Inventory of Amphibians and Reptiles at Manzanar National Historic Site, California

Final Report

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ABSTRACT

We conducted a baseline inventory for amphibians and reptiles at Manzanar National Historic Site, Inyo County, California in 2002-2003. Objectives for this inventory were to: 1) inventory and document the occurrence of reptile and amphibian species at MANZ, with the goal of documenting at least 90% of the species present; 2) provide one voucher specimen for each species identified; 3) provide a GIS-referenced list of sensitive species that are known to be federally- or state-listed, rare, or worthy of special consideration that occur at MANZ; 4) describe park-wide distribution of federally- or state-listed, rare, or special concern species; 5) enter all species data into the National Park Service NPSpecies database; and 6) provide all deliverables as outlined in the Mojave Network Biological Inventory Study Plan. Survey methods included time-area constrained searches, lizard line transects, general surveys, nighttime road driving, and pitfall trapping. We documented the occurrence of ten reptile species (seven lizards and three snakes), but found no amphibians. Based on our findings, as well as literature review and searches for museum specimen records, we estimate inventory completeness for Manzanar to be 50 percent. Although the distribution and relative abundance of common lizard species is now known well enough to begin development of a monitoring protocol for that group, additional inventory work is needed in order to establish a baseline of species occurrence of amphibians and snakes at Manzanar.

Key Words: amphibians, reptiles, Manzanar National Historic Site, Inyo County, California, Owens Valley, Mojave Desert, Great Basin Desert, inventory.

INTRODUCTION

In fiscal year 2000, the National Park Service (NPS) 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 NPS Inventory and Monitoring program, 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 Mojave Network consists of six NPS units in the Mojave and Great Basin biomes: Death Valley National Park (DEVA), Great Basin National Park (GRBA), Joshua Tree National Park (JOTR), Lake Mead National Recreation Area (LAME), Manzanar National Historic Site (MANZ) and Mojave National Preserve (MOJA). A biological inventory study plan was developed in 2001 for the Mojave Network (NPS 2001), and MANZ identified inventory of amphibians and reptiles as a high priority, as no previous inventory had been undertaken for these taxa.

Objectives for this two-year inventory of amphibians and reptiles were to: 1) inventory and document the occurrence of reptile and amphibian species at MANZ, with the goal of documenting at least 90% of the species present; 2) provide one voucher specimen for each species identified; 3) provide a GIS-referenced list of sensitive species that are known to be federally- or state-listed, rare, or worthy of special consideration that occur at MANZ; 4) describe park-wide distribution of federally- or state-listed, rare, or special concern species; 5) enter all species data into the National Park Service NPSpecies database; and 6) provide all deliverables as outlined in the Mojave Network Biological Inventory Study Plan.

STUDY AREA DESCRIPTION

Manzanar National Historic Site was established in 1992 in order to protect and interpret the historical, cultural, and natural resources associated with the relocation of Japanese-Americans during World War II. MANZ is located in Inyo County, in southern California's Owens Valley, between the towns of Independence and Lone Pine. The site encompasses 330 ha, and elevation ranges between about 1167-1220 m. The Owens Valley experiences a predominantly high desert climate, as it is protected from Pacific Ocean air masses by the Sierra Nevada range to the west. Summer high temperatures often exceed 38° C, followed by evenings ranging from 18° C to 24° C. Winter temperatures are moderate and on average drop below freezing about 10 days per year. Precipitation falls as a mix of rain and snow during the months from December through March, and summer precipitation is minimal. Mean annual precipitation totals only about 10 cm.

Biological diversity is greatest along the primary natural watercourse, Bairs Creek, flowing east from the Sierra through the historic site toward the Owens River. Bairs Creek is intermittent, carrying substantial flows during periods of spring and summer runoff, but tapering off to minimal or no flow during fall and winter months. Soils are composed of alluvial materials deposited by erosion of the Sierra Nevada Mountains, and are coarse and well-drained.

MANZ is situated in the central Owens Valley, in an area of transition between the Great Basin Desert to the north and the Mojave Desert to the south (Macey and Papenfuss 1991a, b). Natural vegetation at MANZ is primarily Great Basin Desertscrub, characterized by low shrubs such as sagebrush (*Artemisia tridentata*), saltbush (*Atriplex polycarpa*), and rabbitbrush (*Chrysothamnus nauseosus*). Creosote bush (*Larrea tridentata*), which occurs in the southern Owens Valley, is absent at MANZ. A portion of the site also is covered by a large cottonwood grove that exists in a unique hydrologic area where groundwater remains relatively near the surface. Finally, a small riparian zone is present along Bairs Creek. While some portions of the site contain relatively natural vegetation communities, most of the area reflects the many years of heavy human occupation, and weedy annual plants and non-native trees such as black locust (*Robinia pseudoacacia*) and tamarisk (*Tamarix* spp) are common. In addition, remnants of an historical orchard of pear and apple (*Malus* spp.) trees exist.

METHODS

Sampling Design

We used a combination of non-random, general herpetological survey methods and standardized surveys at random locations to survey for amphibians and reptiles at MANZ. Prior to the start of the inventory we randomly generated sample points throughout the historic site, and conducted both TACS and lizard line surveys at many of these (randomly selected from the larger pool of points), to compare the two methods for inventory purposes and evaluate their potential in long-term monitoring. In addition, we reviewed pertinent literature and searched for museum specimen records, and consulted with local experts regarding possible occurrence of certain species at MANZ.

Generation of Random Point Locations. We generated random points by hand for the amphibian and reptile inventory using a random number table to select among all possible UTM coordinates falling within the historic site. To do this, we used the USGS 7.5 minute topographic map of Manzanar and a standard UTM grid overlay sheet to estimate UTM coordinates (NAD27 datum) for the southwest corner, southeast corner, and northernmost point of the MANZ boundary. For ease of calculation, these points were then extrapolated to create a northwest corner and northeast corner of a rectangle encompassing MANZ, but including area in the northwest and northeast outside the boundary. The UTM bounds for the north, south, east, and west sides of this rectangle were determined to be 4066080 N, 4063960 N, 398480 E, and 396020 E, respectively. Because only the last four digits of each UTM coordinate varied, we used a base-8 random number table (Heyer et al. 1994) to generate eight consecutive random digits, corresponding to the variable four digits of the easting and northing, respectively, of a new random point location. The table was read sequentially, and each octet was visually scanned to see if the resulting UTM would fall within the extended rectangle encompassing MANZ (i.e. 6020-8480 E, 3960-6080 N). The first three pages (1,536 UTM values) of this random number table were used, and 76 points were generated. These points were numbered initially 1-76, so that points outside MANZ are missing from the final list. These were hand plotted on a map, and of these, 43 were determined to fall within the actual boundaries of MANZ. We conducted surveys at the first 19 of these 43 points, as well as at one additional non-random point. We conducted both a time-area constrained search and lizard line transect at 18 points, and conducted a lizard line transect at two additional points. Each point was sampled by each method only once during the inventory. The UTM coordinates of the points surveyed are listed in Table 1, and mapped in Figure 1.

Field Methods

For this inventory, we used a combination of time-area constrained searches (TACS; Persons and Nowak 2006), 100 m long walking transect surveys for lizards (“lizard lines”; Rosen and Lowe 1996), time-recorded visual encounter surveys (“general surveys”), nighttime road driving surveys, and limited pitfall trapping. These methods are outlined below.

Time Area Constrained Searches. Time area constrained searches (TACS) are a version of visual encounter surveys defined by Crump and Scott (1994) in which not only the amount of time spent searching, but also the area covered, are standardized. TACS consist of walking systematically through the sampling area for a specified amount of time, searching all areas within the habitat, and recording reptiles and amphibians encountered (Scott 1994). This method yields a number of individuals and species collected or observed per person-hour. We conducted TACS surveys for a minimum of one person-hour within a one ha square plot (i.e., 100 m x 100 m) centered on a randomly generated point location. We also collected habitat data at these random points, including dominant tree, shrub, and herbaceous plant species and estimated mean height and percent cover of these species and classes. In addition, we estimated percent cover of other habitat elements, such as bare ground, rocks, and woody debris. A copy of the field data sheet used for TACS is reproduced in Appendix A.

Lizard Line Transects. We conducted standardized walking transects for lizards ("lizard lines"), similar to those developed at Organ Pipe Cactus National Monument by Rosen and Lowe (1995, 1996). These 100 m long, 15 m wide transects were centered on the same random point locations as the TACS plot searches, in order to compare survey methods. Like Rosen and Lowe (1995), we made repeated walks of the survey transect throughout the morning or afternoon, in order to detect a peak activity value for multiple lizard species, many of which have different thermal preferences and therefore different temporal activity patterns throughout the day. However, unlike Rosen and Lowe (1995), we did not record distance from midline data for individual observations (with larger sample sizes, these data could be used to refine density estimates and correct for differences in lizard observability between transects, using distance sampling analysis; Buckland et al. 2001). We recorded the species, age or size class, and sex (if possible) for each lizard observed along the transect. Habitat data collected at lizard lines were the same as for TACS, and represented the whole 1 ha plot area the line was located in and not merely the narrow strip transect. As with TACS, we recorded dominant tree, shrub, and herbaceous plant species and estimated mean height and percent cover of these species and classes, as well as estimated percent cover of other habitat elements, such as bare ground, rocks, and woody debris. A copy of the field data sheet used for lizard line transects is reproduced in Appendix A.

Daytime General Surveys. We conducted visual encounter surveys that were not time or area-limited. In these "general surveys," we sampled habitats that appeared to be of high quality for reptiles or amphibians, were otherwise unique, and/or were not represented by TACS plots. The focus of this method was to search selected microhabitats opportunistically without necessarily covering a given area thoroughly.). During daytime general surveys we recorded the area searched (either with GPS points or written route descriptions, or both), start and stop times, weather conditions (temperature, cloud cover, wind, relative humidity) at the beginning and end of each survey, and observations of all amphibians or reptiles encountered during the survey.

Nocturnal General Surveys. Nocturnal general surveys were conducted in the same manner as daytime general surveys, except that they occurred at night. During these surveys, we primarily targeted aquatic habitats along Bairs Creek potentially used by amphibians. These surveys included an aural component, i.e. listening at potential breeding locations for calling amphibians, as well as searching backwaters along the creek for tadpoles and egg masses.

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

Pitfall Traps. Midway through the 2003 field season we installed ten pitfall traps in high quality microhabitats at MANZ (five under trees in blocks 5 and 6, just north of Bairs Creek, and five along Bairs Creek east of the Chicken Ranch), with the hope of detecting additional species not easily found by our other methods. These traps consisted simply of clean plastic 18.9 liter (5 gallon) paint buckets buried flush with the ground surface, and covered by a piece of plywood raised 2-5 cm inches off the surface, designed both to attract animals as potential refugia and to shade buckets from direct sunlight. The traps were not connected by drift fences, as is often done in more permanent installations (e.g., Campbell and Christman 1982, Corn 1994), in order to minimize ground disturbance to the historic site and decrease visibility of the traps to visitors. When open, we checked these traps at least daily. When not in use, we closed the traps with tight fitting plastic lids. UTM coordinates for these traps are given in Table 2, and locations are shown in Figure 2.

Nighttime Road Driving. 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. At MANZ, we were limited to surveying the dirt auto tour route and a few associated administrative roads, totaling only a few miles of roads within the historic site. We also occasionally made passes along US 395 adjacent to MANZ, but this high-speed highway was not generally safe for surveying.

We standardized these surveys by driving a vehicle at slow speeds (20-30 km per hour) within MANZ, identifying all amphibians and reptiles encountered to species and recording if they were either alive on the road (AOR) or dead on the road (DOR), sexing and aging all individuals, as possible, and recording locations to the nearest 0.1 mi using calibrated vehicle odometers. Locations of selected observations were also recorded using GPS.

Spatial Data Collection
Survey area locations were recorded using Garmin® hand-held GPS units (GPSIII Plus, Garmin 12, or e-Trex). In addition, we recorded individual capture locations of some uncommon species. Although the Mojave I&M Network is trying to standardize all spatial data in the NAD83 datum, we used NAD27 in order to match the USGS topographic maps of MANZ. As with other field data, all spatial data were originally recorded on field data sheets (Appendix A) or in field notebooks before being entered into the Microsoft Access® database.

Voucher Specimens
We attempted to document the presence of amphibians and reptiles at MANZ by collecting at least one individual of each species. Specimens were injected with and immersed in 10% formalin for fixing, then transferred to 55% isopropyl alcohol for preservation, using standard techniques (e.g., Simmons 2002). These specimens have been deposited in the natural history collection facility at Death Valley National Park. Each specimen has an NPS-issue specimen tag containing information on species, collector, date of collection, collection site, and NPS (ANCS+) accession and catalog number.

Literature and Museum Specimen Review
Although prior herpetological collecting at MANZ is apparently nonexistent, many specimens have been collected from the general region of the central Owens Valley. The excellent reviews by Macey and Papenfuss (1991a, b) contain both dot distribution maps and specific locality and museum data for specimens collected throughout the Owens Valley, including in the area of MANZ. This was our primary data source for evaluating the possibility of species occurrence at MANZ. We did not duplicate the museum searches of Macey and Papenfuss (1991a,b). However, we did query the online collection databases of the two primary repositories of southern California material (California Academy of Sciences and the Museum of Vertebrate Zoology) for amphibians and reptiles collected since the publication of this source – i.e., between 1990 and 2003. We also consulted with experts familiar with aspects of the herpetofauna in the MANZ region. These experts included Ted Papenfuss, Jonathan Richmond, and David Wake. Contact information for these experts is presented in Appendix B.

Data Analysis
The effectiveness of the different sampling methods was evaluated by determining overall species richness and capture rate per unit effort for each of the sampling methods. The number of species or individuals captured per unit effort was calculated by dividing the number captured or sighted by the total effort for that method or time period. The amount of sampling effort was measured as number of hours spent on each survey multiplied by the number of people per survey (person-hours). Pitfall trap results are given as number of captures per trap day (one trap open for one day), and are not directly comparable with other methods.

Lizard line transect data were analyzed according to the protocol of Rosen and Lowe (1996), whereby the value of interest is the maximum number of each species recorded on any given walk of the transect over the course of the survey ("peak value"). These values are represented as lizards/100 m of transect, facilitating comparison with other studies where transect lengths greater than 100 m were used.

To estimate inventory completeness, we developed a master list of species documented and potentially occurring at MANZ. Based on our expert opinion, probability of species occurrence was ranked as low (0-33%), medium (34-67%), or high (68-100%). In Table 6 these three rankings are coded as 1, 2, and 3, respectively. For quantitative analysis, these rankings were converted to the midpoint of their percentage range, i.e. 0.17, 0.50, and 0.83. These values were used as weighting factors for species not yet documented. For example, two species with rankings of medium probability of occurrence would combine to equal one full expected species (0.50 x 2=1.00 species), whereas six species of low probability of occurrence would be required to equal one full expected species (0.17 x 6=1.02 species). Species found by us during the inventory, or known from previously collected specimens are weighted 1.00. Development of this master list was based on consultation of selected literature sources (Macey and Papenfuss 1991a, b, Stebbins 1985, 2003), personal knowledge of the distribution and habitats of southwestern amphibians and reptiles, data from selected museum collections, personal communications with other herpetologists that have worked in the MANZ region, and results of fieldwork from the 2002-2003 seasons. Such weighting of categorical probability data is generally not recommended for statistical applications; however, we feel it justifiable because we are not using the resulting inventory completeness estimates for statistical probability or hypothesis testing. Instead, we are generating a locally-specific estimate of percent inventory completeness as mandated by the NPS I&M program, in a manner that integrates a range of information including inventory results, pre-existing information, and professional knowledge. These considerations should be kept in mind when interpreting the inventory completeness estimates, and underscore the need to focus on the more detailed discussions in the species accounts - especially for undocumented species.

In addition to the master list, we produced a species accumulation curve (e.g. Scott 1994) to evaluate inventory completeness. This curve is simply a graphical representation of the rate at which we found new species over the course of the entire inventory period.

Data and Other Products

Data products delivered separately to the Mojave Inventory and Monitoring Network include 1) a Microsoft Access® database containing all field data on individual surveys, species observations, and site characterization of the random plot and lizard line surveys; 2) ArcView® GIS shapefiles of random sampling site locations, pitfall trap locations, and voucher specimen locations; 3) updates of the NPSpecies and NatureBib databases for DEVA, updated both online and using the desktop application of NPSpecies; 4) copies of field notes and field data sheets; and 5) photographs (35 mm color slides) of some survey areas and captured animals. Metadata for this inventory is being developed with the assistance of the data manager for the Southern Colorado Plateau Inventory and Monitoring Network (SCPN).

Report Review

In addition to NPS review by the Mojave I&M Network coordinator and staff at MANZ, this report has undergone USGS review in accordance with the USGS Southwest Biological Science Center's (SBSC) peer review policy. This process consisted of initial policy review by the station leader at the Colorado Plateau Research Station and the Center Director at SBSC, followed by peer review coordinated by the SBSC Center Director.

RESULTS AND DISCUSSION

Overview of Inventory Results

We detected ten species of reptiles at MANZ in 2002-2003, but observed no amphibians. Details of the park-wide distribution and habitat associations of each species are found in the species accounts (Appendix C). Scientific and common names follow Stebbins (2003). Scientific names for all amphibian and reptile species mentioned in this report are given in Appendix D.

Within the boundaries of MANZ we recorded 770 individual reptiles that were identified to species, plus about 125 others (all lizards) that were not seen well enough to determine species. Only those 770 individuals positively identified are used in analyses. Of these 770 observations, 762 (99%) were of lizards, with only eight observations of snakes. The most commonly observed species was the Side-blotched Lizard (n = 420), accounting for 55% of all observations. The next most common species was the Western Whiptail (n = 228), comprising 30% of all observations. Together, these two species accounted for 84% of all reptile observations. With the addition of Desert Spiny Lizard (64 observations, 8%) and Zebra-tailed Lizard (40 observations, 5%), these four lizard species comprised 98% of all observations. The numbers of observations of the remaining six species were as follows: Long-nosed Leopard Lizard (n = 7), Glossy Snake (n = 3), Coachwhip (n = 3), Desert Horned Lizard (n = 2), Gopher Snake (n = 2), and Southern Alligator Lizard (n = 1). Numbers of each species observed by each method are summarized in Table 3.

Literature and Museum Specimen Review

In addition to more general references such as Stebbins (1985, 2003), the primary reference used for herpetofauna of the Owens Valley (including the region around MANZ) was Macy and Papenfuss (1991a, 1991b). Our queries of the California Academy of Sciences and the Museum of Vertebrate Zoology for specimens collected since the publication of Macey and Papenfuss (1991a, b) yielded no records for the immediate vicinity of MANZ.

Sampling Effort and Efficacy of Methods

We spent approximately 223 person-hours on surveys for amphibians and reptiles at MANZ between March 2002 and September 2003, and the pitfall traps were open for a total of 245 trap days/nights between 24 June and 13 September 2003 (Table 4). We conducted 40 daytime general surveys, 3 nocturnal general surveys, 18 TACS surveys, 20 lizard line surveys, and 38 night drives. At 18 random points, both a TACS and lizard line were conducted, usually within one day of each other.

The most species detected by a single method was seven, on both TACS and night driving surveys. However, most of the species found during night driving were common diurnal lizards seen shortly before or after sunset. Glossy Snake was the only truly nocturnal species observed during these surveys. General surveys and lizard lines each produced six species, whereas random encounters, pitfall traps, and nocturnal general surveys produced only 5, 4, and 3 species, respectively. Examination of Table 3 shows that most species were common to all of the three primary daytime methods (TACS, lizard lines, general surveys), and the differences are the result of encounters of uncommonly observed species (Desert Horned Lizard, Coachwhip, Gopher Snake). That single observations of these species occurred using one or the other of these three methods is likely the result of chance. More telling is examination of the evenness of species observations within these three methods. Because locations of TACS and lizard lines were randomly chosen, observations are weighted toward the most common species that are distributed throughout the park (Side-blotched Lizard and Western Whiptail), and these methods recorded relatively few of the other two most abundant species (Zebra-tailed Lizard and Desert Spiny Lizard), which, although common, have a more patchy distribution within MANZ. Zebra-tailed Lizards occur in the open, sandy habitats at MANZ, while Desert Spiny Lizards are much more abundant in the riparian areas. Zebra-tailed lizards, in particular, were largely missed by the random point-based surveys. Although a combination of methods is always desirable during a species inventory, used alone general surveys would have given us the best overall picture of both the occurrence and habitat distribution of lizards at MANZ.

Overall, TACS found more individuals per person-hour of surveying (6.7) than the other methods (5.3 for general surveys, 4.1 for lizard lines, 1.3 for nocturnal general surveys, and 0.3 for night driving). This is likely because TACS were generally conducted during peak morning lizard activity times. In addition, the focus of TACS were to observe and record every lizard on the plot, whereas general surveys were often conducted in specific habitats (e.g., riparian thickets) searching for new species, sometimes in microhabitats containing fewer lizards overall than the shrub habitats dominated by the common desert lizard species.

Most animals found during night driving surveys were common diurnal lizards seen shortly before or after sunset. Only four snakes were found during these surveys (three live Glossy Snakes and one dead Coachwhip), for an encounter rate of 0.48 snakes/100 km of driving. Considering only live snakes (i.e., not counting the one dead Coachwhip), the resulting encounter rate decreases to 0.36 snakes/100 km This low rate is likely due to both dry conditions during our inventory, and the fact that roads within MANZ are not paved, which contribute to decreased visibility of snakes on the road, especially small individuals. In addition, dirt roads do not retain heat as well as paved surfaces, and thus may not be as attractive to reptiles for basking at night. Other studies to report these figures include Rosen and Lowe (1996), who recorded 0.67 live snakes/100 km at Organ Pipe Cactus National Monument, and Persons (2001), who recorded 0.94 live snakes/100 km at Wupatki National Monument, Arizona. At a concurrent inventory at Death Valley National Park just east of MANZ (unpublished data), we found 0.62 live snakes/100 km driven during night driving surveys, similar to Rosen and Lowe (1996). On the other hand, an earlier study in the Mojave Desert that quantified results in a similar manner was that of Klauber (1939), who recorded 5.8 live snakes/100 km in the Anza-Borrego Desert region. Future night driving surveys at MANZ should target warm, humid nights, especially after summer rainstorms.

The ten pitfall traps installed midway through the 2003 season caught 24 individuals, or 0.1 lizards per trap day, a trap success rate comparable to areas in northern Arizona (personal observation). Installing and operating pitfall traps is labor intensive, which is why we did not do so at the beginning of this inventory, and they captured predominantly common species. Importantly, however, this technique did capture the only individual of Southern Alligator Lizard observed during this inventory. Capture of rare or secretive species is known to be a particular benefit of using pitfall traps (Campbell and Christman 1982); however, these bonuses are often obtained only after hundreds of hours of trapping effort.

We conducted lizard line surveys in order to compare them with TACS plot surveys for use as an inventory method, but more importantly to evaluate their possible utility in a long-term monitoring program at MANZ. Total numbers of each species observed during lizard line surveys are presented in Table 3, and peak values (maximum number observed on a single walk of the transect over the course of the survey) for each species on each survey, as well as means and standard deviations, are presented in Table 5. Although lizard lines recorded similar numbers of species (six) as TACS (seven), they were more time and labor intensive, and are therefore better suited to long-term monitoring than inventory.

Only two species were observed on lizard lines in sufficient numbers for meaningful analysis, and these were the two most common species overall (Side-blotched Lizard and Western Whiptail). Because few random points fell within either densely treed sections (such as along Bairs Creek) or in the sandy habitats west of the cemetery area, we recorded relatively few Desert Spiny Lizards and Zebra-tailed Lizards, respectively, on the lizard lines. Overall, peak values (± S.D.) of Side-blotched Lizard and Western Whiptail observed/100 m averaged 2.65 (± 3.54) and 2.05 (± 1.86), respectively. If we remove survey #38, with 16 Side-blotched Lizards (mostly young of the year), the mean for that species decreases to 2.26 (±1.97). Peak values for all species are improved if only morning surveys are included (Table 5). While these figures may appear low, they are comparable to figures from Organ Pipe Cactus National Monument's (ORPI) lizard line monitoring data. Rosen (2000) summarized ten years of lizard line data from ORPI, where 21 permanent transects run twice/year produced annual mean peak values (lizards/100 m) of 1.61 for Side-blotched Lizard, and 2.55 for whiptails (mostly Western Whiptail), as well as 0.70 for Zebra-tailed Lizard. Over these 21 transects run twice/year (once in spring, once in summer), these magnitudes of peak values have been adequate for detecting changes in population sizes in response to fluctuations in precipitation and possible concomitant changes in predation pressure (Rosen 2000).

Estimate of Inventory Completeness
Based on our surveys at MANZ in 2002-2003, and evaluation of potential occurrence of undocumented species, we estimate an overall inventory completeness of 50% (Table 6).

Inventory Completeness of Different Taxa Groups
Using the same weighting methods and data from Table 6, we calculated that overall estimated inventory completeness for amphibians is 0% and for reptiles is 54% (78% for lizards and 23% for snakes). The relatively high success rate for lizards is likely because most lizard species are diurnal and conspicuous, and our efforts were biased towards daytime searches that easily detect such species. Many snake species are primarily nocturnal and are extremely secretive in their habits, so a low success rate for snakes is not surprising. However, the single most important factor limiting our success finding snakes at MANZ is the lack of extensive networks of paved roads within the historic site. Based on data from our own studies in Arizona, nighttime road surveys on paved roads are by far the most effective method for detecting both amphibians and snakes. For example, at Petrified Forest National Park (Drost et al. 2000, 2001) and Wupatki National Monument (Persons and Nowak 2006, Persons 2001) the combination of general daytime foot surveys for lizards and nighttime road surveys for amphibians and snakes resulted in an overall estimated inventory completeness of >90% (unpublished data).

Evaluation of Inventory Completeness through Species Accumulation
A species accumulation curve (plotted per survey day) for 2002-2003 MANZ data is shown in Figure 4. The asymptotic curve in Figure 4 suggests that we are close to detecting all the species present at MANZ. However, because our master list estimate of inventory completeness is only 50%, this is probably a false asymptote, and may only indicate that we have detected most of the common species using our current methods. The remaining undetected species may require proportionately greater effort and/or different field methods to detect. Similarly, an asymptotic curve shown after two seasons at some SCPN parks (Nowak et al. 2003) is also misleading, as we were in fact not very close to detecting 90% of the species at most of these parks. Species accumulation curves can be valid estimators of inventory completeness in situations involving large numbers of species, extensive survey periods, and a wide variety of field methods (e.g., Scott 1994). However, at MANZ, given our small sample sizes, limited field methods, and knowledge of the habitats and local distribution of potential species, we believe the master list approach provides a more precise estimate of inventory completeness.

Rare, Exotic, or Sensitive Species
None of the species we documented from MANZ could be considered rare or otherwise of special management concern. In fact, most species at MANZ are widespread and abundant throughout much of the Southwest. The Southern Alligator Lizard is apparently rare at MANZ, but is common just upslope the Sierra Nevada foothills to the west, and is abundant in many other areas, including suburban habitats in coastal southern California. The non-native Bullfrog has been introduced into the Owens Valley (Macey and Papenfuss 1991a), but requires permanent water not found at MANZ.

Specimens Collected

We collected nine reptile specimens at MANZ in 2002-2003. A complete list of these specimens and associated collection and cataloging data is found in Table 7, and a map showing collection locations is presented in Figure 3. All of these specimens are deposited in the natural history collection facility at Death Valley National Park (DEVA). Of the ten species that we observed during this inventory, only the Gopher Snake was not collected. Specimens were collected under research permit number DEVA-2002-SCI-0010, and cataloged under accession number MANZ-00037.

Update of NPSpecies and NatureBib Databases

Prior to this project, no information on amphibians and reptiles at MANZ had been entered in either the NPSpecies or NatureBib databases. In 2004 we added entries for the ten species we documented during this inventory, and in 2005 we added those species considered "probably present" (Table 6) to the online NPSpecies database. We added only species entries into the NPSpecies database, i.e., we did not include subspecies. We also added the only two relevant bibliographic references (Macey and Papenfuss 1991a, b) to the NatureBib database, and linked each species in NPSpecies to these references. Voucher specimen data were also added to the NPSpecies online database. The MANZ NPSpecies checklist field data was certified in early 2004.

Biogeography of the Manzanar Herpetofauna

The Owens Valley encompasses a broad transition zone between Great Basin Desert and Mojave Desert habitats, and this is reflected in the herpetofauna of the MANZ region. Macey and Papenfuss (1991a, b) analyzed the biogeography of the herpetofauna of the entire White-Inyo Mountains region, including Owens Valley, and allocated all amphibian and reptile species into southern, northern, western, endemic, or wide-ranging groups. Of the ten species we documented at MANZ during this inventory, the Southern Alligator lizard is a western species, the Glossy Snake is a southern species, and the remaining eight species are wide-ranging. However, among the nine undocumented species most likely to occur at MANZ (i.e., those ranked as a "3" in Table 6), five are wide-ranging (Night Snake, Common Kingsnake, Long-nosed Snake, Western Patch-nosed Snake, Western Ground Snake), three are southern (Western Banded Gecko, Southwestern Black-headed Snake, Speckled Rattlesnake), and only one is northern (Great Basin Spadefoot). The majority of documented or probable species at MANZ are either southern or wide-ranging, suggesting an overall southern affinity for the herpetofauna. However, many northern species do occur in the Owens Valley as far south as MANZ, but are restricted to more aquatic habitats (e.g., Western Toad, Pacific Treefrog, Western Terrestrial Garter Snake). While MANZ contains elements of different regional herpetofaunas due to its location within a broad habitat transition zone (Owens Valley), the predominance of southern and wide-ranging species is most likely due to its local position within the valley itself, rather than its southerly latitude. Because MANZ has a moderate elevation, it supports a number of southern and wide-ranging desert-adapted species (e.g., Zebra-tailed Lizard, Desert Horned Lizard, Desert Spiny Lizard, Western Whiptail, Glossy Snake) not found further upslope in the foothills of the Sierra Nevada range directly to the west of the site. In addition, MANZ is located away from the bottom of the Owens Valley (Owens River), and therefore lacks aquatic habitats utilized by many northern species in the region.

Anthropogenic factors may also contribute to the current distribution of reptiles and amphibians in the Manzanar area. The intensive and concentrated human use of Manzanar during its tenure as an internment camp during World War II may play a role in the current distribution of species at the site, as some species could have been locally extirpated during this occupation. Extensive habitat changes stemming from modifications of the hydrology of the valley have occurred since that period, as a result of damming and diversion of local water sources. For example, although Bairs Creek was likely never a perennial stream, water flow was less intermittent and more dependable prior to upstream water diversions and lowered ground water levels (Frank Hays, MANZ Superintendent, personal communication). Species such as garter snakes and some amphibians may have occurred previously at MANZ, but may now be unable to recolonize the site from remnant Owens Valley populations due to lack of suitable habitat.

CONSIDERATIONS FOR FUTURE INVENTORY WORK AND LONG-TERM MONITORING

Future Inventory Work

Given our level of effort and a resultant overall estimated inventory completeness of only 50%, reaching the goal of 90% inventory completeness by the end of this project would have required a shift in methodology and/or a substantial increase in the amount of time spent in the field. Because we were interested in evaluating TACS and lizard line transect surveys for possible use as long-term monitoring methods, and because of a desire to conduct these surveys at random locations within MANZ, we may have reduced our ability to detect the full range of species present. These surveys by their nature primarily detected common, conspicuous species that are distributed across the landscape, such as Side-blotched Lizard and Western Whiptail. While some form of standardized methodology is required in a monitoring program, such methods are not necessary for species inventories, and their increased labor diverts available time away from more productive, targeted searches for rare species. As a result, targeted 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, Karns 1986, Scott 1994, Turner et al. 1999).

Although we did establish solid baseline data on species occurrence of lizards at MANZ, more inventory work is needed to establish such a baseline for amphibians and snakes. Surveying during wetter periods will be the most important factor in documenting the amphibian fauna. Surveying under surface objects in late winter or spring when the ground is damp (as after a winter of above average precipitation), especially along Bairs Creek, may turn up salamanders. Similarly, locating temporary pools after heavy spring or summer rains may be needed to detect Great Basin Spadefoots. For snakes, prolonged wetter conditions would undoubtedly help to increase both surface activity and population sizes of many species. Greatly increased pitfall trapping would likely detect some small, secretive snake species (e.g., Western Ground Snake, Night Snake, Southwestern Black-headed Snake). In addition, strategic placement of artificial cover, such as large sheets of roofing tin, could also help detect these species (e.g., Fellers and Drost 1994). Although we only recorded two snake species during road cruising surveys, this method is time- and cost-efficient, and should be continued in an effort to detect snake species, most of which are at least partly nocturnal in mid-summer at MANZ.

Given the <90% completeness of the herpetofauna inventory at MANZ, the NPS may wish to fund additional inventory work in order to establish a more complete baseline of species occurrence. It may be preferable to design a long-term monitoring program such that the percentage of effort allocated to inventory decreases over time, while the percentage of monitoring increases, until a solid baseline of species occurrence exists. It should be noted that inventory and monitoring are not mutually exclusive endeavors. In fact, many methods designed to monitor more inclusive subsets of the herpetofauna community (e.g., road driving surveys for snakes) are the same ones used for inventory. Thus, a well-rounded monitoring program that focuses on each major subset of the herpetofauna (i.e., amphibians, lizards, snakes) will monitor not only the population status of particular focal species within each group (e.g., Side-blotched and Western Whiptail for lizards), but may simultaneously monitor the amphibian and reptile community as a whole, and in the process will document new species and lead toward a more complete baseline of species occurrence.

New species will also be documented opportunistically. Observations and/or collections by NPS staff can be invaluable in these efforts, especially for uncommon or secretive species that are generally undetected during periodic, short duration visits to the site by researchers. Now that solid baseline data exists on occurrence of common species at MANZ, help of interested staff and volunteers can more easily be directed towards documenting suspected species. Road killed animals should be salvaged and placed in the freezer until they can be properly preserved. These specimens should be double or triple bagged in plastic zip-loc or similar bags, with an effort made to squeeze excess air out of the bags, and complete collection data (date, collector, and precise location, preferably with UTM coordinates) included in the bags with the specimens.

Long-term Monitoring

Although we suggest additional inventory work in order to reach a satisfactory level of inventory completeness, some results from this project can be used in guiding a monitoring program at MANZ. Based on our results, monitoring of amphibians or snakes would clearly be difficult. For these groups, initial work should focus on increased inventory efforts, in order to establish a baseline of species occurrence.

For lizards, however, this inventory has established a baseline of species occurrence, and has furthermore identified the dominant species and their general habitat associations within the historic site. Side-blotched Lizards and Western Whiptails were found to be common in all habitats throughout the site, whereas Zebra-tailed Lizards and Desert Spiny Lizards were largely confined to open, sandy areas and riparian and other wooded habitats, respectively. In addition, we have established a baseline for Side-blotched Lizard and Western Whiptail on both TACS plots and lizard line transect surveys. Because lizard lines (Rosen and Lowe 1995, 1996; this study) use the peak value for a transect walk during a survey as the metric for analysis, they help correct for differences in lizard activity throughout the survey period. In addition, because they are linear, and only one walk of the transect is used in the analysis (per species), they avoid double counting, which is a potential problem in using TACS as a monitoring method. However, if monitoring funding is limited, TACS may yield more observations at more sample points throughout MANZ than lizard lines for a given amount of available field time, and may provide a better overall “snapshot” of lizard numbers at the site. Time-recorded general surveys would provide similar data on observations per survey hour, and would be the most cost effective method of the three.

Swann (1999), using transect methods of Rosen and Lowe (1996), used power analysis to evaluate the amount of effort required to detect changes in populations of common lizard species at Tonto National Monument, Arizona, which is similar in size (441 ha) to MANZ. He concluded that the effort needed to detect trends in even the most abundant species would be prohibitive for a small park like Tonto. For example, he determined that detecting a 2% annual decline over 10 years in the two most common lizard species would require 120 person-days of fieldwork annually. Based on these results, he suggested that monitoring of species richness and related parameters (e.g., species diversity), which he estimated would require much less effort, may be more appropriate for monitoring programs in national parks. However, common desert lizards have been successfully monitored for over a decade at Organ Pipe Cactus National Monument, Arizona (ORPI) using line transect methods with only about 40 person-days of fieldwork annually (Rosen 2000). Before implementation of a monitoring program at MANZ, a pilot study should be conducted in order to estimate the number of sites and surveys that will be needed to generate sample sizes adequate for statistical analysis of trends.

It is also clear from our data that monitoring of uncommon species, which are often of interest as potential “vital signs” of ecosystem health, would be extremely difficult in most cases, simply because they are so difficult to locate at all. Furthermore, while some uncommon or restricted species may be of interest to monitor for their own sake, it is unlikely these species can be used as “vital signs” of ecosystem integrity. For these reasons, we propose that monitoring should encompass communities of species (in this case diurnal lizards), and focus especially on the most common species (i.e., Side-blotched Lizard and Western Whiptail). Lizards, which are relatively sedentary, usually show relatively rapid and substantial population responses to fluctuations in precipitation and concomitant variation in primary productivity at a site. For this reason, common diurnal desert lizards have been the centerpiece of herpetofauna monitoring at Organ Pipe Cactus National Monument for over a decade (Rosen 2000, Rosen and Lowe 1996). Careful placement of permanent lizard lines at MANZ could also include Zebra-tailed Lizard and Desert Spiny Lizard, two common species underrepresented on our transect surveys. Finally, our lizard line transects were only 100 m long, in order to stay within the bounds of the 1 ha TACS plots. However, we would recommend establishing longer permanent transects, which would be more efficient for maximizing data collection.

Random placement of transects would allow statistical inference of results to the entire park. However, non-random placement of transects based on habitat and preliminary results of lizard distribution from our inventory would allow for maximization of sample sizes and inclusion of patchily distributed target species (e.g., Zebra-tailed Lizard). In addition, non-random placement of transects would minimize interference with operations of the historic site. Based on comparison with Rosen (2000), whose peak values for common lizard species were similar to ours, we recommend establishing 10-12 lizard lines (200-300 m long) at MANZ, and running these transects twice annually, in late spring and again in mid-summer.

In summary, we recommend a two-pronged approach to the initiation of long-term monitoring of amphibians and reptiles at MANZ. First, if adequate funding is available, we recommend establishment of permanent lizard line transects (Rosen and Lowe 1995, 1996) to monitor the community of common, diurnal lizard species. Second, we recommend increased inventory work, directed at establishing a baseline of species occurrence of amphibians and snakes. Given the difficulty in detecting amphibians and snakes at MANZ, this may take several years. One approach, advanced by Swann (1999), would be to conduct periodic (e.g., every five years or more) complete species inventories, which would aid in the ultimate goal of completion or near completion of the species list, and simultaneously serve as general monitoring of overall diversity. These repeated inventories could strike a balance between allocating effort to finding new species (inventory) and assessing diversity and abundance of common, widespread species (monitoring).

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Table 1. UTM coordinates (NAD27) of point locations used for Time Area Constrained Searches and Lizard Line Transects during an amphibian and reptile inventory at Manzanar National Historic Site, 2002-2003. Point number 33B was created in the field, and was not part of the original randomly generated list. Point number 26, which fell outside the MANZ boundary (Figure 1), was not included in analysis.

Random Point Number	UTM East	UTM North
1	397152	4065726
2	397060	4064925
3	397790	4064321
4	396768	4065301
5	396559	4064866
11	396976	4064367
13	397474	4064189
16	396657	4064642
18	396374	4065119
19	397021	4064420
21	398055	4064493
22	396551	4064459
23	397478	4064643
24	396119	4065132
26	398036	4064100
27	397873	4064429
33	396568	4065130
33B	396371	4065116
34	396999	4064321
37	397940	4064521
38	396929	4064918

Table 2. UTM coordinates (NAD27) of pitfall traps used during an amphibian and reptile inventory at Manzanar National Historic Site in 2003. Traps 1-5 were located along upper Bairs Creek, and traps 6-10 were located ca. 200 m north of there, in blocks 5 and 6.

Trap Number	UTM East	UTM North	EPE (m)
1	396870	4064161	5
2	396876	4064167	5
3	396892	4064160	5
4	396906	4064165	5
5	396915	4064163	5
6	396903	4064362	6
7	396892	4064372	4
8	396926	4064425	4
9	396973	4064454	4
10	397007	4064461	4

Table 3. Amphibian and reptile species documented for Manzanar National Historic Site, and the numbers of each species observed by each method during herpetofauna surveys in 2002-2003. An asterisk (*) denotes a species represented by a voucher specimen. Abbreviations for survey types are: TACS=time-area constrained search 1 ha plots, LL=lizard line transects, GS=general surveys, NGS=nocturnal general surveys, PF=pitfall traps, ND=night driving surveys, and RE=random encounters.

Species	TACS	LL	GS	NGS	PF	ND	RE	Totals
*Long-nosed Leopard Lizard	4		2				1	**7**
*Zebra-tailed Lizard	2	2	24	2		5	5	**40**
*Desert Horned Lizard			1			1		**2**
*Side-blotched Lizard	85	111	202	2	11	7	2	**420**
*Desert Spiny Lizard	8	6	32	1	10	5	2	**64**
*Western Whiptail	30	99	87		2	1	9	**228**
*Southern Alligator Lizard					1			**1**
*Coachwhip	1	1				1		**3**
*Glossy Snake						3		**3**
Gopher Snake	1	1						**2**
Totals	**131**	**220**	**348**	**5**	**24**	**23**	**19**	**770**

Table 4. Number of discrete surveys and total person-hours of each method allocated during an inventory of amphibians and reptiles at Manzanar National Historic Site in 2002-2003.

	General Surveys	**Lizard Lines**	**TACS plots**	**Nocturnal General Surveys**	**Night Drives**	**Pitfall Traps**	**Random Encounters**
Number of Surveys	40	20	18	3	38	245 trap days	6
Total Person-hours	65.2	54.0	19.6	3.8	80.6	N/A	N/A

Table 5. Peak values of lizards observed on line transects at Manzanar National Historic Site in 2002-2003. The peak value represents the greatest number of a given species observed on a single walk of the transect over the course of the survey. One survey (#1), which was conducted from mid-morning until early afternoon, was not used in calculating the means for morning (A.M.) or afternoon (P.M) surveys. Not included here are two observations of snakes, one each of Coachwhip and Gopher Snake.

Transect #	A.M. or P.M.	Side-blotched Lizard	Western Whiptail	Desert Spiny Lizard	Zebra-tailed Lizard
1	both	1	5		
2	P.M.	2			
3	P.M.				
4	A.M.	5	8	1	
5	P.M.	1	3		
11	A.M.		1		
13	A.M.		1		
16	A.M.	5	1		
18	P.M.	1	1		
19	P.M.	3	1		
21	A.M.	1	1		
22	A.M.		2	1	
23	P.M.		1		
24	A.M.	1	2		
27	A.M.	2	1		
33	A.M.	5	3		
33B	A.M.	3	3		1
34	A.M.	5	2		
37	A.M.	2	4	1	
38	A.M.	16	1		
TOTAL	**20**	**53**	**41**	**3**	**1**
Mean		**2.65**	**2.05**	**0.15**	**0.05**
S.D.		**3.54**	**1.86**	**0.36**	**0.22**
Mean A.M.	**(N=13)**	**3.46**	**2.31**	**0.23**	**0.08**
Mean P.M.	**(N=6)**	**1.17**	**1.33**	**0**	**0**

Table 6. All amphibian and reptile species found or expected to occur at Manzanar National Historic Site (MANZ). Ranking of probability of species occurrences is as follows: 1 = low probability, 2 = medium probability, and 3 = high probability. SX = specimen collected, this study. OX = species observed, this study. Weighted total is equivalent to the total number of species expected to occur, and estimated inventory completeness is simply the number documented (SX, SP, OX, or OP) divided by the weighted total. For completeness, all species included as hypothetical in the species accounts (Appendix C) are included here, but those species with essentially zero chance of occurring at MANZ are indicated under status as N/A. For all species, NPSpecies checklist fields for residency and nativity are "resident" and "native," respectively.

Species	Rank	NPSpecies Park Status	NPSpecies Abundance
Slender Salamander (*Batrachoseps* sp.)	1	Unconfirmed	
Owens Valley Web-toed Salamander	N/A		
Great Basin Spadefoot	3	Probably Present	
Western Toad	1	Unconfirmed	
Pacific Treefrog	1	Unconfirmed	
Common Chuckwalla	N/A		
Great Basin Collared Lizard	1	Unconfirmed	
Long-nosed Leopard Lizard	SX	Present in Park	Uncommon
Zebra-tailed Lizard	SX	Present in Park	Common
Desert Horned Lizard	SX	Present in Park	Uncommon
Side-blotched Lizard	SX	Present in Park	Abundant
Western Fence Lizard	1	Unconfirmed	
Desert Spiny Lizard	SX	Present in Park	Common
Sagebrush Lizard	1	Unconfirmed	
Western Skink	1	Unconfirmed	
Western Whiptail	SX	Present in Park	Abundant
Southern Alligator Lizard	SX	Present in Park	Unknown
Western Banded Gecko	3	Probably Present	
Desert Night Lizard	2	Unconfirmed	
Coachwhip	SX	Present in Park	Common
Ring-necked Snake	1	Unconfirmed	
Common Kingsnake	3	Probably Present	
Long-nosed Snake	3	Probably Present	
Western Patch-nosed Snake	3	Probably Present	
Western Ground Snake	3	Probably Present	
Glossy Snake	SX	Present in Park	Common
Gopher Snake	OX	Present in Park	Common
Western Terrestrial Garter Snake	1	Unconfirmed	
Sierra Garter Snake	N/A		
Night Snake	3	Probably Present	
Southwestern Black-headed Snake	3	Probably Present	
Speckled Rattlesnake	3	Probably Present	
Sidewinder	2	Unconfirmed	
TOTAL RANK 1	**9**		
TOTAL RANK 2	**2**		
TOTAL RANK 3	**9**		
TOTAL FOUND (SX, OX, SP, OP)	**10**		
WEIGHTED TOTAL	**20.0**		
ESTIMATED INVENTORY COMPLETENESS	**50.0%**		

Table 7. Amphibian and reptile specimens collected at Manzanar National Historic Site in 2002-2003. Collector initials are: EMN (Erika M. Nowak), TBP (Trevor B. Persons), SH (Scott Hillard), LMC (Laura M. Cunningham), and DJM (David J. Morafka). Specimens are housed in the natural history collection facility at Death Valley National Park, and were collected under accession number MANZ-00037. Field numbers of all specimens, regardless of collector, are cataloged in the field catalog of Trevor B. Persons. UTM coordinates are in the North American Datum of 1927 (NAD27).

Field Number	NPS Catalog Number	Species	Date	Collector	Location	UTM	Notes
TBP 162	MANZ 3312	Desert Spiny Lizard	3/28/02	TBP	Upper Bairs Creek	396633E 4064170N	Juvenile female, 56 mm SVL
TBP 163	MANZ 3313	Long-nosed Leopard Lizard	3/28/02	TBP, DJM, SH, LMC, EMN	Ca. 100 m N of upper Bairs Creek	396700E 4064199N	82 mm SVL
TBP 184	MANZ 3314	Side-blotched Lizard	6/11/02	TBP	Upper Bairs Creek, near SW corner of historic site	396271E 4064010N EPE 7m	Adult female
TBP 185	MANZ 3315	Zebra-tailed Lizard	6/11/02	TBP	Just S of cemetery	396128E 4064719N EPE 4m	Immature male
TBP 196	MANZ 3316	Desert Horned Lizard	6/22/02	SH	Vicinity of cemetery. UTM extrapolated between UTM's 396196E /4065105N (EPE 4m) and 396196E/4065088N (EPE 6m)	396196E 4065097N	Adult male
TBP 270	MANZ 3317	Glossy Snake	8/28/02	SH	On auto tour route ca. 0.2 mi. SE of cemetery	396437E 4064866N	Immatture, AOR
TBP 286	MANZ 3318	Coachwhip	5/25/03	SH	Auto tour route (B Street), vicinity of Block 14	397066E 4065623N	DOR, small adult, frozen prior to preservation
TBP 287	MANZ 3319	Western Whiptail	6/10/03	SH, TBP	Just N of upper Bairs Creek	396762E 4064170N EPE 4m	Adult
TBP 314	MANZ 3320	Southern Alligator Lizard	8/24/03	SH	Under coverboard of pitfall trap #5, along upper Bairs Creek	396915E 4064163N EPE 5m	Hatchling, 39 mm SVL. Fixed in 95% ethanol, transferred to 55% isopropyl

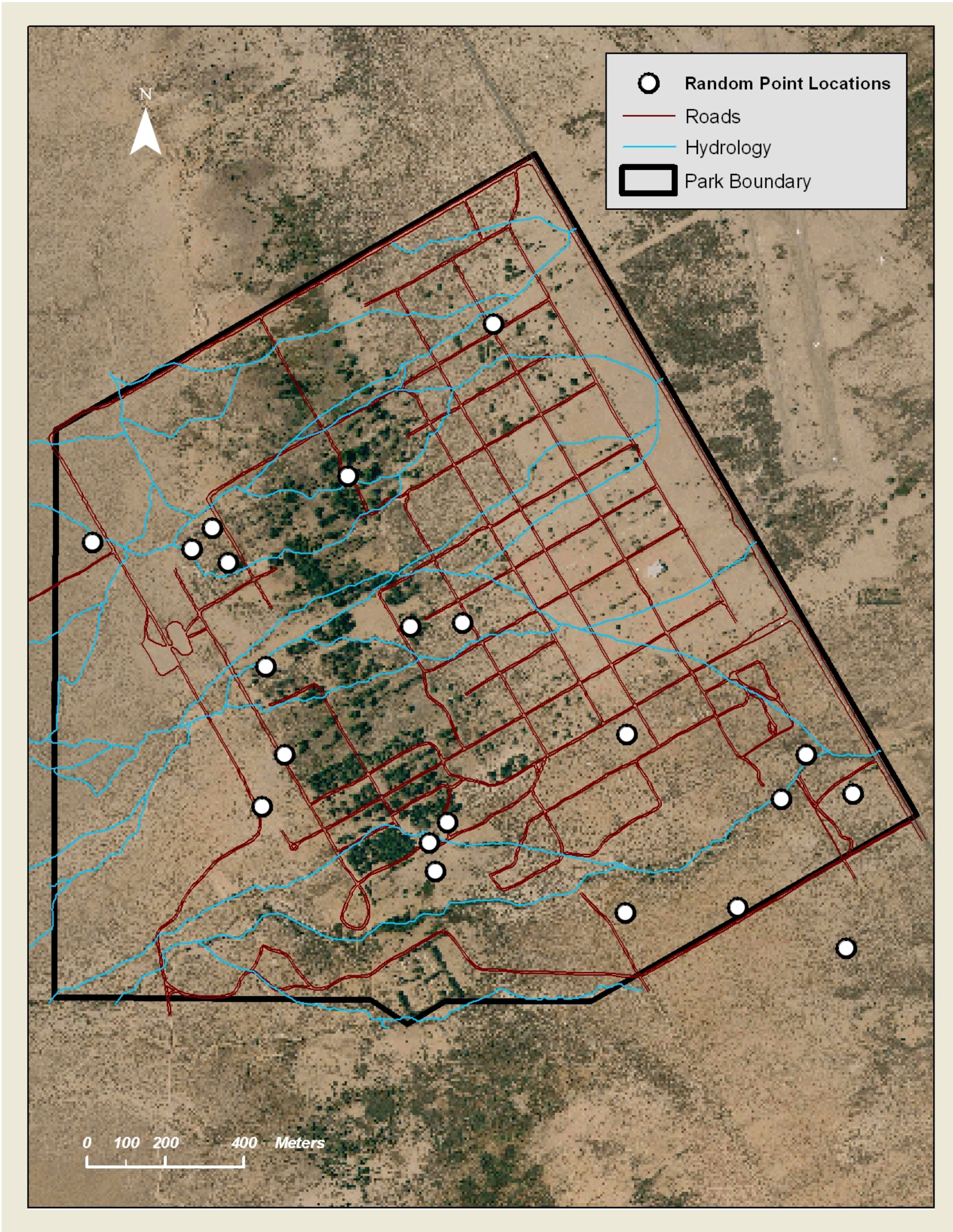

Figure 1. Location of random points used in TACS and lizard line transect surveys for amphibians and reptiles at Manzanar National Historic Site, 2002-2003. The southeastern most point, outside the MANZ boundary, was not included in analysis.

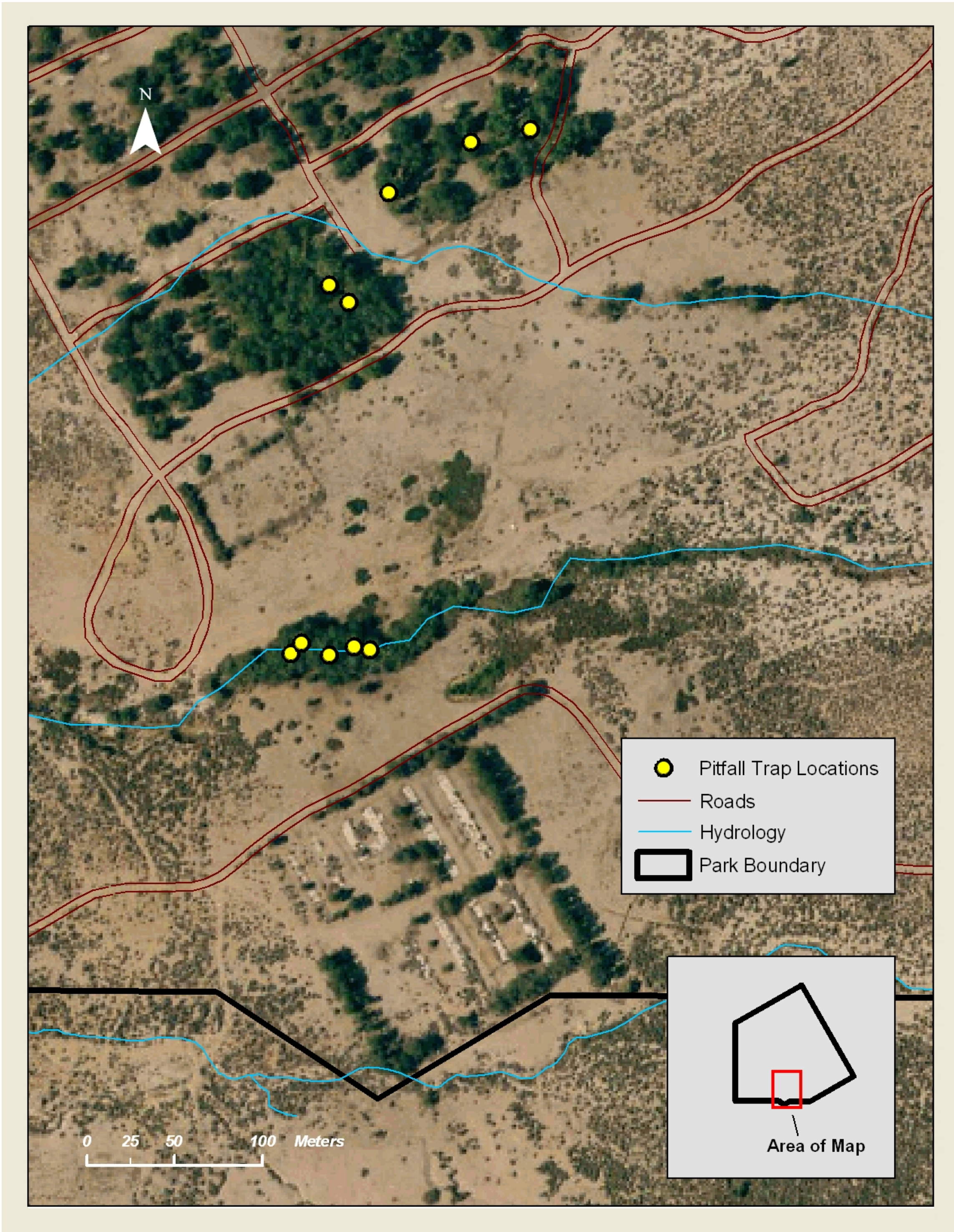

Figure 2. Location of ten amphibian and reptile pitfall traps installed at Manzanar National Historic Site in 2003.

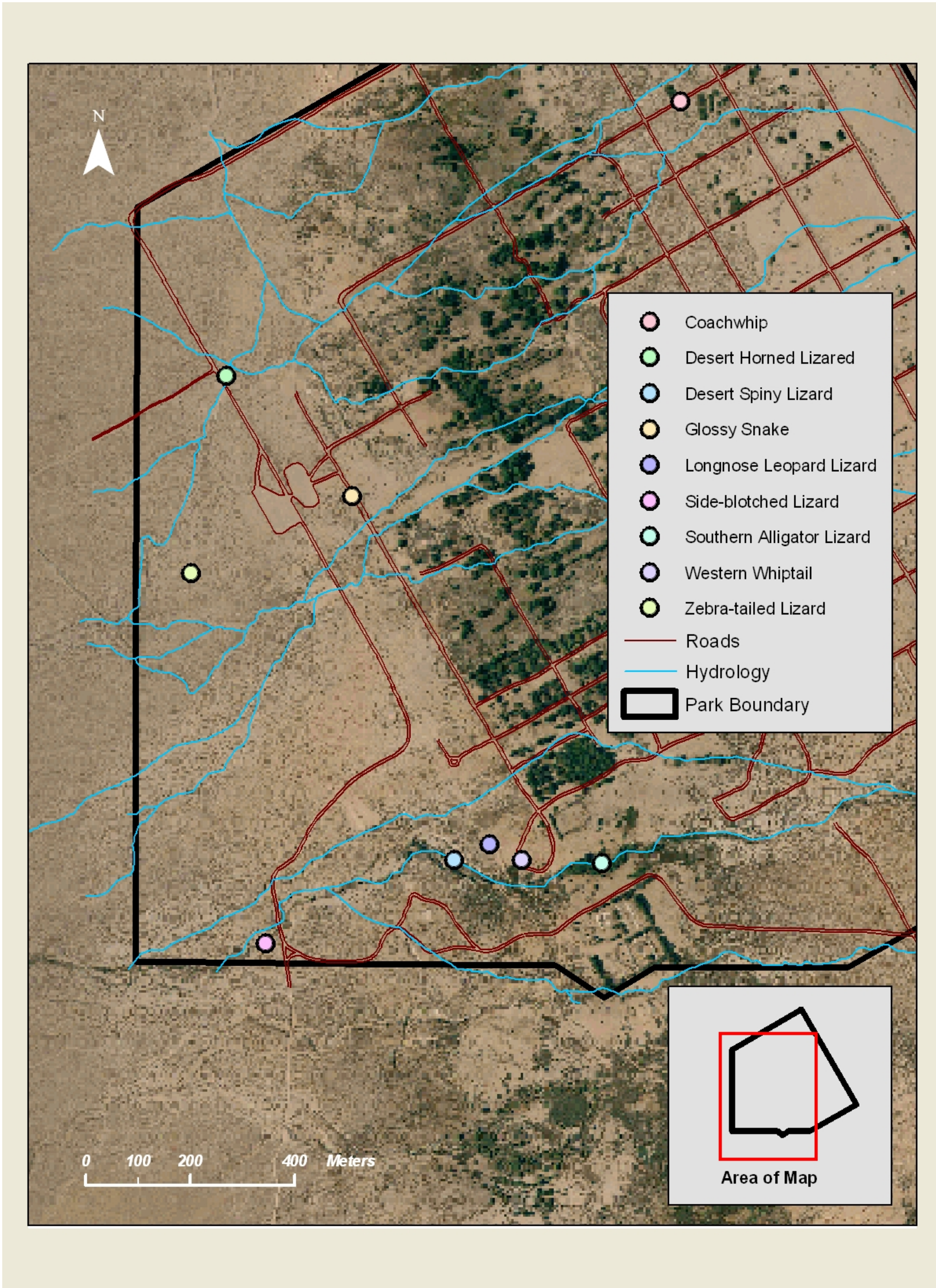

Figure 3. Locations of collection of amphibian and reptile voucher specimens at Manzanar National Historic Site, 2002-2003.

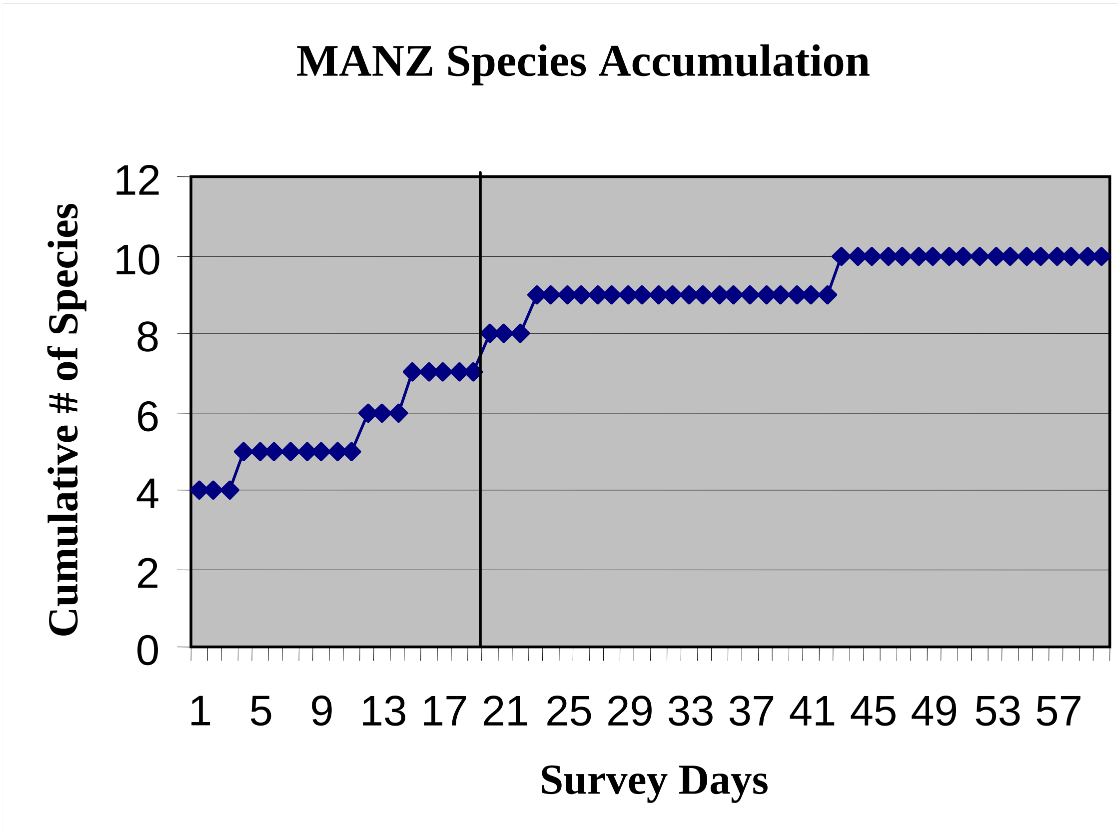

Figure 4. Species accumulation curve for amphibians and reptiles at Manzanar National Historic Site, 2002-2003. The vertical line separates 2002 from 2003 surveys.

Appendix A. Data form (following two pages) developed for herpetofauna TACS plots in the Southern Colorado Plateau I&M Network, and also used at Manzanar National Historic Site for both TACS and lizard line surveys. There are two pages, meant to be photocopied back to back.

Park Code ________________ Pg. ____ of ____

Southern Colorado Plateau Herpetofauna Surveys

Date ________________ Observers ______________________ Location ______________________

GPS Unit ____________ Datum / Zone __________ Survey Type (circle): 1 Ha TACS Plot ~10 Ha TCS survey

UTMs: Easting ____________________ Northing ____________________ EPE __________

Elevation _________ USGS Quad ___________________________ Slope _________ Aspect __________

Description of Plot ____

____

Photo #s ________ Description of Photo Shots____

Landform Class ________________ Soil Type ________________ Surface Water Type ______________

Cover Stratum	Species	% Cover	Height
Tree Total %			
Shrub Total %			
Herbaceous Total %			
Unvegetated Total %	Bedrock		
	Large Rocks (>10 cm)		
	Small Rocks (0.2 - 10 cm)		
	Sand / Bare Soil		
	Litter / Duff		
	Woody Debris (> 1 cm)		
	Biotic Crust		

Park Code ____________ **Pg.** ____ **of** ____

Southern Colorado Plateau Herpetofauna Surveys

Date ____________ **Observers** ____________________ **Location** ____________________________

	Time	% Cloud Cover	Sun Condition	Ta °C	Ts °C	Wind Max. (mph)	Wind Avg. (mph)	rH %
Begin								
End								

HERPETOFAUNA OBSERVATIONS

Species	Time	Sex	Age Class	Notes

Notes ____

Appendix B. Contact information for experts consulted during an inventory of amphibians and reptiles at Manzanar National Historic Site.

Theodore J. Papenfuss, Ph. D. (salamanders)
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Jonathan Richmond (skinks)
Department of Ecology and Evolutionary Biology
University of Connecticut
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Dr. David Wake (salamanders)
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Appendix C. Annotated list of amphibians and reptiles at Manzanar National Historic Site, including all documented and hypothetical species. Because we do not have data on population sizes or density of species at MANZ, the use of the terms abundant, common, uncommon, and rare (the available abundance categories in NPSpecies) are necessarily somewhat subjective. They are designed to describe the relative abundance of a particular species, compared with other, similar species at MANZ, and also with the same species elsewhere throughout its range. Status of all documented and hypothetical species at MANZ, as well as NPSpecies checklist field assignments, are presented in Table 6.

Species Documented from Manzanar National Historic Site

Long-nosed Leopard Lizard (*Gambelia wislizenii*). Long-nosed Leopard Lizards prefer relatively flat ground with widely spaced shrubs for cover, where they often lie in wait to ambush smaller lizard prey. We observed seven individuals of this species at MANZ, and consider it be uncommon. It is probably found in all open habitats at MANZ.

Zebra-tailed Lizard (*Callisaurus draconoides*). This species is common in the open, sandy, shrubby portions of MANZ, particularly west of the developed part of the site where native vegetation (especially saltbush) is well represented. Zebra-tailed Lizards could easily be found in the vicinity of the cemetery.

Desert Horned Lizard *(Phrynosoma platyrhinos*). We only recorded two Desert Horned Lizards during our survey. This cryptic species is probably more abundant than our observations suggest, however we still consider it uncommon at MANZ.

Side-blotched Lizard *(Uta stansburiana*). This was the most frequently observed species at MANZ, accounting for half of all observations. It was usually found on the ground or perched on small rocks, and was abundant in all habitats throughout the historic site.

Desert Spiny Lizard (*Sceloporus magister*). Apparently the only spiny lizard (*Sceloporus*) at MANZ, this species was common wherever three-dimensional habitat (trees, dilapidated edificarian structures) was present. It was most common in the cottonwood groves along Bairs Creek and in the wooded areas in the central part of the historic site.

Western Whiptail *(Cnemidophorus tigris*). This was the second most frequently observed species, after the Side-blotched Lizard. Whiptails were abundant in all habitats throughout MANZ.

Southern Alligator Lizard (*Elgaria multicarinata*). We caught one juvenile of this species under a pitfall trap cover board along Bairs Creek in 2003. Although fairly secretive, the fact that we searched specifically for this species along Bairs Creek throughout this inventory and only found one individual suggests it is rare at MANZ.

Coachwhip (*Masticophis flagellum*). Although we only observed three individual Coachwhips during our inventory, it nonetheless tied (with Glossy Snake) for the most frequently observed snake species. This widespread lizard eating species is probably common in all habitats throughout MANZ.

Glossy Snake (*Arizona elegans*). This species is at the northern edge of its local distribution in the Owens Valley (Macey and Papenfuss 1991b). We found three Glossy Snakes during this inventory. This species is usually nocturnal, and prefers loose substrates for burrowing. Glossy Snakes are probably common at MANZ.

Gopher Snake (*Pituophis catenifer*). Although we only observed two individual Gopher Snakes during this inventory, this widespread generalist species is probably common in all habitats throughout MANZ.

Species That Possibly Occur at Manzanar National Historic Site

Slender Salamander (*Batrachoseps* sp.). Although it is remotely possible that an undiscovered population or species of slender salamander could be found along Bairs Creek at MANZ (David Wake, personal communication), they are much more likely to be found in more mesic situations further upslope in the Sierra Nevada foothills.

Owens Valley Web-toed Salamander (*Hydromantes* sp.). Although informally (it is still undescribed) given the Owens Valley namesake (Macey and Papenfuss 1991a), the species is found at higher elevations in streams along the eastern Sierra Nevada, and is highly unlikely at MANZ (Ted Papenfuss, personal communication).

Great Basin Spadefoot (*Spea intermontana*). This species probably occurs at MANZ, but sufficient spring or summer rains (producing temporary pools, which this species uses for breeding) will likely be needed to detect it.

Western Toad (*Bufo boreas).* This species may occur in the MANZ area, but our failure to detect it during the late spring of 2002 and 2003 when Bairs Creek was flowing suggests it may not occur at MANZ. Bairs Creek alternates between a dry streambed most of the year, and a fast flowing, narrow stream in late spring and early summer, and at least in 2002-2003 did not provide sufficient slow or stagnant backwater pools that would allow Western Toads to breed successfully.

Pacific Treefrog (*Hyla regilla*). This species occurs along the Owens River east of MANZ (TBP, personal observation), but our failure to detect it suggests it probably does not occur at MANZ. Similar to the Western Toad, lack of slow or stagnant water along Bairs Creek probably prevents establishment of Pacific Treefrogs within MANZ. Many herpetologists now place this species with the chorus frogs in the genus *Pseudacris*.

Common Chuckwalla (*Sauromalus obesus*). Although some range maps (e.g., Stebbins 1985, 2003) suggest the Chuckwalla could occur at MANZ, there is virtually no chance that it does. MANZ lacks the extensive rocky habitats used by this large herbivorous lizard. The nearest known population is in the Alabama Hills south of MANZ (Macey and Papenfuss 1991b)

Great Basin Collared Lizard (*Crotaphytus bicinctores*). Habitat in certain areas within MANZ look adequate to support collared lizards, particularly the rocky areas along upper Bairs Creek, and the open, bouldery area in the southwest corner of the monument. However, our failure to detect this conspicuous species suggests that it may be absent.

Western Fence Lizard (*Sceloporus occidentalis*). We did not observe this usually conspicuous lizard at MANZ. Although Western Fence Lizards occur in the Owens Valley, particularly in the pinyon-juniper zone in the foothills (Macey and Papenfuss 1991b), the presence of the ecologically similar desert spiny lizard suggests that it is absent from MANZ.

Sagebrush Lizard (*Sceloporus graciosus*). The Sagebrush Lizard does not generally show much ecological overlap with the other two spiny lizards, and it is typically found at higher elevations (especially in pinyon-juniper woodland) in the region. Although elsewhere it is sometimes found in lower elevation shrub habitats (e.g., Petrified Forest National Park, Arizona; Drost et al. 2001), our failure to detect this diurnal species suggests it is probably absent from MANZ. Although not widely distributed within the Owens Valley itself, Macey and Papenfuss (1991b) report a specimen from four miles north of Lone Pine, probably from the foothills of the Inyo Mountains.

Western Skink (*Eumeces skiltonianus*). Although usually found at higher elevations and in more mesic habitats in the Owens Valley area, this species may possibly occur at MANZ (Jonathan Richmond, personal communication), probably along Bairs Creek. If skinks do occur at MANZ, they are more likely to be this species (versus the similar Gilbert's skink *Eumeces gilberti*), because the Western Skink does occur in the eastern foothills of the Sierras just west of MANZ (Macey and Papenfuss 1991b).

Western Banded Gecko (*Coleonyx variegatus*). Although usually most abundant in rocky habitats, this species probably occurs at MANZ. Our failure to locate it during cover flipping surveys suggests it is at least uncommon, although the lack of paved roads within MANZ probably contributed most to our failure to find this small, nocturnal lizard.

Desert Night Lizard (*Xantusia vigilis*). Night Lizards are found in a variety of habitats in the Owens Valley region (Macey and Papenfuss 1991b). Although they usually occur under downed limbs of Joshua trees (*Yucca brevifolia*), they are sometimes found under other surface objects such as rocks and logs (Macey and Papenfuss 1991b). Desert Night Lizards may occur at MANZ, although areas with suitable cover are limited.

Ring-necked Snake (*Diadophis punctatus*). Isolated relictual populations of this species occur in mesic settings throughout the region, including a recently discovered population at Death Valley National Park (Emmerich and Cunningham 2003). Ring-necked snakes may possibly occur along Bairs Creek, although the species usually prefers habitats with permanent water such as springs.

Common Kingsnake (*Lampropeltis getula*). This species is found throughout the Owens Valley (Macey and Papenfuss 1991b), and almost certainly occurs at MANZ. Common Kingsnakes are active both day and night.

Long-nosed Snake (*Rhinocheilus lecontei*). This primarily nocturnal species is found throughout the Owens Valley (Macey and Papenfuss 1991b), and almost certainly occurs at MANZ as well.

Western Patch-nosed Snake (*Salvadora hexalepis*). The Western Patchnose Snake is found throughout the Owens Valley (Macey and Papenfuss 1991b), and almost certainly occurs at MANZ. Like the Coachwhip, this is a fast, strictly diurnal species.

Western Ground Snake (*Sonora semiannulata*). The Ground Snake has been found at scattered localities in the Owens Valley region (Macey and Papenfuss 1991b), and probably occurs at MANZ. Although seldom seen, this small, insectivorous snake is sometimes locally abundant (Macey and Papenfuss 1991b).

Western Terrestrial Garter Snake (*Thamnophis elegans*). This species of garter snake may occur in Bairs Creek, at least sometimes. Populations occur throughout much of the Owens Valley (Macey and Papenfuss 1991b), and during wetter periods this species may wander far from water. It is possible that Western Terrestrial Garter Snakes may sometimes disperse along Bairs Creek from permanent populations along the Owens River to the east, or from higher up in the Sierra Nevada foothills to the west.

Sierra Garter Snake (*Thamnophis couchii*). The other species of garter snake in the MANZ region, this species occurs along the Owens River and streams draining the eastern Sierra (Macey and Papenfuss 1991b), but is highly aquatic and requires permanent water. It is therefore highly unlikely that the Sierra Garter Snake occurs at MANZ.

Night Snake (*Hypsiglena torquata*). This strictly nocturnal, lizard-eating species is found throughout the Owens Valley (Macey and Papenfuss 1991b), and almost certainly occurs at MANZ. Generally, substantial road cruising survey effort is required to find Night Snakes. Where extensive paved roads are available, surveys often reveal them to be a common species, for example at Petrified Forest National Park (Drost et al. 2001) and Organ Pipe Cactus National Monument (Rosen and Lowe 1996) in Arizona.

Southwestern Black-headed Snake (*Tantilla hobartsmithi*). This species has been recorded at scattered localities in the Owens Valley region (Macey and Papenfuss 1991b), and probably occurs at MANZ. This small, secretive, nocturnal species often occurs around springs or streams (Macey and Papenfuss 1991b), and is most likely to occur at MANZ along Bairs Creek. Extensive pitfall trapping or cover-flipping surveys may be required to document this species.

Sidewinder (*Crotalus cerastes*). Sidewinders may occur at MANZ, although we found no sign of them, including no sign of their distinctive tracks. Macey and Papenfuss (1991b) indicate that the entire Owens Valley is occupied by this species, and locality records are plotted both north and south of MANZ. However, a series of closely spaced locality records plotted from the vicinity of Lone Pine and running to the southeast (probably along US 395) ends abruptly in the area of Lone Pine, with no records in the immediate vicinity of MANZ. Because the species has been recorded in the northern Owens Valley, from south of Big Pine and to the north (Macey and Papenfuss 1991b), it may occur at MANZ, but is apparently rare in the local area, probably due to the lack of large areas preferred sandy habitat.

Speckled Rattlesnake (*Crotalus mitchellii*). Speckled Rattlesnakes prefer rocky habitats, including canyons and foothills, but also occur in valley floors, including the Owens Valley (Macey and Papenfuss 1991b). This species almost certainly occurs at MANZ. Unverified sight records of rattlesnakes reported to us by NPS personnel likely represent this species.

Appendix D. Scientific names of amphibian and reptile species mentioned in the text. Common and scientific names follow Stebbins (2003). Recent studies have proposed changes in the taxonomy of some species found at MANZ, and interested readers should consult Crother (2000) and Crother et al. (2003) for a summary of these proposals.

Amphibians
Slender Salamanders (*Batrachoseps* species)
Owens Valley Web-toed Salamander (*Hydromantes* species)
Great Basin Spadefoot (*Spea intermontana*)
Western Toad (*Bufo boreas*)
Pacific Treefrog (*Hyla regilla*)
Bullfrog (*Rana catesbeiana*)

Lizards
Common Chuckwalla (*Sauromalus obesus*)
Long-nosed Leopard Lizard (*Gambelia wislizenii*)
Great Basin Collared Lizard (*Crotaphytus bicinctores*)
Zebra-tailed Lizard (*Callisaurus draconoides*)
Desert Horned Lizard (*Phrynosoma platyrhinos*)
Side-blotched Lizard (*Uta stansburiana*)
Desert Spiny Lizard (*Sceloporus magister*)
Western Fence Lizard *(Sceloporus occidentalis*)
Sagebrush Lizard (*Sceloporus graciosus*)
Western Whiptail (*Cnemidophorus tigris*)
Southern Alligator Lizard (*Elgaria multicarinata*)
Western Skink (*Eumeces skiltonianus*)
Gilbert's Skink (*Eumeces gilberti*)
Western Banded Gecko (*Coleonyx variegatus*)
Desert Night Lizard (*Xantusia vigilis*)

Snakes
Coachwhip (*Masticophis flagellum*)
Glossy Snake (*Arizona elegans*)
Gopher Snake (*Pituophis catenifer*)
Ring-necked Snake (*Diadophis punctatus*)
Common Kingsnake (*Lampropeltis getula*)
Long-nosed Snake (*Rhinocheilus lecontei*)
Western Patch-nosed Snake *(Salvadora hexalepis*)
Western Shovel-nosed Snake (*Chionactis occipitalis*)
Western Ground Snake (*Sonora semiannulata*)
Western Terrestrial Garter Snake (*Thamnophis elegans*)
Sierra Garter Snake (*Thamnophis couchii*)
Night Snake (*Hypsiglena torquata*)
Southwestern Black-headed Snake (*Tantilla hobartsmithi*)
Sidewinder (*Crotalus cerastes*)
Speckled Rattlesnake (*Crotalus mitchellii*)