an estimated inventory completeness of 22% (Table 3b).

Table p1. Amphibian and reptile species observed at TICA in 2001. An asterisk (*) denotes a species where a voucher specimen was collected.

Sagebrush Lizard
 Rubber Boa*
 Gopher Snake
 Western Rattlesnake

Table p2. Number of individuals and species detected by different methods at TICA in 2001. An “X” in a column indicates that the method was not used at that park.

TICA	Random Plots	General Surveys	Nocturnal General Surveys	Night Driving	Random Encounters	TOTAL
Amphibians						
Individuals	X	0	0	X	0	0
Species	X	0	0	X	0	0
Lizards						
Individuals	X	27	0	X	0	27
Species	X	1	0	X	0	1
Snakes						
Individuals	X	3	0	X	2	5
Species	X	1	0	X	2	3
Total						
Individuals	X	30	0	X	2	32
Species	X	4	0	X	2	4

Three visits were made to TICA, for a total of five days in the field. Fifteen surveys were carried out, concentrated around accessible areas (Cave Trail, Historic Trail, picnic areas, maintenance areas, Nature Trail). Surveys were also carried out on the talus slope on the north side of the canyon, away from public view. In addition, areas to the north of the park boundary were searched, as these were wetland areas created by the water pipeline, and may have constituted valuable amphibian breeding habitat. One lizards and three snake species were detected. One voucher specimen was collected, a road-killed Rubber Boa.

We documented all the species that the TICA rangers are familiar with, and it is unlikely that there are many more undetected reptile or amphibian species present in this unit. However, it would be worth targeting amphibians using minnow/funnel traps in the creek, and the use of coverboards for reptiles might be beneficial here.

q. Zion National Park (ZION)

We recorded 25 species at ZION in 2001 (Table q1), for an estimated inventory completeness of 63% (Table 3b).

Table q1. Amphibian and reptile species observed at ZION in 2001. An asterisk (*) denotes a species where a voucher specimen was collected.

Tiger Salamander
 Southwestern Toad
 Red-spotted Toad
 Canyon Treefrog
 Great Basin Spadefoot
 Desert Tortoise
 Great Basin Collared Lizard
 Longnose Leopard Lizard
 Short-horned Lizard
 Sagebrush Lizard
 Desert Spiny Lizard
 Eastern Fence Lizard
 Tree Lizard
 Side-blotched Lizard*
 Western Skink
 Western Whiptail*
 Plateau Striped Whiptail
 Ringneck Snake
 Common Kingsnake*
 Striped Whipsnake
 Gopher Snake*
 Ground Snake*
 Western Patchnose Snake
 Western Terrestrial Garter Snake
 Western Rattlesnake

Table q2. Number of individuals and species detected by different methods at ZION in 2001.

ZION	Random Plots	General Surveys	Nocturnal General Surveys	Night Driving	Random Encounters	TOTAL
Amphibians						
Individuals	7	95	31	0	0	132
Species	3	5	3	0	0	5
Lizards						
Individuals	237	440	0	0	2	679
Species	10	10	0	0	1	11
Snakes						
Individuals	4	15	0	2	7	29
Species	3	5	0	1	4	8
Tortoises						
Individuals	0	3	0	0	0	3
Species	0	1	0	0	0	1
Total						
Individuals	248	553	31	2	9	844
Species	16	21	3	1	5	25

Five visits were made to ZION, for a total of 25 days in the field. Ninety-one surveys produced 930 observations. Locations surveyed include Coal Pits Wash, Chinle Trail, Gopher Tortoise area by Springdale (Edgemont Trail), ParunawEEP, East Rim Trail, West Rim Trail, Court of the Patriarchs, Weeping Rock, Hidden Canyon, Emerald Pools, Temple of Sinewava, Paru'us Trail, Watchman Trail, Oak Creek, Residence and maintenance areas, Potato Hollow, Wildcat Canyon, Stevens Wash, Pocket Mesa, Smith Mesa, Lava Point, Timber Creek, LaVerkin Creek, Hop Valley, and locations along the Zion-Mt Carmel Highway.

Five amphibian, eleven lizard, eight snake, and one tortoise species were detected at ZION. One Western Whiptail, one Side-blotched Lizard, one Common Kingsnake, one Ground Snake, and two Gopher Snakes were collected by us and/or park staff and preserved. A piece of dried-up snake was discovered by park staff on a maintenance road and identified by one of us (T. Persons) as a Western Patchnose Snake, but was not in suitable condition for preservation.

Priorities for further survey are to attempt to locate the rarer species suspected to occur in ZION, such as Gila Monster and Western Banded Gecko. As with the other parks, the early spring breeding amphibians may be present. There are a number of snake species listed in the expected species list that are likely to occur in this park unit, but are difficult to locate without spending inordinate amounts of time searching. These are species that are frequently opportunistically documented, that is, someone is in the right place at the right time. The park rangers could be encouraged to collect records and to photograph what they observe wherever possible, and indeed many of the rangers that we had contact with at Zion this summer did just that. We were able to verify the presence of the elusive Ringneck Snake based on a photograph and UTMs provided by a ranger.

Appendix E. Scientific names for amphibians and reptiles mentioned in the text.

Amphibians

Tiger Salamander (*Ambystoma tigrinum*)
 Boreal Toad (*Bufo boreas*)
 Great Plains Toad (*Bufo cognatus*)
 Southwestern Toad (*Bufo microscaphus*)
 Red-spotted Toad (*Bufo punctatus*)
 Woodhouse's Toad (*Bufo woodhousii*)
 Canyon Treefrog (*Hyla arenicolor*)
 Mountain Treefrog (*Hyla eximia*)
 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*)
 Spotted Frog (*Rana pretiosa*)

Turtles and Tortoises

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

Lizards

Madrean Alligator Lizard (*Elgaria kingii*)
 Desert Iguana (*Dipsosaurus dorsalis*)
 Common Chuckwalla (*Sauromalus obesus*)
 Common Collared Lizard (*Crotaphytus collaris*)
 Great Basin Collared Lizard (*Crotaphytus bicinctores*)
 Longnose Leopard Lizard (*Gambelia wislizenii*)
 Lesser Earless Lizard (*Holbrookia maculata*)
 Zebra-tailed Lizard (*Callisaurus draconoides*)
 Texas Horned Lizard (*Phrynosoma cornutum*)
 Short-horned Lizard (*Phrynosoma douglassii*)
 Roundtail Horned Lizard (*Phrynosoma modestum*)
 Desert Horned Lizard (*Phrynosoma platyrhinos*)
 Sagebrush Lizard (*Sceloporus graciosus*)
 Desert Spiny Lizard (*Sceloporus magister*)
 Eastern Fence Lizard (*Sceloporus undulatus*)
 Western Fence Lizard (*Sceloporus occidentalis*)
 Tree Lizard (*Urosaurus ornatus*)
 Side-blotched Lizard (*Uta stansburiana*)
 Many-lined Skink (*Eumeces multivirgatus*)

Lizards, con't.

Great Plains Skink (*Eumeces obsoletus*)
 Western Skink (*Eumeces skiltonianus*)
 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*)
 Desert Banded Gecko (*Coleonyx variegatus*)
 Gila Monster (*Heloderma suspectum*)

Snakes

Rubber Boa (*Charina bottae*)
 Spotted Leaf-nosed Snake (*Phyllorhynchus decurtatus*)
 Glossy Snake (*Arizona elegans*)
 Racer (*Coluber constrictor*)
 Ringneck Snake (*Diadophis punctatus*)
 Corn Snake (*Elaphe guttata*)
 Chihuahuan 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 (*Pituophis catenifer*)
 Long-nosed Snake (*Rhinocheilus lecontei*)
 Graham Patchnose Snake (*Salvadora grahami*)
 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*)
 Speckled Rattlesnake (*Crotalus mitchelli*)
 Black-tailed Rattlesnake (*Crotalus molossus*)
 Mojave Rattlesnake (*Crotalus scutulatus*)
 Western Rattlesnake (*Crotalus viridis*)
 Massasauga (*Sistrurus catenatus*)
 Texas Blind Snake (*Leptotyphlops dulcis*)
 Western Blind Snake (*Leptotyphlops humilis*)