National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Herpetological inventory of Craters of the Moon National Monument 1999–2001

Upper Columbia Basin Network

Natural Resource Technical Report NPS/UCBN/NRTR—2010/303

ON THE COVER
View of Big Craters at Craters of the Moon National Monument and Preserve
Photo courtesy of Craters of the Moon National Monument and Preserve

Herpetological inventory of Craters of the Moon National Monument 1999–2001

Upper Columbia Basin Network

Natural Resource Technical Report NPS/UCBN/NRTR—2010/303

John R. Lee
Herpetology Laboratory
Department of Biological Sciences
Idaho Museum of Natural History
Idaho State University
Pocatello Idaho 83209-8007

Charles R. Peterson
Department of Biological Sciences
Idaho State University
Pocatello, Idaho 83209-8007

March 2010

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

The National Park Service, Natural Resource Program Center publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Technical Report Series is used to disseminate results of scientific studies in the physical, biological, and social sciences for both the advancement of science and the achievement of the National Park Service mission. The series provides contributors with a forum for displaying comprehensive data that are often deleted from journals because of page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received formal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data, and whose background and expertise put them on par technically and scientifically with the authors of the information.

Views, statements, findings, conclusions, recommendations, and data in this report are those of the author(s) and do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the National Park Service.

This report is available from the Upper Columbia Basin Network website (http://www.nature.nps.gov/im/units/UCBN) and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/NRPM).

Please cite this publication as:

Lee, J. R., and J. R. Paterson. 2010. Herpetological inventory of Craters of the Moon National Monument 1999–2001: Upper Columbia Basin Network**.** Natural Resource Technical Report NPS/UCBN/NRTR—2010/303. National Park Service, Fort Collins, Colorado.

NPS 131/101586, March 2010

Contents

Contents

Page

Contents

Page

Figures

Figures

Page

Figures

Page

Figures

Page

Tables

Page

Appendices

Page

Executive Summary

The mission of the National Park Service is "to conserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment of this and future generations" (National Park Service 1999). To uphold this goal, the Director of the NPS approved the Natural Resource Challenge to encourage national parks to focus on the preservation of the nation's natural heritage through science, natural resource inventories, and expanded resource monitoring (National Park Service 1999). Through the Challenge, 270 parks in the national park system were organized into 32 inventory and monitoring networks.

The Upper Columbia Basin Network (UCBN) has identified 14 priority park vital signs, indicators of ecosystem health, which represent a broad suite of ecological phenomena operating across multiple temporal and spatial scales. The intent of the UCBN has been to develop a balanced and integrated suite of vital signs that meets the needs of current park management, and that also will accommodate unanticipated environmental conditions and management questions in the future.

The goal of this study was to provide information about the amphibians and reptiles of Craters of the Moon National Monument and Preserve (CRMO). The specific objectives of this project were to determine the occurrence, distribution, relative abundance, and habitat relationships of amphibians and reptiles of CRMO, and to establish the basis for a monitoring program for these animals. Our primary approach was to use 73 drift fence and funnel trap arrays over a 2.5-year period. Sampling sites were selected using a stratified-random sampling scheme based on topography and covertype.

Of eleven species potentially occurring at CRMO, we confirmed the presence of nine (=81%) species. These confirmed species included one amphibian species (Pacific treefrog, *Pseudacris regilla*) and three species of lizards (western skink, *Eumeces skiltonianus*; pigmy short-horned lizard, *Phrynosoma douglassii*; and sagebrush lizard, *Sceloporus graciosus*). We also confirmed the occurrence of five snake species (rubber boa, *Charina bottae*; racer, *Coluber constrictor*; gopher snake, *Pituophis catenifer*; terrestrial garter snake, *Thamnophis elegans*; and western rattlesnake, *Crotalus viridis*). We were unable to detect the presence of Great Basin spadefoot "toads" (*Spea intermontana* = *Scaphiopus intermontanus*) or nightsnakes (*Hypsiglena torquata*). For each of the confirmed species, we provide individual species accounts that include information on NPSpecies codes, occurrence, distribution, relative abundance, habitat relationships, conservation status and management, local natural history, local unusual characteristics, anecdotal observations of interest, and focal animal telemetry. We developed predicted distribution maps for each confirmed species and analyzed the effects of factors such as topography, geology, vegetation, and distance from streams on occurrence and capture rates.

We assigned NPSpecies codes to eighteen species found on the eastern Snake River Plain. We classified nine as being "present", two as "unconfirmed", two as "probably present", one as "historic", and four as "encroaching". The nine confirmed species were denoted as "present". We classified boreal chorus frogs (*Pseudacris maculata*) and Columbia spotted frogs (*Rana lutieventris*) as "unconfirmed". We classified two as "probably present" (Great Basin spadefoots and nightsnakes) and one (boreal toad, *Bufo boreas*) as "historic". The four "encroaching" species include long-toed salamander (*Ambystoma macrodactylum*), long-nosed leopard lizard (*Gambelia wislizenii*), desert horned lizard (*Phrynosoma platyrhinos*), and striped whipsnake (*Masticophis taeniatus*).

The spatial distributions of the species ranged from limited to widespread. The only amphibian detected had a distribution limited to only two locations (campground and visitor's center). Of the three lizard species, two were widespread (sagebrush lizard and western skink), and one had an intermediate distribution (pigmy short-horned lizard). Of the five confirmed snake species, four had intermediate distributions (rubber boa, racer, terrestrial garter snake, and western rattlesnake), and one species (gopher snake) was apparently limited to the lava flows around the Loop Road and Broken Top areas. Species abundance was relatively low overall. The local abundance for all reptile species combined, all snake species combined, and all lizard species combined were each strongly correlated with local richness and differed by collapsed cover type class. Snake abundance and lizard abundance also showed differences correlated with surface geology, usually with high abundance on the older forms.

We detected no threatened, endangered, or sensitive amphibian or reptile species at CRMO. The nine species we confirmed as present are all designated as unprotected nongame wildlife by the state of Idaho. The Idaho Conservation Data Center lists each as S5 and G5, reflecting that these species are all demonstrably widespread, abundant, and secure statewide and globally, respectively.

Our recommendations for monitoring amphibians and reptiles at CRMO include:

1. Support and encourage the contribution of field observations from all personnel, especially for any amphibians, any species observed on the lava flows and wilderness-designated area, and those species not detected in this study.

2. Repeat the visual encounter, dipnet, and driving surveys, in addition to repeating the trapping portion of this study at the 12 long-term sites at 5-10 year intervals, and possibly combined with other monitoring efforts.

3. Continue to update and improve the habitat-based distribution models to potentially help in predicting the effects of future habitat changes.

4. Continue protecting habitat across the Monument in general, and the sagebrush steppe and riparian areas of the North End in particular. Other important areas include the communal rattlesnake den and the areas around Devil's Orchard and Broken Top.

Acknowledgements

Many people contributed to this project, including NPS personnel and SCA volunteers. Mike Munts put in a considerable share of time and effort assisting with constructing and checking traps in addition to discovering the communal rattlesnake den while helping with our radiotelemetry. Joanna Welch assisted in installing and checking traps. Dwayne Moates, Bill Aierstuck, Verda Garner, and in the Maintenance Division provided greatly appreciated assistance with tools, materials, and advice. Mountie Morris made sure we had access to where ever we needed to go, and Doug Owen, Dave Clark, Darren Parsons, Derrick Ivie and others provided important contributed observations. Superintendent Jim Morris provided exceptional support. A special thank you is warranted to all the Student Conservation Association volunteers who put in time on this study. Eric Bland, Zack Bolitho, Carolyn Davis, Alicia Eighmy, Glenn Mutti, Elmar Stamm, and Joe Villacci all spent many long, hot, dirty hours installing drift fences in the most inhospitable places. Beth Colket especially provided many appreciated hours installing and checking the arrays. At Idaho State University (ISU), we received excellent contributions from faculty, staff, and students. Dr. Jay E. Anderson provided critical insight and advice on our vegetative assessment. Ryan Baum, Jeremy Hawk, and Chris Jenkins of the ISU Herpetology Laboratory provided field labor. Michael Legler and Brent Mosier provided excellent field assistance while undergraduates at ISU. A special mention must be made for Tim Weekley. Without him as a technician during the 2000 and 2001 field seasons, the quality of this study could not have been anywhere near its current level. Thank you.

Introduction

Goal and Objectives

The goal of this study was to conduct field studies across Craters of the Moon National Monument and Preserve (CRMO) to document 90% of the amphibian and reptile species potentially occurring on these lands. The specific objectives of this project are as follows:

1. to determine the occurrence of amphibians and reptiles at CRMO;
2. to determine the distribution of amphibians and reptiles at CRMO;
3. to determine the relative abundance of amphibians and reptiles at CRMO;
4. to determine the habitat relationships of amphibians and reptiles at CRMO; and
5. to establish the basis for an amphibian and reptile monitoring program at CRMO.

Background Information

At the time of the initial proposal (1998), CRMO occupied approximately 21,800 ha (54,000 acres) in the eastern Snake River Plain. In 2001, this was expanded to about 101,000 ha (250,000 acres) to encompass the entire Craters of the Moon, Wapi, and King's Bowl lava flows. In this report, all references to "the Monument" refer to the 1998 boundaries. Previous inventory work conducted within the Monument includes the description and mapping of twenty-six vegetation types within the Monument (Day and Wright 1985) and a baseline inventory of wildlife. The wildlife inventory was completed in 1988 by the Cooperative Park Studies Unit at the University of Idaho, with mammals and birds as the primary emphasis (Hoffman 1988). While no systematic methods were used for inventorying amphibians or reptiles, opportunistic observations were recorded for these taxa and added to a computer database of wildlife observation records maintained by the Monument. This database indicates that at least two species of amphibians and eight species of reptiles have been historically recorded within the Monument.

Significance

This study is important for three reasons:

1. It provides information on vertebrate species at CRMO that need to be considered in management plans.
2. It provides baseline information for comparison to future monitoring of amphibians and reptiles at CRMO.
3. It contributes to the overall knowledge of the distribution, abundance, status, and habitat relationships of amphibians and reptiles in Idaho and western North America.

Approach

Our general approach was to use a GIS-based, stratified-random sampling scheme to determine the locations at which we would apply the appropriate detection techniques. To develop a list of the species of amphibians and reptiles potentially occurring at CRMO, we used multiple sources of information (e.g., field guides, databases, etc.). We then determined the sampling techniques expected to have the highest probability of detecting each species if they were present. These techniques included terrestrial drift fences with funnel traps, timed visual encounter surveys (combined with dip-netting in wetland areas), road cruising, and opportunistic observations. Sampling stratification was based upon topography and cover types. We combined topography and cover type information to define environmental types (see GIS Stratification, below).

Scale

We defined both the grain and extent of the spatial and temporal scales for this study after O'Neill and King (1998). The spatial and temporal scales are the spatial and temporal dimensions at which and over which the study was conducted. Grain is the smallest interval over which observations in a data set are made, and extent refers to the total area or time over which observations at the given grain are made. This study had a spatial extent of 21,854 ha. The average distance between trapping sites was 250 m. The environmental type polygons had an average size of 90.4 ha and a median size of 16.7 ha. The temporal grain was defined as the 72 ha interval at which traps were checked from May through August. This was performed over the temporal extent of 2.5 years (1999–2001).

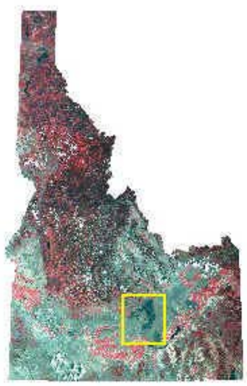
We define the scale of our study for comparison to other and/or future studies and for interpreting our results in their proper context. If multiple studies have different grains or extents, then a comparison of their results might not always be valid. This is because ecological processes can be correlated to different factors when examined at different scales. In some cases, the relationship between two factors may invert when examined at different scales. For example, Rose and Leggett (1990) found predator and prey dynamics to be negatively correlated at broad spatial scales, but positively correlated at finer scales.

Methods

Study Area

Craters of the Moon National Monument and Preserve is located on the eastern Snake River Plain in Butte and Blaine counties (Figure 1) at the foot of the Pioneer Mountains. This area is managed by the National Park Service (NPS) and is surrounded by mostly BLM land and some privately owned lands. Elevations range from 1625 m (5330 ft) on the southern boundary to 2355 m (7725 ft) in the Pioneer Mountains (Day and Wright 1985). The lower elevations are dominated by relatively recent (15,000 to 2,100 years ago) lava flows. Isolated patches of bitterbrush (*Purshia tridentata*) and limber pine (*Pinus flexilis*) can be found within the lava. The higher elevation areas north of the lava flows (i.e., the "North End") are mostly xeric sagebrush, with some forested and riparian areas. The sagebrush steppe is characterized by mountain big sagebrush (*Artemisia tridentata vasyana*), bitterbrush, green rabbitbrush (*Chrysothamnus viridis*), and gray rabbitbrush (*Chrysothamnus nauseosus*). The forested areas include stands of Douglas fir (*Pseudotsuga menziesii*) and quaking aspen (*Populus tremuloides*). The riparian vegetation associated with the two perennial streams includes mostly aspen and willow (*Salix* sp.). Dense monocultures of Great Basin wildrye (*Leymus cinereus*) exist on the alluvial fans at the base of the mountains. The area is considered high desert with annual precipitation averaging 43 cm, mostly in the form of winter snow. Average monthly maximum air temperatures range from –1.7° C in January to 28.7° C in July (Griffith 1983).

During the course of this study, Craters of the Moon was expanded from 21,800 ha to over 101,000 ha. The original proposal for this study covered only the Monument as it existed in 1998. However, the opportunity arose in 2001 to expand the original scope of this project to generate at least some data for the new areas. Some of the resources of this study (time, effort, and materials) were shifted to performing an initial inventory of the Expansion area. Results of our inventory of the Expansion are not covered in this report and will be released separately.



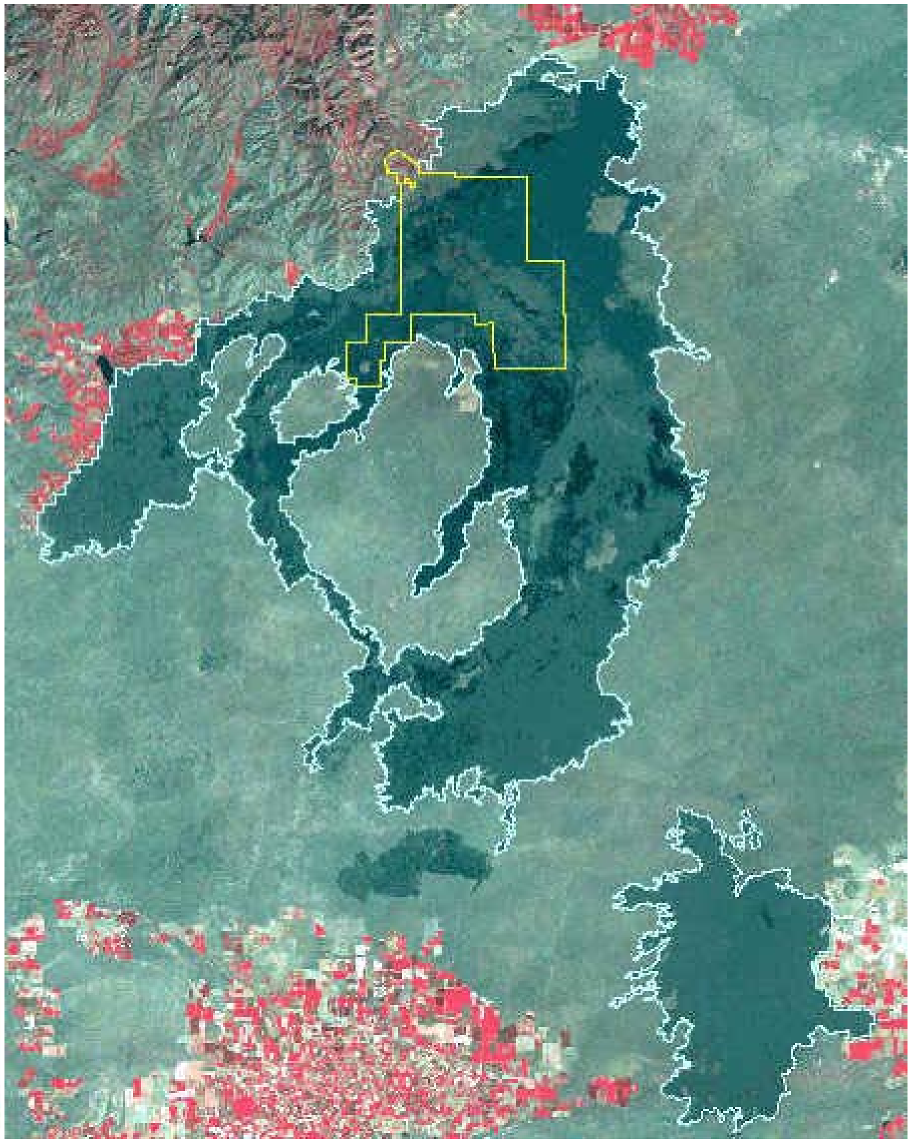


Figure 1. Craters of the Moon National Monument and Wilderness Landsat Thematic Mapper (TM) false color image showing portions of Blaine, Butte, Lincoln, Minidoka, and Power counties. Original boundary at time of the original proposal (1998) is shown in yellow. Current boundary of the expanded NPS Monument and Preserve is shown in light blue.

Potential Species List

The sources of information we used to compile a list of species potentially occurring at CRMO included publications, unpublished sources, existing databases, museum specimens, and predicted habitat distribution maps from the first generation of the Idaho GAP Analysis Program (Groves et al 1997). Publications (e.g., field guides) included books (Linder and Fichter 1977, Nussbaum et al. 1983, Stebbins 1985) and leaflets (Groves 1994). Unpublished data included research reviews (Blakesley and Wright 1988), academic theses (Lovejoy 1980), and project reports (Hoffman 1988, Lee et al. 1998). The existing databases we consulted were the Northern Intermountain Herpetological Database (NIHD) from the Idaho Museum of Natural History, the CRMO wildlife observation database, and the NPS covertype map for CRMO (Day and Wright 1985). The NIHD contains over 10,000 museum records and observations of amphibians and reptiles from the state of Idaho. The CRMO wildlife observation database contains over 6942 wildlife observations (including six amphibian and 156 reptile records) contributed by NPS personnel and visitors. Some of these observations were documented by preserved specimens in the Monument's museum collection. Gap Analysis Maps from Groves et al. (1997) gave the predicted distributions for each amphibian and reptile species in the state of Idaho. The covertype map for the Monument classified vegetation on the Monument into 26 classes based on dominant/co-dominant vegetation and substrate.

From the data sources listed above, we created a set of criteria for determining which of Idaho's 15 species of amphibians and 22 species of reptiles could potentially occur on the Monument. These criteria consisted of a set of eight conditions, which we scored as either true or false for each species. These conditions were as follows:

1. NPS museum specimens exist from within the Monument boundary.
2. NPS wildlife observations exist from within the Monument boundary.
3. NIHD museum records exist from within 50 km of the Monument boundary.
4. NIHD observation records exist from within 50 km of the Monument boundary.
5. Secretive life history aspects make detection of the species difficult.
6. Idaho GAP-1 predictive distribution overlaps the Monument boundary.
7. NPS cover type map indicates appropriate habitat exists on the Monument.
8. The species may be periodically introduced by human activities.

Based on the number of the above conditions that were true for a given species, we assigned an estimated likelihood for that species to occur at CRMO. The likelihood assigned was "likely", "possible", or "unlikely". To qualify as "likely", a species had to meet over half (i.e., 5) of the criteria. Those meeting half, or four of the criteria were classified as being "possible" to occur on the Monument. Species meeting less than half (i.e., 0–3) of the criteria were classified as being "unlikely" to occur at CRMO. Those species classified as "likely" were included on the potential species list for the Monument. This basis for constructing the potential species list is summarized in Tables 1 and 2.

Table 1. Basis for constructing potential amphibian species list. Common names after Crother (2000). See text for explanation of categories. Only those species given a likelihood of Likely were included on the potential species list.

Scientific Name	Common Name	1 NPS Spec.	2 NPS Obs.	3 NIHD Spec.	4 NIHD Obs.	5 Secr. Spp.	6 ID GAP1	7 App. Hab.	8 Pot. Intro	Sum	Likelihood
Ambystoma macrodactylum	long-toed salamander	0	0	1	1	1	1	0	0	4	Possible
Ambystoma tigrinum	tiger salamander	0	0	0	0	1	0	0	1	2	Unlikely
Bufo boreas	western toad	1	1	1	1	0	1	0	0	5	Possible*
Pseudacris regilla	Pacific treefrog	0	1	1	1	0	1	0	1	5	Likely
Pseudacris maculata	Boreal chorus frog	0	1	0	0	0	1	0	1	3	Unlikely
Spea intermontana	Great Basin spadefoot	0	0	1	1	1	1	1	0	5	Likely
Rana catesbiana	bullfrog	0	1	0	0	0	0	0	1	2	Unlikely
Rana pipiens	northern leopard frog	0	1	1	1	0	1	0	0	4	Possible
Rana Luteiventris	Columbia spotted frog	0	1	1	1	0	0	0	0	3	Unlikely

Table 2. Basis for constructing potential reptile species list. Common names after Crother (2000). See text for explanation of categories. Only those species given a likelihood of Likely were included on the potential species list.

Scientific Name	Common Name	1 NPS Spec.	2 NPS Obs.	3 NIHD Spec.	4 NIHD Obs.	5 Secr. Spp.	6 ID GAP1	7 App. Hab.	8 Pot. Intro	Sum	Likelihood
Crotaphytus bicinctores	Great Basin collared lizard	0	0	0	0	0	0	1	0	1	Unlikely
Gambelia wislizenii	longnose leopard lizard	0	0	1	1	0	1	1	0	4	Possible
Eumeces skiltonianus	western skink	0	1	1	1	1	1	1	0	6	Likely
Phrynosoma douglassii	short-horned lizard	0	1	1	1	1	1	1	0	6	Likely
Phrynosoma platyrhinos	desert horned lizard	0	0	1	1	1	0	1	0	4	Possible
Sceloporus graciosus	sagebrush lizard	0	1	1	1	0	1	1	1	6	Likely
Sceloporus occidentalis	western fence lizard	0	0	0	0	0	0	1	0	1	Unlikely
Uta stansburiana	side-blotched lizard	0	0	0	0	0	0	1	0	1	Unlikely
Cnemidophorus tigris	western whiptail	0	0	1	1	0	0	1	0	3	Unlikely
Charina bottae	rubber boa	0	1	1	0	1	1	1	0	5	Likely

Table 2 (continued). Basis for constructing potential reptile species list. Common names after Crother (2000).

Scientific Name	Common Name	1 NPS Spec.	2 NPS Obs.	3 NIHD Spec.	4 NIHD Obs.	5 Secr. Spp.	6 ID GAP1	7 App. Hab.	8 Pot. Intro	Sum	Likelihood
Coluber constrictor	racer	0	1	1	1	0	1	1	0	5	Likely
Diadophis punctatus	ringneck snake	0	0	0	0	1	0	1	0	2	Unlikely
Hypsiglena torquata	nightsnake	0	0	1	1	1	1	1	0	5	Likely
Masticophis taeniatus	striped whipsnake	0	0	1	1	0	1	1	0	4	Possible
Pituophis catenifer	gopher snake	1	1	1	1	0	1	1	0	5	Likely
Thamnophis elegans	terrestrial garter snake	0	1	1	1	0	1	1	0	5	Likely
Thamnophis sirtalis	common garter snake	0	0	0	1	0	1	1	0	3	Unlikely
Crotalus viridis	western rattlesnake	1	1	1	1	0	1	1	0	5	Likely
Chrysemys picta	painted turtle	0	0	0	0	0	0	0	1	1	Unlikely

***** Because western toad populations have experienced declines throughout their range, we rate this species as “Possible” instead of “Likely” even though it meets five of the conditions for inclusion on the potential species list.

Sampling Site Selection

Our approach to selecting the sites for trapping arrays used a GIS to stratify the habitats at CRMO into environmental types based on the main factors (temperature and moisture availability) that we expected to influence local patterns of amphibian and reptile distribution. Within each environmental type, we randomly generated coordinates for sites that would potentially serve as sampling sites. Because checking a large number of trapping arrays can require substantial effort, we imposed a constraint in the GIS to limit the number of sites located in areas with limited access. We ground-truthed each potential site to determine the accuracy of the GIS classification. From those potential sites that had been correctly classified (see below) by the GIS, we selected the actual sampling locations. We chose 84 sites to be sampled during the 2.5 years of the study. This number allowed us to have 12 sites that were sampled continuously for the entire duration of the study (hereafter referred to as the long term sites), and three sets of 24 sites that were each sampled for only a single year. This approach is detailed in the following sections.

GIS Stratification

We used ArcView GIS Version 3.1 for Windows (ESRI, Redlands, CA) to stratify the habitats at CRMO into environmental types. We used cover type and topography to represent differences in moisture and heat availability to define the environmental types. For moisture availability, we collapsed the 26 cover types defined by Day and Wright (1985, Figure 2) for the Monument into seven classes. The classes were constructed such that the moisture requirements for the species within a class were more similar than between classes as follows (covertype numbers refer to Day and Wright (1985) codes):

Bare Lava: Cinder gardens, low-, and medium-density lava flows. Covertype numbers 1–3.
Vegetated Lava: Limber pine and antelope bitterbrush co-occurring on cinders or lava. Covertype numbers 21-23.
Shrublands: Areas dominated or co-dominated by mountain big sagebrush, low sagebrush, or bitterbrush on areas with a soil substrate. Covertype numbers 4–19.
Wildrye: Monocultures of Great Basin wildrye on alluvial soils. Covertype number 20.
Douglas Fir: Areas dominated by Douglas fir and mountain snowberry. Covertype number 24.
Aspen: Areas of upland quaking aspen associated with the Leech and Little Cottonwood Creek drainages. Covertype number 25.
Riparian: Areas of mixed willow, cottonwood, and aspen along Leech Creek and Little Cottonwood Creek drainages. Covertype number 26.

For representing relative differences in environmental surface temperature, we defined three topographic classes based on the differences in the amount and timing of incident solar radiation due to slope and aspect. To do this, we used 30 m USGS Digital Elevation Models (DEM's) to generate a Triangulated Irregular Network (TIN) for the Monument (Figure 3). From the TIN, we extracted slope and aspect coverages. The slope information was reclassified from 91 classes representing slopes of 0-90° into two classes (slope ≤5°, slope >5°). The aspect polygons were reclassified from 361 classes (1-360° plus one class for no aspect) into three classes (no aspect, flat areas; NE, 315-135° aspect; and SW, 135-315° aspect). We intersected the reclassified slope and aspect coverages into our final three topographic classes, defined as follows:

Flat: areas with ≤5° slope and any aspect.
NE slope: areas with >5° slope and aspect between 315° and 135°.
SW slope: areas with >5° slope and aspect between 135° and 315°.

The final environmental type stratification coverage (Figure 4) was generated by intersecting the three collapsed topographic classes with the seven collapsed covertype classes. Of the resulting 21 potential environmental types, only 16 actually existed on the Monument. We used the X-Tools extension to ArcView (DeLaune 1998) to calculate the area of the individual environmental type polygons (Table 3A). Sampling effort was then allocated roughly proportional to the total area of each type (Table 3B). We made sure that the rare types would have at least a single replicate and that the most common environmental types would have 2-3 replicates over the 2.5 years of the study. Some types were sufficiently rare that one or two sampling sites effectively provided complete coverage of that type instead of subsampling it.

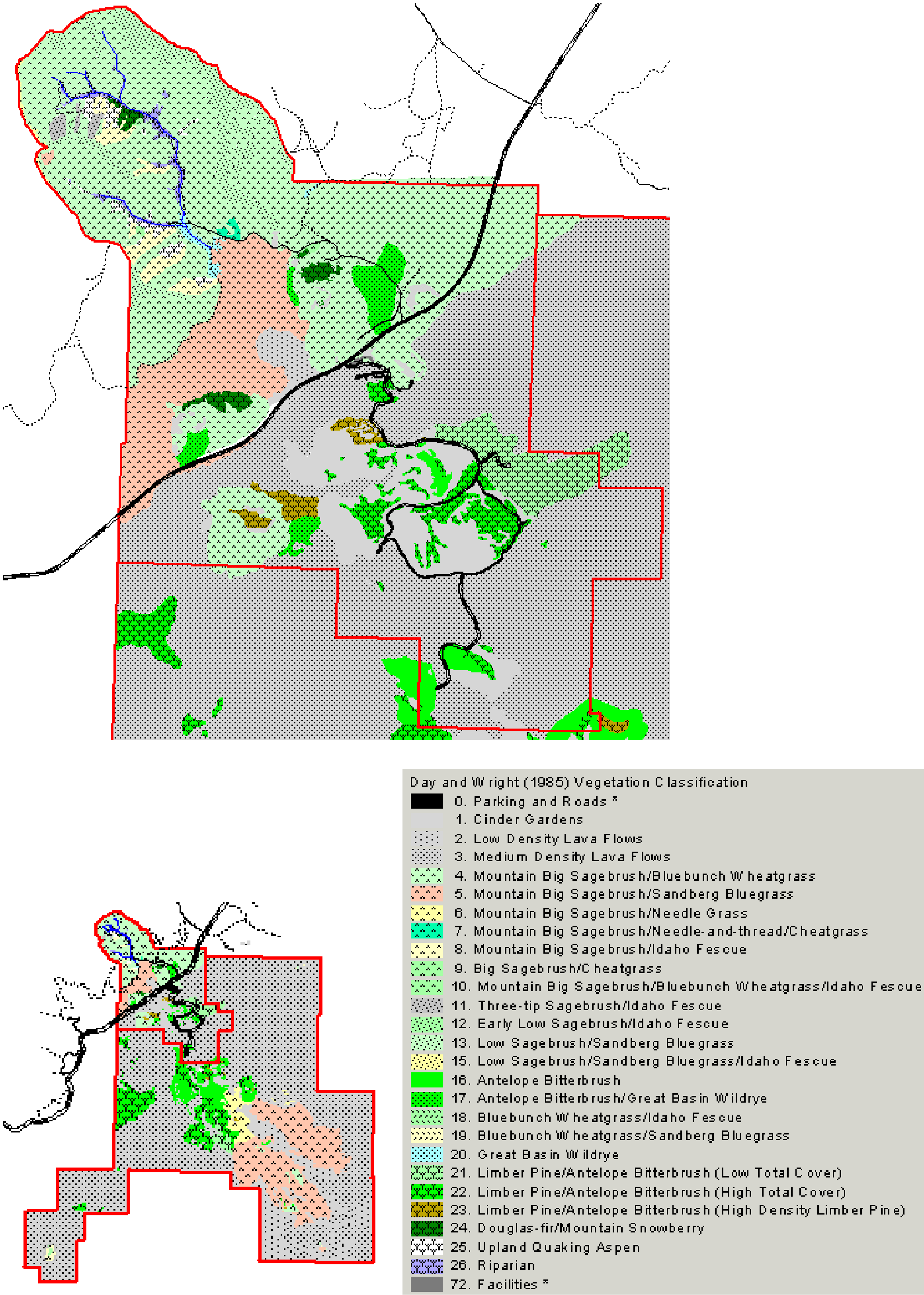


Figure 2. Vegetation types modified from Day and Wright (1985).

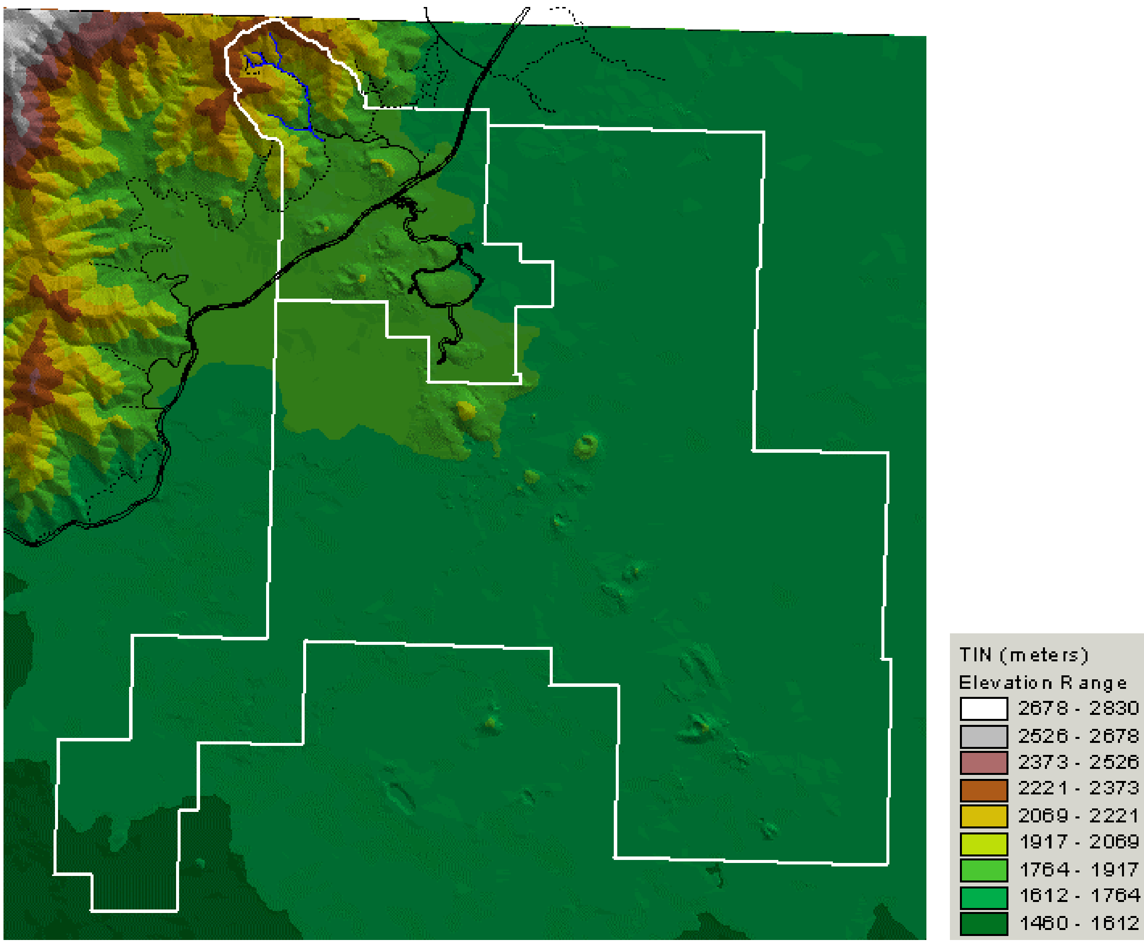


Figure 3. Triangular Irregular Network (TIN) of the Monument.

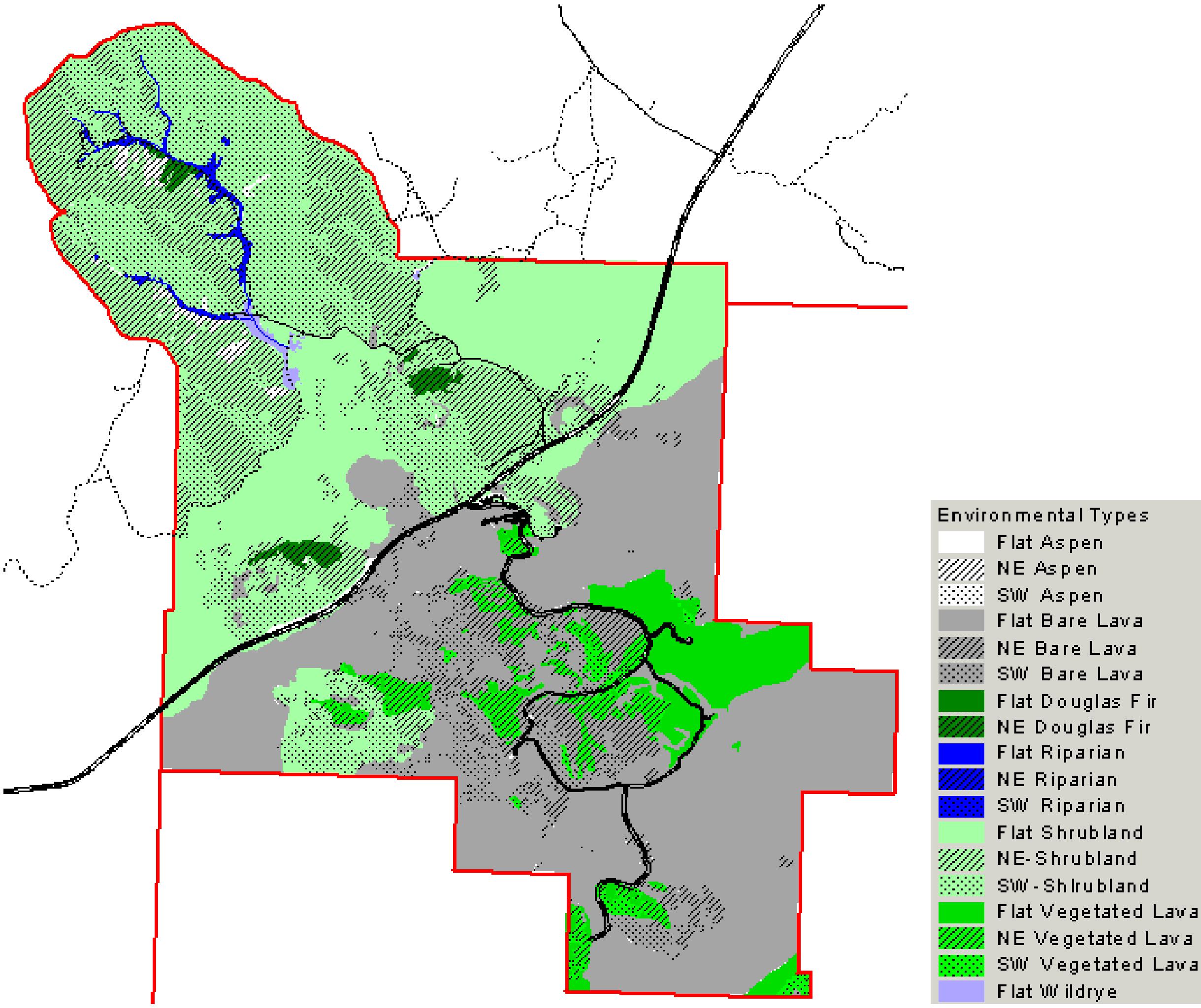


Figure 4. GIS-based environmental stratification of the Monument. (Only Monument shown to allow for magnification sufficient for showing detail.)

Table 3A. Environmental type area and effort. Topography classes defined as Flat (slope < or =5°, no assigned aspect), SW (slope >5°, aspect facing directions 135° through 315°, or NE (slope >5°, aspect facing directions 315° through 135°. Collapsed covertypes based on aggregating types mapped and described by Day and Wright (1985).

	A.	Topography			Total (ha)
		Flat	SW	NE	
Collapsed Covertype	Aspen	0.0	1.7	18.8	21.33
	Bare Lava	1104.1	122.1	159.8	1386.1
	Vegetated Lava	142.0	12.1	83.1	237.2
	Douglas Fir	0.0	0.0	25.4	26.5
	Riparian	4.0	5.1	12.1	21.2
	Shrublands	586.8	558.8	532.8	1678.5
	Wildrye	10.2	0.0	0.0	10.9
	Total (ha)	1848.8	700.3	832.4	3381.64

Table 3B. Environmental type area and effort. Number of sampling sites trapped per environmental type.

	B.	Topography			Total (ha)
		Flat	SW	NE	
Collapsed Covertype	Aspen	0	1	2	3
	Bare Lava	4	2	3	9
	Vegetated Lava	13	1	6	20
	Douglas Fir	0	0	3	3
	Riparian	1	1	1	3
	Shrublands	14	12	6	32
	Wildrye	3	0	0	3
	Total (ha)	35	17	21	73

Identifying Potential Sampling Sites

Within each environmental type, we generated sets of randomly selected potential sites using the Animal Movement Analyst extension to ArcView (Hooge and Eichenlaub 1997). We randomly generated XY coordinates for potential sites within the polygons for each environmental type. We needed to be able to place an array completely within a polygon, so we excluded polygons from consideration first, if they were smaller than 0.1 ha, or second, if a circular 8 m buffer around the point intersected a different environmental type. We slightly shifted the randomly generated locations of some points when doing so allowed the second condition to be met. The effort that would be required for checking trapping arrays caused us to limit selection of the initial sampling sites to relatively accessible areas. We did this by generating 250 m and 700 m buffers around the roads in the Monument's transportation coverage. We rejected points from outside the 250 m buffer when the difference in elevation between the point and the nearest road was greater than 75 m. We rejected all points falling outside the 700 buffer. The first condition excluded the ridge tops on the areas north of the highway, and the second excluded two large areas south of the highway. So as not to exclude these areas, we added 10 points randomly generated in these outlying areas to the list of potential sites. To allow for inaccuracy in the coverages, we generated 3-5 more points for each environmental type than we actually planned to use. This resulted in 170 potential sampling sites that were then groundtruthed for classification accuracy (Figure 5).

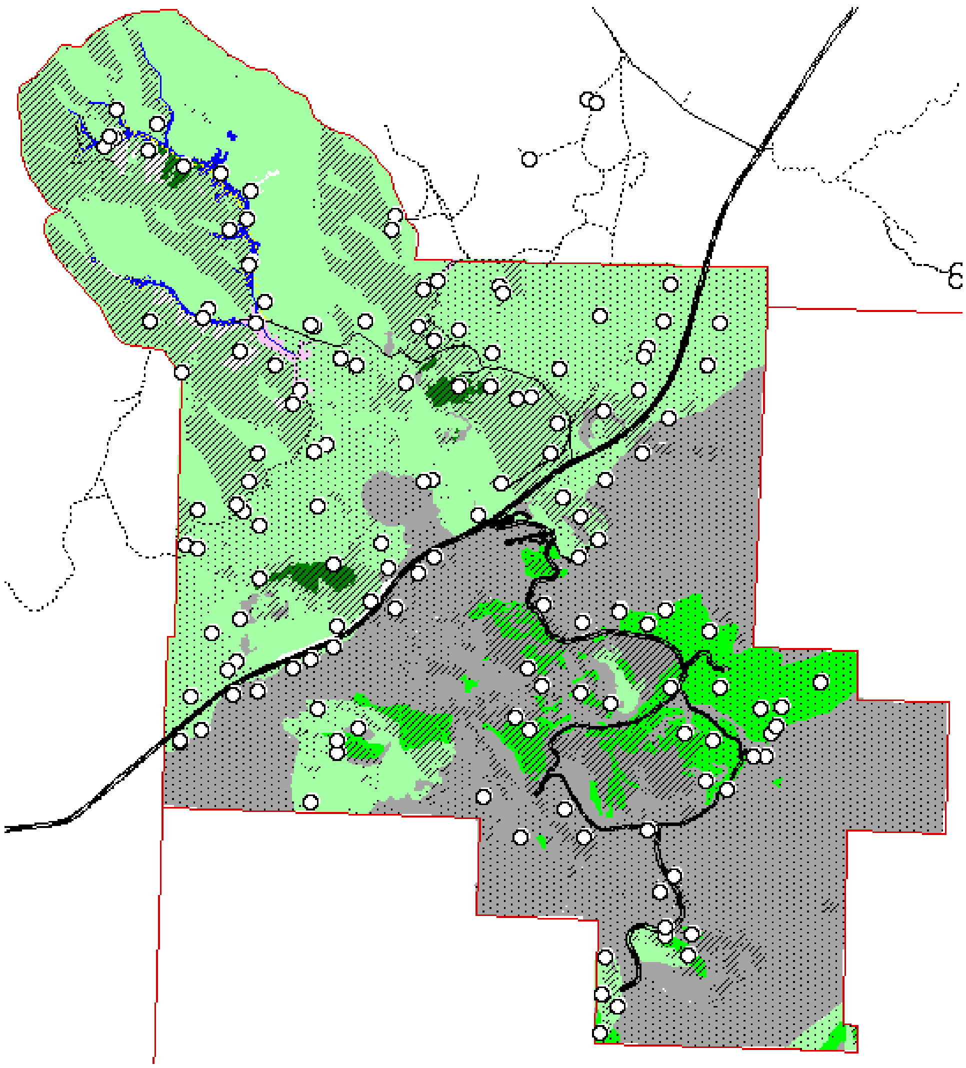


Figure 5. Potential sampling site locations. Site coordinates were randomly generated within each environmental type for accessible areas (see text). Each site was ground-truthed by a field survey team to determine the accuracy with which the GIS classified the topography and covertype class at each location.

Assessing Potential Sampling Sites

To insure that the sites ultimately selected for sampling were accurately classified by the GIS, we used field survey teams to assess all 170 potential sampling sites. The teams used GPS units to navigate to each site. Because the GPS units could be off by dozens of meters at the time (before May 2000), we printed out aerial photos of the site and nearest road from USGS Digital Ortho Quarter Quads (DOQQ's) using ArcView. Upon arrival at the site, the team flagged a 30 x 30 m plot centered on the indicated site coordinates. Using a clinometer and compass, the slope and aspect of the plot were determined and recorded using the Potential Site Assessment data sheet in Appendix A. Next, potential visibility of the site by park visitors was assessed and assigned one of the following:

"N": site Not visible from any road closer than 1000 m.
"V": site visible, but tall Vegetation would mostly hide an array.
"P": site visible with little vegetation, but Paint would disguise the array.
"H": slope or low vegetative cover made the site Highly visible from the road.

The vegetative cover within the plot was described based on the estimated surface area of the plot covered by the foliage of each species. The data sheet listed the most common vegetative species encountered on the Monument, and each was assigned one of the following designations based on the amount of the plot covered by the species:

Abundant - covers over 45% of the plot.
Common - covers ~25–44 % of the plot.
Uncommon - covers ~11–24% of the plot.
Sparse - covers ~1–10% of the plot.
Not Present – species does not occur within the plot.
"+" or "-" used with the above codes to denote gradations within the categories.

In addition to the vegetative cover, the substrate in the plot was also assessed. The same categories as described above for vegetation were used. The types of substrate we assessed were as follows:

Soil: Fine particles <2 mm in size with organic matter.
Sand: Fine particles <2 mm in size without organic matter.
Cinders: Ash/lava particles 2–10 mm in size.
Cobble: In areas with soil, rocks 10-100 mm in size.
Rocks: In areas with soil, rocks >100 mm in size.
Talus: piled rocks or cobble without soil between them.
A'a: continuous expanses of broken, blocky lava.
Pahoehoe: Continuous expanses of relatively smooth or ropey lava.
Outcrops: Contiguous rocky area surrounded by vegetation.
Pahoehoe without cracks: In lava areas, relatively smooth lava with no cracks or cracks less than 30 cm wide/deep.
Breakdown pit: Cone-shaped lava depression, e.g., collapsed lava domes and tubes.
Crack: Crevice with roughly vertical/parallel sides in lava or rock, deeper than wide.
Cave: Cavity with a drip-line, sized large enough for a coyote to enter.

Before leaving the site, the field survey team took digital photos of the plot and the surrounding area. They also logged a GPS rover file from the center of the plot that was later differentially corrected to obtain coordinates accurate to 5 m for the assessed plot.

Selecting Final Sampling Sites

From the 110 sites that had been accurately classified by the GIS stratification (75.3% correct classification rate for topography, 82.4% correct classification rate for vegetation, 64.7% correct classification rate for both), we selected the actual sampling locations based on criteria for visibility, spatial distribution, and effort. These constraints were necessary, although they had the potential to weaken our ability to make statistical inferences about the excluded areas (see Discussion). Sites most often were rejected if they were located in areas where an array could not be hidden from public view. This excluded a large number of the sites in bare cinder patches that were located on the sides of cinder cones. We sought to maximize the spatial coverage of our sites within each environmental type. To do this, we first selected the pair of correctly classified sites within each environmental type that were the farthest apart. For each subsequent site needed within that environmental type, we selected (from correctly classified sites) the site at a maximum distance from those already chosen. When considering the effort required to check each array, we limited the number of sites which would require over 30 minutes of time to check, though this consideration had already been mostly met by the buffer constraints applied in the point-generating process (above).

We originally selected 84 sites to be trapped during the course of the study, but later reduced that number to 73 (Figure 6). Thirty-six sites had trapping arrays installed in 1999 and checked for the first year (July 1999–June 2000). In July 2000, we moved 24 of these arrays to new locations for the second year of trapping (July 2000–June 2001). Those arrays not moved were designated as “long term” arrays that would stay open for the duration of the study to assess temporal variation. We selected these sites based on the 1999 trapping results. We made sure that represented in the long-term arrays were 1) at least one site where each species was detected, 2) covertypes proportional to the entire trapping effort per covertype, and 3) stratification across the number of species detected per site. In July 2001, we again moved the 24 rotational arrays, with 13 being placed in new locations on the Monument and the remainder being used in the parts of the newly expanded portions of the Monument. In addition to the 73 arrays, we placed three sets of individual traps (see below) within the Monument.

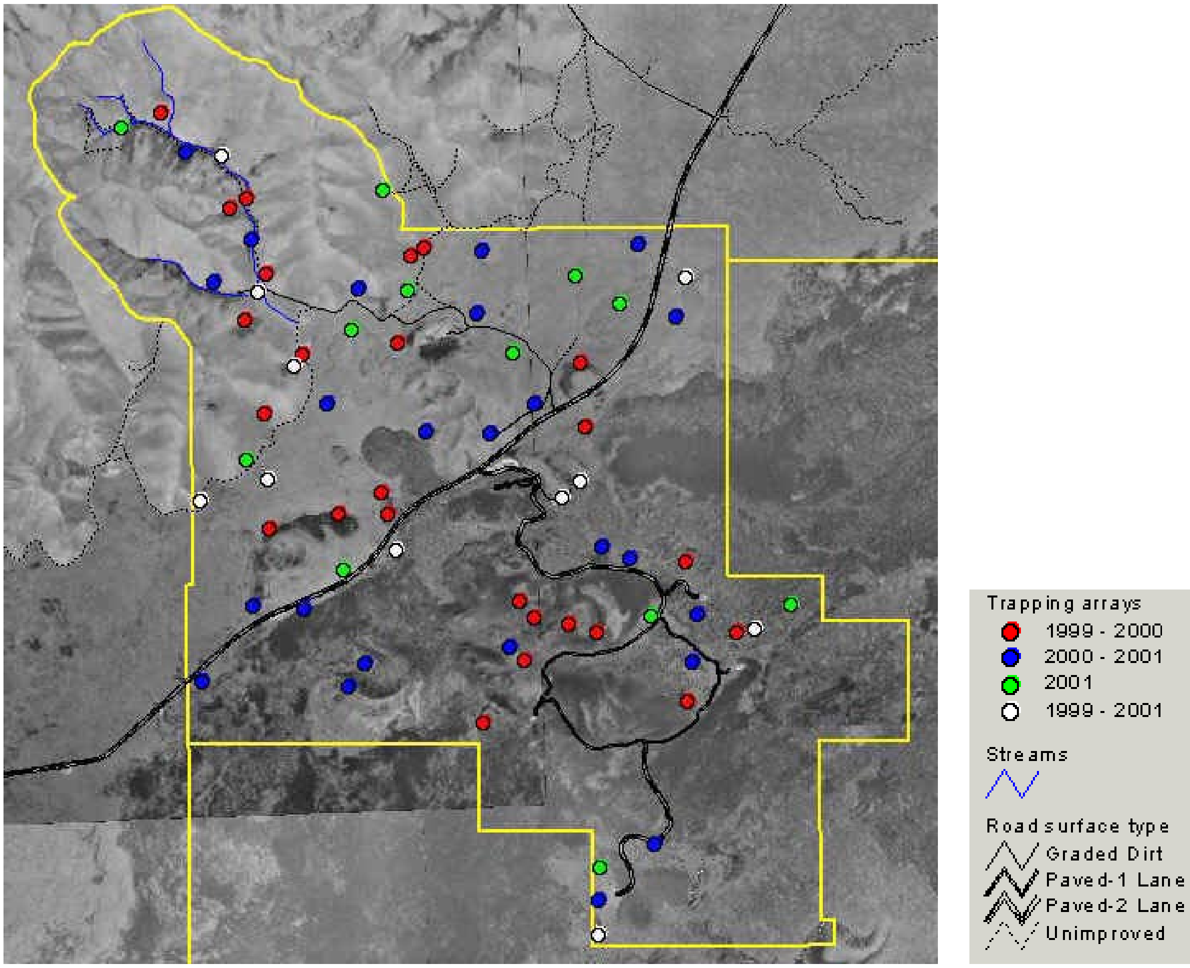


Figure 6. Trapping array locations colored by year. Symbol color indicates year arrays installed and checked. See text for selection criteria.

Amphibian and Reptile Sampling

Technique selection

Because of the differences in ecological characteristics across species, no single technique would be best for detecting all of the animals on the potential species list (Heyer et al. 1994, Olson et al. 1997). The techniques available all differed in terms of detection success, cost to implement, and effort required. For each species, we selected the technique expected to have the greatest potential to detect that species. In general, trapping usually has the greatest potential for detection, because the traps are continuously present in the habitat. However, traps usually have greater implementation costs and require more effort to use than do other techniques. Traps give considerable information for the area in their immediate proximity. Encounter surveys complement trapping because they are considerably cheaper to implement and use. Therefore, they can be used to gain information at more sites or over a larger area. Interpreting the results of encounter surveys can be problematic, as their success can be greatly influenced by factors such as environmental conditions, observer skill, and habitat. Encounter surveys can therefore give limited information across wider areas than do traps. To maximize detection probability for all the species on the potential list across as wide an area possible, we selected trapping as the primary technique to be supplemented by road driving and visual encounter surveys (VES).

Trapping

We used funnel traps, either singly or in conjunction with drift fences, as the main terrestrial sampling technique for reptiles. The funnel traps were constructed of 1/8” galvanized hardware cloth. The body of the trap consisted of a 60 cm long cylinder that was 20 cm in diameter (Figure 7A). A 15 x 20 cm opening in the top center of the body was covered by a slightly larger piece of hardware cloth and hinged using 18-ga wire to serve as a door. The door was held shut using an elastic hair tie that was attached to the body at one end with a wire hook at the other. Two funnels were constructed of hardware cloth, and inserted into the ends of the body. The funnels measured 40 cm wide distally, extended 15 cm into the body, and terminated with a 4 cm diameter opening. All seams on the traps were secured with 1/8” aluminum pop rivets and sealed with silicon caulk. When installed, the traps were partially buried such that the funnel openings were at ground surface level. To thermally protect trapped animals, we placed 2-4 cm of soil within the traps and covered them with shade boards. The shade boards were constructed from 2.5 cm thick Styrofoam sold for housing insulation. Using wire pins and silicon caulk, we joined the long edges of two 60 x 20 cm pieces of Styrofoam at right angles to construct the shade boards. When installed, the shade boards required weighting with several rocks to prevent loss in the high wind environment of the Monument (Figure 7B).

Figure 7A. Funnel traps and drift fence used for terrestrial sampling. Funnel trap: Trap is partially buried such that internal funnel openings are at ground level. Door, shown open, is held closed by elastic hair tie with a wire hook. Note slit in funnel at drift fence edge allowing close fit between trap and fence.

Figure 7B. Funnel traps and drift fence used for terrestrial sampling. Drift fence array showing camouflage paint on two closest wings and Styrofoam shade boards weighted with rocks.

Our trapping arrays consisted of four funnel traps placed at the ends of two drift fences that perpendicularly bisected each other (Figure 7B). The top and bottom of each funnel adjacent to the drift fence was slit vertically such that the fence bisected the funnel. This was done to encourage animals to enter the traps. The fences were constructed of 0.6 x 15 m galvanized aluminum flashing. They were buried in trenches to a depth of approximately 5–9 cm and supported at 1-2 m intervals by 3/8" iron rebar. Each stick of rebar was 75 cm long and was driven into the ground until flush with the top of the drift fence. We placed the rebar such that successive sticks were on alternating sides of the drift fence. To prevent damage by wind, we secured each stick of rebar to the aluminum flashing using two pieces of 18-ga wire.

The orientation of the arrays was determined based on slope and vegetative structure. On slopes, we positioned the drift fences such that two wings ran across the fall line (i.e., perpendicular to the slope), one wing extended upslope, and the fourth wing extended downslope. On more level ground, we positioned the array such that the wings would remain straight and at right angles while intercepting as little woody vegetation (i.e., shrubs and trees) as possible. This was done to minimize impacts to the habitat and to facilitate rehabilitation of the site when the arrays were later removed. In all cases, we attempted to install the funnel traps horizontally instead of inline with the slope. On steep slopes, we found that installing the funnel traps such that their long axis was parallel to the slope of the surface often resulted in eventual displacement of the soil within the traps. This displacement would cause the soil to accumulate under and around the downslope funnel, potentially allowing trapped animals to escape relatively easily.

In areas where the terrain prevented the installation of drift fences (i.e., on or near lava flows) we used individual funnel traps. These were placed against features potentially acting as natural barriers, such as boulders, within fissures, or against the base of lava flows. They were buried and shaded, as were the drift fence traps. We placed the individual traps in groups of four and tried to keep them all within 15 m of each other when possible. Because the individual traps were in different habitat types and could have different capture success compared to the arrays, the data gathered from each method (individual traps vs. arrays) were treated separately.

Locations of the individual traps are shown in Figure 8. In all cases, we were very sensitive to potential negative impacts of our traps and arrays upon the aesthetic experience of visitors to the Monument. We minimized or eliminated visibility by using natural features of the terrain or vegetation, and by painting our arrays and shade boards to match the surroundings. We found that using two or three colors of flat latex paint (usually reddish-brown to match the cinders, light gray-green for sagebrush and highlights, and dark gray for shadow) was adequate to render partially exposed arrays virtually indistinguishable to the untrained eye at distances over about 50 m (Figure 7B).

Traps were checked every 72 hours and captures were recorded on a Trap Checking Datasheet (Appendix B) using the codes given in Appendix C.

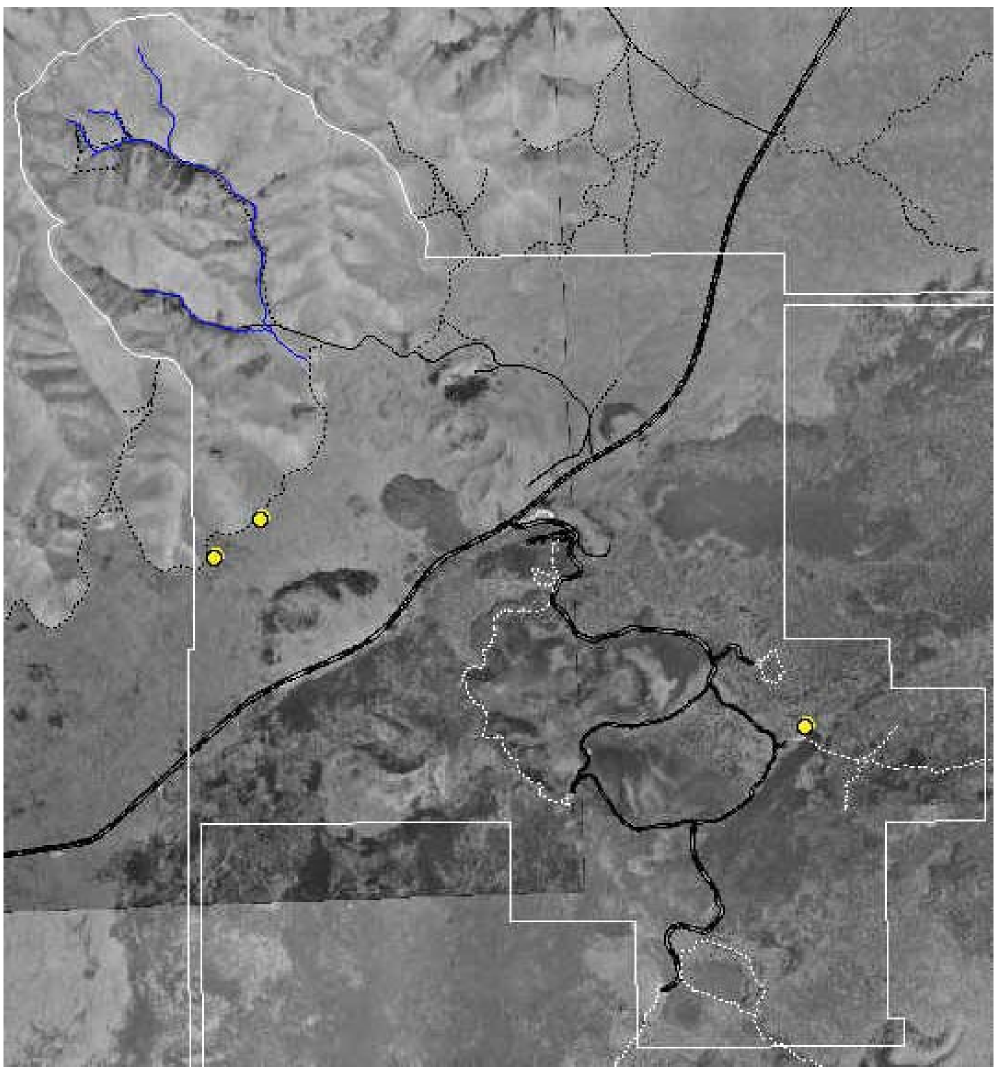


Figure 8. Locations of individual trap sets. Individual trap sets were groups of four funnel traps placed without a drift fence. They were installed adjacent to rocks or within lava cracks in an attempt to sample areas unsuitable for the installation of arrays.

Road Driving

Road driving is a survey type conducted on roads from a vehicle, where observations of animals crossing or basking upon the road surface are recorded (Shaffer and Jutterbock 1994). We constantly surveyed the roads throughout the day while in transit to survey and trapping sites, and we conducted standardized driving surveys during some evenings when surface temperatures were suitable (15-25◦C). Observations in transit to arrays were recorded as incidental observations (below). The standardized driving surveys consisted of traveling the roads on the Monument at low speeds (5–25 mph, depending on road type). During these surveys, we visually scanned the roads for amphibians and reptiles. We attempted to capture most animals seen, and recorded the data using the form in Appendix D. Our route consisted of the Loop Road, Highway 93, and the North End roads (Figure 9).

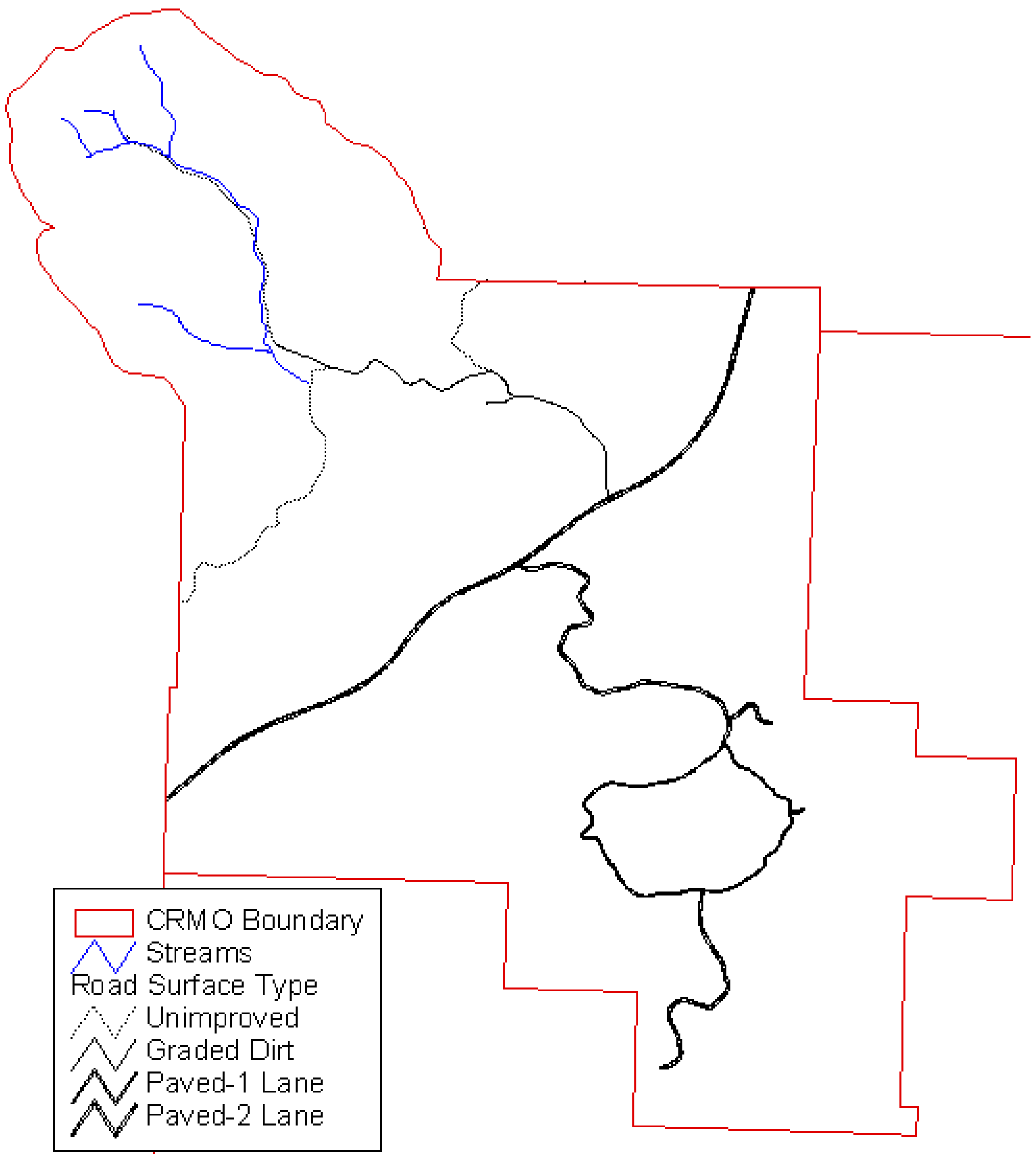


Figure 9. Driving survey route for CRMO. Total driving length=57.4 km. Only those roads driven during the surveys are shown.

Visual Encounter Surveys

Visual encounter surveys (VES) consist of moving through a predetermined area for a set amount of time, during which the observers are actively searching for animals. Depending on the habitat type, the VES could also include turning cover objects or using dip nets to maximize the potential for detection of hidden animals. We used VES to increase our spatial coverage into areas of the Monument that were not suitable for trapping (i.e., remote and/or difficult to access locations). The protocol used differed slightly depending upon if we were surveying terrestrial or riparian/aquatic areas.

Our protocol for terrestrial areas consisted of spending two observer-hours covering a 4 ha (200 x 200 m) area for a sampling effort equal to 0.5 observer hours/ha. Kipukas (isolated areas of vegetation that were not covered, but rather surrounded by, the lava flows) were felt to be of special interest, so we surveyed their entire areas. During the surveys, we turned surface cover objects (i.e., logs, limbs, rocks, etc.) and searched underneath them when doing so would not degrade the habitat. After searching underneath cover objects, we returned them as closely as possible to their original positions. In addition to live animals, we also searched for reliable signs that could be identified to the species level (i.e., shed snake skins or horned lizard scat).

The 4 ha area of the terrestrial VES was centered around features that we felt had a high probability of being habitat for reptiles. These sites included areas around perennial water holes, edges of lava flows, or vegetated patches associated with cinder cones or craters. Some VES were conducted in areas centered on particular trapping arrays for comparison of the two techniques. Locations of the terrestrial VES are shown in Figure 10.

In riparian areas, our protocol differed because the features on which we centered the surveys were the perennial streams at the northern end of the Monument. For these surveys, observers covered a 500 m stretch of the stream, focusing on the banks and the area extending 3 m away from the edge of the water. Over 90% of the stream sections were less than 1 m wide and under 10 cm in depth. In those very rare areas with abundant emergent vegetation or algae, we used dip nets to detect concealed amphibians. This technique has been documented to be effective in other studies (Crisafulli 1997). Locations of these dipnet surveys are shown in Figure 11.

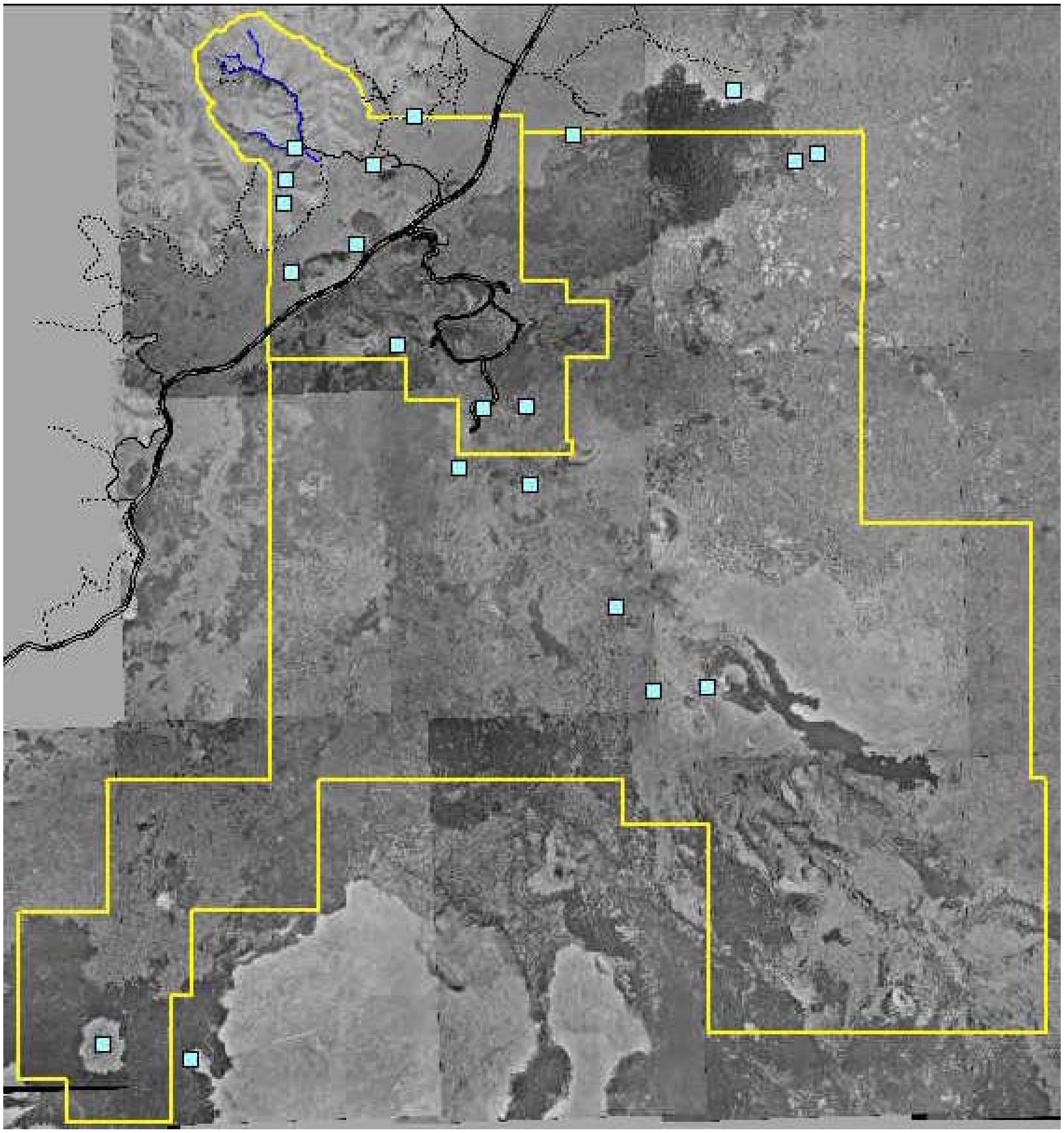


Figure 10. Locations of terrestrial visual encounter surveys. Kipukas were surveyed in their entirety. The rest of the surveys were of four ha plots

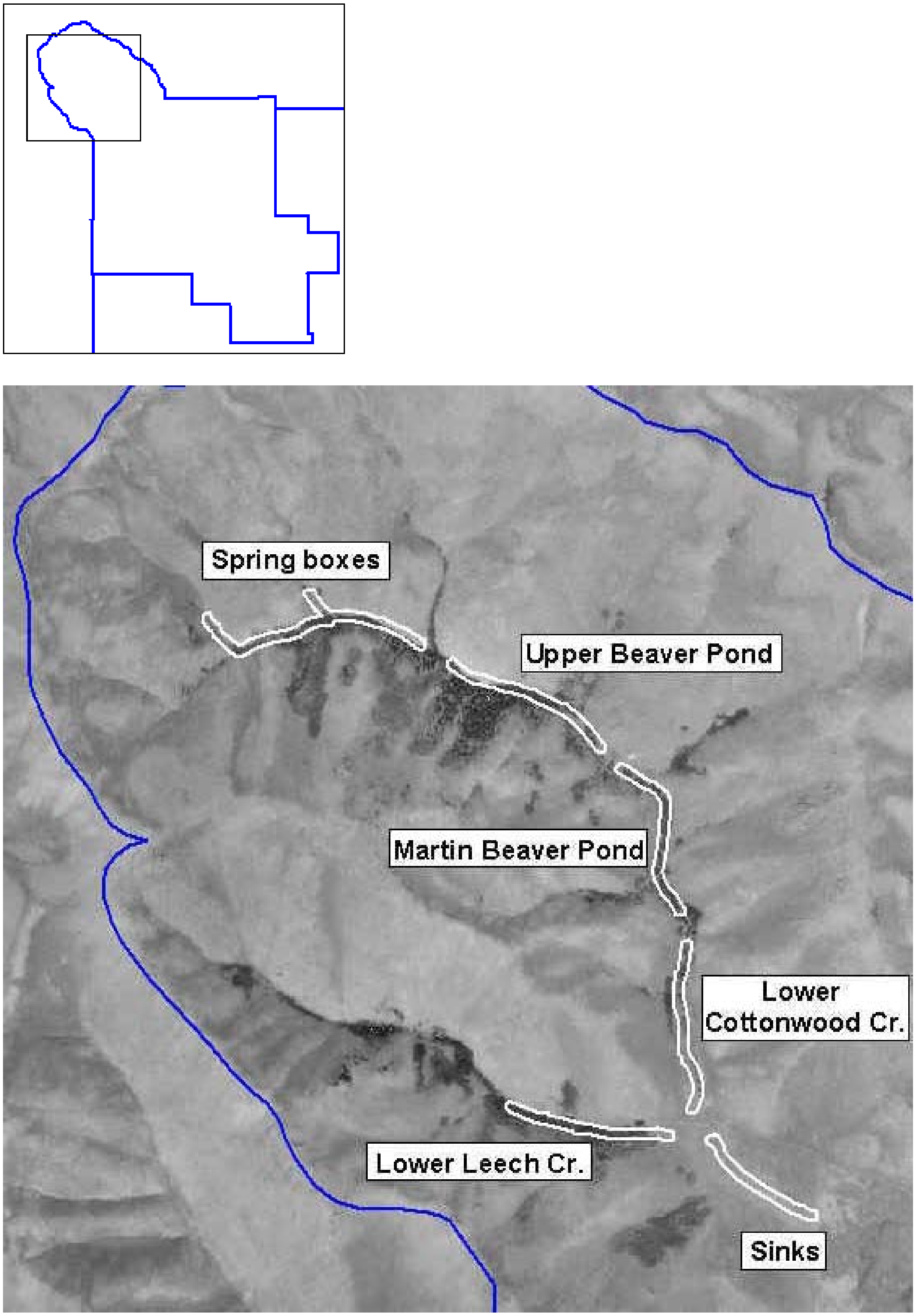


Figure 11. Dipnetting survey locations.Each survey covered approximately 500 m of the stream and 3m of both banks. Inset map shows location of larger image.

Incidental and Contributed Observations

During the course of this study, we recorded incidental observations made by our field team and observations contributed by NPS personnel. We defined incidental observations as those made by our field team during the course of our activities when animals not within our traps were seen. Contributed observations were those reported to us by personnel not directly involved in our fieldwork. We recorded incidental observations whenever we encountered a species that was neither in a trap nor observed during an active survey. We provided observation forms and training to NPS personnel each year of the study to improve the quality of contributed observations. If the contributed observations did not have GPS coordinates with the data, we contacted the observers and asked them to mark the point on a DOQQ. We then displayed a series of buffer circles around the point, and asked them which corresponded to the size of the area in which they felt 95% sure the observation was made. The radius of the buffer they indicated was recorded as the accuracy of location, and 30 m was recorded as the mapping accuracy from the DOQQ. When GPS coordinates that had not been differentially corrected were given, the mapping accuracy was recorded as 100 m in 1999, then 10 m after May 2000.
For all incidental and contributed observations, data other than the location coordinates were collected. These included general habitat descriptions, weather conditions (air temperature, cloud cover, wind strength), and a brief description of the appearance and behavior of the animal.

Sampling Schedule

We checked all traps at 72-hour intervals during the times listed below:
1999: 20 June – 16 September
2000: 17 May – 02 July
23 July – 10 September
2001: 09 May – 03 July
04 August – 07 September

Standardized driving surveys were conducted on the following dates:
1999: 18 Jun, 25 Jun, 02 Jul, 07 Jul, and 12 Sep
2000: 27 May, 02 Jun, 16 Jun, 09 Jul, 11 Jul, 13 Aug, and 26 Aug
2001: 12 May, 18 May, 24 May, 27 May, 02 Jun, 20 Jun, and 29 Aug

We conducted terrestrial visual encounter surveys on the following dates:
1999: 14 Jun, 29 Jun, 08 Jul, 13 Jul, 15 Jul, and 12 Sep
2000: 27 May, 20 Jun, 21 Jun, 24 Jun, 27 Jun, 28 Jun, 13 Aug and 06 Sep
2001: 12 Jun and 09 Aug

We conducted stream surveys for amphibians on the following dates:
1999: 14 Jul and 15 Jul
2000: 16 Jun and 17 Jun

Summaries of the sampling days and the corresponding techniques are shown in Figure 12.

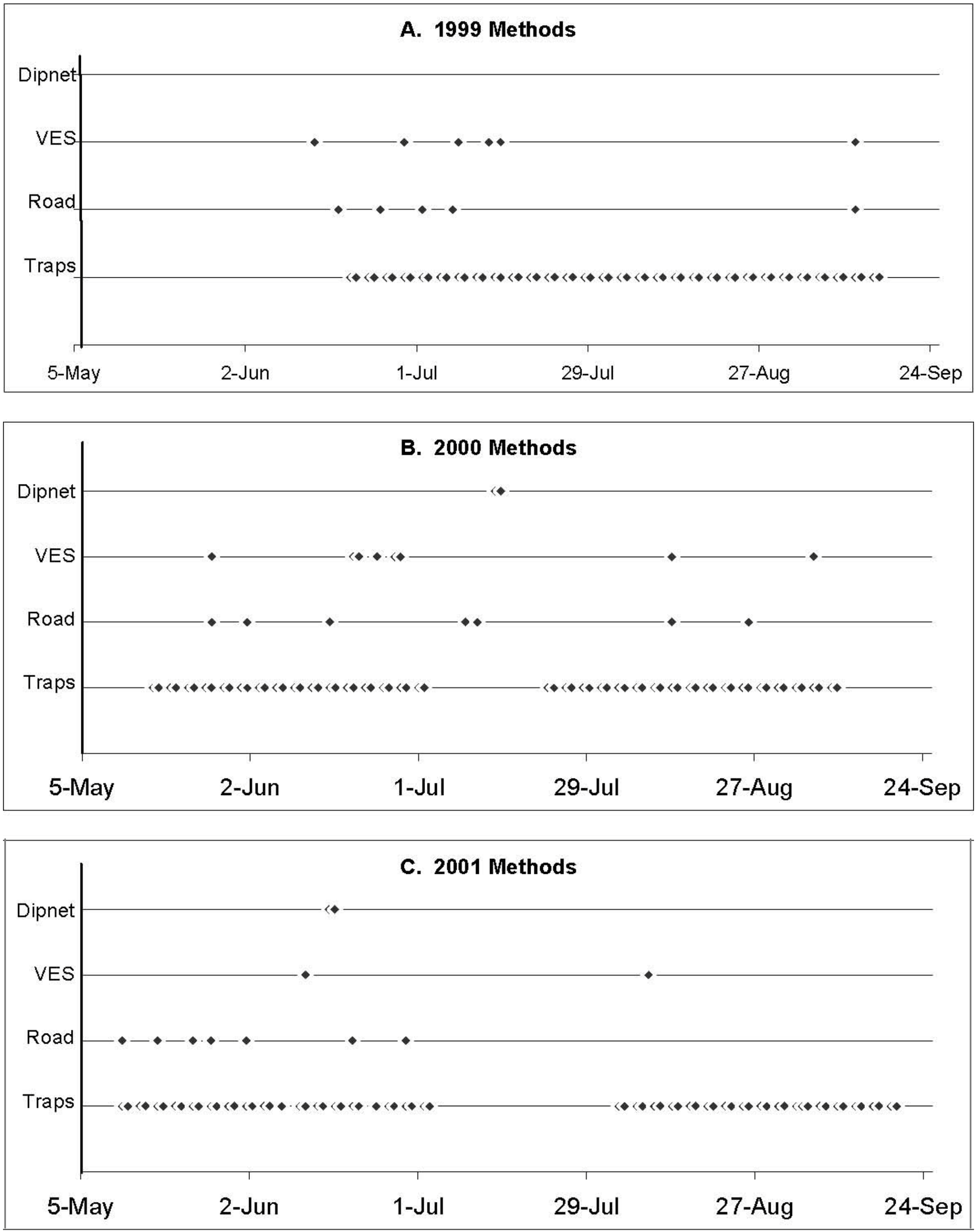


Figure 12. Summary of sampling techniques and dates.

- **A.** Summary of 1999 field season.
- **B.** Summary of 2000 field season. Trapping arrays were moved during July.
- **C.** Summary of 2001 field season. Trapping arrays were moved during July.

Other Animal Species

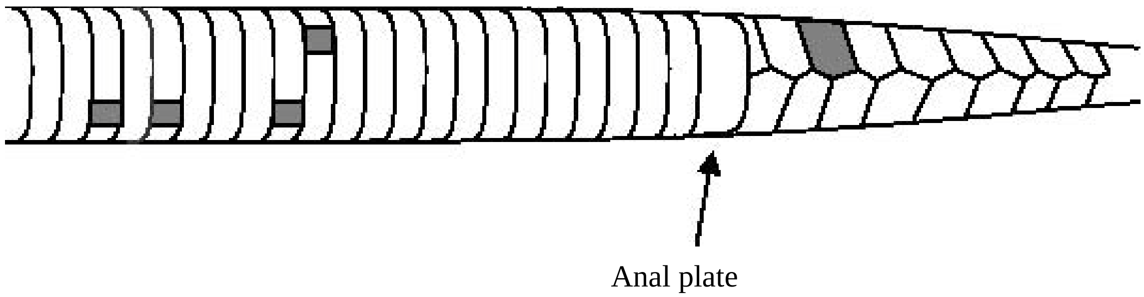
During the course of this study, we recorded numerous observations of wildlife species other than amphibians and reptiles. Funnel traps can capture insects, small mammals, and some birds on occasion. We identified the birds and mammals to species when possible and recorded those data on the Trap Capture Data form as well. Incidental observations of other noteworthy wildlife were recorded on the Monument's wildlife observation forms and turned in to the Resources Management Division.

Animal Processing

Upon capture of live animals, we individually marked each and recorded morphological data. We used a scale clipping system on the ventral scales of all snakes, and a toe clipping system for all lizards. Morphological data were recorded for each capture as well (see below). For scale clipping snakes, a square section of four ventral scales was removed with iridotomy or cuticle scissors, as was appropriate to the size of the animal. The sections removed extended from the caudal edge of a ventral scale to the anterior edge of the same scale. The width of the removed section was the same as the anterior-posterior length of the scale. All scale clip codes consisted of a three-digit number, each digit being represented by the number of unclipped scales between successive clipped scales, reading from anterior to posterior (Figure 13A). All clips were placed on the animal's right side of centerline, except in the case of a 0 (zero) digit. As a zero clip would mean no scales between consecutive clips, the posterior scale was clipped on the animal's left side of centerline for clarity. Codes using successive zero clips (i.e., 100, 200, etc.) were excluded to prevent successive ipsilateral clips. We avoided the ventral midline to prevent potential damage to the ventral blood vessels. In addition to the unique individual code, we also clipped one side of a predetermined subcaudal scale as a cohort mark.

This helped us be able to determine the difference between scars resulting from our scale clips and those naturally incurred by the animals. For toe-clipping lizards, the distal portion of at least one toe on each of three feet was removed using cuticle scissors. Each foot was assigned a two-letter code indicating animals left or right and front/rear (example: LF=Left Front, RR=Right Rear) and the toes were assigned a digit from one to five (anterior to posterior), with those on the front indicating the individual unique ID, and those on one rear foot indicating the cohort mark (Figure 13B).

A.



B.

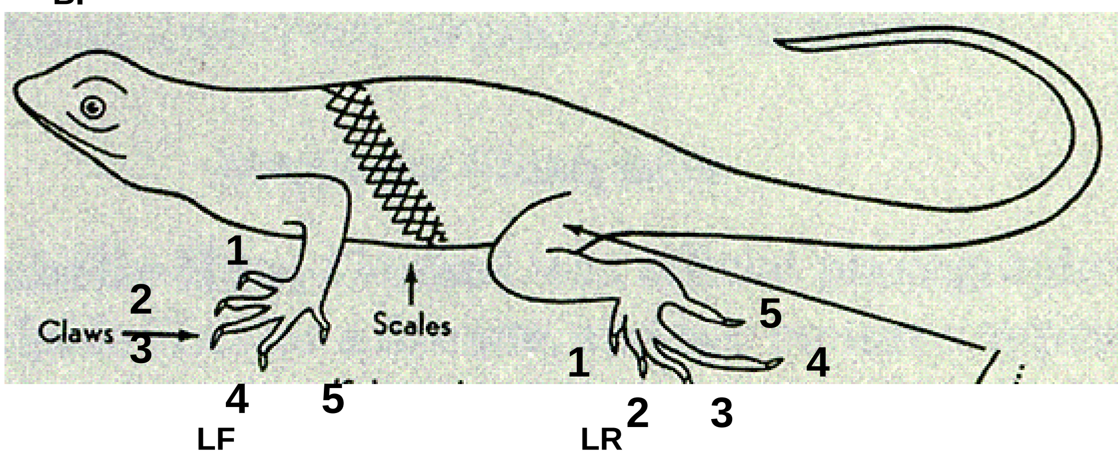


Figure 13A. Examples of marking codes for snakes and lizards. Ventral scale clip code for a snake. By counting the uncut scales between clips from anterior to posterior, and counting subcaudal scales from the anal scute, this code would be read as 130-L2.

Figure 13B. Examples of marking codes for snakes and lizards. Toe clip coding for a lizard. Toes are numbered anterior to posterior and feet are assigned letter codes denoting animals left and right, front and rear. Image from Stebbins (1985).

We recorded morphological data including sex, length, and condition. For snakes, we determined sex by the combination of probing (Schaefer 1934), hemipenal eversion (Gregory 1983) and visual examination of the tail. Determination of sex in lizards was done based on color, presence/prominence of femoral pores, and visual examination of the tail for all species except for western skinks (*Eumeces skiltoniatus*). Determination of sex in skinks was problematic except for during the breeding season, when the males would display an orange tinge around their head (Nussbaum et al. 1983). We measured snout-to-vent length (SVL) to the nearest millimeter in all animals under 50 cm in length. For snakes greater than this length, we recorded only to the nearest 5 mm. Tail length (TAIL) was also measured to the nearest millimeter, and we recorded if the tail was complete or not. We determined reproductive condition by palpating for follicles/eggs. We also recorded presence of food, and manually induced regurgitation when possible to identify prey items.

Processing of all animals except for western rattlesnakes (*Crotalus viridis*) was done in the field. Rattlesnakes were returned to and processed in the laboratory at Idaho State University (ISU) for safety reasons. Animals processed in the field were immediately released, and rattlesnakes were released within 72 hours of capture.

Voucher Specimens

We prepared voucher specimens of each species recorded during this study. When possible, vouchers were prepared from road-killed animals or those lost to accidental trap associated mortality. When no incidentally killed specimens were available, we sacrificed animals for preservation to insure that we included at least one adult male, adult female, and juvenile of each species. Animals were sacrificed via injection of a veterinary euthanasia solution (SleepAway, Fort Dodge Laboratories). Animals were fixed via injection with 10% Formalin solution, rinsed with water, and then preserved in 70% ethanol for storage (Pisani 1973). All specimens received a catalog number from the Idaho Museum of Natural History herpetology collection and from the National Park Service. All processing data for the specimens were recorded.

Focal Animal Studies

Because of some novel habitat relationships that became evident in the early part of the study (e.g., numerous rubber boas (*Charina bottae*) in sagebrush and lava, and gopher snakes (*Pitouphis catenifer*) only in lava), we decided to perform limited focal animal studies. These studies involved surgically implanting radiotransmitters (SB-2, Holohil Systems, Ontario) into 1-2 individuals of some species and tracking them over time. Rubber boas, racers, rattlesnakes, and gopher snakes were the only species for which we captured animals large enough to receive a transmitter after this phase of the study began. The snakes captured for these studies were returned to the ISU laboratory for the surgery, held for one week to allow for adequate recovery, then released back at their capture locations. We then relocated each animal 1-2 times per week. Upon locating each individual, we recorded location, habitat, and behavior using the data form shown in Appendix E.

Data Management

All data were recorded on the appropriate form (see Appendices) and simultaneously duplicated in our notebooks while in the field, then later entered into Microsoft Excel spreadsheets. The data forms were printed directly from the spreadsheet pages to reduce transcription errors. Location and attribute data from the spreadsheets were imported into ArcView as tables and used to prepare event themes as was appropriate. All data were backed up to CD once per month.

Statistical Analyses

We used a combination of analytical techniques to examine richness, abundance, and to predict distribution. We used univariate Analysis of Variance (ANOVA) and multiple regression to examine overall richness, snake richness, and lizard richness. We also used univariate ANOVA and multiple regression to examine overall species abundance, snake species abundance, and lizard species abundance. We used multiple regression to correlate richness/abundance to continuous variables (i.e., elevation, slope, distance to water, distance to the highway, environmental type patch size, covertype patch size) and indicator coded variables representing the categorical variables of collapsed cover type, topography and geology. Because of the reduction in degrees of freedom resulting from simultaneously comparing this number of variables, we also entered the categorical variables of cover type, topography, and geological group into univariate ANOVA analyses. When Levine's test indicated violation of the assumption of error variance equality, we conducted a Kruskal-Wallis nonparametric test instead of the univariate ANOVA. In addition to these analyses, we also generated predictive models of distribution for each species.

Predictive models of probability of occurrence were created using logistic regression, principal components analysis (PCA), trapping rates by environmental type, indicator kriging, and indicator cokriging for each species. Of the resulting models, we selected the best model for each species by comparing the area under the curve (AUC) statistic from receiver-operator characteristic (ROC) plots. For each species we also used the ROC plots to determine the probability of occurrence threshold for predicting presence on the probability maps. By combining these predicted presence maps for all the species, we constructed maps predicting species richness for lizards, snakes, and all reptiles.

We calculated the repeatability of species detection for each of the long-term arrays. This was done by assigning a code of 1 or 0 to each array for each year that each species was detected at that location. The sum of the codes indicated the number of years a species was detected at that array, and the repeatability was calculated as 1 minus the standard deviation. By calculating the standard deviation across all years and species for each array, we determined the repeatability for each array (array repeatability). Similarly, we calculated species repeatability by determining the standard deviation across all arrays for each species.

All analyses were conducted using SPSS Version 10 for Windows (SPSS, Inc., Chicago). When the assumptions of normality and homoscedasticity were not met, we used the nonparametric equivalents (e.g., Kruskal-Wallis test or logistic regression analysis). All hypothesis testing was performed at the 0.95 confidence level, except for when application of the Bonferroni sequential adjustment of significance level was required to preserve alpha=0.05 (Rice 1989).

Map Preparation

All maps in this report were generated using ArcView Version 3.2 or ArcGIS Version 8.0 (ESRI, Redlands, CA). Except where indicated, all maps are plotted in NAD 27, Zone 12T coordinates. All distances and areas indicated are in metric units

Assigning NPSpecies Codes

We followed the NPS definitions for park status, species abundance, residency, species nativity, management priority, and exploitation concern (Appendix F). When possible, we crosswalked our numerical results with these definitions. For example, we used the NPS definitions to assign abundance rankings to each species trapped, and then examined our graph of relative abundance to estimate numerical equivalents for these rankings. Because these estimates are affected by the number of arrays we used, the numerical equivalents we define should not be applied to other studies.

The NPSpecies codes do not contain categories to describe distribution across an area, so we constructed the following to aid in description. We used the term “widespread” for a species if we observed it across large areas with a relatively even distribution of points. For practical purposes, this usually indicated that a species was found both north and south of the highway. For those species mostly limited to one side of the highway, or those showing a patchy or clumped distribution, we assigned a code of “intermediate”. When the species was known from only a few points that were all located in a relatively small area, we used the term “limited” to describe the distribution. We referenced the Idaho Conservation Data Center (ICDC) of the Idaho Department of Fish and Game (http://www2.state.id.us/fishgame/info/cdc/cdc.htm) for all information pertaining to the conservation status and management priority for each species.

Environmental Data

We obtained precipitation and air temperature data from a remote weather station located on Broken Top approximately 4 km south of the Craters of the Moon visitor’s center. These data are archived by the NOAA ARL Field Research Division and were accessed via the Internet at http://www.met.utah.edu/mesowest/. We calculated the deviation from normal for monthly precipitation totals and monthly average air temperature. For these calculations, we used the 40-year averages as the normals.

Results and Discussion

Confirmed Species

Pacific treefrog (*Pseudacris regilla*)
Park Status: Present
Species abundance: Occasional
Residency: Unknown
Species nativity: Unknown
Species of management priority: No
Species of exploitation concern: No
Occurrence: The occurrence of Pacific treefrogs at CRMO is documented only by two desiccated specimens found dead in public restrooms; one in the campground and the other from the Visitor's Center. This species can possibly be transported with firewood or on recreational vehicles. Given that the only two individuals found were in areas frequented by park visitors, and the lack of breeding habitat (see summary of habitat relationships, below), this species is probably not a resident of the Monument.
Distribution: Limited. The only records are from locations in the campground and visitor's center, roughly 200 m apart.
Relative Abundance: Considering the number of visitors to the park each year, and that only two specimens were found during the three summers of our study, we consider it rare to encounter this species.
Habitat Relationships: Unknown for CRMO. Statewide, this species is usually found near riparian areas or some other water source. These features may also be located in such varied habitats as talus slopes, agricultural areas, deserts, meadows, and forested areas. Ephemeral water features may be used for breeding (Nussbaum et al. 1983).
Conservation Status and Management: Statewide, this is an unprotected nongame species ranked S5 (demonstrably widespread, abundant, and secure). Globally, Pacific treefrogs are ranked G5 (demonstrably widespread, abundant, and secure, ICDC 2003).

Western skink (*Eumeces skiltonianus*)
Park Status: Present
Species abundance: Common
Residency: Breeder
Species nativity: Native
Species of management priority: No
Species of exploitation concern: No
Occurrence: The occurrence of western skinks at CRMO is documented by 58 trapping records from 19 sites, three contributed observations from two sites, two incidental observations from two sites, and 11 historic records from 10 sites (Figure 14).
Distribution: This species is widespread, with the highest probabilities of occurrence in Devil's Orchard, the Cave's areas, and the lower portions of the Leech Creek and Little Cottonwood Creek drainages (Figures 15 and 16). This species is probably one of the few that occurs in high numbers on the newer lava flows. In 2001, we placed individual funnel traps in a series of fissures in the lava near the Caves Area parking lot. This one site produced nearly a fourth (15 of 58) of the skink captures for the study in the single year it was open.

Abundance: The 58 records for this species make it common at CRMO. Abundance was (marginally) negatively correlated with northeastern facing slopes (β =-1.214, p=0.062).
Habitat Relationships: At CRMO, western skinks are positively correlated with the presence of lava (β =4.095, p=0.018) and negatively correlated with the presence of northeast facing slopes (β =-3.922, p=0.020). We trapped skinks in all collapsed covertypes except for Douglas Fir and Wildrye. In the state of Idaho, western skinks are found in grasslands, montane parklands, shrubland, open forest, juniper woodlands, riparian areas, and lava (Scott et al. 2002). They are often found in association with nearby water and/or rocks, but not always.
Conservation Status and Management: Statewide, this is an unprotected nongame species ranked S5 (demonstrably widespread, abundant, and secure). Globally, western skinks are ranked G5 (demonstrably widespread, abundant, and secure, ICDC 2003).
Local Natural History: Determining the sex of Western Skinks is problematic outside of the breeding season (Stebbins 1985). Neonates (<5.5 cm SVL) appeared in the traps during the middle of August. Average adult size was 6.4 cm SVL and 14.6 cm total length. The largest skink we captured measured 9.7 cm SVL and 16.8 cm total length and was of indeterminate sex.
Local Unusual Characteristics: We captured two color morphs of western skinks in the lava areas. The most common morph had typical coloration for the species. The less common morph (34% of all captures) lacked the light dorsal stripes.
Anecdotal Observations of Interest: This is the reptile species most commonly encountered by visitors to the Monument, mainly along the trails in Devil’s Orchard, the Caves Area, and the Broken Top/Buffalo Caves area.

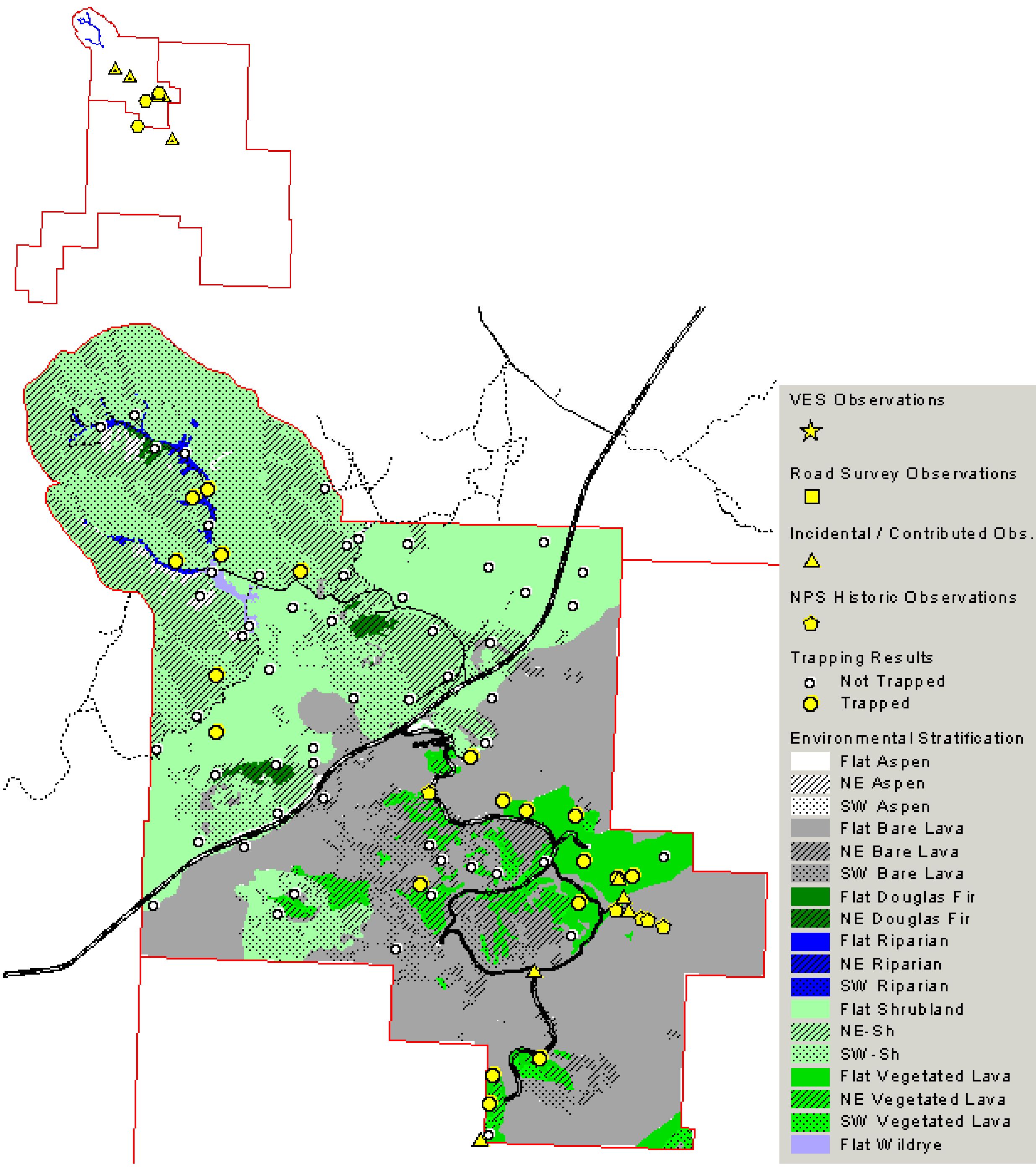


Figure 14. Distribution of Western Skink observations.

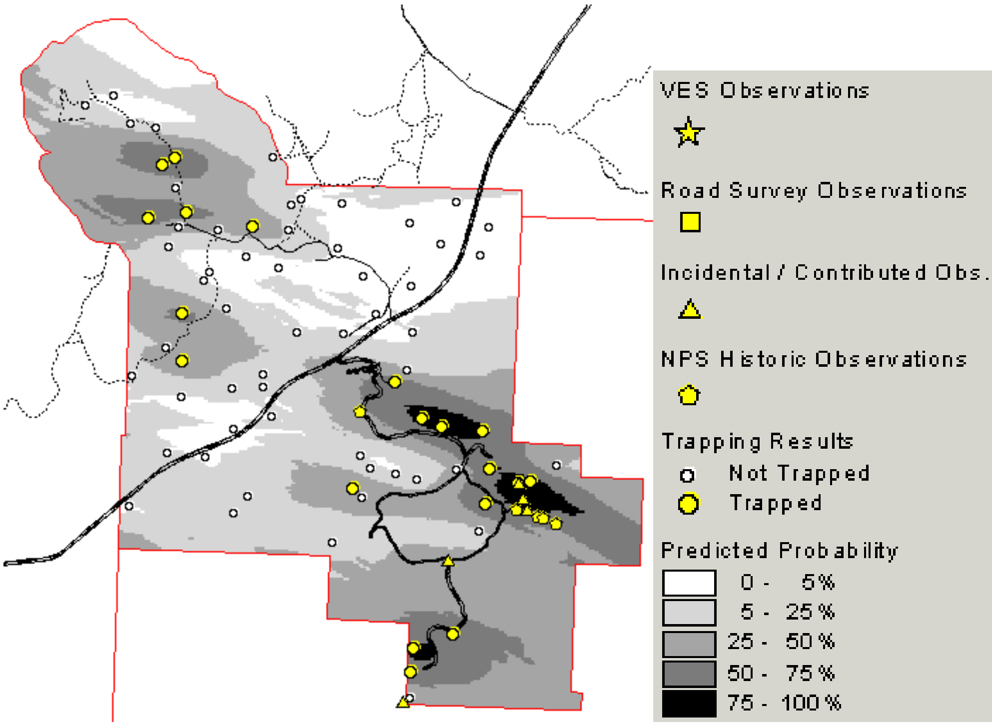


Figure 15. Probability of occurrence for Western Skinks for the Monument based on indicator kriging.

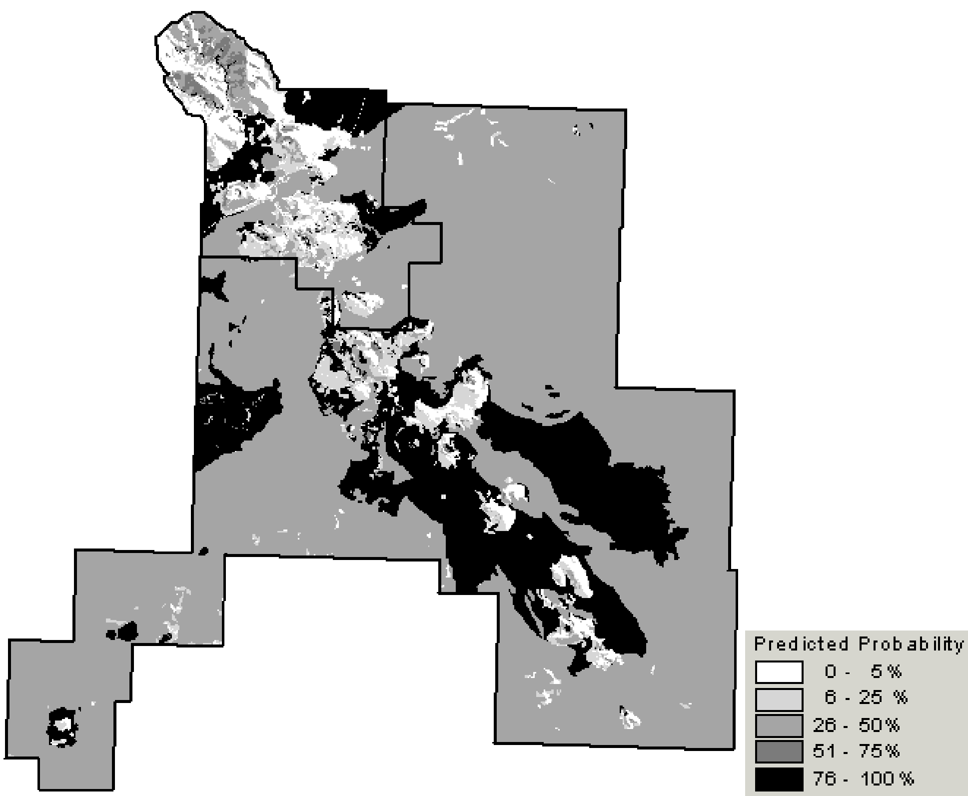


Figure 16. Probability of occurrence for Western Skinks for the Wilderness based on environmental type trapping probability.

Pigmy short-horned lizard (*Phrynosoma douglassii*)
Park Status: Present
Species abundance: Uncommon - Common
Residency: Breeder
Species nativity: Native
Species of management priority: No
Species of exploitation concern: No
Occurrence: The occurrence of pigmy short-horned lizards at CRMO is documented by nine trapping records from six sites, two VES records from two sites, two road survey records from one site, 10 contributed observations from 10 sites, nine incidental observations from seven sites, and six historic records from six sites.
Distribution: This species has an intermediate distribution, being found most commonly on the sagebrush flats south of Goodale's Cutoff and along the highway (Figure 17).
Relative Abundance: Abundance was positively correlated with the presence of grass (β ; = 0.492, p=0.029). Short-horned lizards were captured in traps only nine times during this study. However, funnel traps may not be the best technique, as most of those we trapped were juveniles. This is supported by the fact that we have a total of 23 driving, VES, contributed, and incidental observations for this species.
Habitat Relationships: At CRMO, pigmy short-horned lizards are negatively correlated with southwest slopes (β =-4.223, *p*=0.003) and (marginally) negatively correlated with riparian areas (β =-2.104, p=0.096). We trapped horned lizards only in the shrubland collapsed covertype (Figures 18 & 19). Elsewhere in Idaho, they are found in grasslands, shrublands, juniper woodlands, and sand dunes, often in association with loose soils and anthills (Scott et al. 2002).
Conservation Status and Management: Statewide, this is an unprotected nongame species ranked S5 (demonstrably widespread, abundant, and secure). Globally, pygmy short-horned lizards are ranked G5 (demonstrably widespread, abundant, and secure, ICDC 2003).
Local Natural History: Neonates (<3.2 cm SVL) appeared in the traps toward the end of August. Average adult size was 5.0 cm SVL and 7.3 cm total length. The largest short-horned lizard we captured was a male that measured 6.8 cm SVL and 9.6 cm total length.
Local Unusual Characteristics: None noted.
Anecdotal Observations of Interest: During the course of this study, the number of horned lizard observations increased each year. From out work at the INEEL, we believe horned lizard populations in the region were reduced during the drought years of the early 1990's. It was not until 1998-1999 that we began to see this species again in areas of the INEEL where it had been relatively common in the 1970's and late 1980's. The increasing numbers of observations by year we made may be part of the same trend. However, we have no hard data to support this speculation.

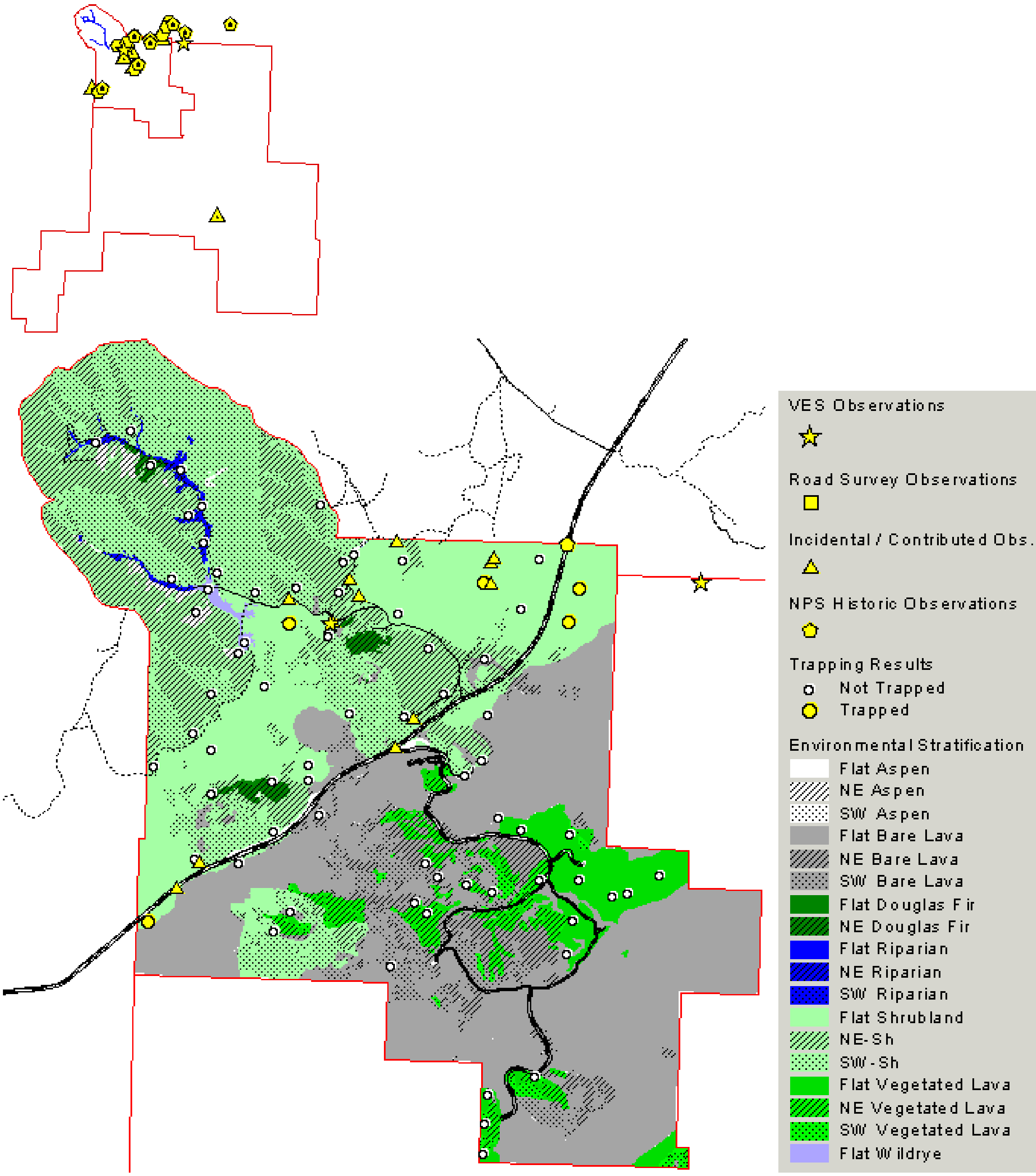


Figure 17. Distribution of Pigmy Short-horned Lizard observations.

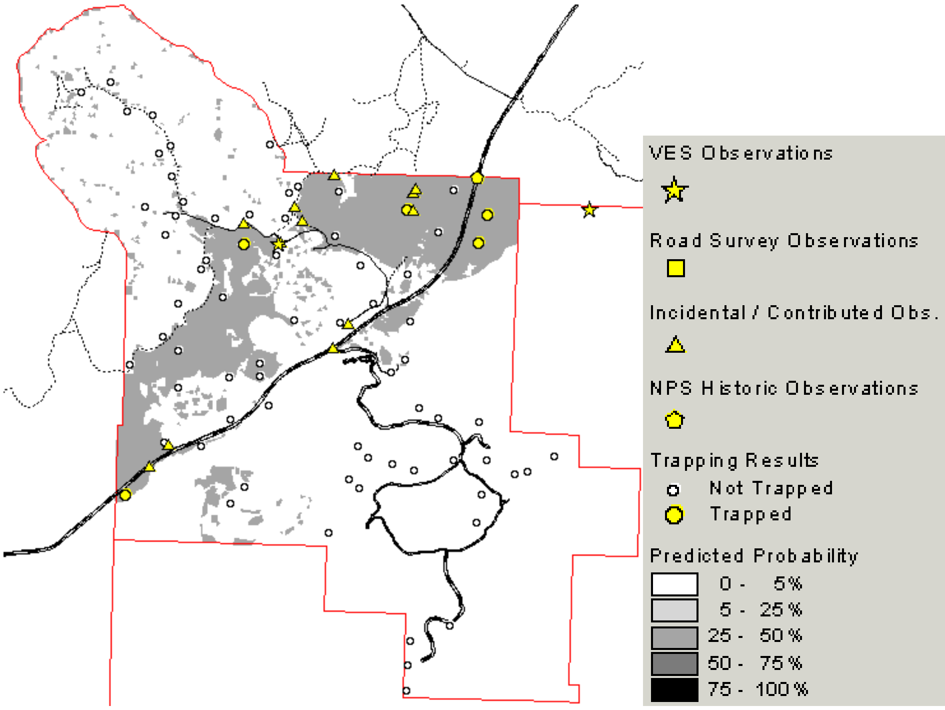


Figure 18. Probability of occurrence for Pigmy Short-horned Lizards for the Monument based on principal components logistic regression.

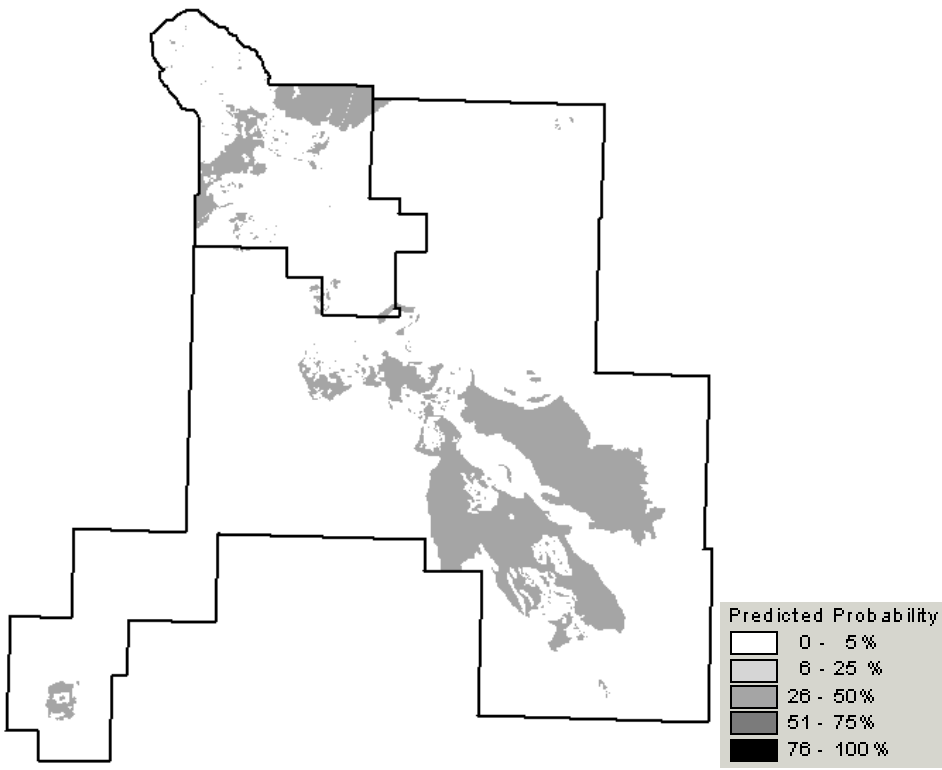


Figure 19. Probability of occurrence for Pigmy Short-horned Lizard for the Wilderness based on environmental type trapping probability.

Sagebrush lizard (*Sceloporus graciosus*)
Park Status: Present
Species abundance: Abundant
Residency: Breeder
Species nativity: Native
Species of management priority: No
Species of exploitation concern: No
Occurrence: The occurrence of sagebrush lizards at CRMO is documented by 323 trapping records from 34 sites, 27 VES records from 10 sites, 13 road survey records from 13 sites, 10 contributed observations from nine sites, 24 incidental observations from 14 sites, and five historic records from three sites (Figure 20).
Distribution: This species is widespread across the Monument, with the highest probabilities of occurrence being in those areas from the Group Campground to the lower portions of the Little Cottonwood drainage, and from the western gate on Goodale's Cutoff to the north slopes of Grassy cone (Figures 21 and 22). Sagebrush Lizards can be found across almost the entire Monument, including on isolated kipukas. Of all the species in our study, we trapped this one at the most (34) sites.
Relative Abundance: This was the most commonly captured reptile during our study, averaging 9.5 individuals per trapping array where detected.
Habitat Relationships: At CRMO, sagebrush lizards are negatively correlated with vegetated lava (β =-0.886, p=0.004). Sagebrush lizards were captured in all of the collapsed covertypes. Elsewhere in Idaho, this species is found in grasslands, shrublands, dunes, lava, and juniper woodlands, usually in association with loose, sandy soils, rocks and or logs (Scott et al. 2002).
Conservation Status and Management: Statewide, this is an unprotected nongame species ranked S5 (demonstrably widespread, abundant, and secure). Globally, sagebrush lizards are ranked G5 (demonstrably widespread, abundant, and secure, ICDC 2003).
Local Natural History: Neonates (<3.2 cm SVL) appeared in the traps toward the end of August. Average adult size was 5.1 cm SVL and 11.6 cm total length for males and 5.4 cm SVL and 11.5 cm total length for females. The largest sagebrush lizard we captured (female) measured 6.0 cm SVL and 14.5 cm total length.
Local Unusual Characteristics: None noted.
Anecdotal Observations of Interest: At individual arrays, we would often go 6-12 days with no captures of sagebrush lizards, only to then capture multiple individuals over a 1-3 day period. We could find no meteorological explanation for this, as the high and low capture days were not synchronous across all the arrays. One potential explanation could be that the lizards are responding to local variations in temperature, prey availability, intraspecific competitors, or predators. Another could be that social factors are involved and the center of activity for all the lizards in a specific habitat patch shifts over several days.

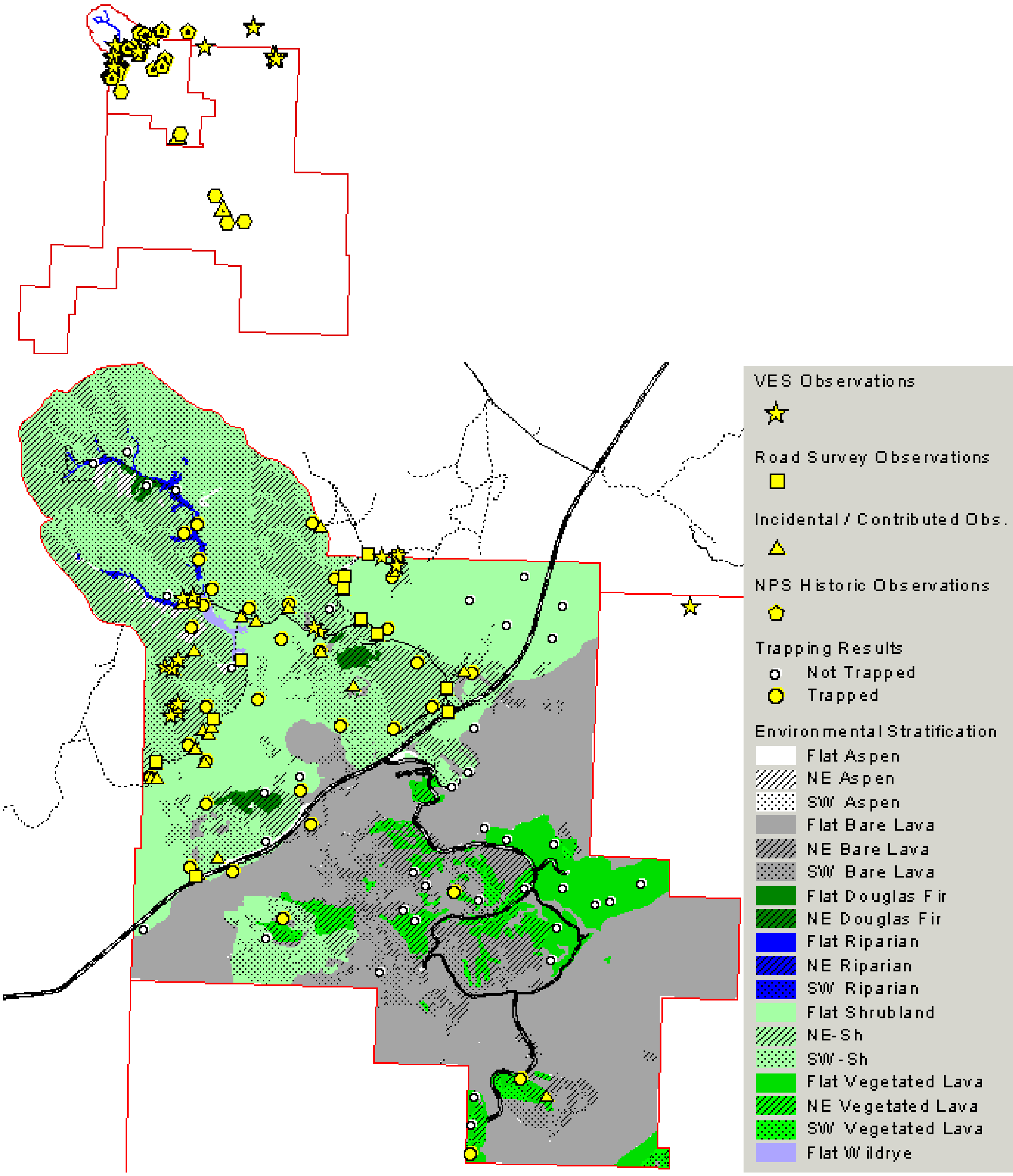


Figure 20. Distribution of Sagebrush Lizard observations.

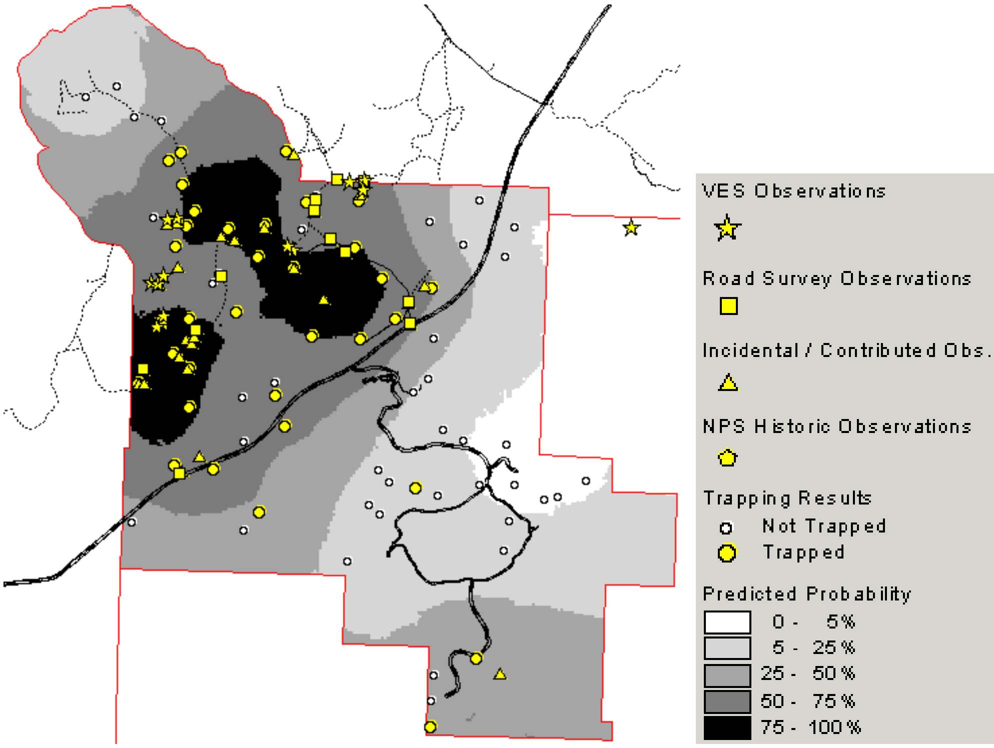


Figure 21. Probability of occurrence for Sagebrush Lizards for the Monument based upon indicator kriging.

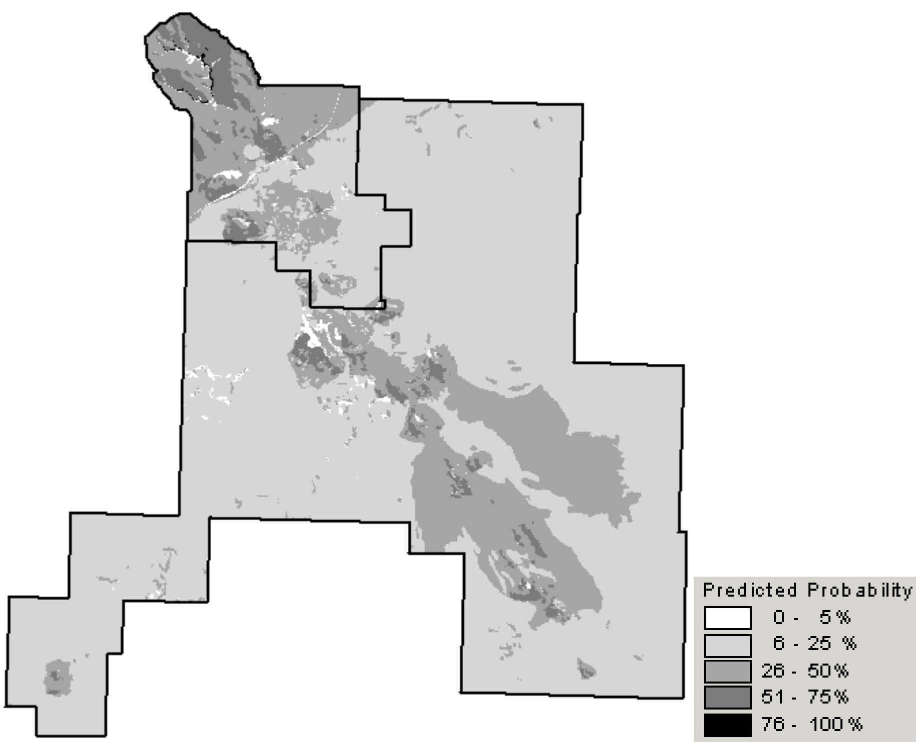


Figure 22. Probability of occurrence for Sagebrush Lizards for the Wilderness based on environmental type trapping probability.

Rubber boa (*Charina bottae*)
Park Status: Present
Species abundance: Common
Residency: Breeder
Species nativity: Native
Species of management priority: No
Species of exploitation concern: No
Occurrence: The occurrence of rubber boas at CRMO is documented by 80 trapping records from 30 sites, seven road survey records from five sites, three contributed observations from three sites, five incidental observations from five sites, and 10 historic records from 10 sites (Figure 23).
Distribution: This species has an intermediate distribution, being found throughout the North End, with the highest probabilities of occurrence associated with the Little Cottonwood Creek drainage (Figure 23). However, roughly a quarter of our captures of this species was caught out in the sagebrush flats and even in the northern edges of the lava flows. This species was the second-most widely trapped species, appearing in 30 of our arrays.
Relative Abundance: This species is common at CRMO, averaging 2.7 captures per site where it was detected. With 80 captures, this was the most commonly trapped snake species of our study.
Habitat Relationships: At CRMO, rubber boas are negatively correlated with distance from a stream (β =-0.001, p<0.001), and were trapped in all seven collapsed covertypes. Statewide, they are found in a variety of habitats including grasslands, montane parklands, meadows, shrublands, forests, riparian, and lava, and typically near water (Scott et al. 2002).
Conservation Status and Management: Statewide, this is an unprotected nongame species ranked S5 (demonstrably widespread, abundant, and secure). Globally, rubber boas are ranked G5 (demonstrably widespread, abundant, and secure, ICDC 2003).
Local Natural History: Neonates (<26.0 cm SVL) appeared in the traps around mid-August. Average adult size was 43.7 cm SVL and 49.5 cm total. The largest rubber boa (female) we captured measured 55.5 cm SVL and 65.5 cm total length.
Local Unusual Characteristics: Rubber boas at Craters of the Moon were found in some of the driest-appearing habitats encountered. Previous work in Idaho found this species on sage-covered hillsides overlooking water (M.E. Dorcas, unpublished data), but not at the distances seen in our study. In addition, the number of rubber boas we captured was well above what we expected based on our other studies in the region. Finally, roughly a third of the rubber boas captured had orange to red colored ventral scales, while the rest showed the more typical yellow coloration.
Anecdotal Observations of Interest: We recaptured a rubber boa on 29 July 2000 in the LC5 trapping array. It had been initially captured and marked on 05 June 2000 in the LC2 array, evidently having moved over 650 m (straight-line distance) in almost two months. This is notable both for the small size of the animal (28 cm total length) and the fact that this was one of only eight recaptured snakes (over 227 captures) for the whole study. A second item of interest was the number of times we captured multiple animals in a single array or trap. On three occasions, we captured two rubber boas in different traps of the same arrays, and on four occasions, (two on the same day) we captured two in the same traps.
Focal Animal Telemetry: We tracked one rubber boa captured in the WC5 array on 02 June 2000 (Figure 26). From its release on 09 Jun until we last detected the signal on 28 Aug, this snake showed very little activity. It was seen aboveground on only a single occasion, being

underground in vegetated lava the rest of the time. This snake changed locations by 1-10m on numerous occasions, but most of the time we found it under a particular large boulder. Because rubber boas are generally considered a riparian animal, the fact that this one was initially captured (and remained) over 2 km from the nearest surface water is notable. However, caves roughly 500 m to the south that were surveyed by NPS personnel in 1999 contained ice and water throughout the summer. Therefore, rubber boas at CRMO may be able to gain access to subsurface water and thus be able to range more widely from streams than this species normally does.

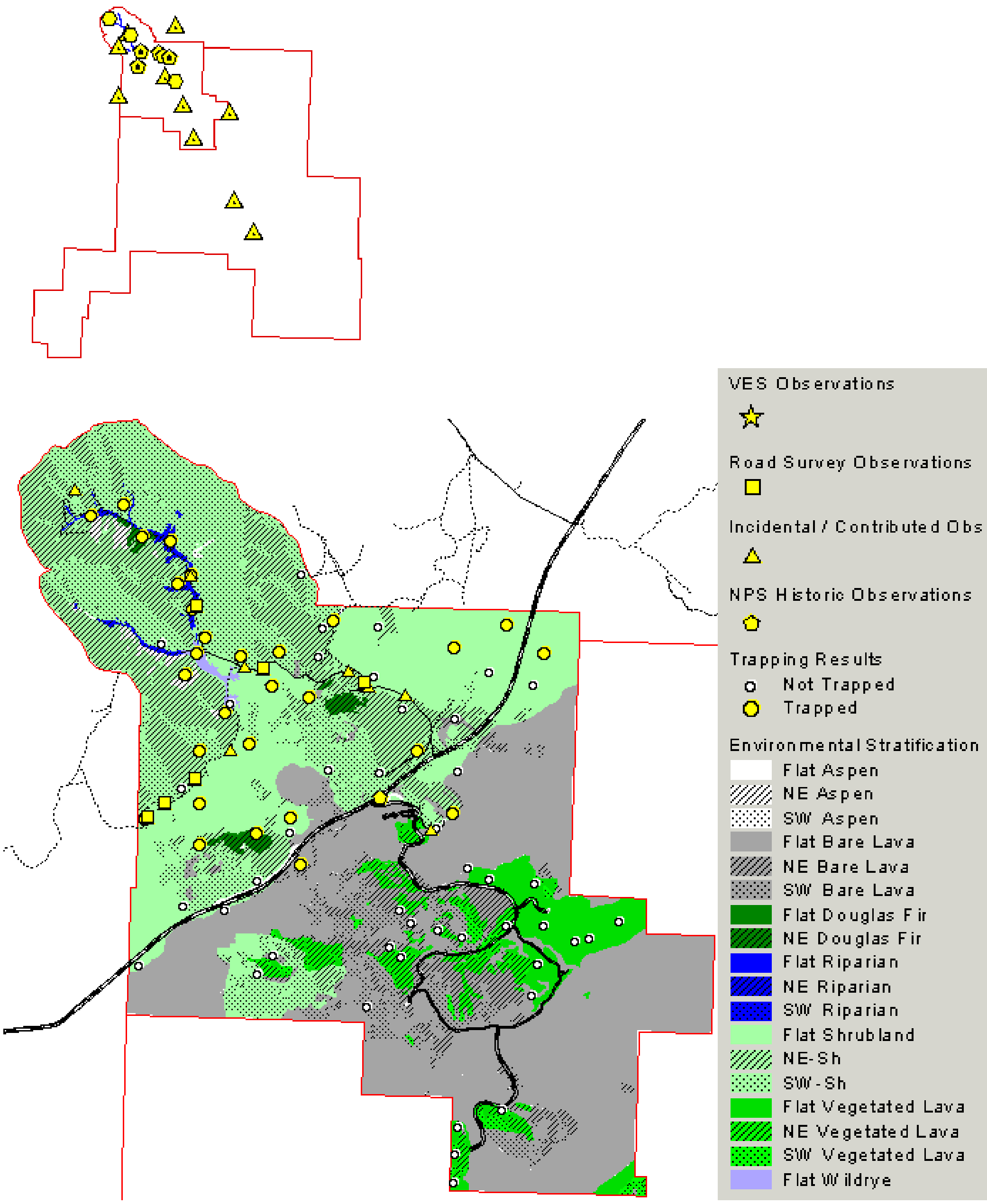


Figure 23. Distribution of Rubber Boa observations.

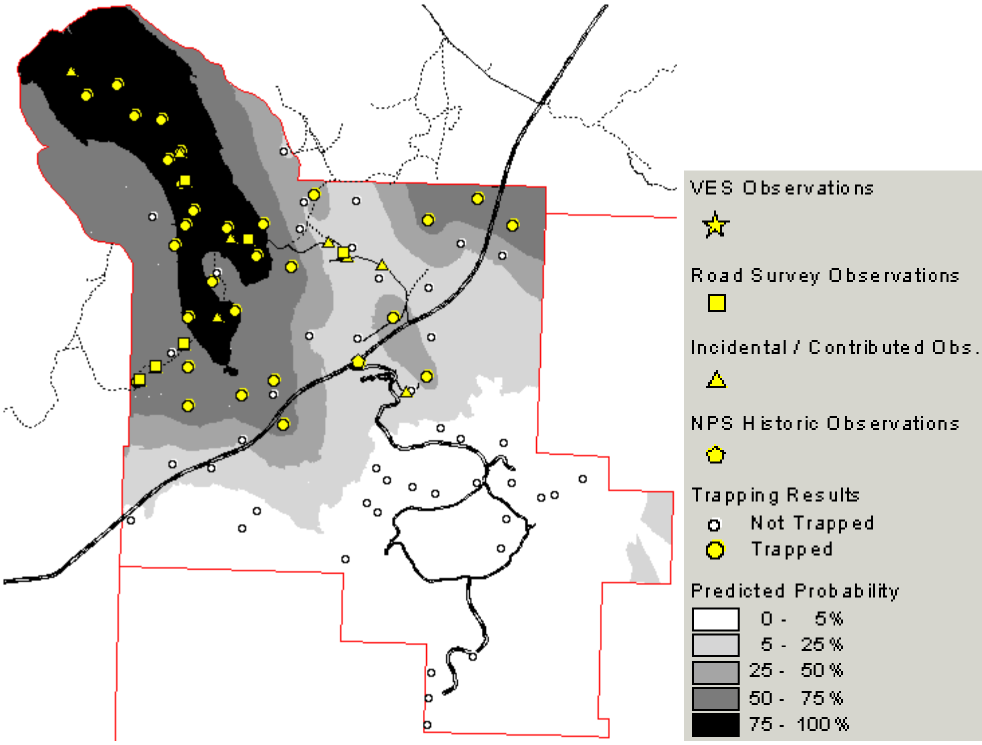


Figure 24. Probability of occurrence for Rubber Boas for the Monument based upon indicator kriging.

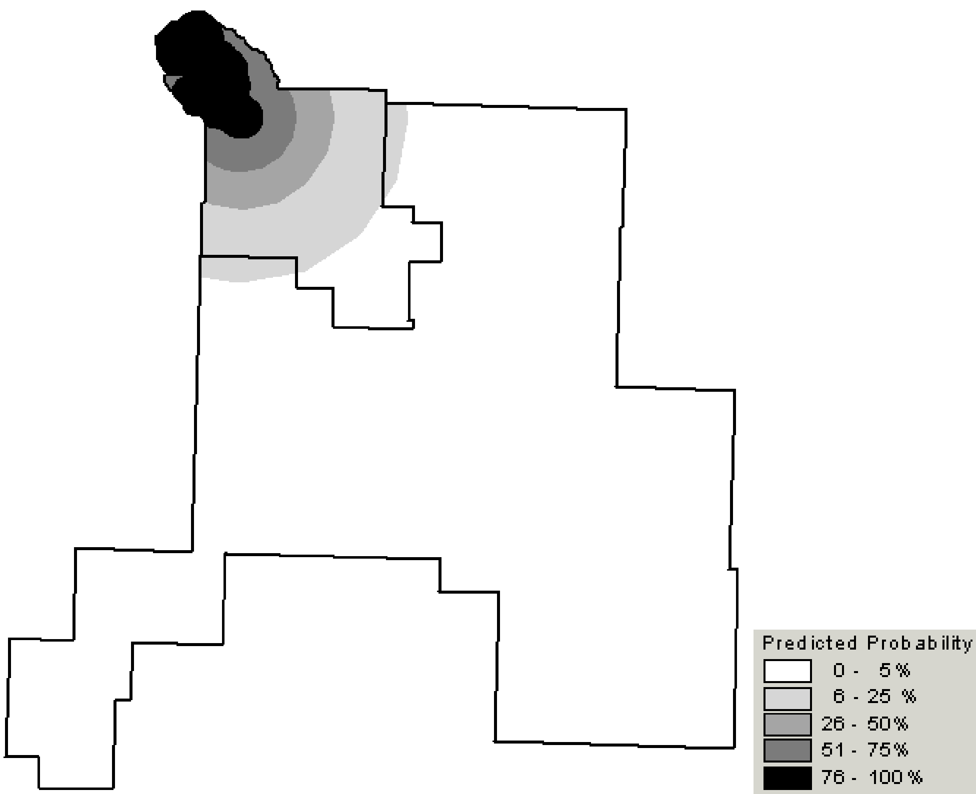


Figure 25. Probability of occurrence for Rubber Boas for the Wilderness based on logistic regression.

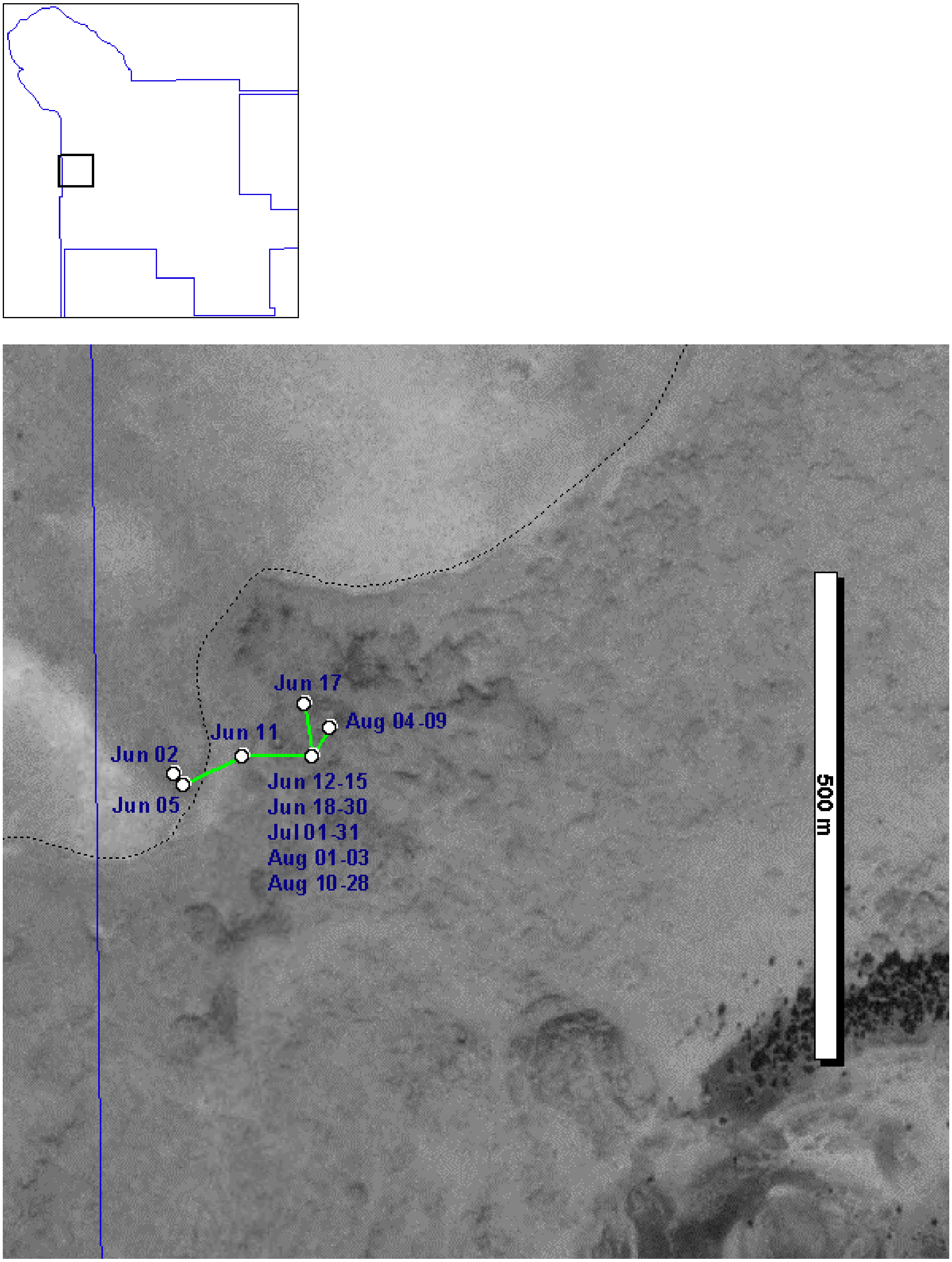


Figure 26. Movements of Rubber boa #1 at Craters of the Moon in 2001. Black square on the inset map shows location of the larger image.

Racer (*Coluber constrictor*)
Park Status: Present
Species abundance: Common
Residency: Breeder
Species nativity: Native
Species of management priority: No
Species of exploitation concern: No
Occurrence: The occurrence of racers at CRMO is documented by 50 trapping records from 18 sites, two VES records from two sites, five contributed observations from three sites, six incidental observations from six sites, and one historic record from one site (Figure 27).
Distribution: This species has an intermediate distribution, being found throughout the North End, with the highest probabilities of occurrence associated with the northeastern, forested canyon slopes of the riparian areas, and the lower elevation slopes and flats along Goodale's Cutoff.
Relative Abundance: We made 50 captures of racers throughout the course of this study, making them a common species.
Habitat Relationships: At CRMO, racers were negatively associated with the principal component describing vegetated lava (β =-1.379, p=0.003). The highest probability of occurrence for racers was in the wildrye flats, aspens, and southwest-facing riparian areas of the north end of the Monument (Figures 28 & 29). We trapped racers in aspen, riparian, shrubland, and wildrye covertypes. Statewide, they may be found in grasslands, montane parkland, meadows, shrublands, open forests, riparian areas, dunes, and lava (Scott et al. 2002).
Conservation Status and Management: Statewide, this is an unprotected nongame species ranked S5 (demonstrably widespread, abundant, and secure). Globally, racers are ranked G5 (demonstrably widespread, abundant, and secure, ICDC 2003).
Local Natural History: Neonates (<25.0 cm SVL) appeared in the traps toward the middle of September. Average adult size was 53.5 cm SVL and 70.8 cm total length for males and 56.7 cm SVL and 74.1 cm total length for females. The largest racer (female) we captured measured 80.5 cm SVL and 106.0 cm total length.
Local Unusual Characteristics: We observed fewer neonates/juveniles than we expected. Of the 49 trap captures, only two were small enough to exhibit the typical juvenile coloration.
Anecdotal Observations of Interest: We hand captured an adult racer that was being mobbed by a group of four wrens on 14 July 1999. This was about 15 m from the LC2 array, yet we did not capture this species in that array until 24 May 2001, when we found two adults in a single trap.
Focal Animal Telemetry: We implanted a transmitter into an adult racer captured on 30 May 2000 in the RC2 array (Figure 30). It spent most of the time between then and early September around the research camp and on the ridgetop to the immediate south. Most of the relocations when it was inactive were in a small rock outcrop located roughly halfway up the hillside. On 23 June, we tracked and visually confirmed its location in lava over 2500 m to the south-southwest (beyond the Monument boundary). On 27 June, the snake had returned to the small outcrop overlooking the research camp. We have no explanation for this behavior.

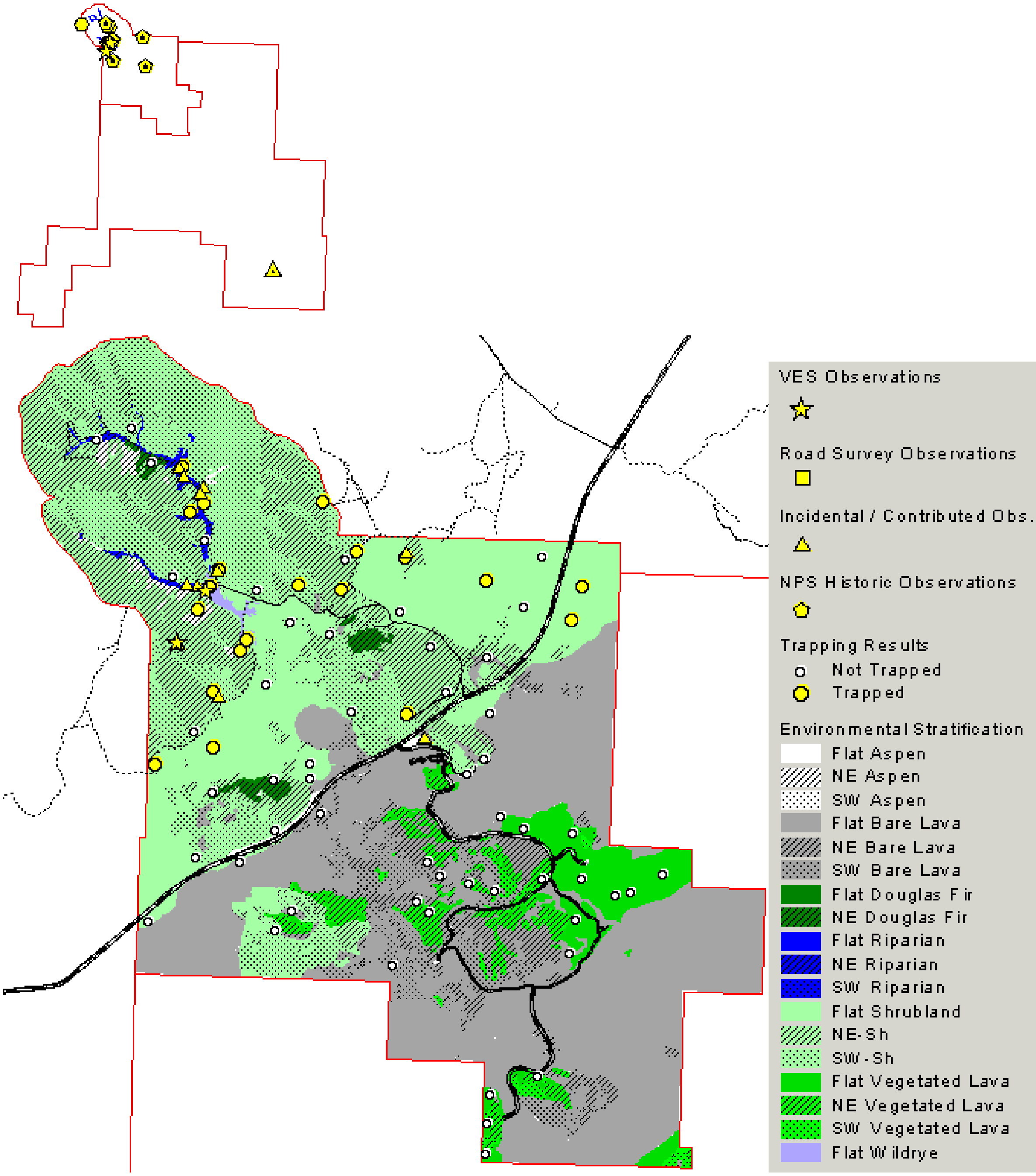


Figure 27. Distribution of Racer observations.

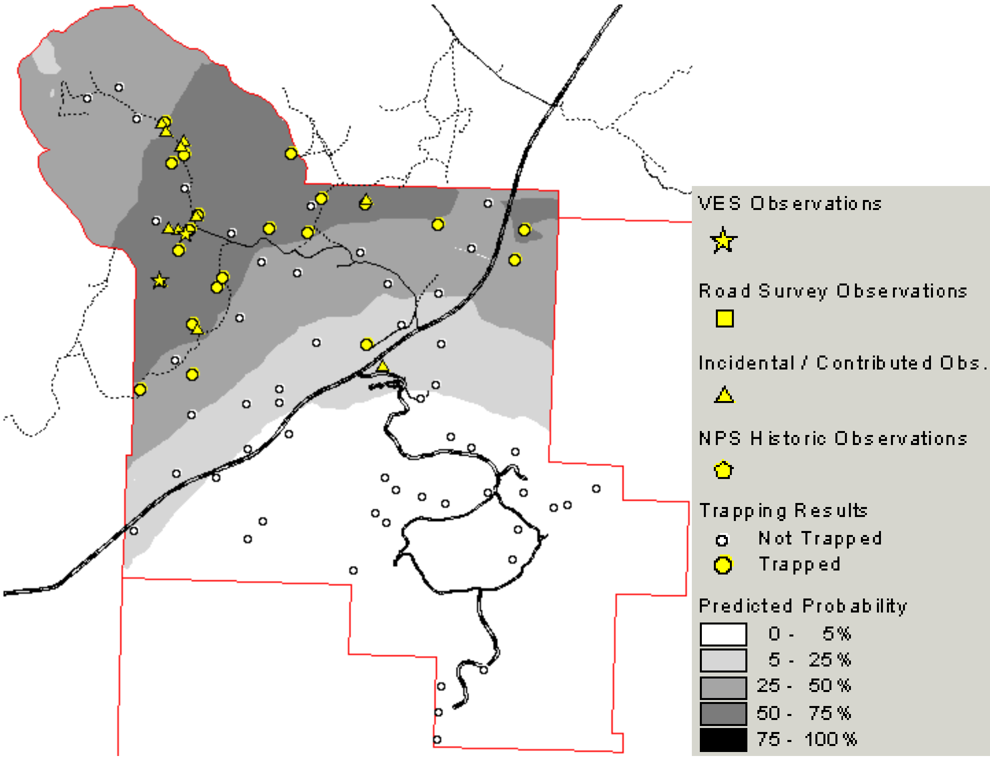


Figure 28. Probability of occurrence for Racers for the Monument based upon indicator cokriging (distance from stream as secondary variable).

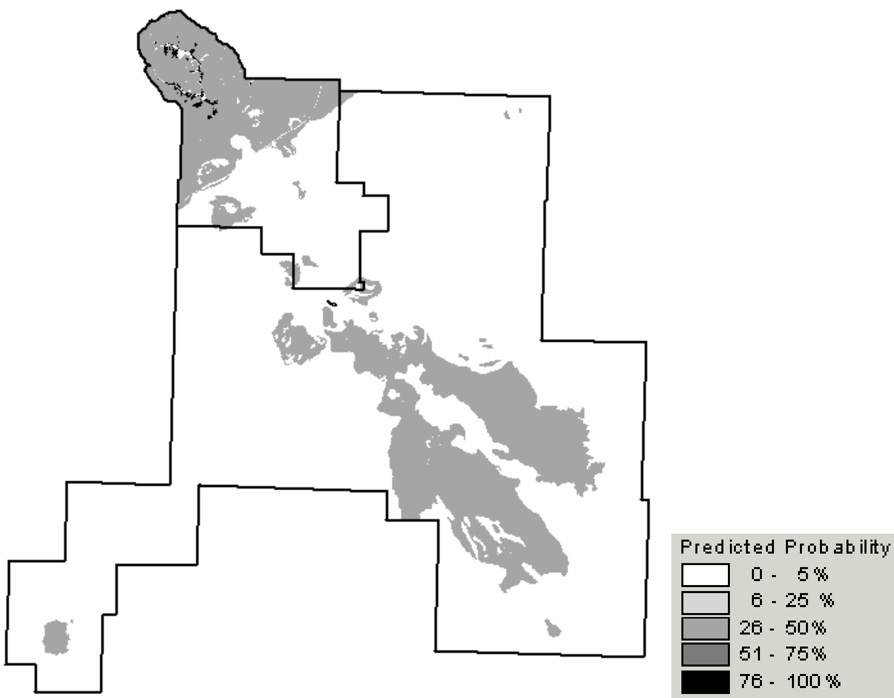


Figure 29. Probability of occurrence for Racers for the Wilderness based on environmental type trapping probability.

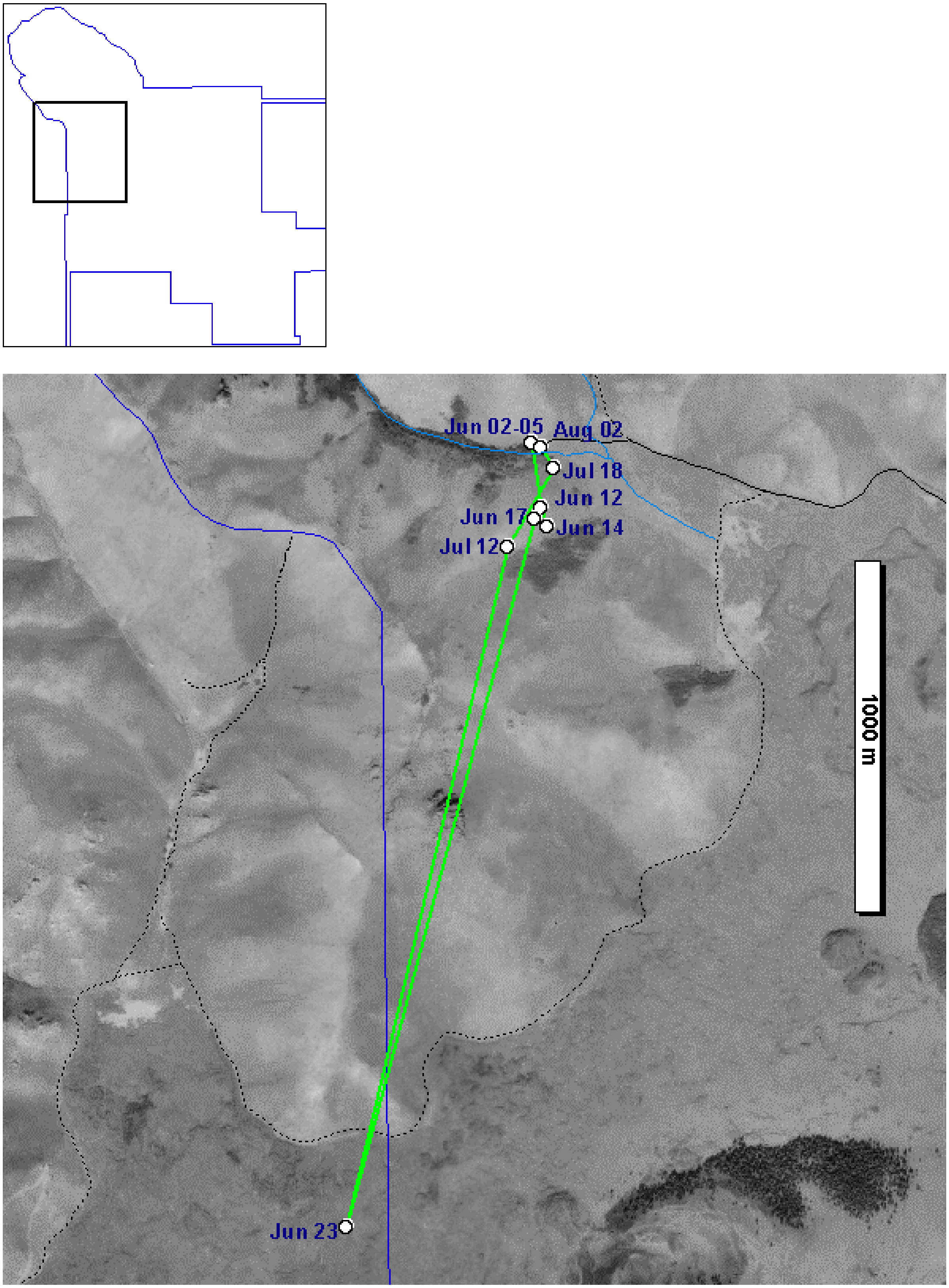


Figure 30. Movements of Racer #1 at Craters of the Moon in 2001. Black square on the inset map shows location of the larger image.

Gopher snake (*Pituophis catenifer*)
Park Status: Present
Species abundance: Uncommon-Common
Residency: Breeder
Species nativity: Native
Species of management priority: No
Species of exploitation concern: No
Occurrence: The occurrence of gopher snakes at CRMO is documented by only six trapping records from four sites, seven contributed observations from five sites, one incidental observation from one site, and 29 historic records from 22 sites (Figure 31).
Distribution: Gopher snakes at CRMO appear to have an inexplicable limited distribution, with the highest probabilities of occurrence around the Loop Road, especially to the east and southeast in the Caves and Broken Top areas (Figures 32 & 33).
Relative Abundance: We trapped this species only rarely (6 times, the least of all species), but contributed and historic observations suggest that it is locally common in the areas where it occurs.
Habitat Relationships: The most puzzling aspect of this study was the fact we trapped gopher snakes at CRMO exclusively in the bare lava and vegetated lava covertypes of the younger lava flows. This was reflected strongly in the principal components analyses, with their occurrence being predicted by the components reflecting variation in the presence of vegetated lava (β =2.585, p=0.042) and bare lava (β =1.404, p=0.041). Elsewhere in Idaho, these snakes are found in lava as well, but they are also commonly encountered in grasslands, montane parklands, meadows, shrublands, open forests, riparian areas, dunes, and even agricultural areas (Scott et al. 2002). We have no explanation why none were captured in the sagebrush areas of the Monument.
Conservation Status and Management: Statewide, this is an unprotected nongame species ranked S5 (demonstrably widespread, abundant, and secure). Globally, gopher snakes are ranked G5 (demonstrably widespread, abundant, and secure, ICDC 2003).
Local Natural History: Average adult size was 93.1 cm SVL and 105.0 cm total length. The largest gopher snake (male) we captured measured 105.5 cm SVL and 123.5 cm total length.
Local Unusual Characteristics: See *Habitat Relationships* above. In addition, the gopher snakes at Craters tended to be darker in color than those from other parts of Idaho. This may reflect localized adaptation to match the dark color of the lava.
Anecdotal Observations of Interest: This is the most commonly reported species in the NPS wildlife database for CRMO. Gopher snakes are occasionally seen during guided tours of the Broken Top/Buffalo Caves trail by personnel in the Interpretative Division. More frequently, they can be found as road-killed animals between the Broken Top picnic area and the Tree Molds parking lot.
Focal Animal Telemetry: We radiotracked two gopher snakes during the course of our study. The first was captured 11 August 1999 in the SC array west of the Spatter Cones area (Figure 34). From there, it moved westward into Pahoehoe of the Big Craters Flow. We occasionally saw it basking at the surface, but most of the time the snake was underground when we relocated it. The capture site was in sparse Limber Pine and Bitterbrush, but the snake didn’t return to this type of habitat during the time we tracked it (until 01 September). The second gopher snake we tracked was captured in the BT array in the dense Limber Pines and Bitterbrush on the northeast slope of Broken Top (Figure 35). This snake also moved into Pahoehoe from the vegetated

habitat. The rest of our relocations of this animal were in cracks of the lava between Broken Top and the Spatter Cones. We were not able to install arrays in Pahoehoe or A'a, so if the two snakes we radiotracked behaved similarly to others in the area, then our low capture rates for this species may be explainable. The only other places (2 arrays) where we detected gopher snakes were in Limber Pine / Bitterbrush habitats located within 50 m of a lava flow. As ferns, mosses, and droppings from small mammals can be easily found in fissures in some of the lava flows, then the gopher snakes at Craters may be part of a unique community.

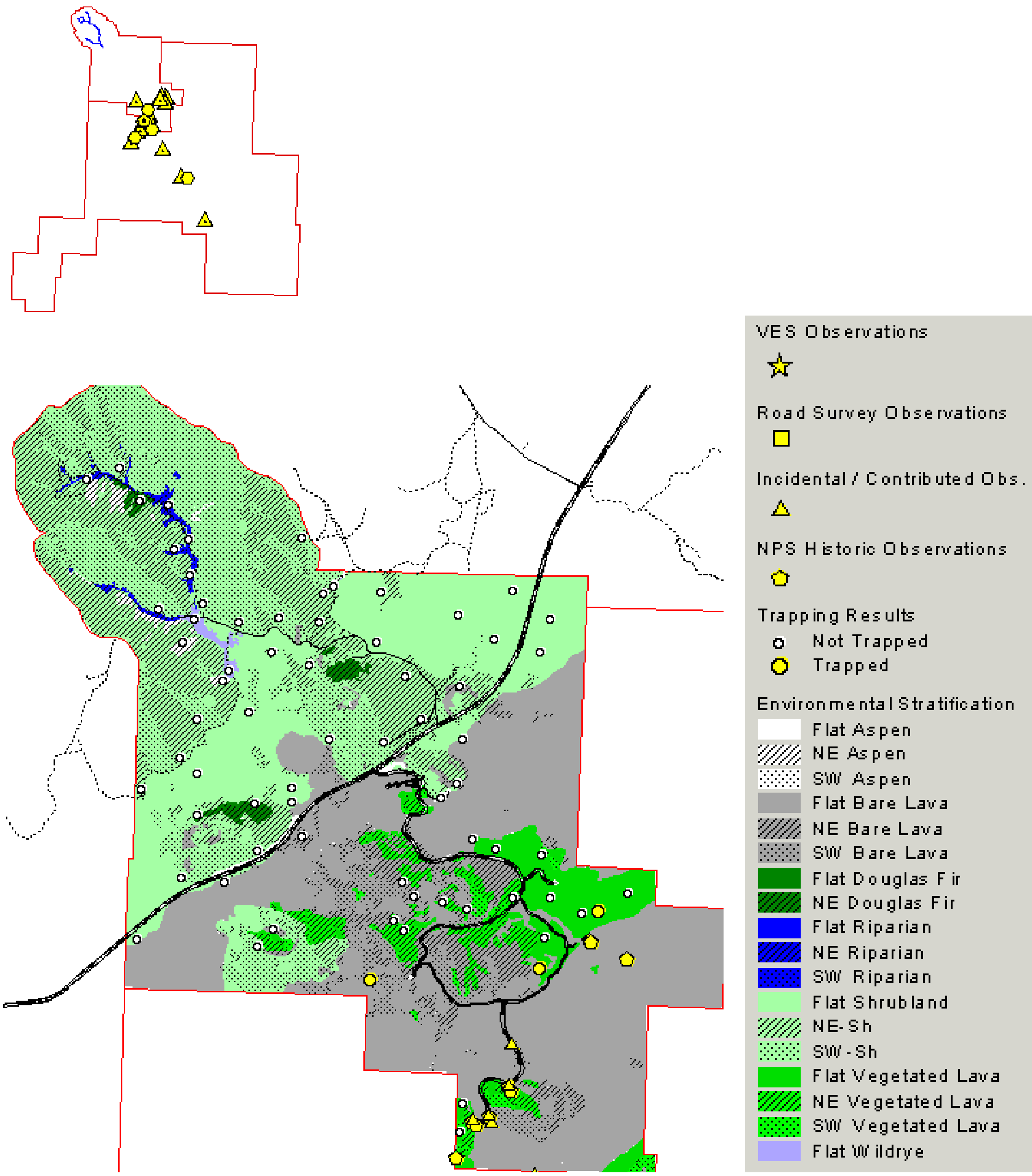


Figure 31. Distribution of Gopher Snake observations.

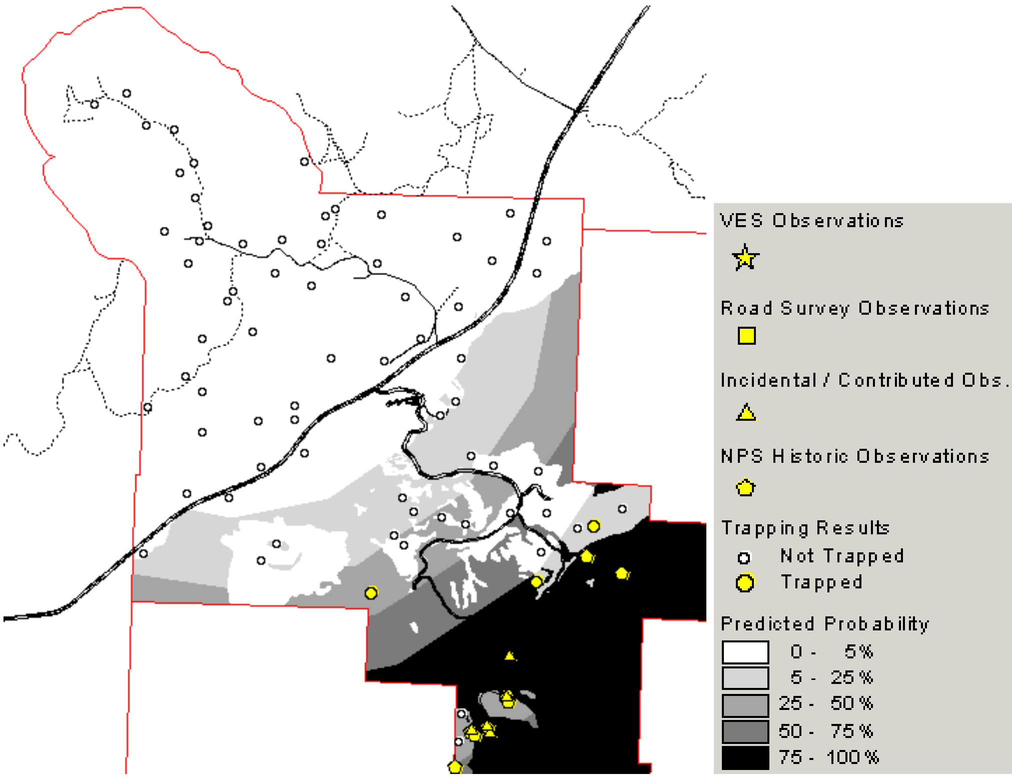


Figure 32. Probability of occurrence for Gopher Snakes for the Monument based upon logistic regression.

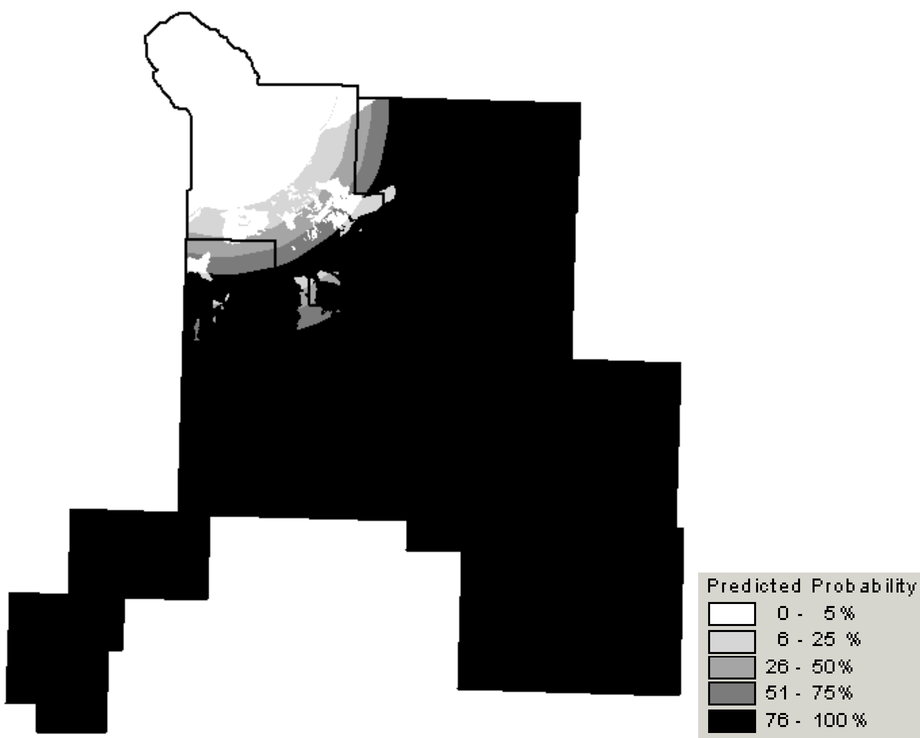
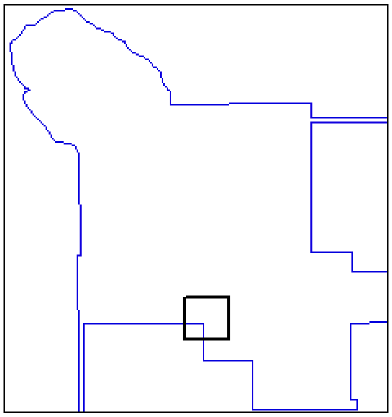


Figure 33. Probability of occurrence for Gopher Snakes for the Wilderness based on logistic regression.



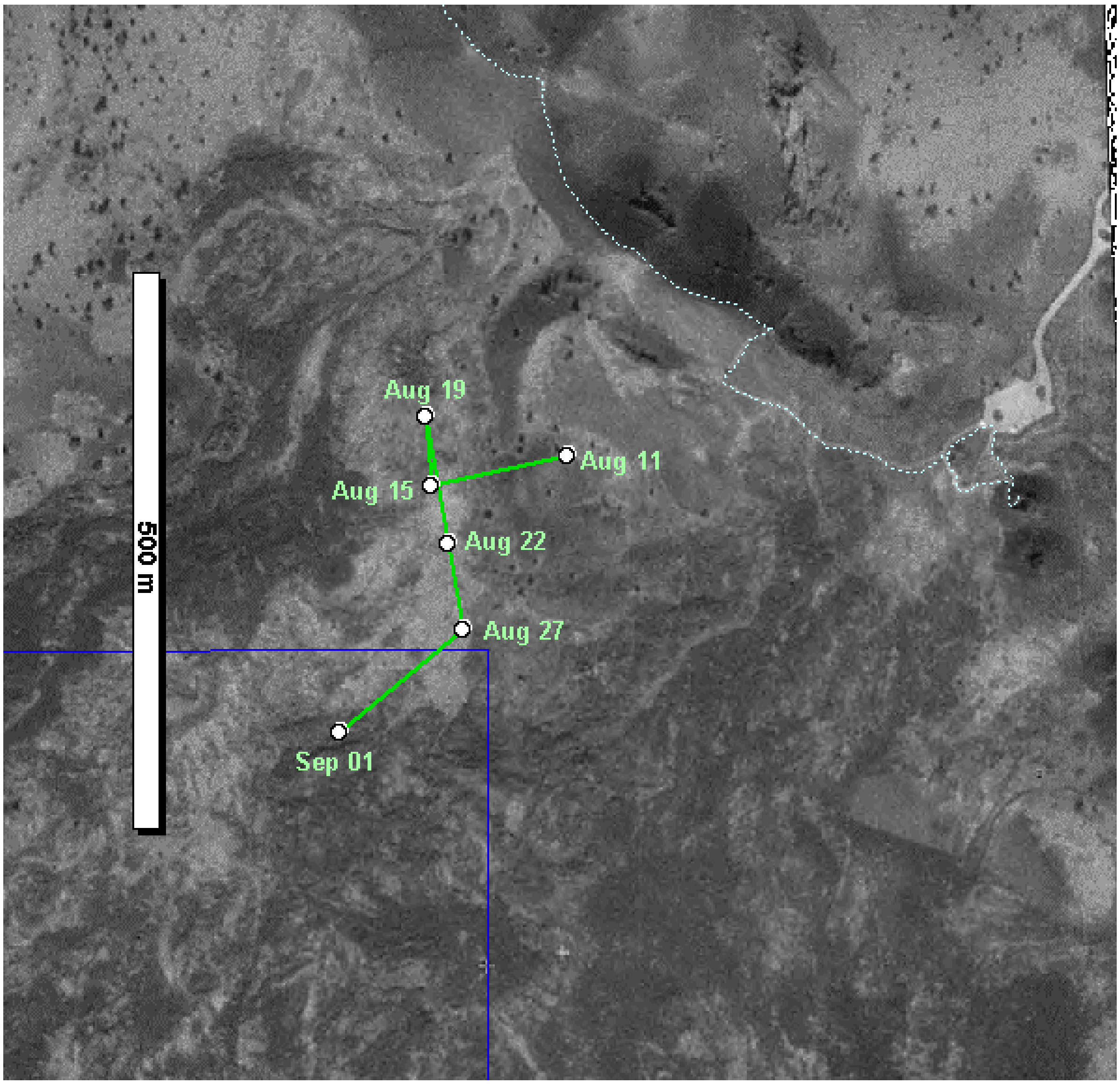


Figure 34. Movement of Gopher snake #1 at Craters of the Moon in 1999. Black square on the inset map shows location of the larger image.

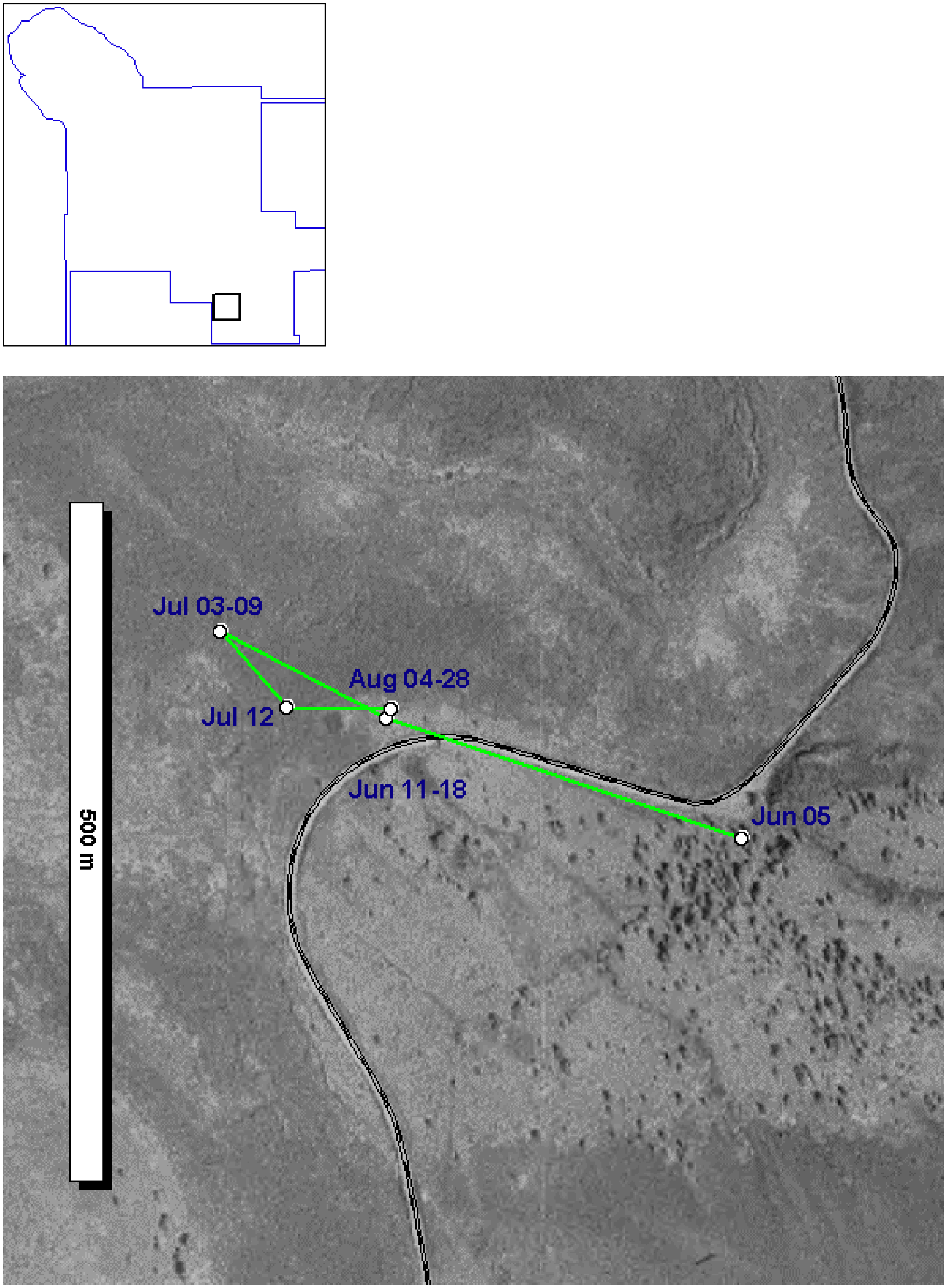


Figure 35. Movement of Gopher snake #2 at Craters of the Moon in 2001. Black square on the inset map shows location of the larger image.

Terrestrial garter snake (*Thamnophis elegans*)
Park Status: Present
Species abundance: Common
Residency: Breeder
Species nativity: Native
Species of management priority: No
Species of exploitation concern: No
Occurrence: The occurrence of terrestrial garter snakes at CRMO is documented by 64 trapping records from 16 sites, five road survey records from five sites, six contributed observations from five sites, three incidental observations from three sites, and four historic records from three sites (Figure 36).
Distribution: Garter snakes at CRMO have an intermediate distribution across the North End that was similar to that of racers, with the highest probabilities of occurrence associated with the northeastern, forested canyon slopes of the riparian areas, and the lower elevation slopes and flats along Goodale's Cutoff (Figures 37 & 38).
Relative Abundance: This was the second most trapped snake species of our study, with 64 trapping records and averaging 4.0 captures per location detected.
Habitat Relationships: At CRMO, garter snake presence was positively correlated with riparian areas (β =2.323, p=0.031). The highest probabilities of occurrence were in flat and southwestern riparian areas, aspen groves, and wildrye flats. We trapped garter snakes in the collapsed covertypes at CRMO of aspen, riparian, shrub, and wildrye. Statewide, they are usually found near water in such varied habitats as urban, disturbed, grassland, montane parkland, meadow, shrubland, forest, riparian, marsh, dunes, and lava areas (Scott et al. 2002).
Conservation Status and Management: Statewide, this is an unprotected nongame species ranked S5 (demonstrably widespread, abundant, and secure). Globally, terrestrial garter snakes arevranked G5 (demonstrably widespread, abundant, and secure, ICDC 2003).
Local Natural History: Neonates (<27.0 cm SVL) began to appear in the traps around the first week of September. Average adult size was 50.1 cm SVL and 66.5 cm total length for the males and 57.8 cm SVL and 73.1 cm total length for the females. The largest garter snake (female) we captured measured 71.8 cm SVL and 92.1 cm total length.
Local Unusual Characteristics: None noted.
Anecdotal Observations of Interest: None noted.
Focal Animal Telemetry: We captured no garter snakes that were large enough to accommodate a radiotransmitter after we began the telemetry portion of this study.

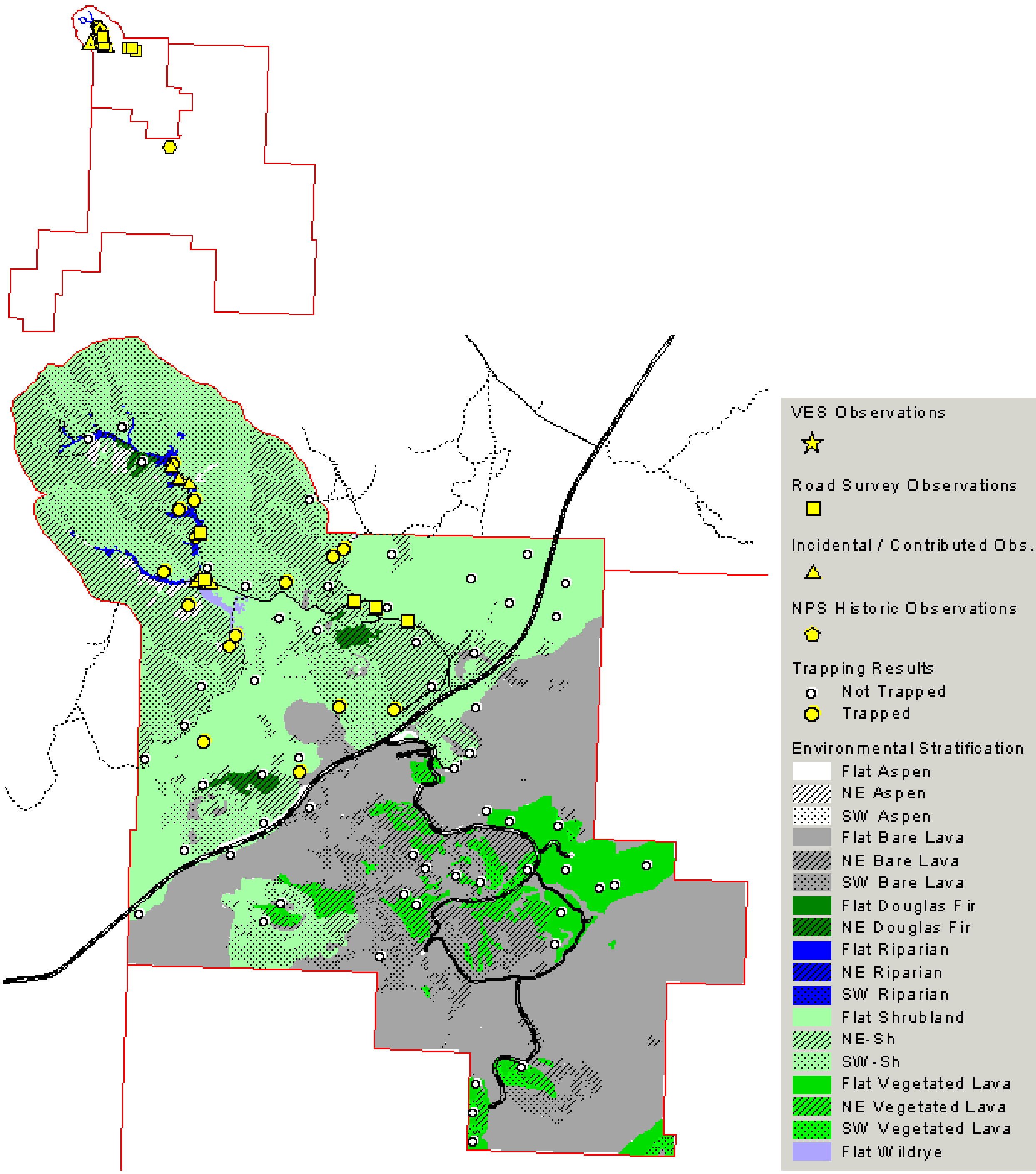


Figure 36. Distribution of Terrestrial Garter Snake observations

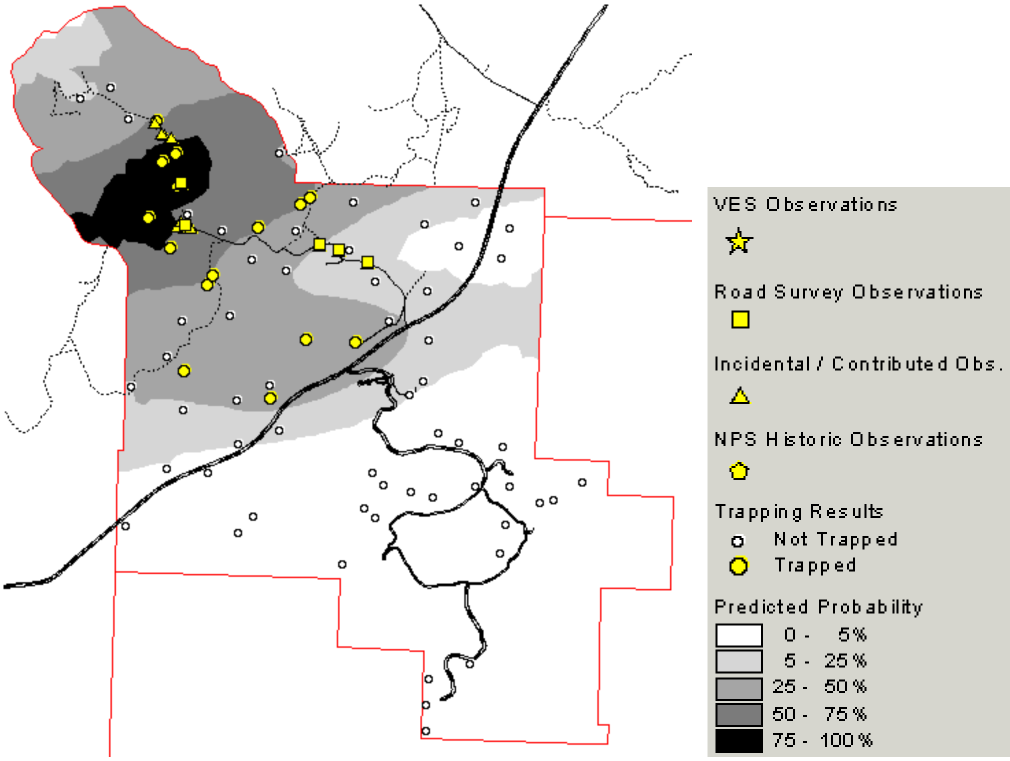


Figure 37. Probability of occurrence for Terrestrial Garter Snakes for the Monument based upon indicator kriging.

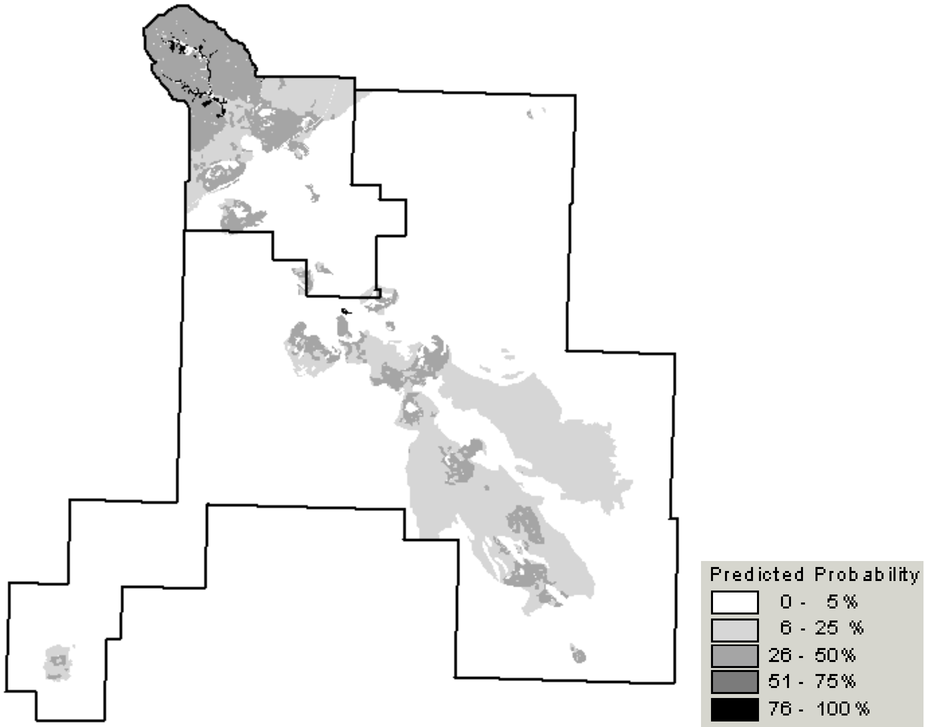


Figure 38. Probability of occurrence for Terrestrial Garter Snakes for the Wilderness based on environmental type trapping probability.

Western rattlesnake (*Crotalus viridis*)
Park Status: Present
Species abundance: Uncommon-Common
Residency: Breeder
Species nativity: Native
Species of management priority: No
Species of exploitation concern: No
Occurrence: The occurrence of western rattlesnakes at CRMO is documented by 13 trapping records from nine sites, three VES records from one site, two road survey records from two sites, 10 contributed observations from eight sites, three incidental observations from three sites, and 14 historic records from three sites (Figure 39).
Distribution: Rattlesnakes at CRMO had an intermediate distribution across the North End, with the highest probabilities of occurrence along Goodale's Cutoff and along the highway (Figures 40 and 41). We only trapped rattlesnakes on the areas to the north of the lava flows; however, historic and contributed observations indicate that they may occasionally be seen in lava as well.
Relative Abundance: We trapped relatively few (13) rattlesnakes. During the spring and fall, they can be seen in relatively high numbers around the den, but they are encountered only rarely in the summer.
Habitat Relationships: Rattlesnakes at CRMO were (marginally) negatively associated with vegetated lava (β =-1.00, p=0.057). We trapped only them in the collapsed covertypes of shrublands and wildrye. Elsewhere in Idaho, they can be found in grasslands, montane parklands, meadows, shrublands, forests, riparian, marsh, dunes, and lava areas (Scott et al. 2002).
Conservation Status and Management: Statewide, this is an unprotected nongame species ranked S5 (demonstrably widespread, abundant, and secure). Globally, Western Rattlesnakes are ranked G5 (demonstrably widespread, abundant, and secure, ICDC 2003).
Local Natural History: Average adult size was 76.6 cm SVL and 82.4 cm total length for males and 64.1 cm SVL and 67.9 cm total length for females. The largest rattlesnake (male) we captured measured 101.5 cm SVL and 108.9 cm total length.
Local Unusual Characteristics: We captured no neonates or juveniles in our traps during this study. The only young rattlesnakes observed were two dead neonates found with a postpartum female near a communal den. This communal den was the only one found during the study, and is located upslope from the WC3 trap site. Physically, the den is a talus slope adjacent to a large rocky outcrop.
Anecdotal Observations of Interest: See below.
Focal Animal Telemetry: We radiotracked two rattlesnakes during this study. The first was captured by hand at the Research Camp on 21 July 1999. We tracked it until it entered the communal den on 10 Sep of 1999 (Figure 42). When it emerged from hibernation in the spring of 2000, we captured it and replaced the transmitter on 01 June. During the spring and summer of 2000, it returned to many of the locations of the previous year, but we never observed it returning to the riparian areas or the creeks. The second rattlesnake was captured 02 June 2001 crossing the north end road roughly 200 m north of the gate on the highway (Figure 43). Interestingly, this snake stayed in areas adjacent to the highway for the entire time we tracked it. At some point between the third and fifth of August, this snake was presumably eaten by a predator. We found the transmitter alone with its antenna wire mangled. We were unable to locate the snake's carcass or to determine the cause of death.

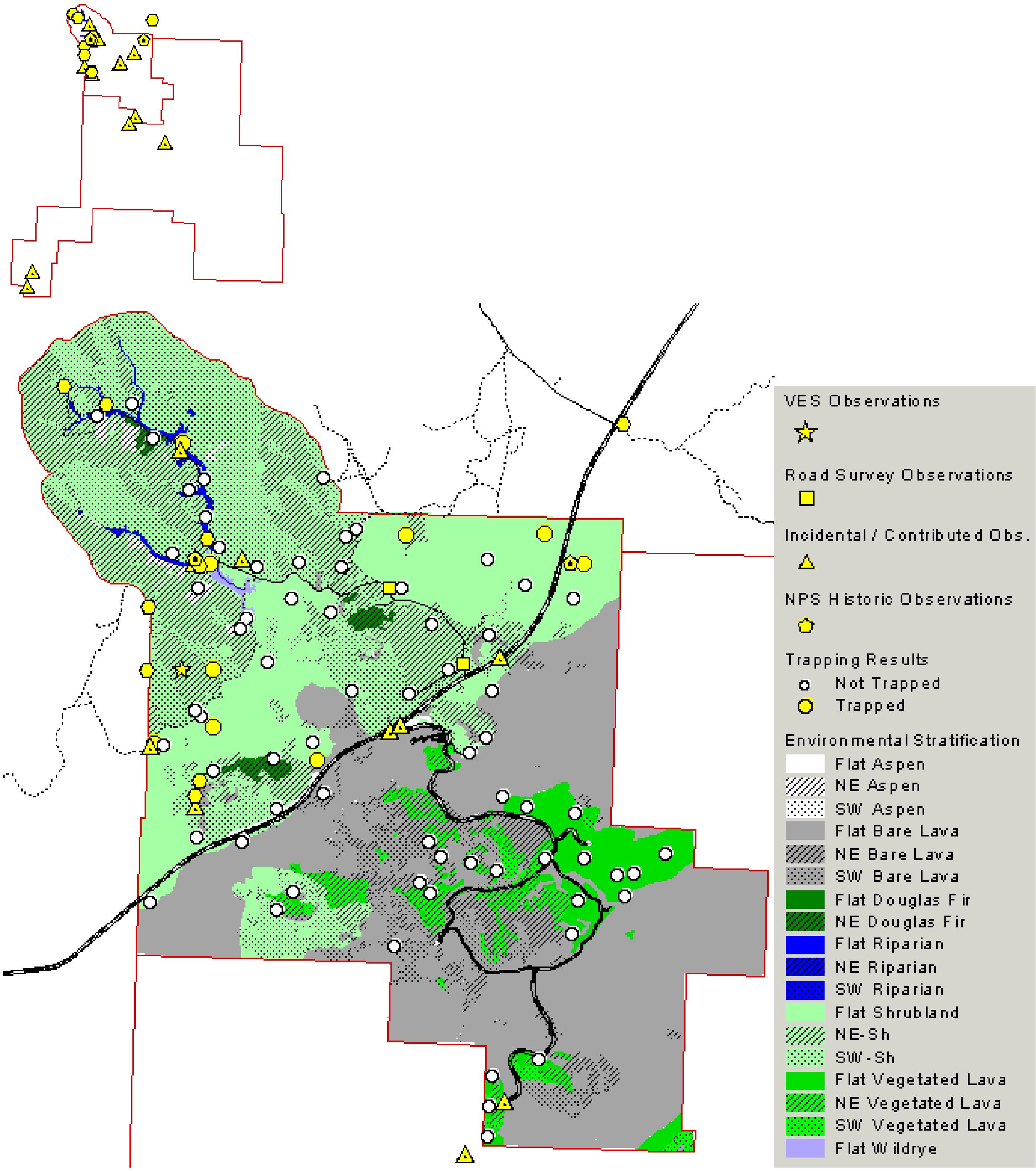


Figure 39. Distribution of Western Rattlesnake observations.

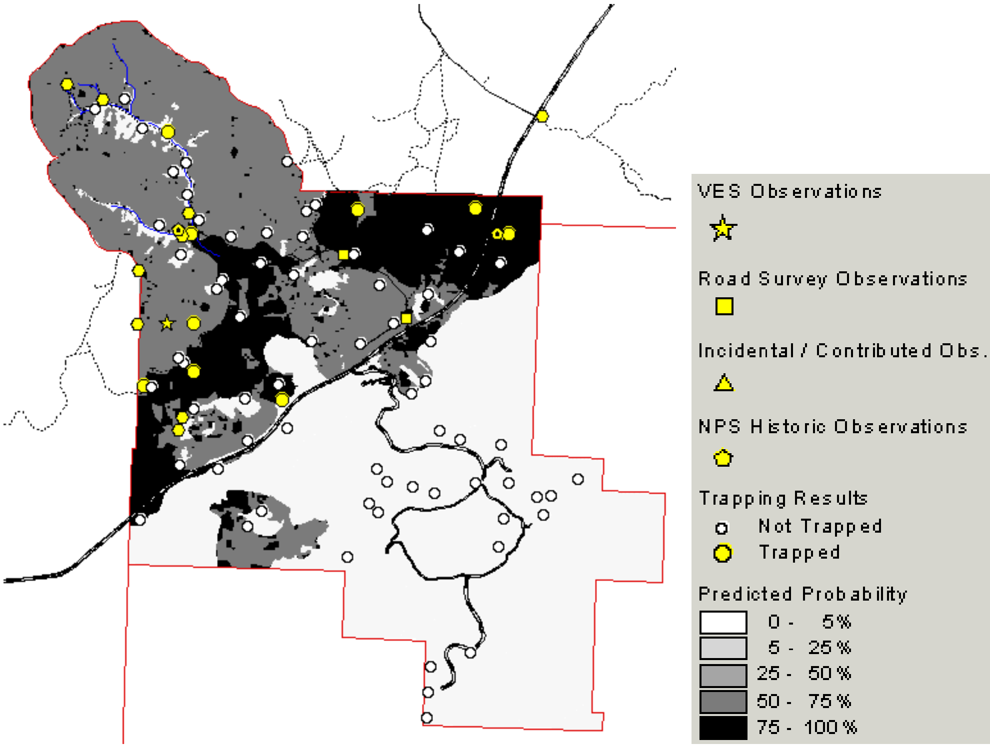


Figure 40. Probability of occurrence for Rattlesnakes for the Monument based upon environmental type trapping probability.

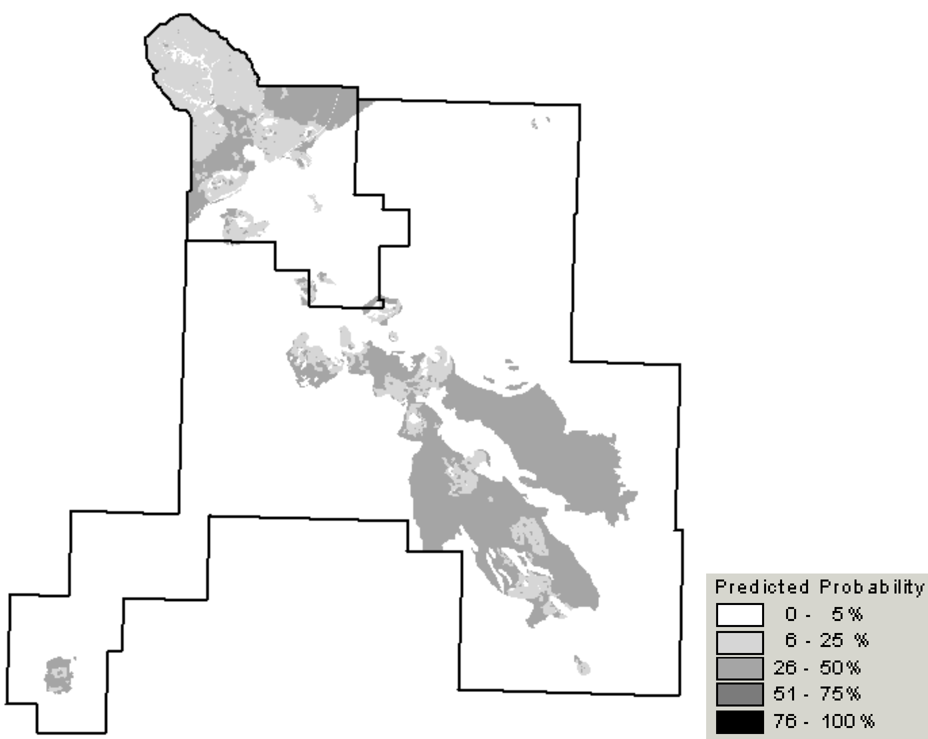


Figure 41. Probability of occurrence for Rattlesnakes for the Wilderness based on environmental type trapping probability.

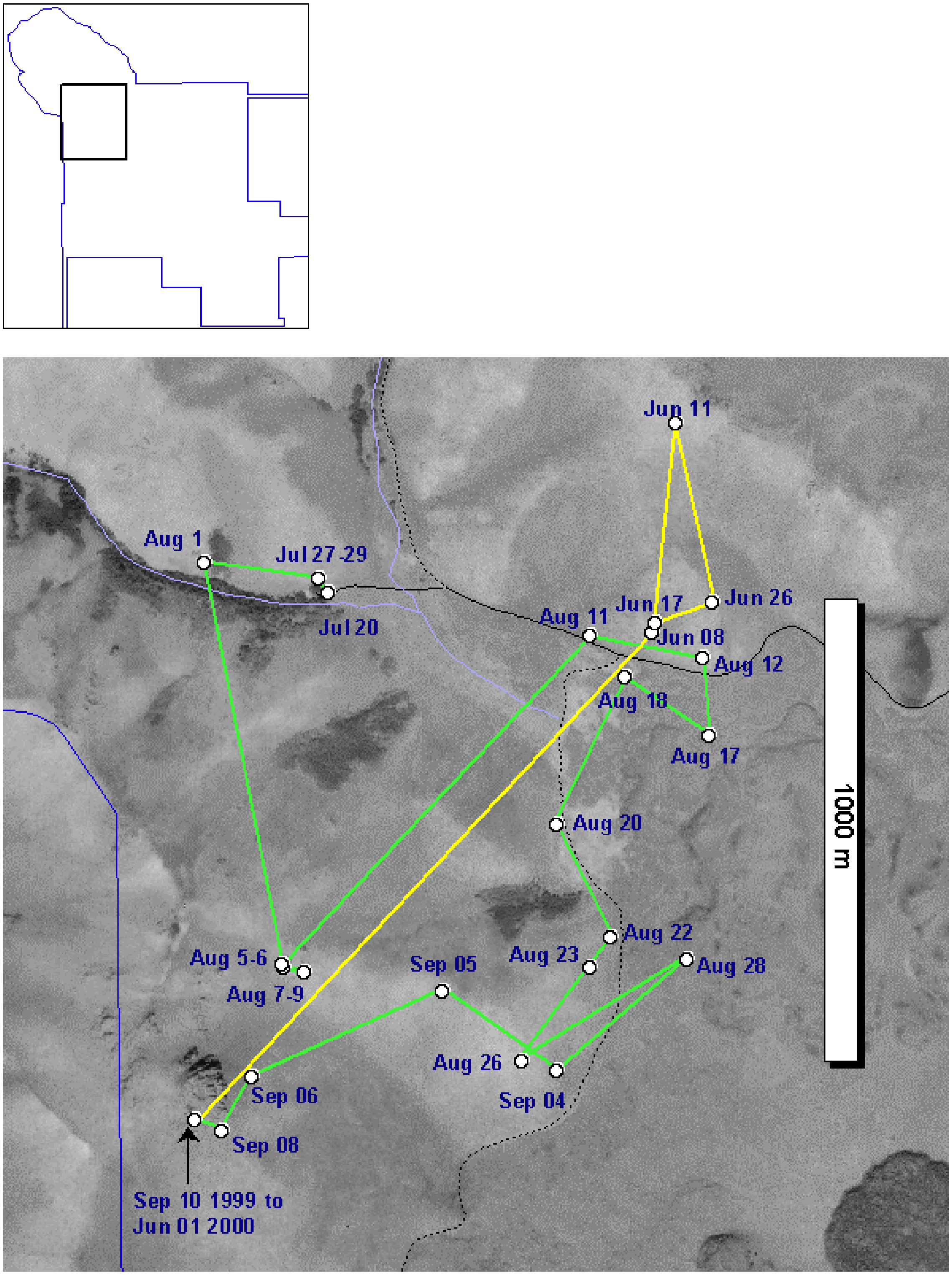
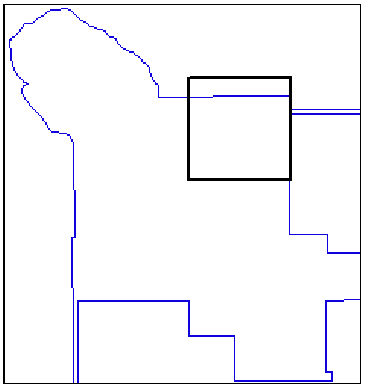


Figure 42. Movements of Rattlesnake #1 at Craters of the Moon for 1999-2000. Black square on the inset map shows location of the larger image. Movements for 2000 shown in yellow.



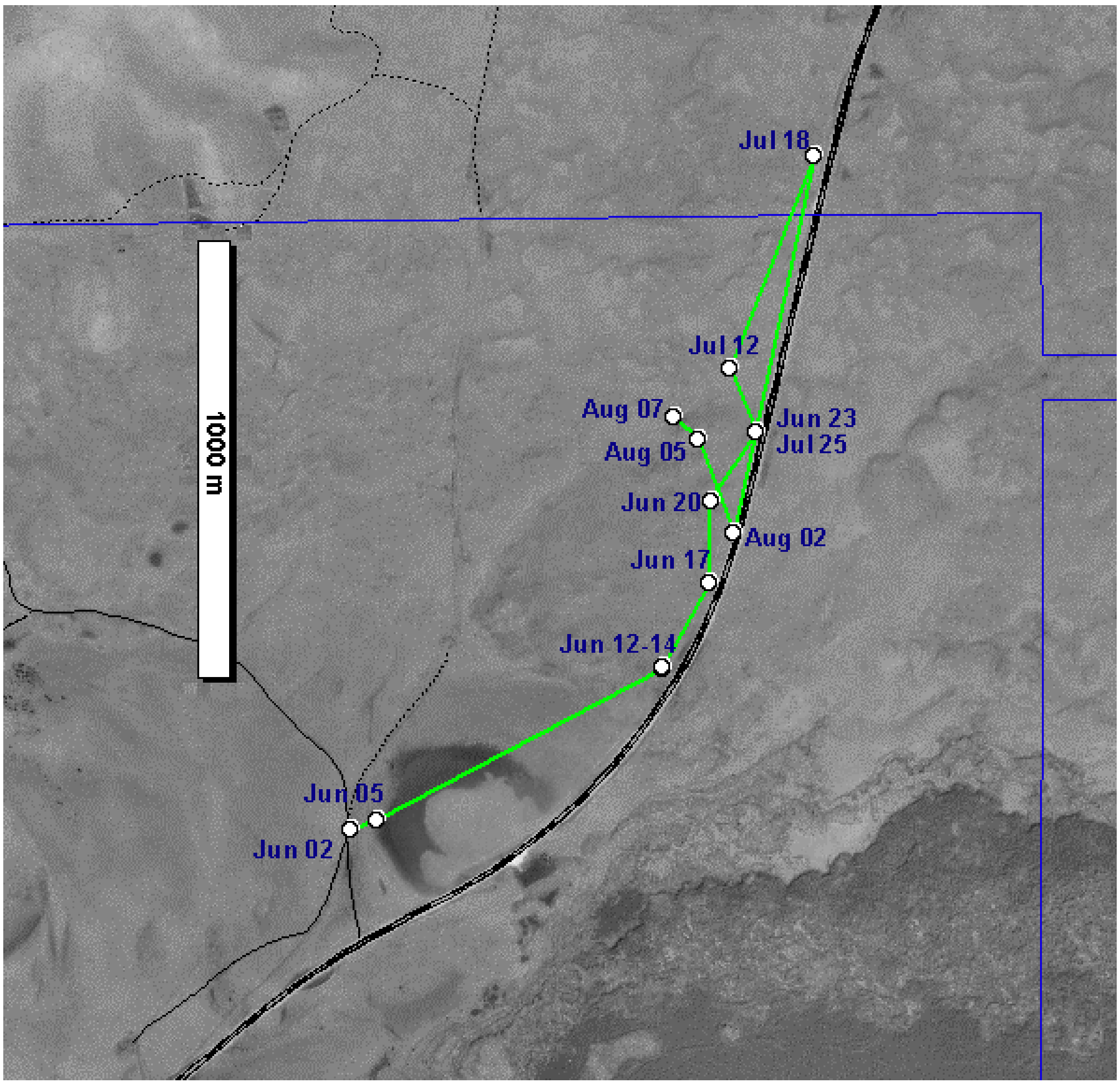


Figure 43. Movements of Rattlesnake #2 at Craters of the Moon for 2000. Black square on the inset map shows location of the larger image.

Unobserved Species

Long-toed salamander (*Ambystoma macrodactylum*)

Little Cottonwood and Leech Creeks have the appropriate habitat for this species, with the exception of breeding areas. This species is found in moist areas of desert brush, open forests, dry woodlands, humid forests, and along rocky shores of mountain lakes. It breeds in small ponds, vernal pools, or small lakes. Such habitat apparently existed up until the last decade at the Martin Mine site. This species is not obvious, usually only being found as larvae in the breeding areas, or under rocks or logs as adults, so presence of these salamanders could easily have been missed in the past. Known populations exist 28 km to the west in the Fish Creek drainage, and so it is possible that this species historically occurred on the Monument. If so, its future natural reestablishment would depend on the return of beavers (or other sources of permanent water) combined with adequate connectivity of appropriate habitat between CRMO and a source population. Such a combination of factors may not be possible.

Boreal chorus frog (*Pseudacris maculata*)

The occurrence of Pacific treefrogs at CRMO is known only from an historical record in 1988, and unverified contributed observations in 1999. These observations (captured in 1988, only heard in 1999) were from the residence area of the Monument. This small species can possibly be transported with firewood or on recreational vehicles. Given the location and circumstances of the observations, and the lack of breeding habitat (below), this species is probably not a resident of the Monument. Considering the number of visitors to the park each year, and the paucity of observations of this species, during the three years of our study, we consider it rare to encounter this species. Statewide, this species is associated with damp grassy or marshy areas, damp wooded areas, or along ditches or other sources of water (Nussbaum et al. 1983).

Western toad (*Bufo boreas*)

This species was last observed in the Monument in 1987. This species is usually detected in lakes or ponds as adults in spring and summer during breeding activities, or as larvae or metamorphs. The historical records for CRMO indicate adults being observed in the campground and vicinity of the visitor’s center. Western Toads were observed in Arco and Mackay in 2000 and 2001 by NPS and BLM personnel. However, this species has disappeared from many parts of its historic range across southeastern Idaho for reasons not completely understood, and so return of adequate breeding habitat to the Monument would not insure return of this species.

Great Basin spadefoot (*Spea intermontana*)

The predicted range of this species encompasses CRMO, and large numbers can be observed in the Big Lost River sinks and spreading areas on the INEEL during normal to high water years. Spadefoots are usually found in dry, sandy, soils, and they have the ability to aestivate for years at a time. Following heavy storms, these animals may emerge from the ground in large numbers to breed in temporary ponds. When no permanent water sources exist in their preferred habitat, detecting this species is difficult during times without adequate heavy rains. Given the prevailing conditions during the 1999–2001 summers when we conducted this study, it is possible that we failed to detect this species, as they remained underground.

Columbia spotted frog (*Rana lutieventris*)
The Monument is within the predicted range of this species, and historical records suggest it may have been present at the Martin Mine site as recently as 1975 when the beaver ponds were active. Spotted frogs can still be found in the Fish Creek drainage, and this species has the ability to disperse to adjacent drainagess (Pilliod 2001). Possibly, this species historically occurred in the north end, but left with the decline of the beaver ponds and/or reclamation of the Martin Mine site. If beaver become reestablished in the north end, spotted frogs could potentially have the highest probability of recolonizing the Monument of all the historically-occurring amphibian species.

Night snake (*Hypsiglena torquata*)
The study area is within the predicted range of this species, and it has been observed in Arco and east of Butte City on the INEEL. Terrestrial funnel trapping is the best way to detect this species, but even in areas where this snake occurs, the low capture rates can make detection problematic. Little is known about this species in general for Idaho, and any observations from CRMO would be very important with regards to broadening our current understanding of the statewide distribution of nightsnakes.

Striped whipsnake (*Masticophis taeniatus*)
These snakes occur northeast, east, and south of CRMO, and the appropriate habitat of rocky slopes, canyons, and open flats is found on the Monument. At the Orchard Training Area near the Snake River Birds of Prey Area, this species was trapped commonly in sage/rabbitbrush. This snake is most commonly associated with parts of the Great Basin ecosystem farther to the southwest, and consequently CRMO may be slightly above its elevational range. Discovery of this species along the eastern and/or southern boundaries of the Monument would not be surprising.

Long-nosed leopard lizard (*Gambelia wislizenii*)
This species is also most typically associated with parts of the state farther to the southwest. What is hypothesized to be a relict population exists on Circular Butte of the INEEL, and individuals have been caught just west of American Falls. In 2001, this species was discovered along the boundary of the expansion area to the southwest of Carey Kipuka. It potentially could be found near Laidlaw Park, or other areas along the southern boundary.

Desert horned lizard (*Phrynosoma platyrhinos*)
These lizards fall into the same general distribution pattern for southern Idaho as striped whipsnakes and long-nosed leopard lizards. Historical records exist from northeast of Jerome, and we discovered this species at one location in the Expansion with leopard lizards. Thus, we feel that this species too may potentially occur along the southern boundary of the Monument.

Sampling Site Characteristics

The characteristics of the 73 sites trapped are given in Table 4. Because of the unique character of the landscape at CRMO, many of the environmental types were spatially confounded. This is reflected in the riparian, aspen, Douglas fir, and sagebrush occurring almost completely north of the highway, and the vast majority of the lava and limber pine occurring south of the highway (Figure 2). Also notable are the relative levels of cover type heterogeneity; high north of the highway and lower to the south.

Table 4. Summary of site characteristics and captures. Descriptions of column headings given in Appendix D.

Site	Northing	Easting	Open1	Close1	Open2	Close2	Open3	Close3	Open4	Close4	Open5	Close5	Set	Days	Colveg
CA1	4813555	294964	27-Jun-99	16-Sep-99	17-May-00	1-Jul-00							1	126	Vegetated lava
DO	4814202	294533	27-Jun-99	16-Sep-99	17-May-00	1-Jul-00							1	126	Vegetated lava
EC1	4817026	292181	20-Jun-99	15-Sep-99	18-May-00	2-Jul-00							1	132	Shrubland
EC2	4817100	292293	20-Jun-99	15-Sep-99	18-May-00	2-Jul-00							1	132	Wildrye
GC1	4814747	291442	20-Jun-99	15-Sep-99	18-May-00	2-Jul-00							1	129	Doug-fir
GCG	4816250	292029	11-Jul-99	16-Sep-99	17-May-00	1-Jul-00							1	112	Bare lava
H02	4815446	293683	9-Jul-99	16-Sep-99	17-May-00	1-Jul-00							1	114	Bare lava
H03	4814761	291832	29-Jun-99	15-Sep-99	18-May-00	2-Jul-00							1	123	Shrubland
LC1	4818388	289980	20-Jun-99	15-Sep-99	18-May-00	2-Jul-00							1	132	Shrubland
LC3	4817605	290724	29-Jun-99	15-Sep-99	18-May-00	2-Jul-00							1	123	Riparian
LC4	4817509	290576	20-Jun-99	15-Sep-99	18-May-00	2-Jul-00							1	132	Shrubland
NEG	4816020	293656	18-Jul-99	16-Sep-99	17-May-00	1-Jul-00							1	105	Bare lava
NHF	4814920	291833	23-Jun-99	15-Sep-99	18-May-00	2-Jul-00							1	129	Shrubland
NLR	4813605	293724	3-Jul-99	16-Sep-99	17-May-00	1-Jul-00							1	120	Bare lava
NWLR	4813376	293053	9-Jul-99	16-Sep-99	17-May-00	1-Jul-00							1	114	Vegetated lava
OHQ1	4813898	293030	9-Jul-99	16-Sep-99	17-May-00	1-Jul-00							1	114	Vegetated lava
OHQ2	4813749	293160	9-Jul-99	16-Sep-99	17-May-00	1-Jul-00							1	114	Bare lava
OHQ3	4813683	293466	9-Jul-99	16-Sep-99	17-May-00	1-Jul-00							1	114	Vegetated lava
RC1	4816916	290875	20-Jun-99	15-Sep-99	18-May-00	2-Jul-00							1	132	Shrubland
RC3	4816506	290665	23-Jun-99	15-Sep-99	18-May-00	2-Jul-00							1	129	Aspen

Table 4. (Continued) Summary of site characteristics and captures. Descriptions of column headings given in Appendix D.

Site	Northing	Easting	Open1	Close1	Open2	Close2	Open3	Close3	Open4	Close4	Open5	Close5	Set	Days	Colveg
SC	4812830	292679	12-Jul-99	16-Sep-99	17-May-00	1-Jul-00							1	111	Bare lava
SELR	4812954	294501	3-Jul-99	16-Sep-99	17-May-00	1-Jul-00							1	120	Bare lava
WC1	4816186	291164	20-Jun-99	15-Sep-99	18-May-00	2-Jul-00							1	132	Wildrye
WC3	4815663	290817	20-Jun-99	15-Sep-99	18-May-00	2-Jul-00							1	132	Shrubland
BT	4811673	294165					24-Jul-00	10-Sep-00	10-May-01	3-Jul-01			2	102	Vegetated lava
DO2	4813731	294619					24-Jul-00	10-Sep-00	10-May-01	3-Jul-01			2	102	Vegetated lava
EC3	4817048	292804					23-Jul-00	10-Sep-00	9-May-01	2-Jul-01			2	103	Shrubland
ELR	4813298	294567					24-Jul-00	10-Sep-00	19-May-01	3-Jul-01			2	93	Vegetated lava
GCG2	4816493	292751					23-Jul-00	10-Sep-00	9-May-01	2-Jul-01			2	103	Shrubland
H05	4817059	294215					23-Jul-00	10-Sep-00	9-May-01	2-Jul-01			2	103	Shrubland
H06	4816394	294519					24-Jul-00	10-Sep-00	10-May-01	3-Jul-01			2	102	Shrubland
H07	4813895	291107					24-Jul-00	10-Sep-00	10-May-01	3-Jul-01			2	102	Shrubland
H08	4813945	290641					23-Jul-00	10-Sep-00	9-May-01	2-Jul-01			2	103	Shrubland
H09	4813282	290165					24-Jul-00	10-Sep-00	10-May-01	3-Jul-01			2	102	Shrubland
LC5	4818032	290195					23-Jul-00	9-Sep-00	9-May-01	2-Jul-01			2	102	Doug-fir
LC6	4817232	290747					23-Jul-00	9-Sep-00	9-May-01	2-Jul-01			2	102	Riparian
MDH	4816756	291693					23-Jul-00	10-Sep-00	9-May-01	2-Jul-01			2	103	Shrubland
NWLR2	4813490	292931					24-Jul-00	10-Sep-00	19-May-01	3-Jul-01			2	93	Vegetated lava
PC1	4814366	293791					24-Jul-00	10-Sep-00	19-May-01	3-Jul-01			2	93	Vegetated lava
PC2	4814250	294029					24-Jul-00	10-Sep-00	19-May-01	3-Jul-01			2	93	Vegetated lava
RC4	4816856	290405					23-Jul-00	9-Sep-00	9-May-01	2-Jul-01			2	102	Aspen

Table 4. (Continued) Summary of site characteristics and captures. Descriptions of column headings given in Appendix D.

Site	Northing	Easting	Open1	Close1	Open2	Close2	Open3	Close3	Open4	Close4	Open5	Close5	Set	Days	Colveg
SiC1	4813390	291635					24-Jul-00	10-Sep-00	10-May-01	3-Jul-01			2	102	Shrubland
SiC2	4813197	291470					24-Jul-00	10-Sep-00	10-May-01	3-Jul-01			2	103	Shrubland
SSC1	4815666	293224					23-Jul-00	10-Sep-00	9-May-01	2-Jul-01			2	103	Shrubland
SSC2	4815419	292822					23-Jul-00	10-Sep-00	9-May-01	2-Jul-01			2	103	Shrubland
SSC3	4815447	292247					23-Jul-00	10-Sep-00	9-May-01	2-Jul-01			2	103	Shrubland
TM2	4811194	293644					24-Jul-00	10-Sep-00	19-May-01	3-Jul-01			2	93	Shrubland
WC6	4815738	291375					23-Jul-00	9-Sep-00	9-May-01	2-Jul-01			2	102	Shrubland
CA4	4813779	295459									5-Aug-01	7-Sep-01	3	33	Vegetated lava
DHC	4816388	291619									4-Aug-01	6-Sep-01	3	33	Shrubland
EC4	4816716	292140									4-Aug-01	6-Sep-01	3	33	Shrubland
H10	4816537	294027									5-Aug-01	7-Sep-01	3	33	Shrubland
H11	4814235	291466									5-Aug-01	7-Sep-01	3	33	Shrubland
LC7	4818268	289630									4-Aug-01	6-Sep-01	3	33	Riparian
LRI	4813731	294215									5-Aug-01	7-Sep-01	3	33	Vegetated lava
MFN	4816799	293639									4-Aug-01	6-Sep-01	3	33	Shrubland
QSC	4817629	291947									4-Aug-01	6-Sep-01	3	33	Shrubland
SSC4	4816133	293061									4-Aug-01	6-Sep-01	3	33	Shrubland
TM3	4811498	293674									5-Aug-01	7-Sep-01	3	33	Shrubland
WC7	4815250	290632									4-Aug-01	6-Sep-01	3	33	Shrubland
NERI	4816719	291271									4-Aug-01	6-Sep-01	3	33	Shrubland
GC2	4814628	290821	23-Jun-99	15-Sep-99	18-May-00	2-Jul-00	24-Jul-00	10-Sep-00	10-May-01	3-Jul-01	5-Aug-01	7-Sep-01	LT	129	Doug-fir
B1	4814810	293452	9-Jul-99	16-Sep-99	17-May-00	1-Jul-00	24-Jul-00	10-Sep-00	10-May-01	3-Jul-01	5-Aug-01	7-Sep-01	LT	249	Shrubland
B2	4814961	293612	26-Jun-99	16-Sep-99	17-May-00	1-Jul-00	24-Jul-00	10-Sep-00	10-May-01	3-Jul-01	5-Aug-01	7-Sep-01	LT	262	Bare lava
CA2	4813577	295135	27-Jun-99	16-Sep-99	17-May-00	1-Jul-00	24-Jul-00	10-Sep-00	10-May-01	3-Jul-01	5-Aug-01	7-Sep-01	LT	261	Vegetated lava
H01	4816744	294622	9-Jul-99	16-Sep-99	17-May-00	1-Jul-00	24-Jul-00	10-Sep-00	10-May-01	3-Jul-01	5-Aug-01	7-Sep-01	LT	249	Shrubland
H04	4814393	291940	12-Jul-99	16-Sep-99	17-May-00	1-Jul-00	24-Jul-00	10-Sep-00	19-May-01	3-Jul-01	5-Aug-01	7-Sep-01	LT	237	Bare lava

Table 4. (continued) Summary of site characteristics and captures. Descriptions of column headings given in Appendix D.

Site	Northing	Easting	Open1	Close1	Open2	Close2	Open3	Close3	Open4	Close4	Open5	Close5	Set	Days	Colveg
LC2	4817988	290508	20-Jun-99	15-Sep-99	18-May-00	2-Jul-00	23-Jul-00	9-Sep-00	9-May-01	2-Jul-01	4-Aug-01	6-Sep-01	LT	267	Shrubland
TM	4810882	293640	27-Jun-99	16-Sep-99	17-May-00	1-Jul-00	24-Jul-00	10-Sep-00	19-May-01	3-Jul-01	5-Aug-01	7-Sep-01	LT	252	Shrubland
WC2	4816081	291101	20-Jun-99	18-May-00	18-May-00	2-Jul-00	23-Jul-00	9-Sep-00	9-May-01	2-Jul-01	4-Aug-01	6-Sep-01	LT	267	Aspen
WC4	4815072	290822	20-Jun-99	15-Sep-99	18-May-00	2-Jul-00	23-Jul-00	10-Sep-00	9-May-01	2-Jul-01	4-Aug-01	6-Sep-01	LT	268	Shrubland
WC5	4814906	290216	20-Jun-99	15-Sep-99	18-May-00	2-Jul-00	23-Jul-00	9-Sep-00	9-May-01	2-Jul-01	4-Aug-01	6-Sep-01	LT	267	Shrubland

Technique Relative Effectiveness

The techniques we used differed in their ability to detect the species of reptiles at Craters of the Moon (Table 7). Trapping, contributed observations, and incidental observations each detected all eight reptile species. Road driving surveys detected five species, and VES detected four species. Though trapping produced the highest total number of captures, it was not the best technique for all species. We only trapped six gopher snakes, while receiving eight contributed and incidental observations (seven and one, respectively). Similarly, we trapped nine shorthorned lizards, and received 19 contributed (10) and incidental (9) observations. That our VES efforts produced only 4% of our total observations was unexpected. In the appropriate habitats and at the appropriate times of the year, this has been a very successful technique in our other studies. We believe the reason this technique was of limited usefulness at Craters of the Moon to be related to the low numbers and densities of reptiles overall at the Monument.

Table 7. Summary of occurrence data.

Common	Scientific	Trapping		VES		Driving	
name	name	records	sites	records	sites	records	sites
Pacific treefrog	*Pseudacris regilla*	0	0	0	0	0	0
western skink	*Eumeces skiltonianus*	58	19	0	0	0	0
short-horned lizard	*Phrysoma douglassii*	9	6	2	2	2	1
sagebrush lizard	*Sceloporus undulatus*	323	34	27	10	13	13
rubber boa	*Charina bottae*	80	30	0	0	7	5
racer	*Coluber constrictor*	50	18	2	2	0	0
gopher snake	*Pitouphis catenifer*	6	4	0	0	0	0
wandering terrestrial garter snake	*Thamnophis elegans*	64	16	0	0	5	5
western rattlesnake	*Crotalus viridis*	13	9	3	1	2	2
	Snakes	213	43	5	3	14	12
	Lizards	390	50	29	12	15	14
	All	603	65	34	15	29	26

Common	Contributed		Incidental		NPS Historic		Total	
name	records	sites	records	sites	records	sites	records	sites
Pacific treefrog	0	0	2	2	0	0	2	2
western skink	3	2	2	2	11	10	74	33
short-horned lizard	10	10	9	7	6	6	38	32
sagebrush lizard	10	9	24	14	5	3	402	83
rubber boa	3	3	5	5	10	10	105	53
racer	5	3	6	6	1	1	64	30
gopher snake	7	6	1	1	29	22	43	33
wandering terrestrial garter snake	6	5	3	3	4	3	82	32
western rattlesnake	10	8	3	3	14	3	45	26
total snakes	31	25	18	18	58	39	339	174
total lizards	23	21	35	23	22	19	514	148
All	54	46	53	41	80	58	853	322

Repeatability of Trapping

Even though the density of reptiles at Craters of the Moon was low, our trapping had an overall repeatability of 83.8% over the three field seasons of the study (Table 11). The 12 long-term arrays detected an average of 2.9 species (ranging from one to five), and repeatability ranged from 64% to 93%. Repeatability was highest in those arrays that detected the fewest species (Figures 44-45). On a per species basis, repeatability ranged from 71% for rubber boas to 95% for gopher snakes and short-horned lizards. Species that were detected in the most arrays tended to have lower repeatability than did the less-widely distributed species (Figure 46). Interestingly, however, species repeatability was not affected by local abundance (Figure 47).

Table 11. Repeatability by site for long-term arrays at Craters of the Moon.

		Number of years detected									
Site	Covertype	rubber boa	racer	western rattlesnake	gopher snake	terrestrial garter snake	western skink	pigmy short-horned lizard	sagebrush lizard	Array Repeat-ability	Number of Species
LC2	riparian	2	1	1		3				0.78	4
RC2	wildrye	1	2	1		3			1	0.71	5
WC2	aspen	3	2			1				0.86	3
GC2	Douglas fir	1							2	0.86	2
H1	shrubland	1	3	2				2		0.78	4
WC4	shrubland	2	2	1		1	1		3	0.64	6
WC5	shrubland	3	2	1					3	0.86	4
B1	veg lava						1			0.93	1
CA2	veg lava				1		2			0.86	2
TM	veg lava								1	0.93	1
B2	bare lava	1								0.93	1
H4	bare lava	3							1	0.93	2
	Average	1.9	2	1.2	1	2	1.3	2	1.8	0.838	2.9
	Repeatability	0.71	0.76	0.76	0.95	0.9	0.86	0.95	0.81		
	# individuals	28	26	8	1	38	6	3	50		
	# sites	9	6	5	1	4	3	1	6		
	ind/site	3.1	4.3	1.6	1	9.5	2	3	8.3		

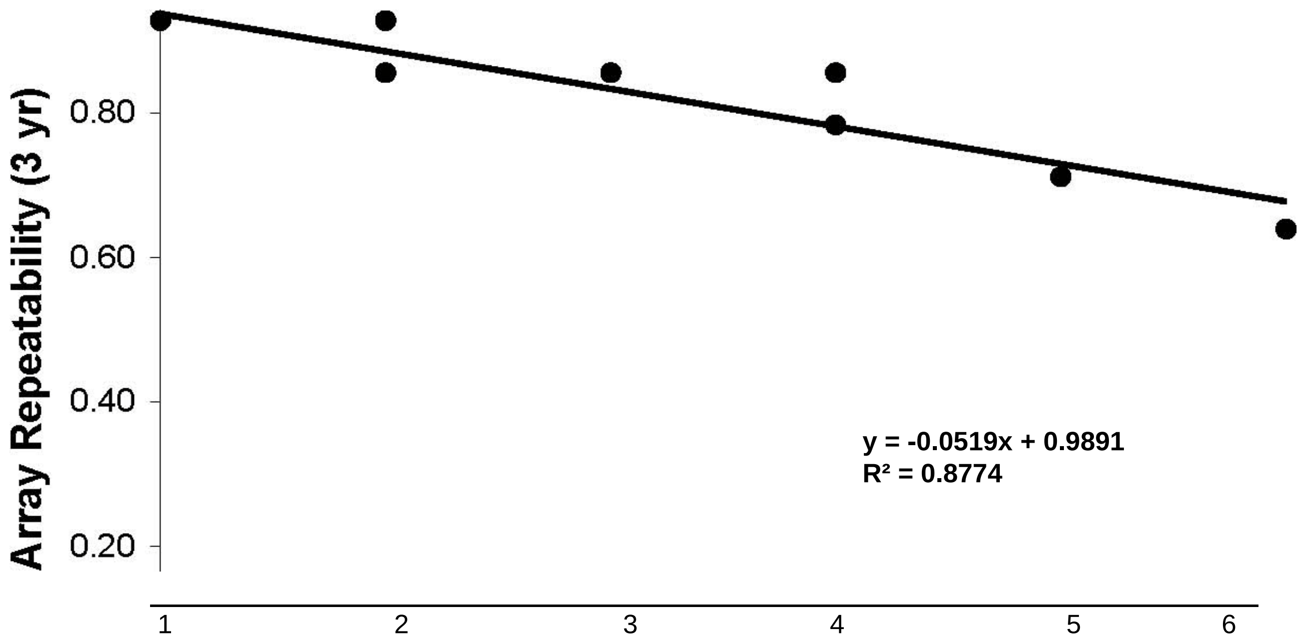


Figure 44. Effect of site richness on trapping repeatability for Craters of the Moon.

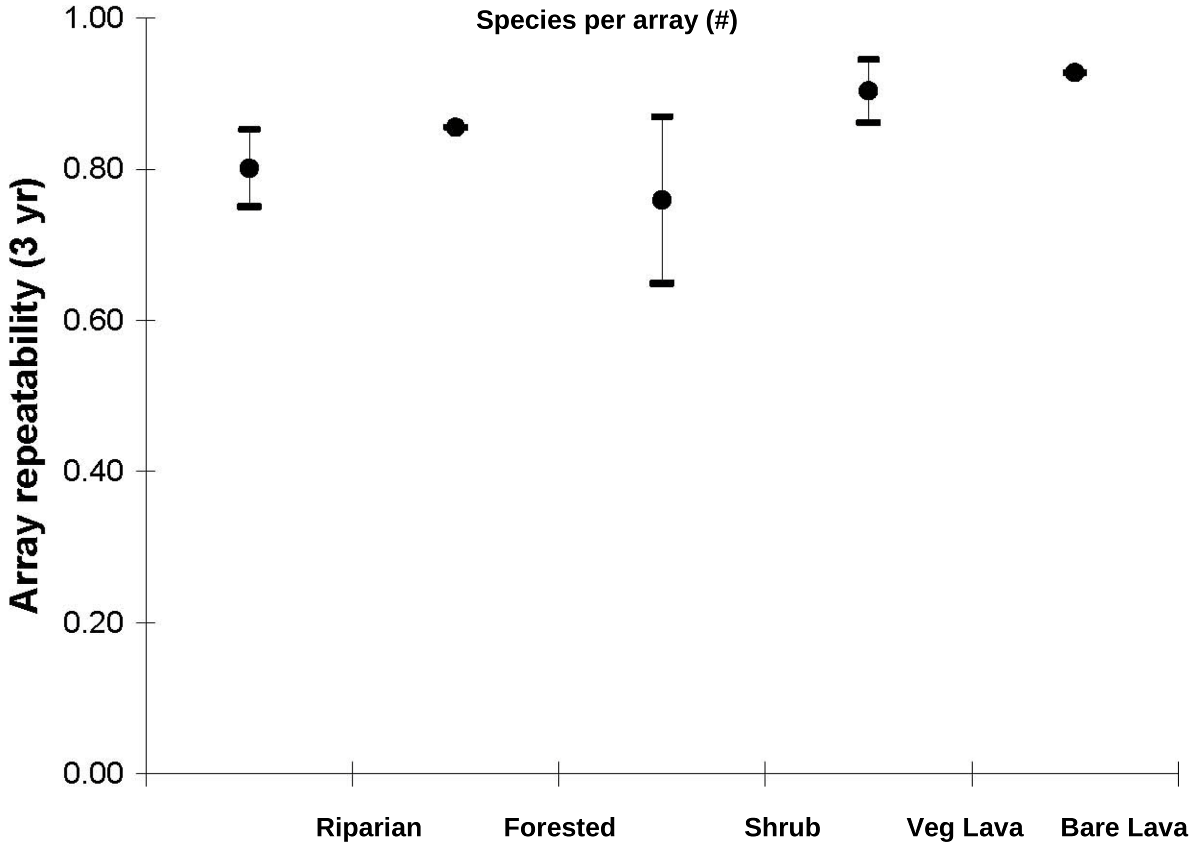


Figure 45. Effect of covertype on trapping repeatability.

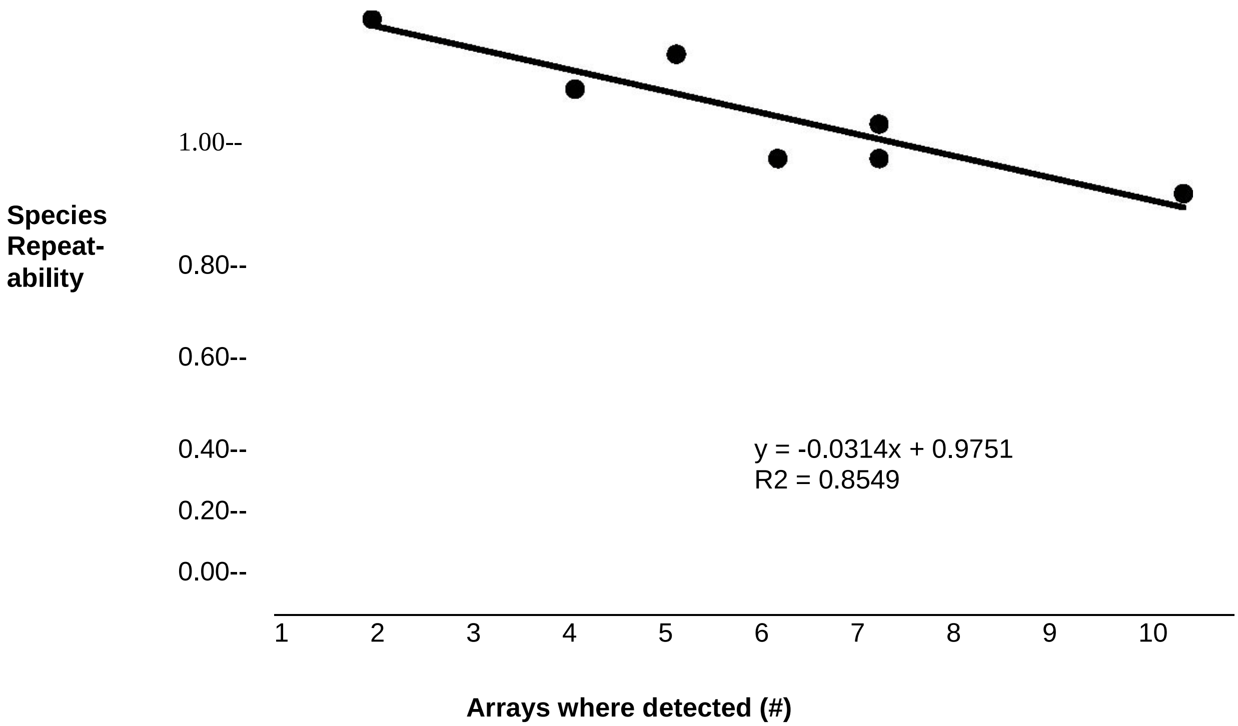


Figure 46. Effect of distribution on trapping repeatability.

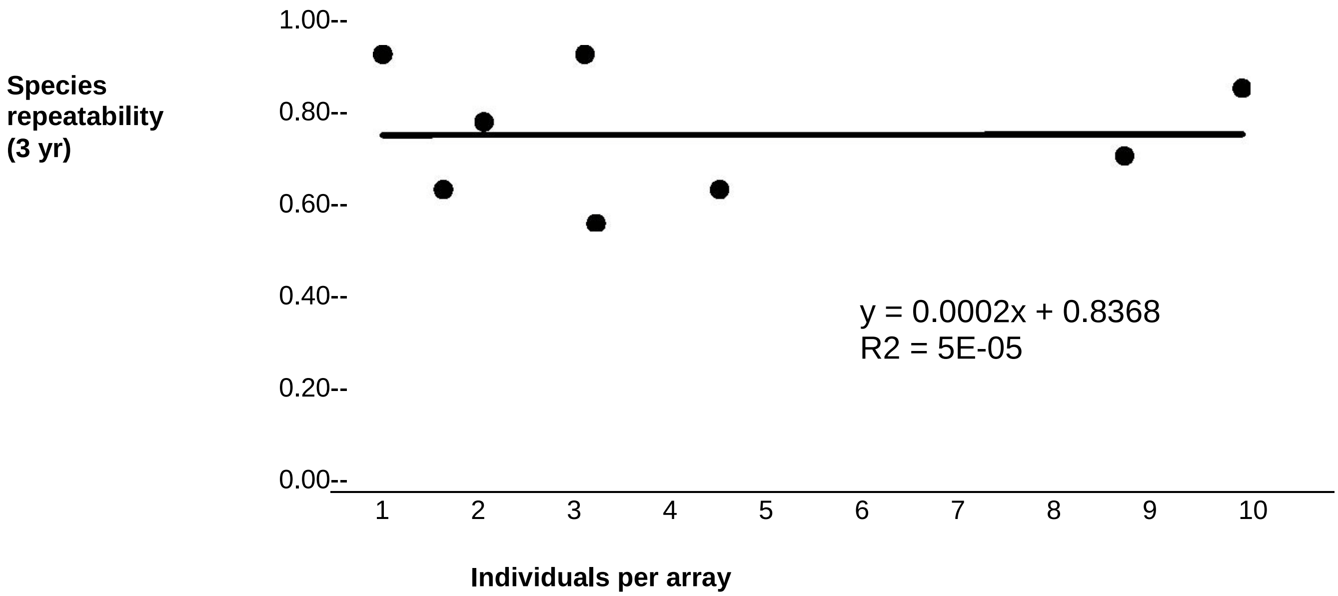


Figure 47. Effect of abundance on trapping repeatability.

Summary of NPSpecies Code Assignments

Park Status

We classified nine species as being "Present", two as "Unconfirmed", two as "Probably Present", one as "Historic", and four species as "Encroaching". The species classified as "Present" include the Pacific treefrog, western skink, pigmy short-horned lizard, sagebrush lizard, rubber boa, racer, gopher snake, terrestrial garter snake, and western rattlesnake. Boreal chorus frogs were believed to have been heard on several occasions, but since neither the calls were recorded, nor any specimens found, we classified this species as "Unconfirmed". We also classified Columbia spotted frogs as "Unconfirmed". This species occurs in the vicinity (Fish Creek Drainage), and could be the species identified as a "bullfrog" in the NPS observational database. The two species we classified as "Probably Present" are Great Basin spadefoots and night snakes. Both of these species are fossorial, and can easily be missed, even after repeated surveys. We classified boreal toads as "Historic" based on a preserved specimen, and multiple historic observations balanced against the current lack of suitable breeding habitat. The four species we classified as "Encroaching" include long-toed salamander (*Ambystoma macrodactylum*), long-nosed leopard lizard (*Gambelia wislizenii*), desert horned lizard (*Phrynosoma platyrhinos*), and striped whipsnake (*Masticophis taeniatus*). Long-toed salamanders can be found at Fish Creek Reservoir (66 km east of the visitor's center). We found both long-nosed leopard lizards and desert horned lizards in 2001 on portions of the Expansion area 41 km southwest of the visitor's center. These species may be present in sandy sagebrush areas in the southern portion of the Wilderness area. Striped whipsnakes can be found 58 km northeast of the visitor's center in the area around Atomic City. This species may occur on rocky areas within sagebrush along the southern and southeastern boundaries of the Wilderness. Given our limited effort in these areas, any of these reptile species may eventually be found in limited portions of the Wilderness.

Species Abundance (Relative)

Of the nine species present in the park, we classified one as "Abundant", five as "Common", and two as "Uncommon" and one as "Occasional" (Table 6, Figure 48). The 323 trapping records for sagebrush lizards (*Sceloporus graciosus*) represent over half of all the trapping data. This species can be seen daily in suitable conditions and habitat in relatively large numbers. For these reasons, we feel confident in our classification of this species as abundant at CRMO. We feel that the two Pacific treefrog (*Pseudacris regilla*) specimens are quite likely accidental introductions, given their location and the lack of breeding habitat. These observations were both in the same year of the three summers of our study, so we assigned this species to the "Occasional" category. The remaining species all qualify as somewhere between Common and Uncommon. Using a strict interpretation of the NPSpecies guidelines, the majority of the reptiles at CRMO qualify as Uncommon in abundance. Uncommon species are those likely to be seen monthly in appropriate season/habitat and Common species are those that may be seen daily in limited numbers in the suitable season/habitat. Based upon our results, the remaining seven species may be seen at least weekly, but not daily in the appropriate season and habitat (Figures 49-52). We believe that these species are best described under the current system as Uncommon/Common. By using a more general interpretation (to reflect the overall lower densities of reptiles compared to other taxa) of the NPSpecies guidelines, the majority of the reptiles at CRMO qualify as Common in abundance. We base our adjustment of the guidelines to reflect differences in the order of magnitude at which species are observed. Rare species are those seen during the study up to 10^0 (1) times, Uncommon are those seen 10^0–10^1 (1-10) times, Common 10^1-10^2 (10-100) times, and Abundant species are those seen greater than 10^2 (100) times. Under this system, western skinks, rubber boas, racers, terrestrial garter snakes, and western rattlesnakes are classified as "Common", and gopher snakes and pigmy short-horned lizards are classified as "Uncommon".

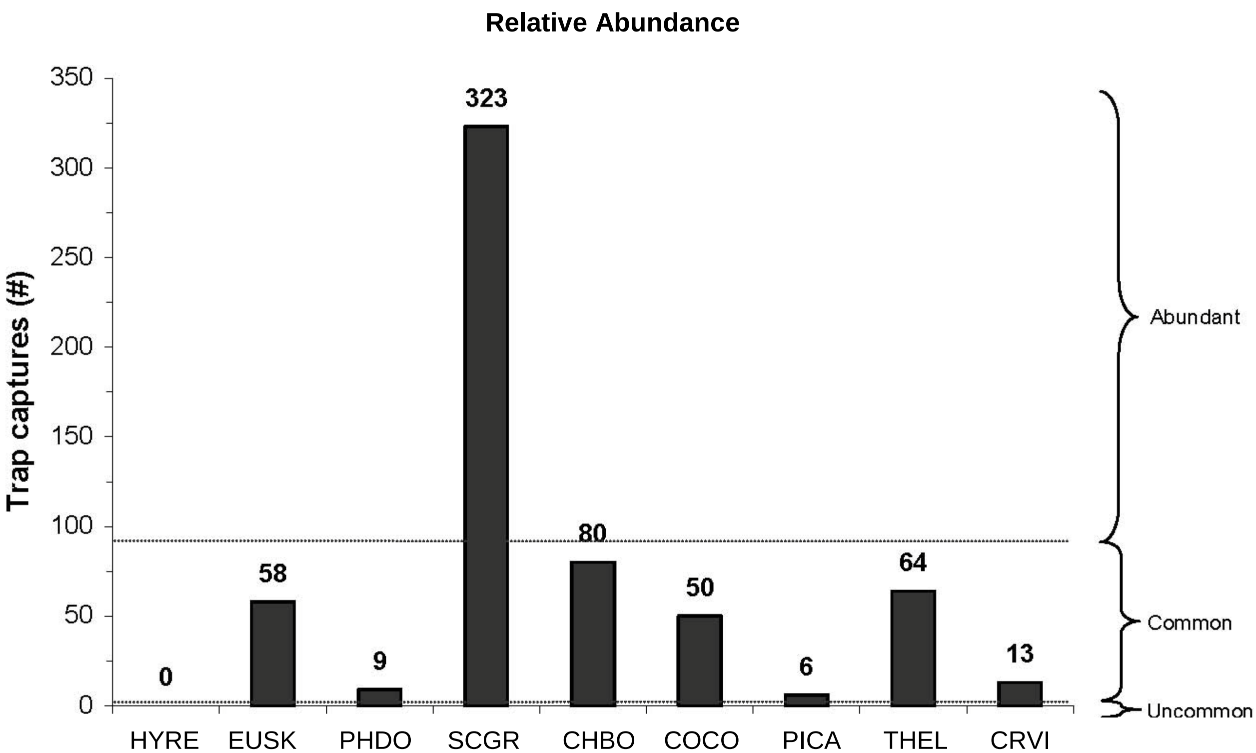
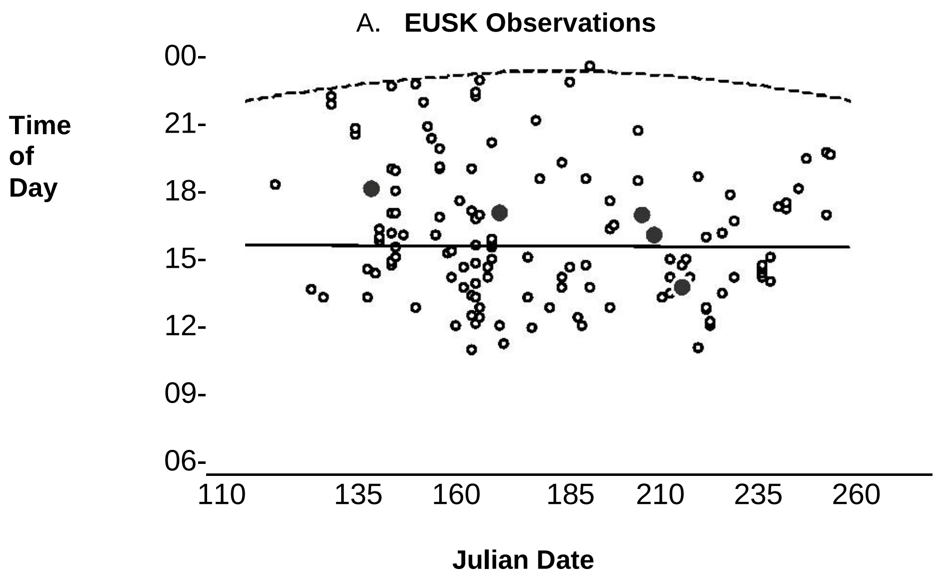


Figure 48. Relative abundance based on trapping results.

Table 6. Summary of information for amphibians and reptiles of CRMO. Only those species whose potential presence was determined to be “likely” or “possible” to occur are included.

Scientific Name	Common Name	Detected	Park Status	Species Abundance	Residency	Species Nativity	Mgmt Priority	Exploitive Concerns
Ambystoma macrodactylum	long-toed salamander	no	Encroaching	-	-	-	-	-
Masticophis taeniatus	striped whipsnake	no	Encroaching	-	-	-	-	-
Gambelia wislizenii	longnose leopard lizard	no	Encroaching	-	-	-	-	-
Phrynosoma platyrhinos	desert horned lizard	no	Encroaching	-	-	-	-	-
Bufo boreas	western toad	no	Historic	-	-	-	-	-
Rana lutieventris	Columbia spotted frog	no	Unconfirmed	-	-	-	-	-
Pituophis catenifer	gopher snake	yes	Present	Uncommon	Breeder	Native	No	No
Pseudacris maculata	boreal chorus frog	yes	Unconfirmed	-	-	-	-	-
Pseudacris regilla	Pacific treefrog	yes	Present	Occasional	Unknown	Unknown	No	No
Coluber constrictor	racer	yes	Present	Common	Breeder	Native	No	No
Thamnophis elegans	terrestrial garter snake	yes	Present	Common	Breeder	Native	No	No
Phrynosoma douglassii	short-horned Lizard	yes	Present	Uncommon	Breeder	Native	No	No
Eumeces skiltonianus	western skink	yes	Present	Common	Breeder	Native	No	No
Crotalus viridis	western rattlesnake	yes	Present	Common	Breeder	Native	No	Yes *
Sceloporus graciosus	sagebrush lizard	yes	Present	Abundant	Breeder	Native	No	No
Charina bottae	rubber boa	yes	Present	Common	Breeder	Native	No	No
Hypsiglena torquata	night snake	no	Prob. Pres	-	-	-	-	-
Spea intermontana	Great Basin spadefoot	no	Prob. Pres	-	-	-	-	-

* Rattlesnakes have the potential for exploitation through collection for their hides or through persecution.



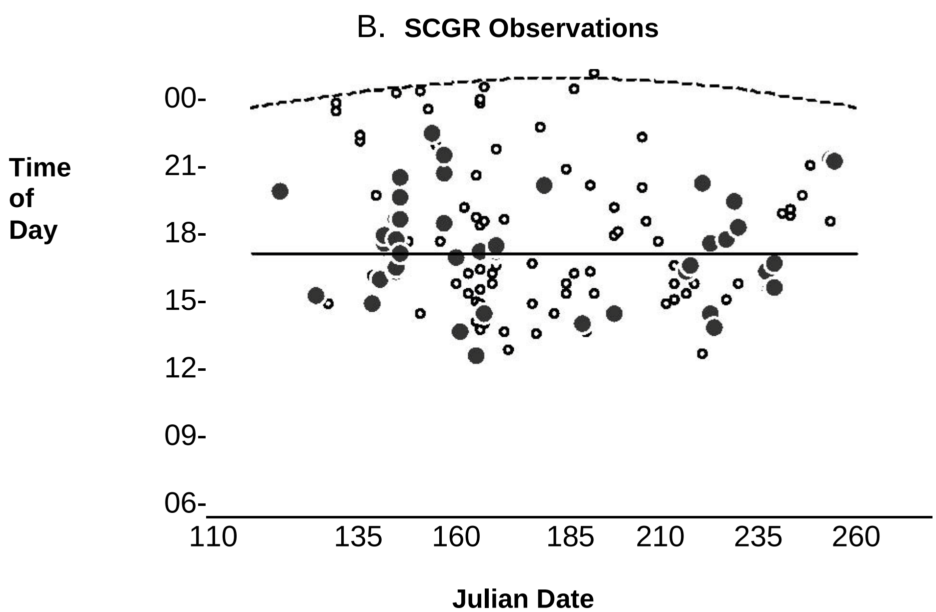
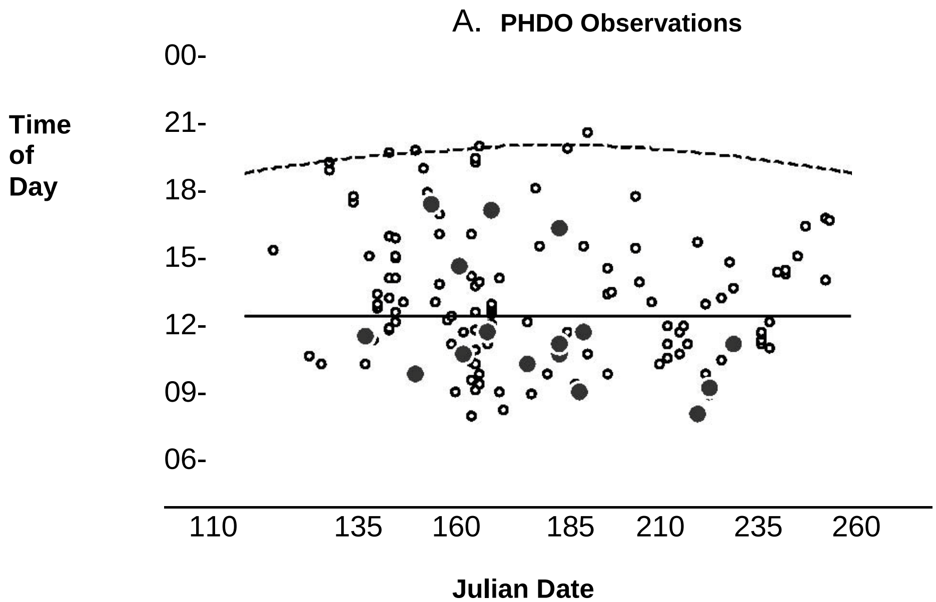


Figure 49A. Temporal distribution of reptile observations. All reptile observations shown as small open symbols. Dashed lines represent time of sunset, dotted lines show time of solar noon. Western skinks observations.

Figure 49B. Temporal distribution of reptile observations. All reptile observations shown as small open symbols. Dashed lines represent time of sunset, dotted lines show time of solar noon. Sagebrush lizard observations.



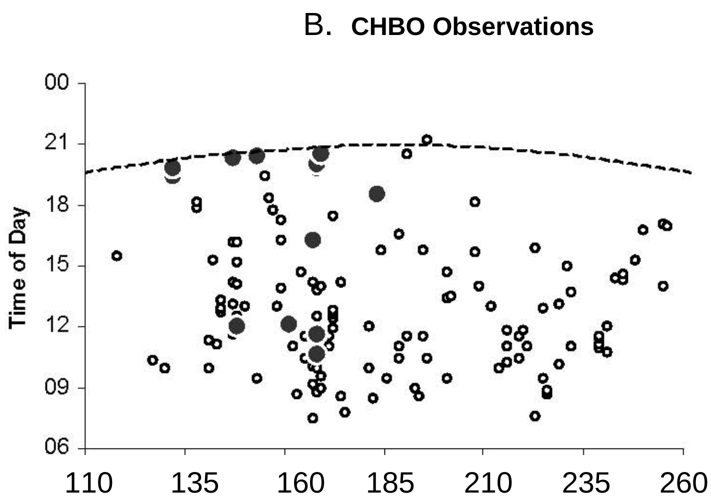
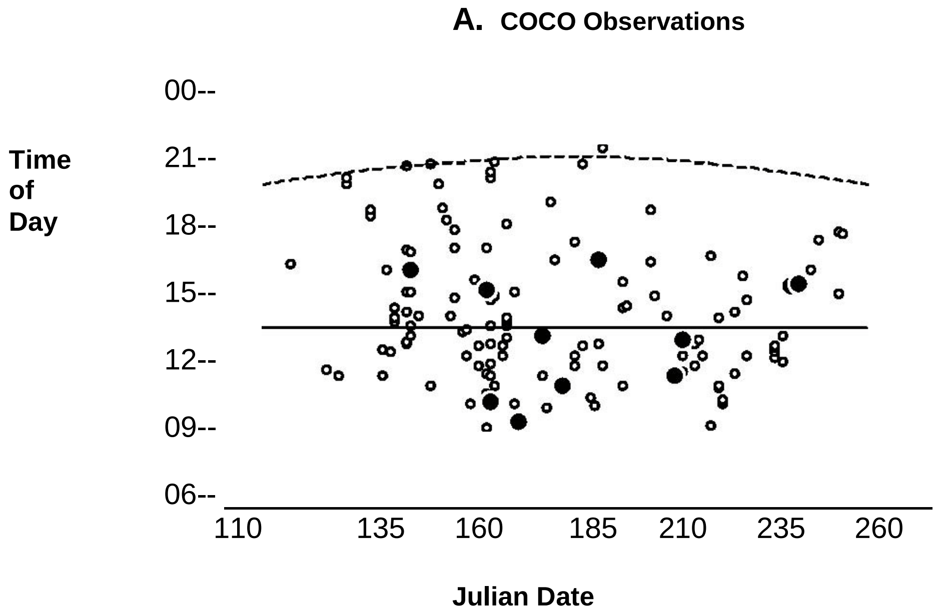


Figure 50A. Temporal distribution of reptile observations. All reptile observations shown as small open symbols. Dashed lines represent time of sunset, dotted lines show time of solar noon. Pygmy short-horned lizard (*Phrynosoma douglassii*) observations.

Figure 50B. Temporal distribution of reptile observations. All reptile observations shown as small open symbols. Dashed lines represent time of sunset, dotted lines show time of solar noon. Rubber boa (*Charina bottae*) observations.



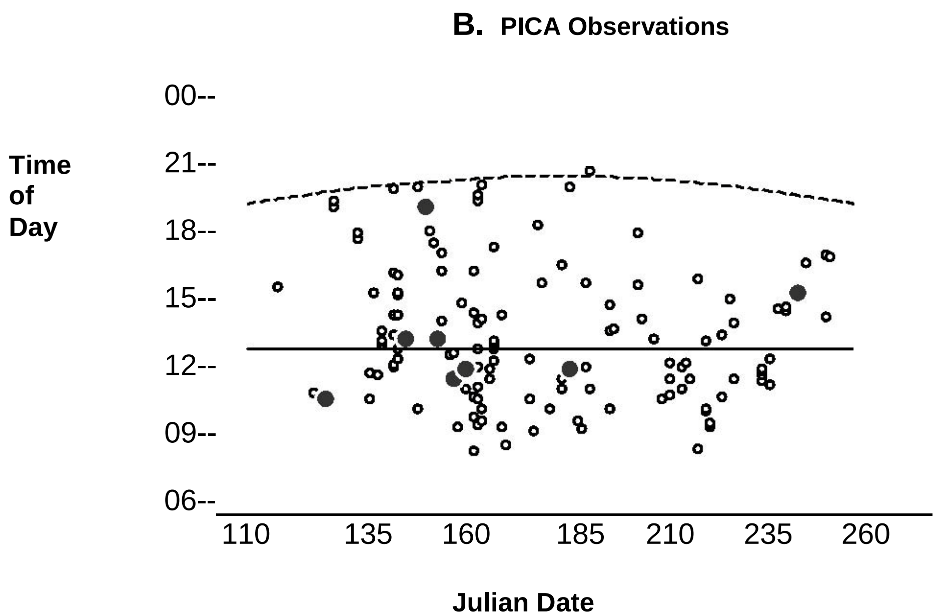
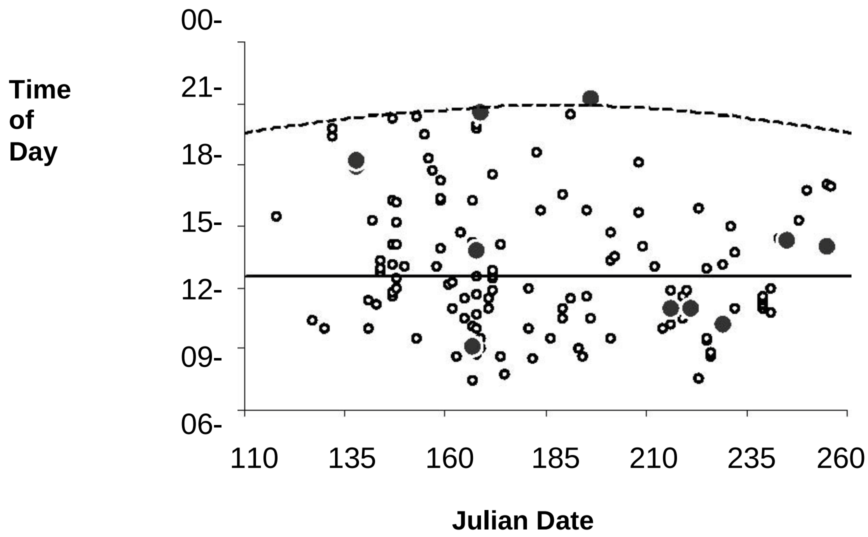


Figure 51A. Temporal distribution of reptile observations. All reptile observations are shown as small open symbols. Dashed lines represent time of sunset, dotted lines show time of solar noon. Racer (*Coluber constrictor*) observations.

Figure 51B. Temporal distribution of reptile observations. All reptile observations are shown as small open symbols. Dashed lines represent time of sunset, dotted lines show time of solar noon. Gopher snake (*Pituophis catenifer*) observations.

A. **THEL Observations**



B. **CRVI Observations**

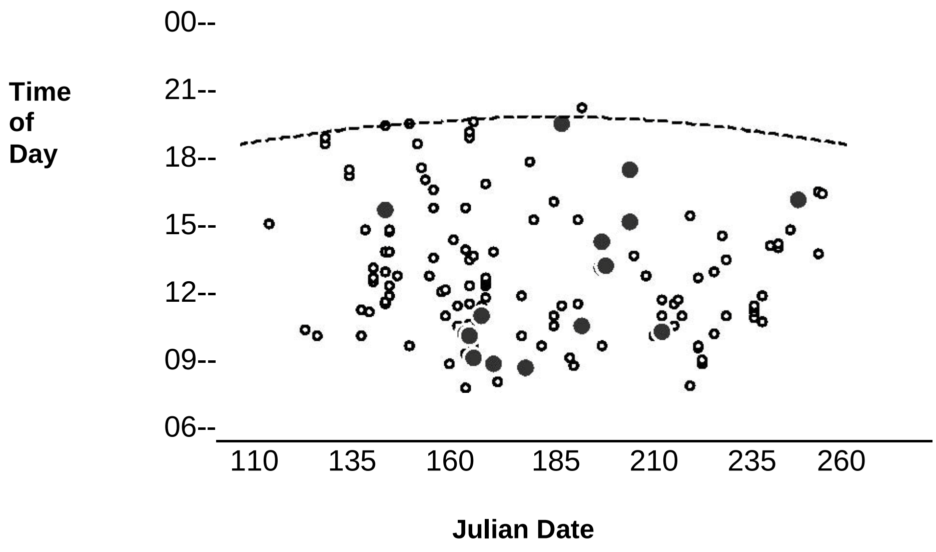


Figure 52A. Temporal distribution of reptile observations. All reptile observations are shown as small open symbols. Dashed lines represent time of sunset, dotted lines show time of solar noon. Terrestrial garter snake (*Thamnophis elegans*) observations.

Figure 52B. Temporal distribution of reptile observations. All reptile observations are shown as small open symbols. Dashed lines represent time of sunset, dotted lines show time of solar noon. Rattlesnake (*Crotalus viridis*) observations.

Residency
We classified all species detected (except Pacific treefrogs) as “Breeders” in the park. We believe park visitors intermittently introduce Pacific treefrogs (unintentionally) and therefore assigned this species to the “Unknown” residency class.

Species Nativity
We classified all species detected (except Pacific treefrogs) as “Native” to the park. We believe park visitors intermittently introduce Pacific treefrogs (unintentionally) and therefore we assigned this species to the “Unknown” nativity class.

Management Priority
We consider none of the species detected to require management priority, based on 2003 listings from the Idaho Conservation Data Center.

Exploitation Concerns
The only species we deem to potentially have exploitation concerns is the western rattlesnake. All rattlesnakes face potential pressure from commercial collecting for the skins and these animals have been historically persecuted by humans for perceived safety concerns.

Summary of Species Information

Occurrence
We confirmed nine (1 amphibian; Pacific treefrog, three lizards; western skink, pigmy short-horned lizard, and sagebrush lizard, and five snakes; rubber boa, racer, gopher snake, terrestrial garter snake, and western rattlesnake) of the eleven potentially occurring species as being present within our study area (81%; Table 6, Figure 53). Historically, at least two additional amphibians (western toads and spotted frogs/bullfrogs, see Amphibian Breeding Habitat, below) probably occurred at CRMO and are most likely not currently present. One additional amphibian (Great Basin spadefoot, *Spea intermontana* (=*Scaphiopus intermontanus*)) and one snake species (night snake, *Hypsiglena torquata*) are probably present, but their secretive habits can easily cause them to have been missed. Both of these fossorial species occur northeast of CRMO on the INEEL (Cooper and Peterson 1995). Spadefoots can go for several years without breeding when conditions are unfavorable, during which time their presence can easily go undetected. The presence of night snakes was unknown for the INEEL until trapping began in 1994 at one site 35 km to the northeast of the Monument’s visitor center. During 1994–2003, night snakes represented less than 0.5% of the total captures (11 of 4000+) for all species on the INEEL (C. Jenkins, unpublished data). Additionally, one specimen was found in 1998 near the hospital in Arco (M. Apel, personal communication). We would not be surprised if either or both of these species are eventually found at CRMO.

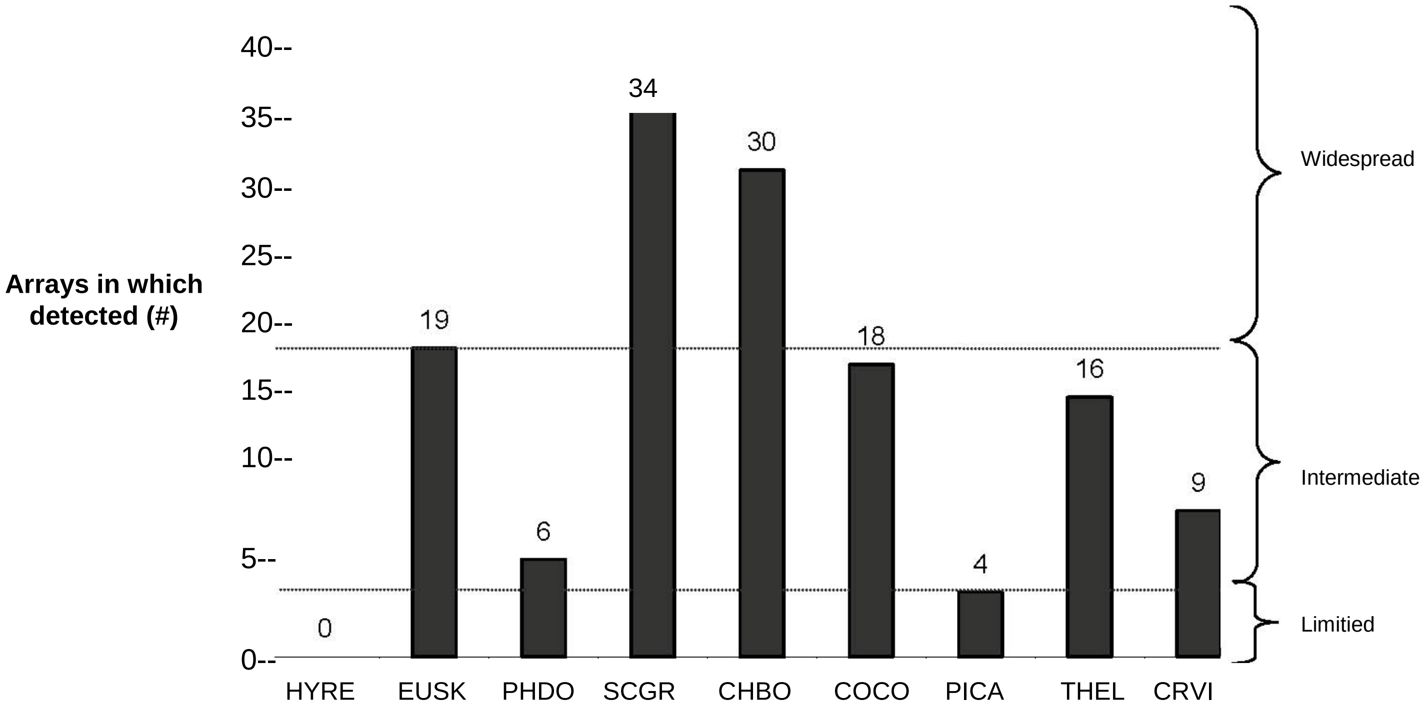


Figure 53. Overall distribution based on trapping results.

Distribution

Spatial Distribution: We described the spatial distribution of the amphibians and reptiles of Craters of the Moon based upon trapping/observational data and the predicted probability of occurrence maps (Tables 6-8, Figures 14–41). We classified two species as having widespread distributions, five as intermediate, and one as limited. The two widespread species, western skinks and sagebrush lizards seem to be distributed across the entire monument. The highest probabilities of occurrence for skinks in the Devil's Orchard and Caves areas (Figures 15 and 16) and for sagebrush lizards on the southwestern slopes of the North End (Figures 21 and 22). The species with intermediate distributions were pigmy short-horned lizards, rubber boas, racers, terrestrial garter snakes, and rattlesnakes. All of these species, except for horned lizards, were found throughout the entire North End. Horned lizards were only found in the sagebrush flats south of Goodale's Cutoff and along the Highway (Figures 17-19). Rubber boas had the highest predicted probability of occurrence associated with Little Cottonwood Creek (Figures 24 and 25). Racers and garter snakes had the highest predicted probabilities of occurrence on the lower-elevation slopes and along Goodale's Cutoff (Figures 28 and 29, and 37 and 38). Rattlesnakes had the highest predicted probability of occurrence on the sagebrush flats south of Goodale's Cutoff and along the highway (Figures 40 and 41). We assigned gopher snakes to the limited category because they were observed mostly in the general vicinity of Broken Top and the Caves area (Figures 32 and 33).

Table 8. Summary of models selected to predict probability of occurrence for reptiles at Craters of the Moon.

Species	Model used	AUC	R Squared	Probability threshold	Omnibus test statistic	Omnibus significance level	Significant predictors	Predictor test statistic	Predictor significance level	Predictor effect size
rubber boa	indicator kriging	0.987		0.378						
racer	indicator cokriging	0.951	0.429				distance to a stream	Wald=11.81	0.001	-0.001
rattlesnake	environmental type	0.847		0.085						
gopher snake	logistic regression	0.958	0.572	0.089	chi^2=16.10	0	distance to a stream	Wald=4.447	0.035	0.002
							presence of bare lava	Wald= 3.567	0.059	4.095
garter snake	indicator kriging	0.964		0.31						
skink	indicator kriging	1		0.5						
horned lizard	principal components	0.947	0.52	0.031	chi^2=16.697	0	presence of a southwest slope	Wald=4.521	0.033	-4.223
sagebrush lizard	indicator kriging	0.953		0.227						

We observed very few species of reptiles in the Wilderness area, but received some contributed observations over the course of the study. Sagebrush lizards, gopher snakes, and a garter snake were observed along the Wilderness trail on rare occasions. During 2001, two rattlesnakes were seen along the trail leading to Carey Kipuka during a routine bird survey (M. Munts, personal communication). Doubtless, reptiles do occur throughout the Wilderness area, but their apparent low density in these habits makes an accurate assessment problematic.

Temporal Distribution: In 1999, we detected neither short-horned lizards nor gopher snakes until late July (though all traps were not open until mid-July), and no rattlesnakes until August. In 2000, we did not detect all the species in our traps until the end of July. In 2001, we had detected all species in the traps by mid-June, but the ensuing hot dry summer greatly reduced capture rates thereafter.

Abundance (Overall)

Abundance of reptiles at CRMO is influenced by several variables (Table 10). Regression analysis indicated that total reptile richness explained over 65% of the variation in total abundance (F=106.850, p<0.001, adj. r^2=0.659). Univariate analyses showed no evidence for an effect due to topography (F=0.683, p=0.566), and collapsed cover type had a marginally-significant effect on total reptile species abundance (F=2.126, p=0.053), with the lowest values associated with bare lava, vegetated lava, and Douglas fir (Figure 57). Snake richness explained over 87% of the variation in snake abundance (F=518.408, p<0.001, adj. r^2=0.878). Univariate analyses showed no evidence for an effect due to topography (F=0.496, p=0.686), but differences existed among collapsed cover types (χ^2=24.531, p<0.001), with the highest values appearing to be associated with wildrye areas (Figure 58). Geologically, the intrusive rock and surficial deposits of the north end were associated with higher snake abundances (χ^2=21.057, p<0.001, Figure 59). Lizard richness explained over 87% of the variation in lizard abundance (F= 18.408, p<0.001, adj. r^2=0.878). Univariate analyses showed no evidence for an effect due to topography (F=0.496, p=0.686), but differences existed among collapsed cover types (χ^2=24.531, p<0.001), with the highest values appearing to be associated with wildrye areas (Figure 60). Geologically, the intrusive rock and surficial deposits of the north end were associated with higher lizard abundances (χ^2=21.057, p<0.001, Figure 61). We found a significant relationship between abundance and distribution for the reptiles at Craters of the Moon (p<0.001, adj. r^2=0.876, Figure 62).

Table 10. Summary of analyses for abundance of reptiles at Craters of the Moon.

	Analysis	Omnibus test stat	Omnibus significance	Adjusted R-squared	Predictors	Predictor test stat	Predictor significance	Predictor effect size
Total abundance	Linear regression- Full model	F= 14.043	0	0.659	Total richness			
	Linear regression- Collapsed	F= 106.85	0	0.595	Total richness	t= 10.377	0	0.497
	Kruskal-Wallis- topo and env type	Chi²= 19.591	0.188					
	ANOVA- topo	F= 0.683	0.566					
	ANOVA- env type	F= 2.126	0.053	0.097	Bare lava	t= -1.866	0.067	-0.557
					Shrub	t= -0.011	0.058	0.305
					Veg lava	t= -0.822	0.039	-0.422
Snake abundance	Linear regression- Full model	F= 48.997	0		Snake richness			
	Linear regression- Collapsed	F= 4518.408	0	0.877	Snake richness			
	Kruskal-Wallis- topo and env type	Chi²= 34.531	0.003	0.878	FI-Ri, F-Wi, NE-As, and SW appear to be higher	t= 22.769	0	0.69
	ANOVA- topo	F= 0.496	0.686					
	Kruskal-Wallis- env type	Chi²= 24.531	0		Riparian and wildrye appear to be higher			
Lizard abundance	Linear regression- Full model	F= 16.313	0	0.694	Lizard richness			
	Linear regression- Collapsed	F= 143.877	0	0.665	Lizard richness	t= 11.995	0	1.164
	ANOVA- topo and env type	F= 0.859	0.616					
	ANOVA- topo	F=1.540	0.212					
	ANOVA- env type	F=1.272	0.278					

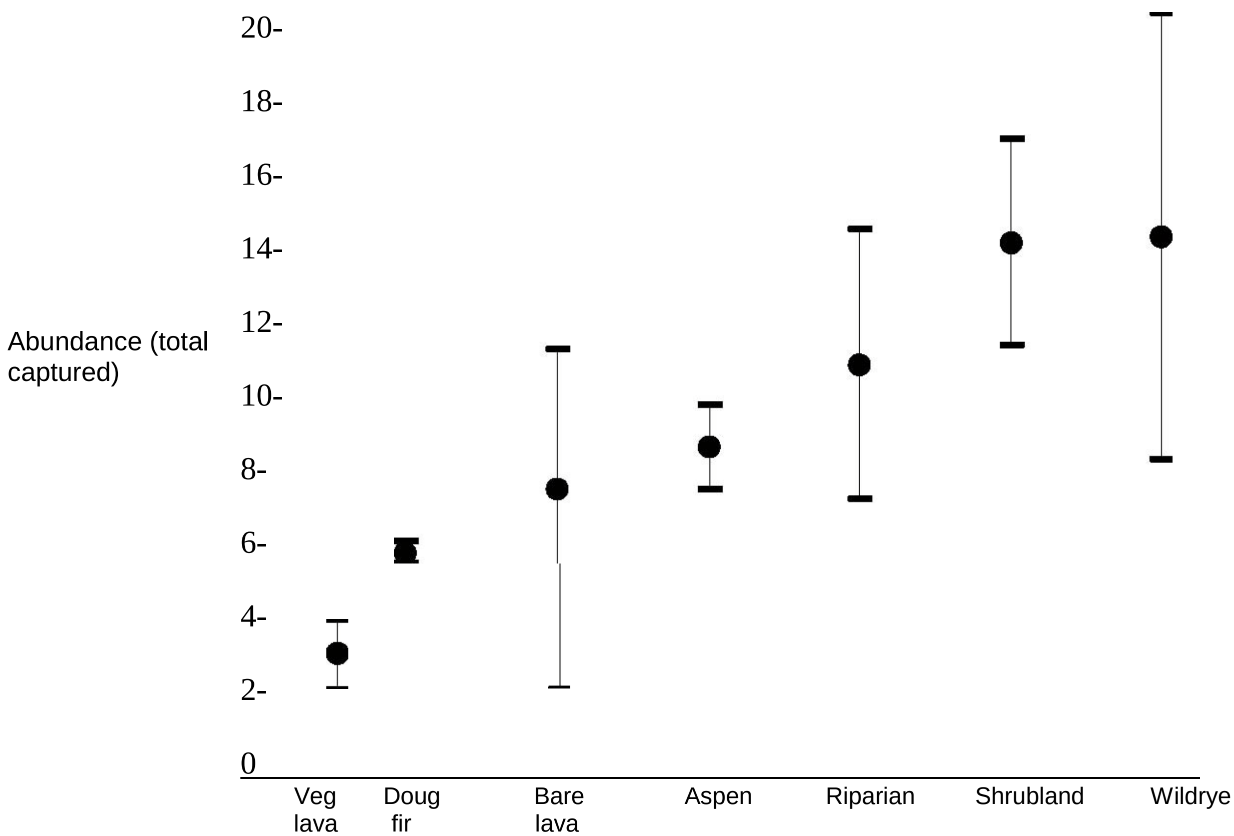


Figure 54. Total reptile abundance by cover type.

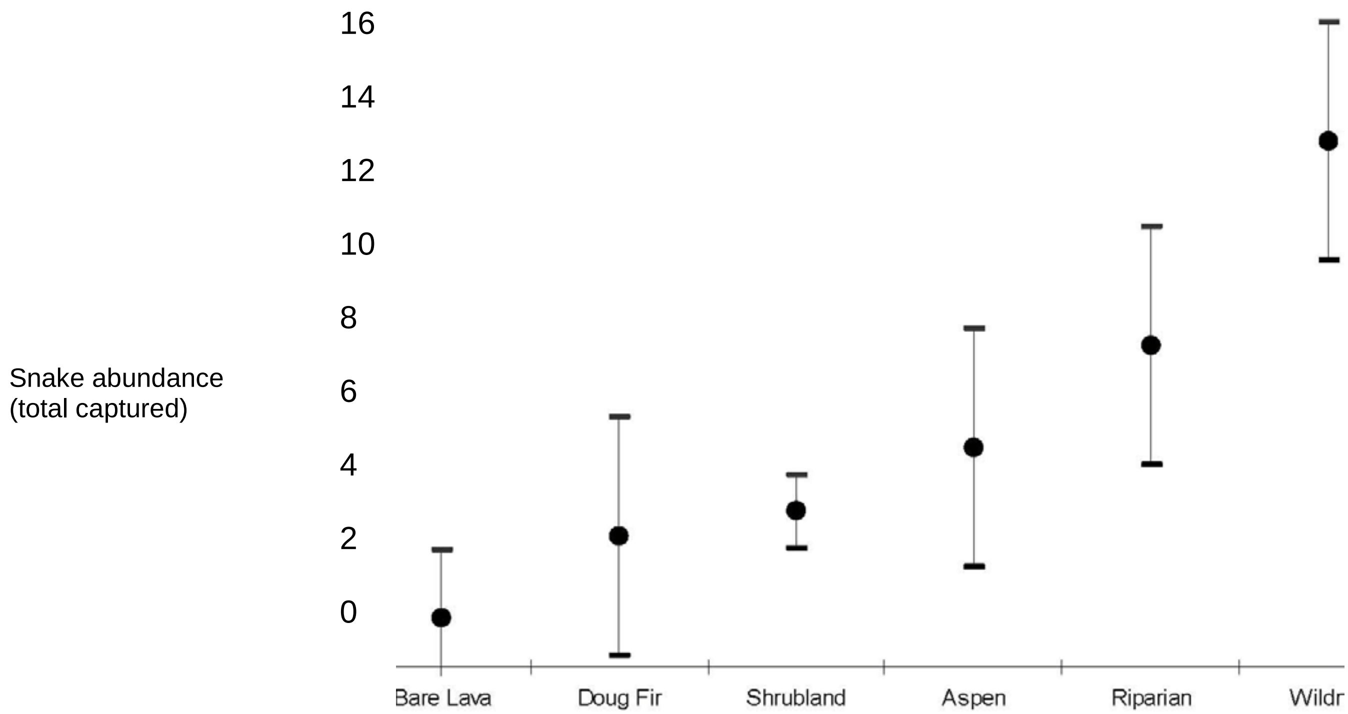


Figure 55. Snake abundance by cover type.

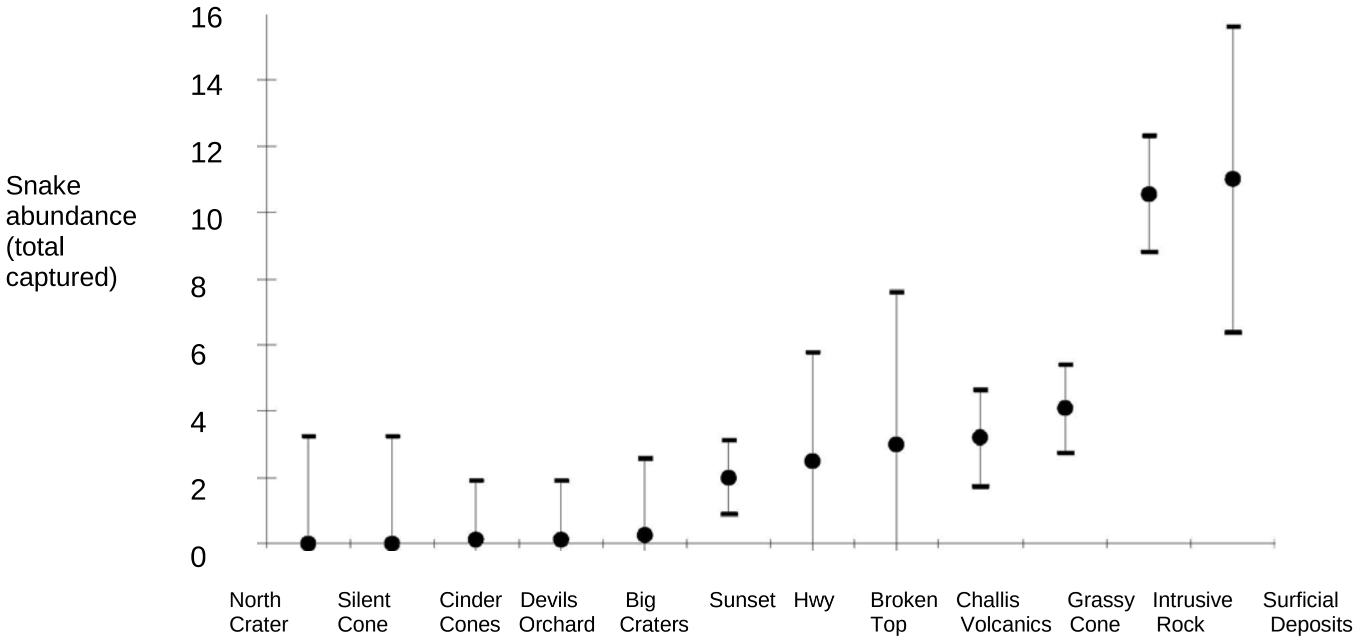


Figure 56. Snake abundance by geology.

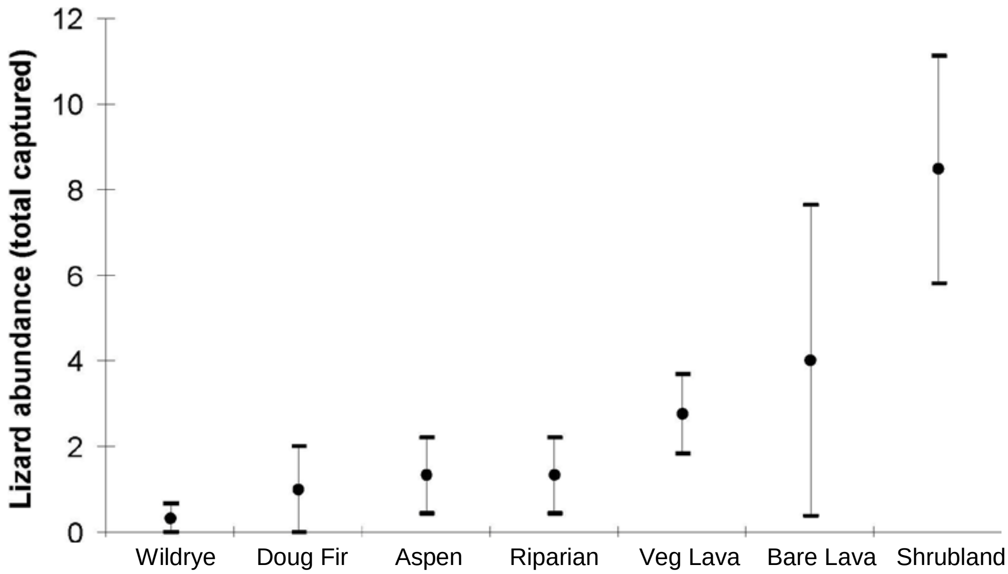


Figure 57. Lizard abundance by covertype.

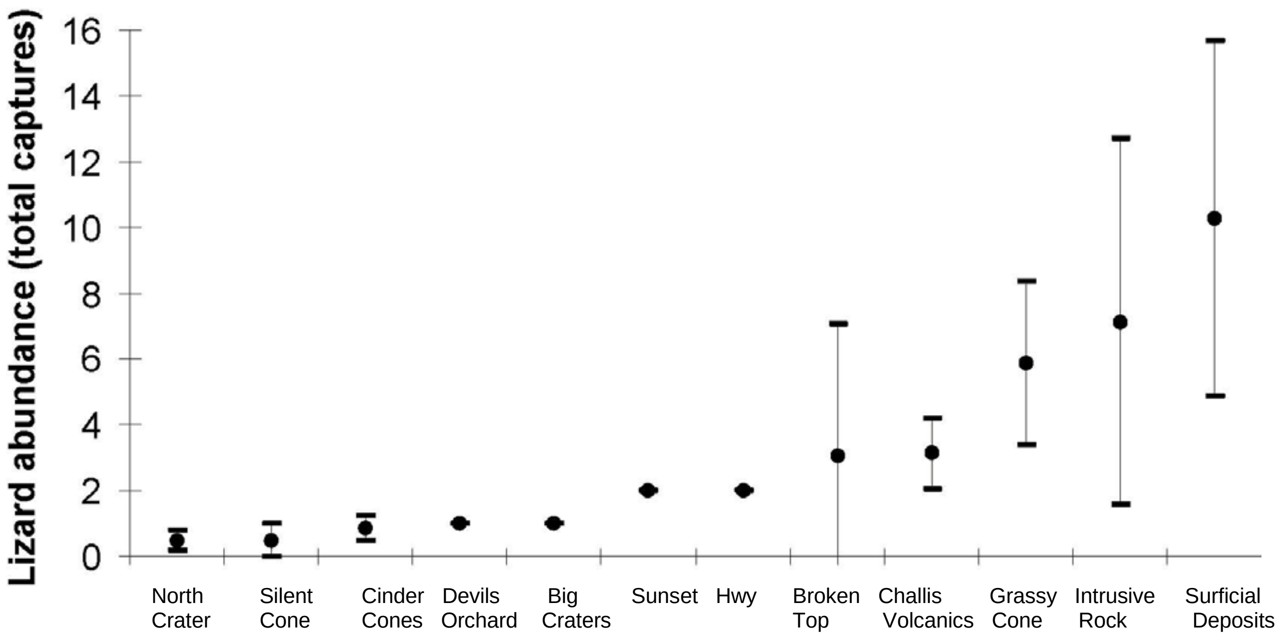


Figure 58. Lizard abundance by geology.

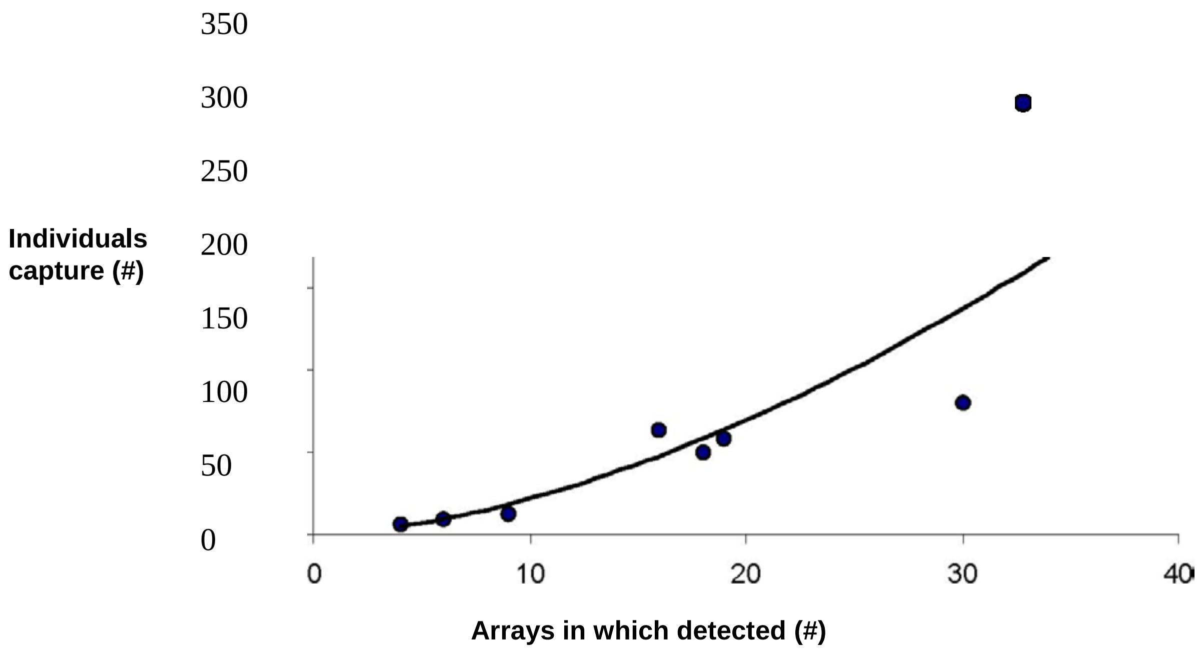


Figure 59. Relationship of distribution and abundance for reptiles at Craters of the Moon.

Habitat Relationships

Each reptile species was detected in 1-7 of the seven collapsed covertypes, and each collapsed covertype had observations for 2-7 species. Sagebrush lizards and rubber boas were detected in all cover types. Skinks were trapped in all cover types except for Douglas fir and wildrye. Racers and garter snakes were trapped in aspen, riparian, shrub, and wildrye areas. Rattlesnakes were trapped only in shrublands and wildrye, and gopher snakes were trapped only in bare lava and vegetated lava. Horned lizards were only detected in shrublands, which had the greatest species richness. The shrublands contained all reptile species except for gopher snakes (i.e., 7 species). Of the cover types having five species, aspen and riparian areas contained all species except for rattlesnakes, gopher snakes, and horned lizards, and the wildrye areas had all species except for gopher snakes, skinks, and horned lizards. The four species found in vegetated lava were rubber boas, gopher snakes, skinks, and sagebrush lizards. Bare lava contained only three species, namely rubber boas, gopher snakes, and skinks. The cover type with the lowest richness was Douglas fir, in which we only detected rubber boas and sagebrush lizards.

Conservation Status

We detected no threatened, endangered, or sensitive herpetological species at CRMO. All eight reptile species are listed as unprotected nongame wildlife by the state of Idaho. All are ranked as S5 and G5 by the Natural Heritage Project, reflecting that they are demonstrably widespread, abundant, and secure statewide and globally, respectively. With the exception of Pacific treefrogs, we feel that all species detected are native resident breeders on the Monument. Two additional species that might occur on CRMO (night snakes and Great Basin spadefoots)are listed as S3 (vulnerable) and S4 (not rare, apparently secure, but with cause for long-term concern) respectively.

Voucher Specimens

We documented the presence of all species detected with preserved voucher specimens. We prepared 24 voucher specimens during the course of this study (Appendix G).

Species Richness

Species richness for reptiles at CRMO (8 species; 5 snakes and 3 lizards) is influenced by several environmental variables (Table 9). Regression analysis indicated that total reptile species richness was inversely correlated to distance from known surface water (F=26.160, p<0.001, adj. r^2=0.259). Univariate analyses showed no evidence for an effect due to topography (F=1.021, p=0.365), but collapsed cover type did have an effect on total reptile species richness (χ^2=22.143, p=0.001), with the lowest values associated with bare lava, vegetated lava, and Douglas fir (Figure 63). In general, the older geologic classes had highest overall richness, with the Intrusive Rock, Surficial Deposits, Challis Volcanics, and Highway Flow of the north end, and the Broken Top Flow having the highest average richness (Figure 64). Species richness for snakes at CRMO decreases as distance to surface water increases (F=37.056, p<0.001, adj. r^2=0.334, Table 9). Univariate analyses showed flat areas had 0.077 fewer snake species than did northeast slopes and 0.323 fewer snake species than did southwest slopes (F=19.836, p<0.001). Differences also existed by collapsed cover type (χ^2=30.998, p<0.001), with the highest values associated wildrye, riparian, and aspen areas (Figure 65). The geologic classes with the highest snake species richness were Intrusive Rock of the north end, and the Big Craters Flow having the highest average richness (Figure 66). Richness of lizard species at CRMO differed by topographic class and environmental type. Areas occurring on flat areas or southwestern slopes had higher lizard richness than areas with northeastern aspects (F=39.465, p<0.001, adj. r^2=0.613, Figure 67). Lizard richness appears to be higher in vegetated lava, aspen, wildrye, and riparian areas (Figure 68). By combining the predictive distribution maps for all the species, we were able to generate maps predicting species richness for Craters of the Moon (Figures 69-71). These maps show lizard richness, snake richness, and all reptile species richness as predicted from our probability of occurrence maps.

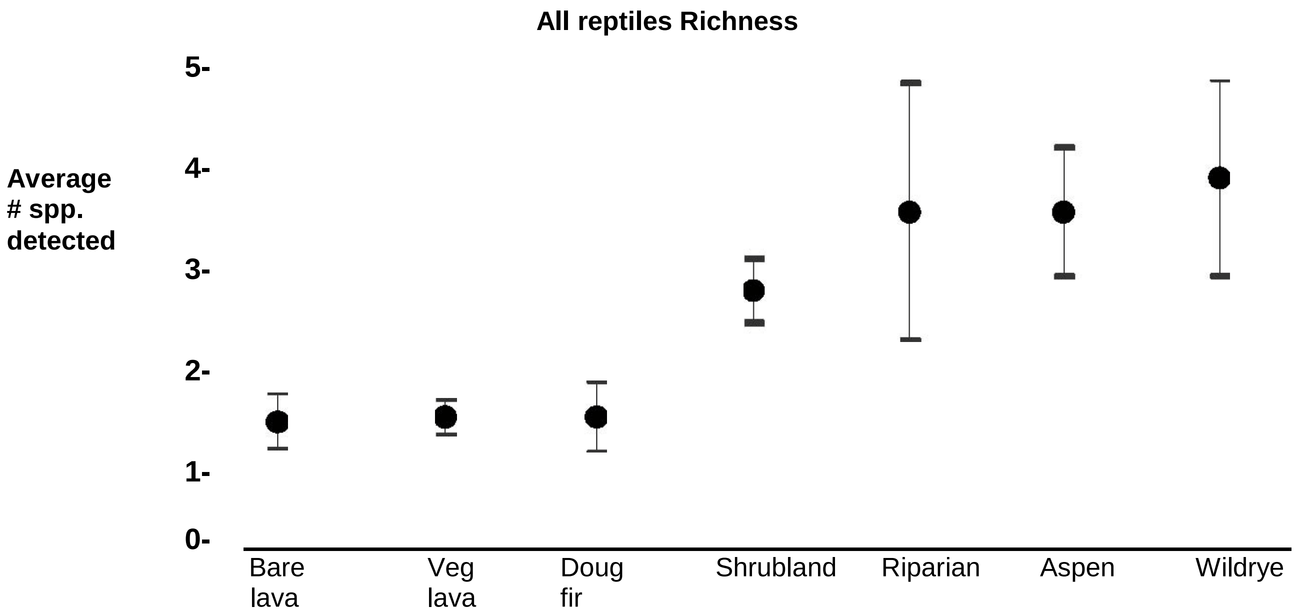


Figure 60. Overall species richness by covertype.

Table 9. Summary of analyses of species richness for reptiles at Craters of the Moon.

	Analysis	Omnibus test stat	Omnibus significance	Adjusted R-squared	Predictors	Predictor test stat	Predictor significance	Predictor effect size
Total richness	Linear regression- Full model	F= 3.046	0.010	0.210	Stream distance			
	Linear regression- Collapsed	F= 26.160	0	0.259	Stream distance	t= 5.115	0	-0.0004
	Kruskal-Wallis- topo and env type	Chi^2= 25.528	0.043		Southwest riparian appears to be the highest			
	ANOVA- topo	F= 1.021	0.365					
	ANOVA- env type	Chi^2= 22.143	0.001		Bare lava and Veg lava appear to be the lowest			
Snake richness	Linear regression- Full model	F= 3.819	0.002	0.268	Stream distance			
	Linear regression- Collapsed	F= 37.056	0	0.334	Stream distance	T= -6.087	0	-0.0004
	Kruskal-Wallis- topo and env type	Chi^2= 25.528	0.004		SW-VL, F-VL, NE-VL and NE-BL appear to be lower			
	ANOVA- topo	F= 19.836	0	0.436	Flat	t= 4.822	0	0.9710
					NE slope	t= 4.028	0	1.0480
					SW slope	t= 4.476	0	1.2940
	Kruskal-Wallis- env type	Chi^2= 30.998	0		Wildrye, Riparian, and Aspen appear to be higher			
Lizard richness	Linear regression- Full model	F= 1.171	0.337	0.022				
	ANOVA- topo and env type	F= 0.651	0.819					
	ANOVA- topo	F=39.465	0	0.613	Flat	t= 7.332	0	0.7710
					NE slope	t= 4.557	0	0.6190
					SW slope	t= 6.624	0	1
	ANOVA- env type	F=18.751	0	0.630	Riparian	t= 2.847	0.006	1
					Shrub	t= 8.718	0	0.938
					Veg lava	t= 6.249	0	0.8500

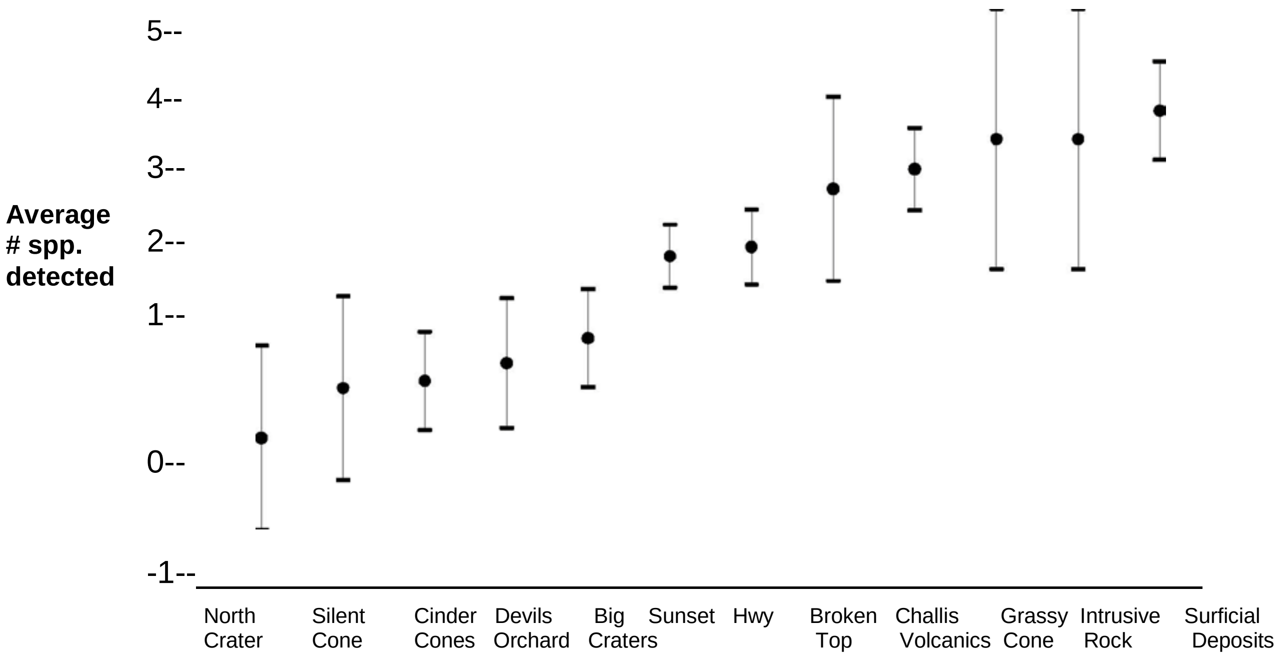


Figure 61. Overall species richness by general geology.

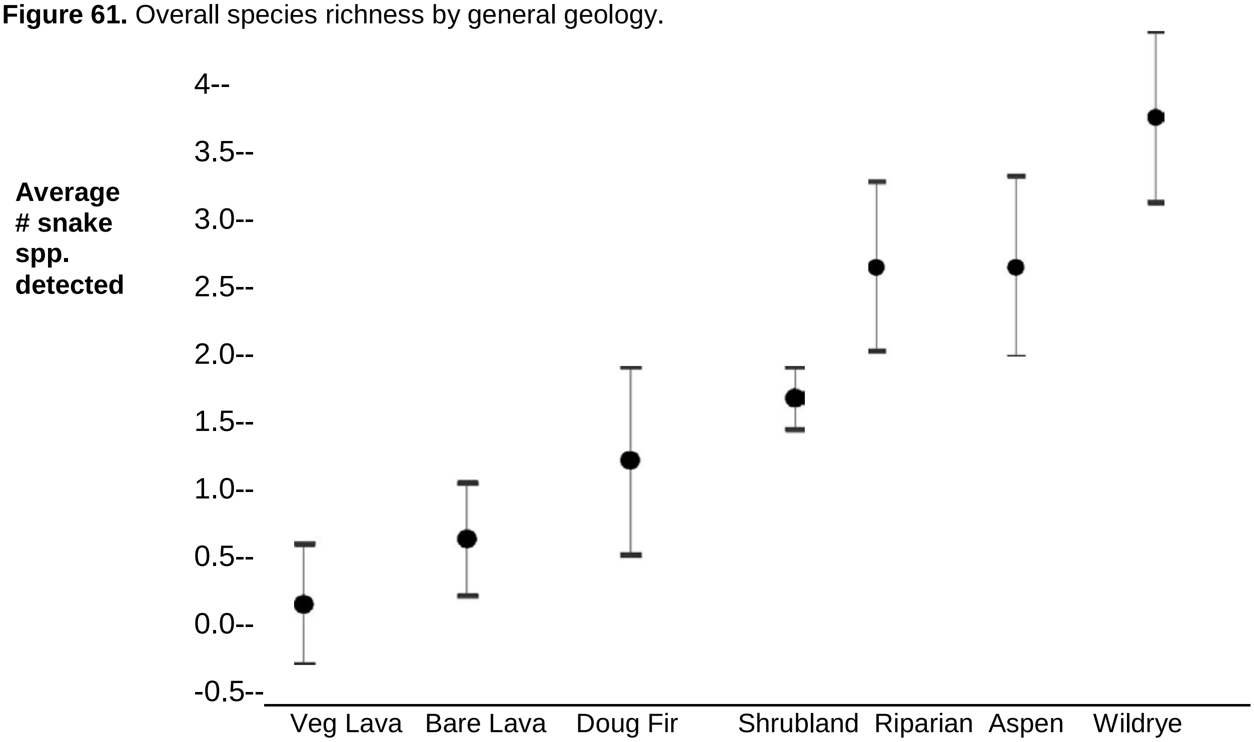


Figure 62. Snake species richness by cover type.

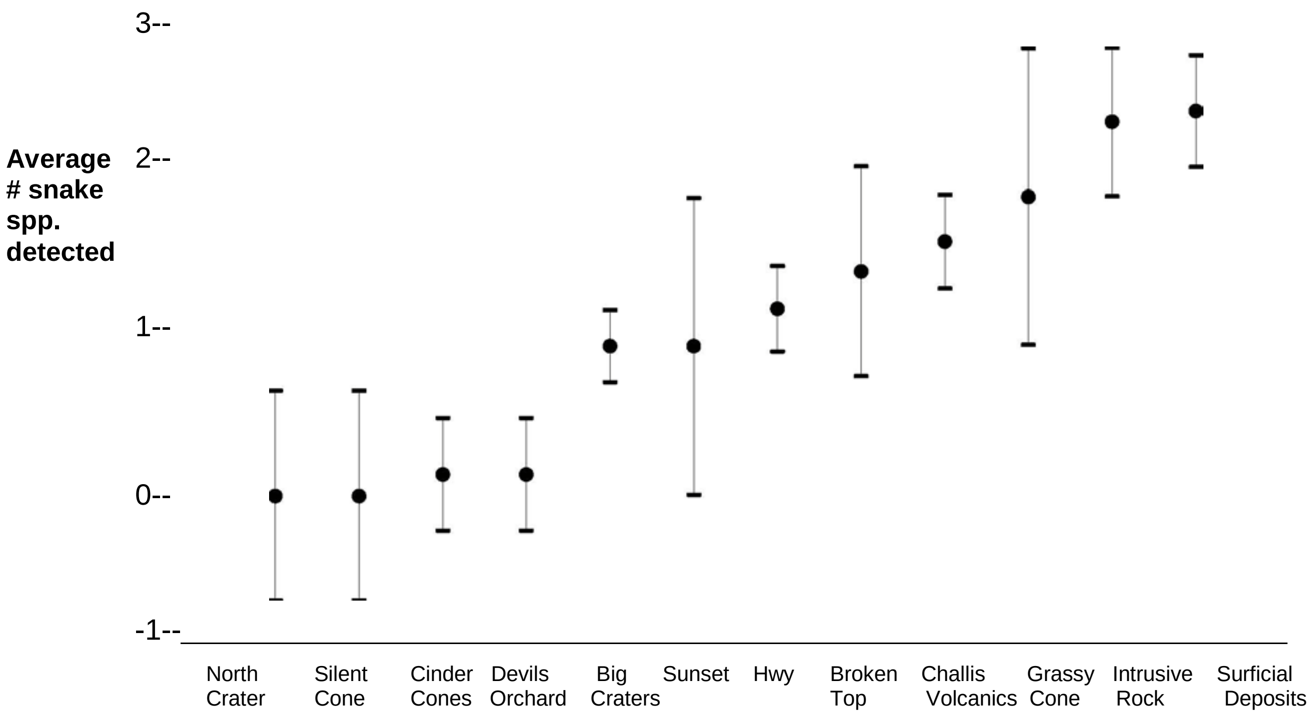


Figure 63. Snake species richness by general geology.

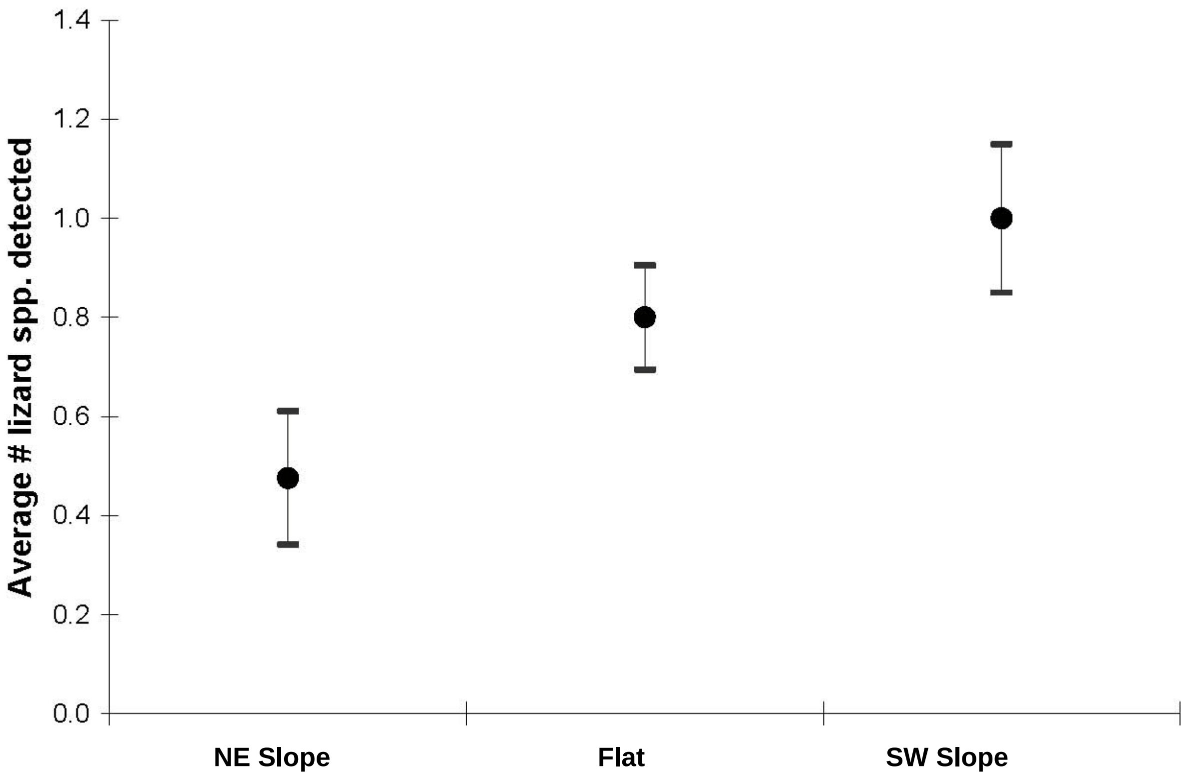


Figure 64. Lizard species richness by topographic classes.

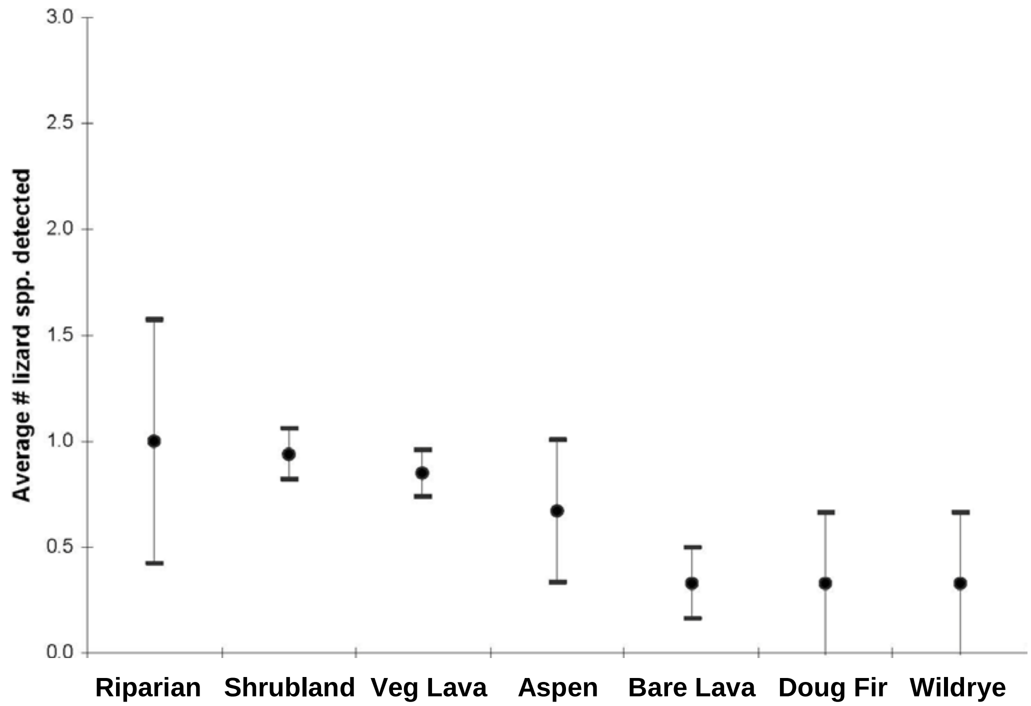


Figure 65. Lizard species richness by cover type.

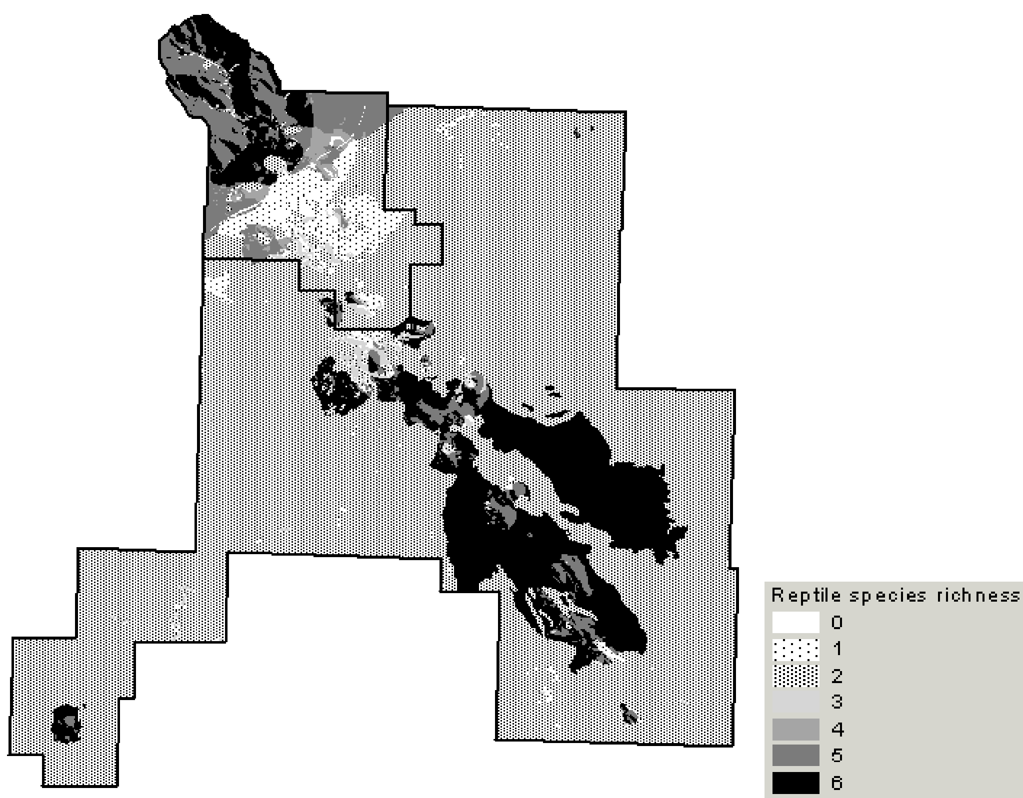


Figure 66. Predicted species richness for all reptiles at Craters of the Moon.

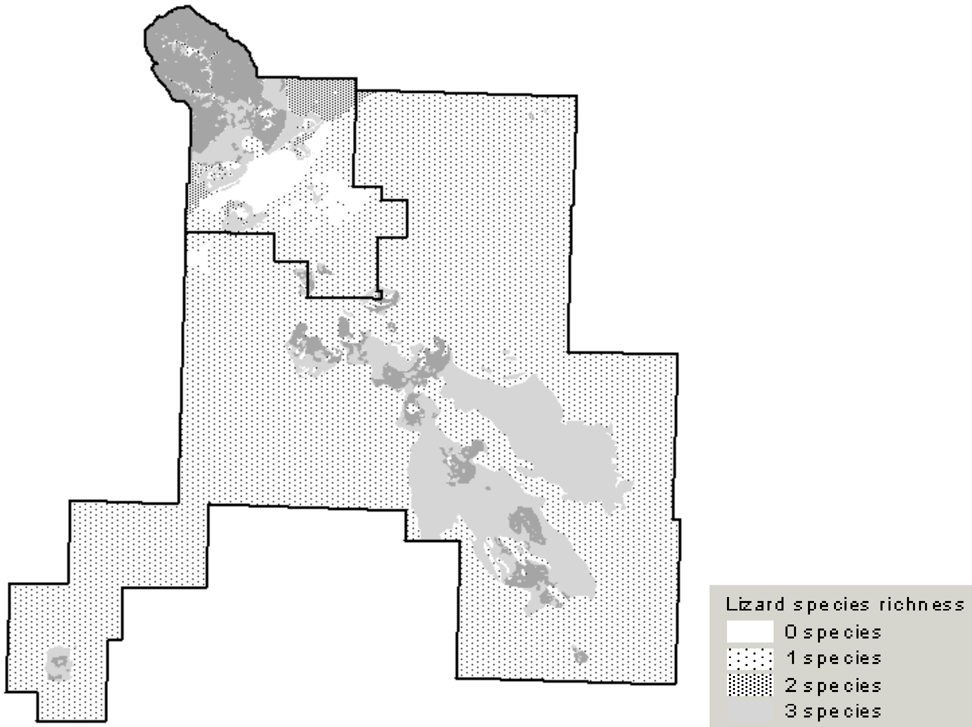


Figure 67. Predicted species richness for lizards at Craters of the Moon.

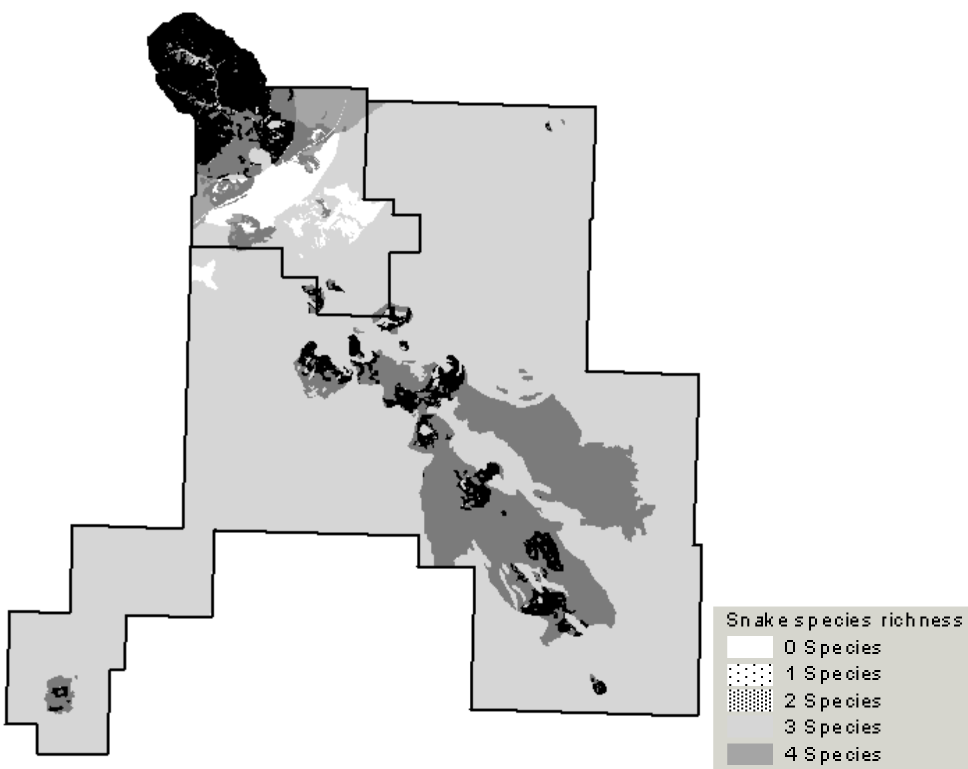


Figure 68. Predicted species richness for snakes at Craters of the Moon.

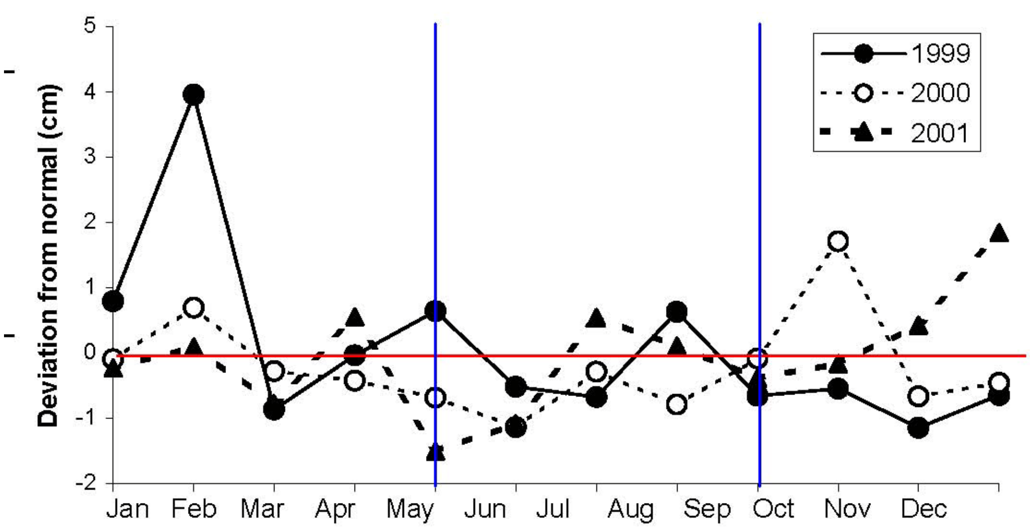
Environmental conditions

Deviations from normal monthly precipitation and average air temperature are shown in Figure 72. Of the 15 months of this study, precipitation was two standard errors (SE) greater than normal for two months, and 2SE less than normal for 11 months (Figure 72A). Average air temperature was 2 SE higher for 9 months and 2 SE lower for 3 months (Figure 72B). We found no effect of average temperature, total precipitation, or their deviations from normal on neither the total number of reptiles captured per month or monthly trapping rates.

Crosswalking CRMO vegetation codes to Idaho GAP2

Definite differences exist between the NPS and Idaho GAP2 covertype maps for Craters of the Moon (Figure 73). This is due to differences in the data used, mapping methodology, spatial resolution, classification algorithms, and ground truthing (Day and Wright 1985, Scott et al. 2002). Data for creation of the NPS map were taken from non-georeferenced aerial photographs, while the Idaho GAP2 cover data were remotely sensed using the Landsat Thematic Mapper satellite. The base map for NPS map was created by outlining visible “patches” on clear sheets of acetate atop the aerial photographs, and the Idaho GAP2 cover data were in the form of a spatially-rectified geodatabase. Creators of the NPS map did not state the spatial resolution (i.e., minimum size “patch” outlined) they used, while the Idaho GAP2 cover map has 30m pixel resolution and a 2 ha minimum mapping unit (i.e., except for riparian areas, all covertypes had to occur on a minimum of 22 adjacent pixels to be mapped). The NPS map used a manual (visual) classification algorithm, and the Idaho GAP map was created using both supervised and unsupervised classification algorithms using the ERDAS (TM) ISODATA algorithm. Creators of the NPS map conducted extensive ground-truthing on the Monument to fine-tune their polygon classification. The Idaho GAP2 cover map was ground-truthed, but none of the data to do so were collected from the Monument area.

A. **Monthly Precipitation Totals**



B. **Monthly Average Air Temperature**

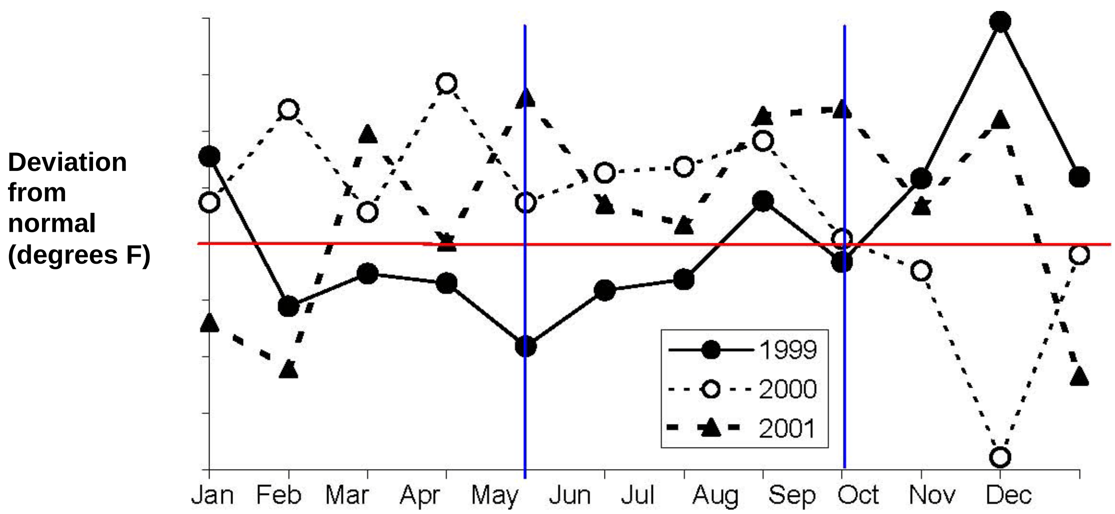
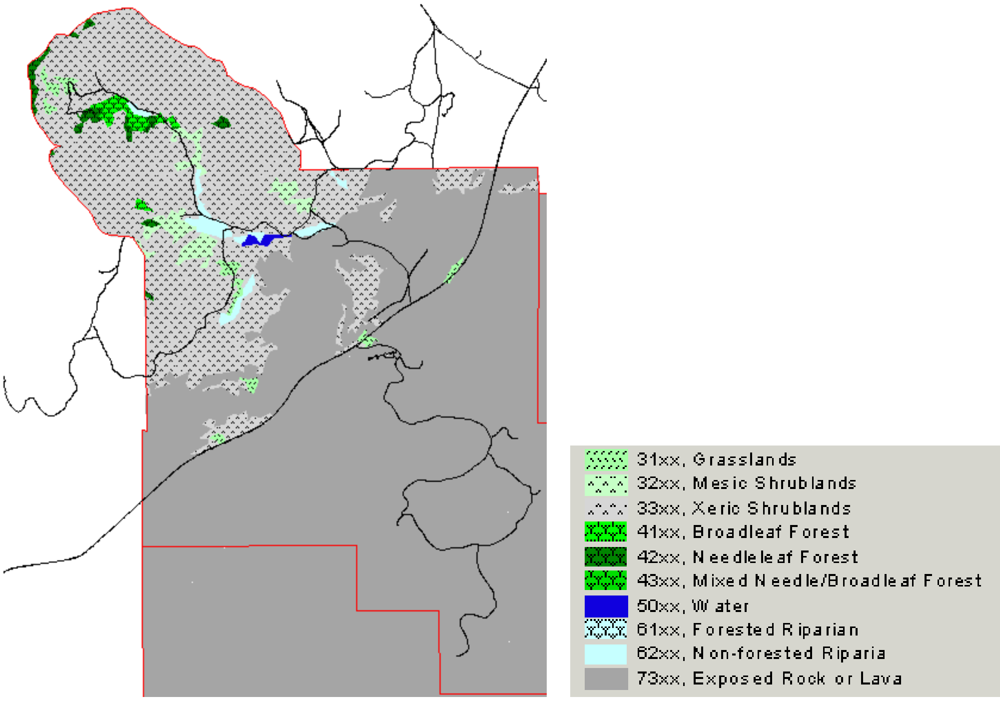


Figure 69A. Environmental Summary for Craters of the Moon 1999 – 2001. Red lines indicate zero deviation, or normal levels, blue lines indicate the beginning and ending months of the field season for this study. Deviation from normal monthly precipitation totals.

Figure 69B. Environmental Summary for Craters of the Moon 1999 – 2001. Red lines indicate zero deviation, or normal levels, blue lines indicate the beginning and ending months of the field season for this study. Deviation from normal monthly average air temperature.

A.



B.

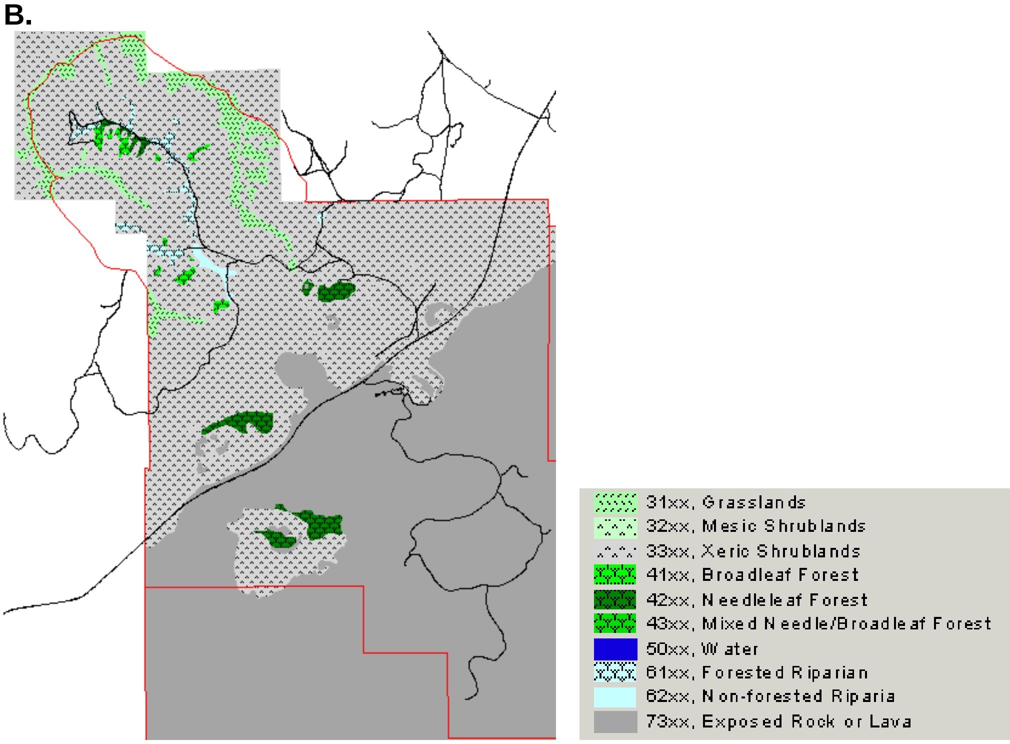


Figure 70A. Vegetation Crosswalking. Idaho GAP2 Vegetation Map for Craters of the Moon.

Figure 70B. Vegetation Crosswalking. NPS Covertype Map for Craters of the Moon coded to IGAP definition.

Additional differences exist in the classification systems used for each map. The NPS map classes were based on vegetative associations (floristic-based groupings defined by the most abundant species) only. The Idaho GAP2 cover map classes are generally hierarchical, where the broadest groups are (variably) based mostly on physiognomy, and subsequent subclasses based upon level of disturbance, environment, associations, or floristic characters. Using the class definitions and characteristics from both sources, we were able to construct a table to crosswalk the classifications of the two maps (Table 5). The 26 classes defined for the NPS map translate into 14 classes as used in the Idaho GAP2 cover map. Most of the differences are due to the NPS map splitting groups based on additional species present in addition to the dominant vegetation. For example, the NPS map has six classes dominated by Mountain Big Sagebrush (classes 4–9) that are separated by the co-occurring grass species. In the Idaho GAP2 cover classification system, these are all represented by a single class (3305: Non-forested lands: Xeric Shrublands: Mountain Big Sagebrush).

The two covertype maps have different strengths and weaknesses. The NPS map suffers from high spatial error and a subjective classification system, while accurately describing the vegetative makeup of the specific patches. The Idaho GAP2 cover map has lower spatial error associated with the patches and has an objective classification system, but the classification accuracy per patch is extremely low (53%) in the more heterogeneous areas. The spatial error in the NPS map is the result of tracing the patches on a series of aerial photos that had not been orthorectified. When these tracings were then collectively digitized into the GIS, the random roll, pitches, and yaws of the aircraft from which the photographs were taken caused misalignment of adjacent tracings. The subjective classification system of the NPS map accurately describes the floristic composition of the patches as delineated. However, neither the rules by which patches were split or grouped, nor the amount of vegetative cover within a patch necessary for inclusion in a specific group, were given. For these reasons, the NPS map is of limited use for comparisons to future studies seeking to identify potential changes in covertype or habitat. The Idaho GAP2 cover map classifies land cover on a per pixel basis based on the species that covers over 50% of the pixel. This, when combined with the two ha minimum mapping unit makes patch delineation a more objective process. However, the Idaho GAP2 cover map for the Monument is crippled by the low classification accuracy resulting from lack of specific field data. For example, all ridge tops on the north end are dominated by low sage with sparse vegetative cover. The Idaho GAP2 cover map correctly delineates these polygons, but assigns them to a Lodge Pole pine class (a species not present at CRMO). In addition, two tracts of Douglas fir, each over 9 ha in area (one on the north side of Grassy Cone, the other on the northeast side of Sunset Cone at the group campground) do not appear at all on the Idaho GAP2 map.

Table 5. Craters of the Moon / Idaho GAP2 Vegetation Crosswalking.

GAP2 Code	Idaho GAP Description	Area (ha)	CRMO code	CRMO Description	Area (ha)
3101	Foothills Grassland	41	11	Three-tip Sagebrush / Idaho Fescue	41
3104	Montane Parklands and Subalpine Meadows	0.4	18	Bluebunch Wheatgrass / Idaho Fescue	0.4
3109	Perennial Grassland	19	19	Bluebunch Wheatgrass/Sandberg Bluegrass	10
			20	Great Basin Wildrye	9
3304	Bitterbrush	562	16	Antelope Bitterbrush	477
			17	Antelope Bitterbrush/Great Basin Wildrye	85
3305	Mountain Big Sagebrush	1122	4	Mountain Big Sagebrush/Bluebunch Wheatgrass	1122
			5	Mountain Big Sagebrush/Sandberg Bluegrass	2527
			6	Mountain Big Sagebrush/Needlegrass	315
			7	Mountain Big Sagebrush/Needle-andthread/ Cheatgrass	2
			8	Mountain Big Sagebrush/Idaho Fescue	98
			10	Complex of Types 4 and 8	4
3307	Basin & Wyoming Big Sagebrush	7	9	Big Sagebrush/Cheatgrass	7
3315	Low Sagebrush	168	12	Early Low Sagebrush/Idaho Fescue	0.4
			13	Low Sagebrush/Sandberg Bluegrass	126
			14	Low Sagebrush/Idaho Fescue	26
			15	Complex of Types 13 and 14	15
4101	Aspen	15	25	Upland Quaking Aspen	15
4205	Limber Pine	1299	22	Limber Pine / Antelope Bitterbrush	1212
			23	Limber Pine/Antelope Bitterbrush (High Density Limber Pine)	87
4212	Douglas Fir	29	24	Douglas Fir/Mountain Snowberry	29
6102	Broadleaf Dominated Riparian	30	26	Riparian	30
7301	Lava	13009	1	Cinder Gardens	484
			2	Low Density Lava Flows	12525
7302	Vegetated Lava	2422	3	Medium Density Lava Flows	2196
			21	Limber Pine/Antelope Bitterbrush (Low Total Cover)	226

Management Implications and Recommendations

This section summarizes our interpretation of the management implications of this study for reptiles and our recommendations for monitoring these species. Despite three seasons of effort representing over 3500 field hours and over 9000 trap nights, we are still uncertain about the occurrence of three species (night snake, Pacific treefrog, and Spadefoot toad) at CRMO. In addition, gopher snakes, with only 43 records for the entire study, are potentially the most interesting species at CRMO. Even though this species is commonly encountered in sagebrush steppe habitats in areas adjacent to the Monument, we never trapped any in this habitat type within the boundaries. Why this species is found exclusively in the lava flows, particularly around the Caves area and Broken Top, is most intriguing and presents yet another unique aspect of the ecology of the Monument. We are frustrated by the lack of information that we were able to collect for the lava flows, as they are the most common and unique habitat on the Monument. Areas in this habitat where trapping arrays could be placed were extremely limited, and those we did place had limited success. The individual traps worked especially well for Western Skinks in the lava flows, and visual encounter surveys of these habitats were mostly ineffective. From the contributed observations, we know several species occur within the flows, but apparently, at such low densities that encountering them is mostly a matter of chance. For this reason, our first recommendation is to:

(1) *Support and encourage the contribution of amphibian and reptile field observations*. Training in species identification and observation reporting could significantly improve the information for CRMO, especially if support materials (e.g., species identification cards, simple data forms) are included. The total number of hours that personnel in the Maintenance, Enforcement, Interpretive, and Resource Management Divisions spend on the lava flows and in the Wilderness annually could potentially provide a significant amount of information. The rarity with which reptile observations occur in these areas would prevent recording such observations from taking an undue amount of time away from the regular duties of the employees. In addition to observations in the lava and Wilderness areas, any amphibian observations should receive extra attention to detail. As this study and the historical records apparently indicate that Craters has lost all members of an entire order of vertebrates (Anura; frogs and toads) within the last two decades, evidence that any of these species currently occur or return would be most welcome. Such an event may not be possible however, until either beavers return to the riparian areas, and/or water levels in the streams increase.

(2) *Improve predicted distribution models*. As better data become available (such as finer resolution DEM's, improved cover type maps), more accurate predicted distribution models and maps could be produced. As cover type is one of the main determinants of occurrence at CRMO, better cover type maps could potentially help in predicting future changes in reptile distribution and abundance resulting from changes in habit. Such changes could occur through natural succession, introduced exotic species, and/or fire.

(3) *Establish a reptile-monitoring program*. We recommend repeating all the visual encounter surveys, and the trapping portion of this study (at the 12 long-term sites), at 5-10 year intervals. Because insects, small mammals, and some birds were observed during our work, we believe that repeat trapping at out 12 long-term sites could be incorporated into an efficient multispecies monitoring program. Because we have already developed the sampling scheme and collected

baseline species and habitat data, it should take less time and cost less money to monitor than it did for this initial survey. The annual variation in detection rates for our trapping efforts suggests that the monitoring be done in a temporally-adaptive fashion. If monitoring efforts during a particular year detect far fewer species in the areas where we found them, then the first step would be to examine environmental factors during that time. The 2001 field season occurred during a period of abnormally high temperatures and low rainfall and this shows in the greatly reduced capture rates during that season. Low detection rates during times of environmental extremes may not necessarily be cause for concern. However, if monitoring efforts during normal years have little success, then this may suggest at least a shorter interval be used before the next monitoring is done (i.e., repeat monitoring in 3-5 years instead of 5-10 years).

(4) *Habitat protection*. Though listed last, this is not the least important of our recommendations. Even though the sagebrush steppe portions of the Monument are not the resource for which CRMO was established to preserve, they are nevertheless important in their own right. These are among the most diverse and productive reptile habitats on the Monument, and potentially at the most risk due to fire and invasive weeds. The riparian areas of Little Cottonwood and Leech Creek canyons are also areas with high reptile species diversity and abundance, in addition to having the greatest potential for amphibian breeding habitat. While the public does not have general access to these portions of the Monument, the threat of fire remains. Perhaps the fire management plan for the Monument may be reviewed with respect to its potential impacts on herpetological biodiversity.

Literature Cited

Blakesley, J. A., and R. G. Wright. 1988. A review of scientific research at Craters of the Moon National Monument. Station Bulletin 50 *of the* Forest, Wildlife, and Range Experiment Station, College of Forestry, Wildlife, and Range Sciences, University of Idaho, Moscow, ID.

Crisafulli, C. M. 1997. A habitat-based method for monitoring pond-breeding amphibians. Pages 94-96 *in* D. H. Olson, W. P. Leonard, and R. B. Bury, editors. Sampling amphibians in lentic habitats. Society for Northwestern Vertebrate Biology.

Cooper, S. L., and C. R. Peterson. 1995. The distribution and status of amphibians and reptiles on the INEL: Implications for future site development and environmental restoration operations. Annual Technical Report to DOE-ID. 1995:93-96. T. D. Reynolds, and R. C. Morris, editors. Environmental Science and Research Foundation Report Series, Number 12.

Crother, B. I. 2000. Scientific and standard English names of amphibians and reptiles of North America North and Mexico with comments regarding confidence in our understanding. SSAR Herpetological Circular No. 29: iv+1-82.

Day, T. A. and R. G. Wright. 1985. The vegetation types of Craters of the Moon National Monument. Bulletin Number 38, College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow, ID.

DeLaune, M. G. 1998. XTools ArcView extension (Version 10/18/1998). Oregon Department of Forestry, Salem, OR.

Gregory, P. T. 1983. Identification of sex of small snakes in the field. Herpetological Review 14(2): 42- 43.

Griffith, B. 1983. Ecological characteristics of mule deer: Craters of the Moon National Monument, Idaho. Cooperative Park Studies Unit/University of Idaho Report B83-2:109.

Groves, C. 1994. Idaho's amphibians and reptiles: description, habitat, and ecology. Nongame Wildlife Leaflet #7, Idaho Department of Fish and Game, Boise, ID.

Groves, C. R., B. Butterfield, A. Lippincott, B. Csuti, and J. M. Scott. 1997. Page 372 *in* Atlas of Idaho's wildlife: integrating Gap analysis and natural heritage information. Idaho Department of Fish and Game, Nongame and Endangered Wildlife Program, Boise, ID.

Heyer, W. R., M. A. Donnelly, R. W. McDiarmid, L. C. Hayek, and M. S. Foster. 1994. Measuring and monitoring biological diversity. Page 364 *in* Standard methods for amphibians. Smithsonian Institution Press, WA.

Hoffman, R. A. 1988. Craters of the Moon National Monument baseline inventory and monitoring (wildlife) final report-1988. Report B-88-4, University of Idaho, Cooperative Park Studies Unit, Moscow, ID.

Hooge, P. N., and B. Eichenlaub. 1997. Animal movement extension to ArcView. Ver. 1.1. Alaska Biological Science Center, U.S. Geological Survey, Anchorage, AK.

Lee, J. R., S. C. Doering, and C. R. Peterson. 1998. Monitoring amphibian and reptile populations on the Idaho National Engineering and Environmental Laboratory: Indicators of environmental health and change. *In* Annual Technical Report to DOE-ID: T.D. Reynolds and R.W. Warren, editors. Environmental Science and Research Foundation Report Series, Number 27. 1997:52-55

Linder, A. D. and E. Fichter. 1977. The amphibians and reptiles of Idaho. Idaho State University Press, Pocatello, ID. 78 p.

Lovejoy, S. H. 1980. Patterns in the distribution of plants and animals on lava flows and kipukas in southeastern Idaho. Unpublished Master's thesis. Idaho State University, Pocatello, ID.

Nussbaum, R. A., E. D. Brodie, Jr., and R. M. Storm. 1983. Amphibians and reptiles of the Pacific Northwest. University of Idaho Press, Moscow, ID. 332 p.

O'Neill, R. V., and A. W. King. 1998. Homage to St. Michael; or why are there so many books on scale? *In* Peterson, D. L., and V. T. Parker, editors. Ecological scale: Theory and applications. Columbia University Press, NY.

Olson, D. H., W. P. Leonard, and R. B. Bury. 1997. Sampling amphibians in lentic habitats. Society for Northwestern Vertebrate Biology, Olympia, WA. 134 p.

Rice, W. R. 1989. Analyzing tables of statistical tests. Evolution 43:223-225.

Rose, G.A., and W. C. Legget. 1990. The importance of scale to predator-prey spatial correlations: An example of Atlantic fishes. Ecology 62:319-326.

Pisani, G. R. 1973. A guide to preservation techniques for amphibians and reptiles. Herpetological Circular No. 1, Society for the Study of Amphibians and Reptiles. St. Louis, MO.

Schaefer, W. H. 1934. Diagnosis of sex in snakes. Copeia 1934:181.

Scott, J. M., C. R. Peterson, J. W. Karl, E. Strand, L. K. Svancara, and N. M. Wright. 2002. A Gap analysis of Idaho: final report. Idaho Cooperative Fish and Wildlife Research Unit. Moscow, ID.

Shaffer, H. B., and J. E. Juterbock. 1994. Night driving. Pages 163-166 *in* Heyer, W. R., M. A. Donnelly, R. W. McDiarmid, L. C. Hayek, and M. S. Foster, editors. Measuring and monitoring biological diversity standard methods for amphibians.

Stebbins, R. C. 1985. A field guide to western reptiles and amphibians: The Peterson field guide series. Houghton Mifflin Company, Boston, MA.

Appendix A. Potential Site Assessment Form and Data. Refer to text for row descriptions.

Site ID:	1	2	3	4	5	6	7	8	9	10	11	12	13
Northing:	4816227	4818032	4816856	4816794	4817225	4818281	4816727	4816756	4816596	4815687	4816493	4817059	4816394
Easting:	292465	290195	290405	290365	290743	289584	291252	291693	292259	291275	292751	294215	294519
Date:	19-08-99	24-09-99	24-09-99	24-09-99	22-09-99	24-08-99	24-08-99	14-09-99	24-08-99	22-09-99	24-08-99	23-09-99	28-09-99
Rover file:	RO81919A	R092415A	R092419A	R092419A	R092219A	R082413C	R082413C	R091422A	R082413C	R092219A	R082413C	R092320A	R092814A
Picture:	1NE	2SW	3NW	4NE	5NW	6Sw	7NE	8NE	9NW	10NW	11NW	12SW	13SW
Highest corner:	SW	SW	NW	NE	NW	SW	NE	NE	NW	NW	SW	SW	SW
Lowest corner:	NE	NE	SW	SE	SE	NE	SW	SW	SE	SE	NE	NE	SE
Hi to lo slope:	37	49	28	26	17	35	30	36	6	3	2	5	10
Visibility:	N-GC	N	N	N	NW	N	N	V	N	N	N-GC	VP	V
Trees:													
Aspen	N	N	A-	A-	S+	A	N	N	N	N	N	N	N
Cottonwood	N	N	N	C	N	N	N	N	N	N	N	N	N
Douglas fir	A	A	N	N	N	N	N	N	N	N	N	N	N
Limber Pine	S-	N	N	N	N	N	N	N	N	N	N	N	N
Other	N	N	N	N	N	S	N	N	N	N	N	N	N
Shrubs:													
Sagebrush	N	N	C	N	C	N	A	A	C+	A	A	C+	N
Bitterbrush	N	N	N	N	N	N	A	A	C+	A	A	C	A
Rabbitbrush	N	N	S-	N	C	N	N	N	S-	N	N	C-	A
Tansybrush	N	N	N	N	N	N	N	N	N	N	N	N	N
Currant	N	N	N	N	S	N	N	N	N	N	N	N	N
Snowberry	S	S-	C	C	N	S+	S	N	S-	N	N	N	N
Serviceberry	N	N	N	N	N	N	N	N	N	N	N	N	N
Other	N	N	N	N	C	S-	N	N	N	N	N	N	N
Grasses/forbs:													
GB Wildrye	N	N	S+	C	A-	N	N	N	N	N	N	S-	N
Other grasses	S-	C-	S	C+	S	A	S+	S-	S	C	S+	S+	C+
Herbs	N	N	S	C	C	S-	S	N	S-	S-	S-	S-	C+
Substrate:													
Soil	A	A	C	C	A	A	A	A	S	S	A	A-	A
Cinders	N	N	N	N	A	N	A	A	S	N	A	A-	A
Cobble	C	N	N	N	N	N	N	N	A	A	N	C	N
Rocks	N	N	N	N	N	C	N	N	S	C	C	C-	S
Outcrops	N	N	N	N	N	N	N	N	S	N	N	S-	N
A'a	N	N	N	N	N	N	N	N	N	N	N	N	N
Pahoehoe w. cracks	N	N	N	N	N	N	N	N	N	N	N	N	N
Pahoehoe w/o cracks	N	N	N	N	N	N	N	N	N	S	N	N	N

Site ID:	14	15	16	17	18	19	20	21	22	23	24	25	26
Northing:	4816470	4816196	4814809	4813661	4813297	4814303	4813967	4815159	4813360	4816680	4816359	4811519	4811673
Easting:	293992	293953	292272	290251	290165	290665	291245	292632	294334	292468	293292	294367	294165
Date:	28-09-99	27-09-99	18-10-99	29-09-99	29-09-99	17-08-99	30-09-99	28-09-99	20-08-99	24-08-99	23-09-99	27-09-99	27-09-99
Rover file:	R092814A	R092719A	R101817A	R092919A	R092919A	R093014A	R093014A	R092820A	RO82022A	R082413C	R092314A	R092714A	R092714A
Picture:	14SW	15SW	16SE	17NW	18NW	19SW	20NE	21NW	22SE	23NE	24NW	25SW	26SW
Highest corner:	SW	SW	SE	FLAT	NW	NE	NE	NW	SW	NE	SE	SW	SW
Lowest corner:	NE	NE	NW	FLAT	SE	SW	SW	SE	NE	SW	3	NE	NE
Hi to lo slope:	8	8	4	0	8	51	4	15	15	2	V	23	18
Visibility:	V	V	H,P	P	P	H	H	H	V	N		V	V
Trees:													
Aspen	N	N	N	N	N	N	N	N	N	N	N	N	N
Cottonwood	N	N	N	N	N	N	N	N	N	N	N	N	N
Douglas fir	N	N	N	N	N	N	N	N	N	N	N	N	N
Limber Pine	N	N	S-	N	N	N	S	N	N	N	N	C	C+
Other	N	N	N	N	N	N	N	N	N	N	N	N	N
Shrubs:													
Sagebrush	N	S+	N	A	A	S-	A	N	N	A	A-	A	A
Bitterbrush	A	A	N	A	A	S-	A	C+	C+	A	C+	A	A
Rabbitbrush	A-	A-	S-	S	S	N	S	C	C+	S	S-	S	S
Tansybrush	N	N	N	N	N	N	N	N	N	N	N	N	N
Currant	N	N	N	N	N	N	N	N	S-	N	N	N	N
Snowberry	N	N	N	N	N	N	N	N	N	S-	N	N	N
Serviceberry	N	N	N	N	N	N	N	N	N	N	N	N	N
Other	N	N	N	N	N	S	N	N	N	N	N	N	N
Grasses/forbs:													
GB Wildrye	N	N	N	N	N	N	N	N	N	S-	N	N	N
Other grasses	A	C+	S	S	S	S-	C	C	S-	S	S-	C	C
Herbs	C	C	S-	N	N	N	S	S	N	S-	S-	S	S-
Substrate:													
Soil	A	A	S	A-	C+	N	A	A	A	A	A	C	C
Cinders	A	A	S	A-	C+	N	A	A	A	A	A	C	C
Cobble	N	N	N	N	S-	A	N	N	N	N	N	N	N
Rocks	N	N	N	N	N	N	S	N	N	N	N	N	N
Outcrops	N	N	N	N	N	N	N	N	N	N	N	N	N
A'a	N	N	C	N	N	N	N	N	N	N	N	N	N
Pahoehoe w. cracks	N	N	N	N	N	N	N	N	N	N	N	N	N
Pahoehoe w/o cracks	N	N	A	N	N	N	S	N	N	N	N	N	N

Appendix A (continued). Potential Site Assessment Form and Data. Refer to text for row descriptions.

Site ID:	27	28	29	30	31	32	33	34	35	36	37	38
Northing:	4814188	4813389	4816990	4816113	4814379	4812497	4811695	4815961	4813558	4813255	4813298	4813698
Easting:	280437	290351	292831	292944	294165	292976	294384	294203	291302	291562	2945657	294567
Date:	17-08-99	29-09-99	23-09-99	23-09-99	09-02-99	15-10-99	27-09-99	28-09-99	29-09-99	29-09-99	09-02-99	09-02-99
Rover file:	R093014A	R092919A	R092320A	R092314A	R092314A	R090222A	R101515A	R092719A	RO92915A	R092915A	R090219A	R090219A
Picture:	7NE	28NE	29SE	30SW	31N	32SE	33SW	34NW	34NW	36SW	37SW	38SW
Highest corner:	NE	NE	SE	SW	NE	SE	SW	NW	NE	SW	SW	SW
Lowest corner:	SW	SW	NW	NE	SW	NW	NE	SE	SW	NE	NE	NE
Hi to lo slope:	7	9	7	20	8	2	56	8	2	43	9	8
Visibility:	V	P	N	V	N	N	H	H	P	N	V	N
Trees:												
Aspen	N	N	N	N	N	N	N	N	N	N	N	N
Cottonwood	N	N	N	N	N	N	N	N	N	N	N	N
Douglas fir	N	N	N	N	N	N	N	N	N	S-	N	N
Limber Pine	N	N	N	N	S	N	C	N	N	A	S	S-
Other	N	N	N	N	N	N	N	N	N	N	N	N
Shrubs:												
Sagebrush	A	C	C+	A	N	N	A	N	S	S	C-	N
Bitterbrush	A	C	N	A	C	N	A	C+	S	C-	A	A-
Rabbitbrush	S	S	S-	N	S	N	S	C+	N	N	A	A-
Tansybrush	S	S-	N	N	N	N	N	N	S	S	N	N
Currant	N	N	N	N	N	N	N	N	N	C-	N	N
Snowberry	N	N	N	N	N	N	N	N	N	S	N	N
Serviceberry	N	N	N	N	N	N	N	N	N	N	N	N
Other	N	N	N	N	N	N	N	N	N	N	N	N
Grasses/forbs:												
GB Wildrye	N	N	C+	N	N	N	N	N	N	S-	N	N
Other grasses	S	C	C+	C+	S-	N	S	C	S	C-	S	S-
Herbs	S	N	N	C+	N	S-	S	S	S	S-	N	N

Appendix A (continued). Potential Site Assessment Form and Data. Refer to text for row descriptions.

Site ID:	27	28	29	30	31	32	33	34	35	36	37	38
Substrate:												
Soil	A	C+	C	A	A	N	A	A	N	C	A	A
Cinders	A	C+	C	A	A	N	A	A	N	C	A	A
Cobble	C	N	S	N	S-	N	N	N	N	S	N	N
Rocks	C	N	S	N	S-	N	N	N	N	N	N	N
Outcrops	S-	N	N	N	N	N	N	N	N	N	N	C-
A'a	N	N	N	N	N	A+	N	N	N	N	N	N
Pahoehoe w cracks	N	N	N	N	N	N	N	N	A	N	N	N
Pahoehoe w/o cracks	N	N	S	N	N	S-	N	N	A	N	N	N

Appendix A (continued). Potential Site Assessment Form and Data. Refer to text for row descriptions

Site ID:	39	40	41	42	43	44	45	46	47	48	49	50	51
Northing:	4812790	4811194	4813895	4814063	4814681	4815203	4815918	4815299	4816446	4817839	4818172	4815664	4814420
Easting:	291246	293644	291107	291431	292128	290317	293282	293323	291487	290758	289906	293986	293162
Date:	09-29-99	9/27/199	28-09-99	28-09-99	30-09-99	22-09-99	26-08-99	02-09-99	14-09-99	24-09-99	25-08-99	28-09-99	14-10-99
Rover file:	R092915A	R092714A	R092820A	R092820A	R093017A	R092215A	R082613A	R090213A	R091422A	R092415A		R092814A	R101419A
Picture:	39NE	40SW	41NW	42NW	43NW	44NE	45SW	46SW	47NE	48NW	49SW	50SW	51NE
Highest corner:	NE	SW	NW	NW	NW	NE	SW	SW	NE	NW	SW	SW	NE
Lowest corner:	SW	NE	SE	SE	NE	SW	NE	NE	NW	SW	NE	SE	SW
Hi to lo slope:	27	10	14	16	25	29	10	11	5	25	40	6	11
Visibility:	P	V	V	H	N	V	V	H	V	N	N	H	H,C
Trees:													
Aspen	N	N	N	N	N	N	N	N	N	C	A	N	N
Cottonwood	N	N	N	N	N	N	N	N	N	N	N	N	N
Douglas fir	N	N	N	N	N	N	N	N	N	N	N	N	N
Limber Pine	S-	S-	N	S	C	N	N	S-	N	N	N	S-	N
Other	N	N	N	N	N	N	N	N	N	N	N	N	N
Shrubs:													
Sagebrush	C	A	A	C	S	A	A	N	A	C	N	S-	N
Bitterbrush	A-	A	A	C	C	A	A	A	A	N	N	S-	S-
Rabbitbrush	N	S	S	S	C	S	S-	A	S-	N	N	N	N
Tansybrush	N	N	N	N	S	N	N	N	N	N	N	S	S-
Currant	N	N	N	N	N	N	N	N	N	N	N	N	N
Snowberry	N	N	N	N	N	N	N	N	N	S	C-	N	N
Serviceberry	N	N	N	N	N	N	N	N	N	N	N	N	N
Other	N	N	N	N	N	N	N	N	N	N	N	N	N
Grasses/forbs:													
GB Wildrye	S-	N	N	N	N	N	N	S-	N	C	N	N	N
Other grasses	C+	S-	S	S	S-	C	C+	S-	C	S-	A	S-	S-
Herbs	S-	N	S	N	N	S	S-	S	S	S	C+	S-	S-
Substrate:													
Soil	C	C	A	A	C	A	A	A	C	A	A	N	N
Cinders	A	C	A	A	C	A	A	A	S-	C	N	N	N
Cobble	N	N	N	N	C	S-	N	N	C	N	N	N	N
Rocks	N	N	N	N	C	N	N	N	C	S-	N	N	N
Outcrops	N	N	N	N	N	N	N	N	C	N	N	N	N
A'a	N	N	N	N	N	N	N	N	N	N	N	N	N
Pahoehoe w. cracks	N	N	N	S-	C	N	N	N	N	N	N	A	A+
Pahoehoe w/o cracks	N	N	N	N	C	N	N	N	S	N	N	A	A

Appendix A (continued). Potential Site Assessment Form and Data. Refer to text for row descriptions

Site ID:	52	53	54	55	56	57	58	59	60	61	62	63
Northing:	4813411	4812894	4812175	4811755	4812050	4811109	4814276	4814357	4812555	4812502	4812726	4813171
Easting:	295084	294678	294247	294171	294132	293814	293484	293792	294023	293501	293345	295008
Date:	27-09-99	14-10-99	15-10-99	27-09-99	18-10-99	15-10-99	14-10-99	14-09-99	15-10-99	15-10-99	15-10-99	14-10-99
Rover file:	R092719A		R1520A		R1017A	R101520A	R101419A	R101817A	R101520A	R101515A	R101515A	R101419A
Picture:	52NE		54SW		56SW	57SE	58NW	59NE	60SW	61NW	62NE	63NW
Highest corner:	NE		SW	site is no good	NE	SE	NW	SW	NE	NW	NE	NW
Lowest corner:	SW		NE		SW	NE	NE	SE	NW	SE	SW	SW
Hi to lo slope:	7		6		16	4	14	10	3	12	2	4
Visibility:	N		H		N	V	P,C	P	H	H	H	H
Trees		Point is only 10 m off loop road. Won't fit										
Aspen	N		NE		N	N	N	N	N	N	N	N
Cottonwood	N		NE		N	N	N	N	N	N	N	N
Douglas fir	N		NE		n	N	N	N	N	N	N	N
Limber Pine	S-		S-		N	S	N	S	S-	N	N	N
Other	N		NE		N	N	N	N	N	N	N	N
Shrubs												
Sagebrush	S-		N		N	C	N	N	N	N	N	N
Bitterbrush	N		N		N	C	S-	S	S-	N	N	N
Rabbitbrush	S-		N		N	S	N	S-	N	N	N	N
Tansybrush	S-		S-		N	S-	S-	N	N	N	S-	N
Currant	N		N		N	N	N	N	N	N	N	N
Snowberry	N		N		N	N	N	N	N	N	N	N
Serviceberry	N		N		N	N	N	N	N	N	N	N
Other	N		N		N	N	N	N	N	N	N	N
Grasses/forbs:												
GB Wildrye	N		N		N	N	N	N	N	N	N	N
Other grasses	S-		S-		N	S	S	S-	S-	S-	S-	N
Herbs	S-		S-		S-	S	S	N	S-	S-	S-	N
Substrate:												
Soil	A		N		N	N	N	A	N	N	N	N
Cinders	A		N		N	A	N	A	N	N	N	N
Cobble	N		N		N	S	N	N	N	N	N	N
Rocks	A		N		N	N	N	N	N	N	N	N
Outcrops	N		N		N	N	N	S-	N	N	N	N
A'a	N	A	N		N	A	N	N	N	A+	N	A+
Pahoehoe w cracks	C+	N	N		N	N	A	N	N	N	N	N
Pahoehoe w/o cracks	C+	N	A+		A+	N	A	S-	A+	S	A+	N

Appendix A (continued). Potential Site Assessment Form and Data. Refer to text for row descriptions

Site ID:	64	65	66	67	68	69	70	71	72	73
Northing:	4813171	4813700	4813871	4813668	4816400	4815439	4816227	4816755	4815145	4818507
Easting:	294894	290808	290556	290602	290958	290736	292730	294155	293468	289640
Date:	09-02-99	17-08-99	17-087-99	17-08-99	22-09-99	22-09-99	23-09-99	23-09-99	2/9/1999	24-08-99
Rover file:	R090213A		R092921A	R092921A	R092219A	R092215A	R092314A	R092320A	R090213A	R082413C
Picture:	64SE				68SW	69NW	70SW	71SW	72SW	73SW
Highest corner:	SE	NE	NE	SW	Sw	NW	SW	SW	SW	SW
Lowest corner:	NW	NW	SW	NE	NE	SE	NE	NE	NE	SE
Hi to lo slope:	10	18	5	1	39	23	33	5	13	54
Visibility:	H	H	V	H	V	V	V	HP	H	N
Trees										
Aspen	N	N	N	N	N	N	N	N	N	N
Cottonwood	N	N	N	N	N	N	N	N	N	N
Douglas fir	N	N	N	N	N	N	S-	N	N	N
Limber Pine	N	N	N	N	N	N	N	N	S-	N
Other	N	N	N	N	N	N	N	N	N	S-
Shrubs										
Sagebrush	N	S-	A	N	A	A	A	S	N	A
Bitterbrush	A	S-	A	N	A	A	A	C	A	N
Rabbitbrush	N	N	N	N	N	S-	S-	S+	S	S
Tansybrush	N	S-	N	S-	N	N	N	N	N	N
Currant	N	N	N	N	N	N	N	N	S-	N
Snowberry	N	N	N	N	N	N	N	N	N	C
Serviceberry	N	N	N	N	N	N	N	N	N	N
Other	N	N	N	S-	N	N	N	N	N	S-
Grasses/forbs:										
GB Wildrye	N	S-	N	N	N	N	N	N	N	S-
Other grasses	S	S-	S-	N	C	C	C+	A-	C	S
Herbs	N	N	S-	N	S-	S	C+	S-	C	S-
Substrate:										
Soil	A	S-	A	N	A	A	A	C	A	A
Cinders	A	S-	A	N	A	A	A	C	A	N
Cobble	N	N	N	N	N	N	N	N	N	N
Rocks	N	N	N	N	N	N	N	N	N	C
Outcrops	C	N	N	N	N	N	N	S-	N	N
A'a	N	A+	N	N	N	N	N	N	N	N
Pahoehoe w cracks	N	N	N	A+	N	N	N	N	N	N
Pahoehoe w/o cracks	N	N	N	N	N	N	N	S-	N	N

Appendix B. Trap checking form.

Date: ______________ NORTH END / SOUTH END Observers: ______________

		SNAKES					LIZARDS			MAMMALS																COMMENTS
Array	Time	CHBO	COCO	CRVI	PICA	THEL	EUSK	PHDO	SCGR	MILO	MIMO	MUER	NECI	PEMA	PEPA	REME	SOMO	SOVA	SPCO	SPLA	TAAM	TAHU	TAMI	THTA	ZAPR	(Which traps animals were in, other observations, etc.)

Appendix C. Codes used for trap captures.

Code	Scientific name	Common name	Features
MILO	*Microtus longicaudus*	longtailed vole	Reduced ears, tail noticeably longer than hindfoot
MIMO	*Microtus montanus*	montane vole	Reduced ears, tail shorter than or about equal to hindfoot
MUFR	*Mustella frenatus*	longtailed weasel	White feet, long tail
OCPR	*Ochatona princeps*	pika	Small mean rabbit with tiny round ears
PEMA	*Perimyscus maniculatus*	deer mouse	Big ears, white feet/belly, sharply bicolored tail, no cheek pouches
PEPA	*Perignathus parvus*	Great Basin pocket mouse	Long tail with crest of black hairs at the tip, large hindfeet, has cheek pouches
REME	*Reithrodondymys megalotis*	western harvest mouse	Front incisors deeply grooved-looks like 4 teeth, no cheek pouches
SOMO	*Sorex monticola*	montane shrew	Very small, usually dead, purple teeth, short fur, tiny eyes
SPLA	*Spermophilis lateralis*	golden-mantled ground squirrel	Gold hue on head and front legs, large, dorsal stripes
TAAM	*Tamias amoenus*	yellow pine chipmunk	Ears blackish in front, white behind
TAHU	*Tamiasciurus hudsonichus*	red squirrel	Black band between light belly and dark dorsum
TAMI	*Tamias minimis*	least chipmunk	Smaller and not as brightly colored
THAT	*Thomomys talpoides*	northern pocket gopher	Large cheek pockets, small eyes, large fore claws
ZAPR	*Zapus princeps*	western jumping mouse	Dark dorsal band, large hindfeet, tail much longer than body

Appendix D. Column heading descriptions for Table 4 column headings.

Heading	Description
SITE	Site name as used in our records
NORTHING	UTM NAD 27 Zone 12 Northing in meters
EASTING	UTM NAD 27 Zone 12 Easting in meters
OPEN1	Date array opened for the 1999 field season
CLOSE1	Date array closed for the 1999 field season
OPEN2	Date array opened for the Spring 2000 field season
CLOSE2	Date array closed for the Spring 2000 field season
OPEN3	Date array opened for the Fall 2000 field season
CLOSE3	Date array closed for the Fall 2000 field season
OPEN4	Date array opened for the Spring 2001 field season
CLOSE4	Date array closed for the Spring 2001 field season
OPEN5	Date array opened for the Fall 2001 field season
CLOSE5	Date array closed for the Fall 2001 field season
SET	Group to which array belonged
	1=1999 and Spring 2000 field seasons
	2=Fall 2000 and Spring 2001 field seasons
	3=Fall 2001 field season
	LT=1999 through Fall 2001 field seasons
DAYS	Total days array was open
COLVEG	Collapsed vegetation class in which array located

Appendix E. Incidental Small Mammal Trap Captures.

Code	#	Scientific name	Common name	Traps	Habitats
MIMO	21	*Microtus montanus*	Montane vole	B1, B2, EC1, EC2, GC1, H1, LC2, LC3, LC4, NWLR, RC1, RC2, SSC2, WC3, WC4	Bare cinder patch, Douglas fir, Great Basin Wildrye, Limberpine/Bitterbrush Low Density Limberpine, Limberpine/Bitterbrush Low Total Cover, Riparian, Sagebrush
MUFR	5	*Mustella frenatus*	Longtailed weasel	B1, LC1, LC3, SELR, SiC1	Limberpine/Bitterbrush Low Density Limberpine, Riparian, Sagebrush
OCPR	1	*Ochatona princeps*	Pika	SiC1	Limberpine/Bitterbrush Low Density Limberpine
PEMA	70	*Perimyscus maniculatus*	Deer mouse	B1, B2, CA2, DO, DO2, ELR, GC1, H1, H2, H3, LC2, NEG, NHF, NLR, NWLR, NWLR2, OHQ1, OHQ2, OHQ3, PC1, RC1, SC, SELR, SiC2, SSC1, SSC2, TM, WC4, WC5	Bare cinder patch, Douglas fir, Limberpine/Bitterbrush Low Density Limberpine, Limberpine/Bitterbrush Low Total Cover, Riparian, Sagebrush
PEPA	135	*Perignathus parvus*	Great Basin pocket mouse	B1, B2, BT, EC1, EC2, EC3, GCG, GCG2, H1, H10, H2, H3, H5, H6, H8, LC1, LC2, LC3, LC4, LC6, MDH, MFN, NEG, NERI, NWLR, OHQ1, OSA, OSW-IT, PC1, RC1, RC2, RC4, SELR, SiC2, SSC1, SSC2, SSC3, TM, TM2, TM3, WC1, WC3, WC4, WC5	Aspen, Bare cinder patch, Great Basin Wildrye, Limberpine/Bitterbrush High Total Cover, Limberpine/Bitterbrush Low Density Limberpine, Limberpine/Bitterbrush Low Total Cover, Riparian, Sagebrush
REME	14	*Reithrodondymys megalotis*	Western harvest mouse	B1, B2, EC2, EC3, GCG, H2, NHF, NWLR, QSC, SSC1, WC4	Bare cinder patch, Great Basin Wildrye, Limberpine/Bitterbrush Low Density Limberpine, Limberpine/Bitterbrush Low Total Cover, Sagebrush
SOMO	64	Sorex monticola	Montane shrew	B2, CA2, CA3, EC2, H1, H3, H4, LC1, LC2, LC3,LC4, LC5, OHQ2, RC1, RC2, RC4, SELR, SiC2, TM, WC2, WC3, WC4, WC4-BP	Aspen, Bare cinder patch, Douglas fir, Great Basin Wildrye, Lava, Limberpine/Bitterbrush Low Density Limberpine, Limberpine/Bitterbrush Low Total Cover, Riparian, Sagebrush
SPLA	13	Spermophilis lateralis	Golden-mantled ground squirrel	B1, CA1, DO, GC2, NLR, SC, SSC2	Douglas fir, Limberpine/Bitterbrush Low Density Limberpine, Limberpine/Bitterbrush Low Total Cover, Sagebrush
TAMI	105	Tamias minimis	Least chipmunk	B1, B2, BT, CA1, CA2, DHC, DO, EC2, GC1, GC2, H1, H2, H4, H5, LC4, LC5, LC6, NHF, NLR, NWLR, NWLR2, OHQ3, OSA, RC3, SC, SELR, SiC1, SiC2, TM, TM2, WC2, WC3, WC4-BP	Aspen, Bare cinder patch, Douglas fir, Great Basin Wildrye, Lava, Limberpine/Bitterbrush High Total Cover, Limberpine/Bitterbrush Low Density Limberpine, Limberpine/Bitterbrush Low Total Cover, Riparian, Sagebrush
THAT	25	Thomomys talpoides	Northern pocket gopher	B2, DO, GCG, H1, H3, H6, LC1, LC2, LC3, LC5, RC2, SC, WC1, WC5	Bare cinder patch, Douglas fir, Great Basin Wildrye, Limberpine/Bitterbrush Low Total Cover, Riparian, Sagebrush
ZAPR	36	Zapus princeps	Western jumping mouse	LC2, LC3, LC6, RC2, RC3, WC2	Aspen, Great Basin Wildrye, Riparian

Appendix F. Road driving survey data form.

Road driving survey data form

Date: ______________________________ Observer(s):_______________________________________

START: ______________________________ END: ______________________________________

START	END
Time: ________________________	Time: ______________________
Odometer: ____________________	Odometer: __________________
Te: __________________________	Te: ________________________
Ta: __________________________	Ta: ________________________
Wind: ________________________	Wind: ______________________
Clouds: ______________________	Clouds: ____________________

OBSERVATIONS: ____________________________

Species	Northing	Easting	Live/Dead	Te	Ta	Wind	Behavior:

Other observations/comments:

____

____

____

Appendix G. Data form used for collecting data for radiotelemetric focal animal studies.

Channel: 00 **Freq: 151.180** **PICA #323** **Species:**	**Channel: 01** **Freq: 151.383** **Species: CRVI #325**	**Channel: 03** **Freq:151.663** **Species: COCO #314**	**Channel: 04** **Freq:151.873** **Species: (open)**	**Channel: 05** **Freq: 151.892** **Species: CHBO #315**
Observer: Date: Northing: Easting: Air Temp: Opr. temp Slope: Aspect Time: Wind **Animal actions:**	Observer: Date: Northing: Easting: Air Temp: Opr. temp Slope: Aspect Time: Wind **Animal actions:**	Observer: Date: Northing: Easting: Air Temp: Opr. temp Slope: Aspect Time: Wind **Animal actions:**	Observer: Date: Northing: Easting: Air Temp: Opr. temp Slope: Aspect Time: Wind **Animal actions:**	Observer: Date: Northing: Easting: Air Temp: Opr. temp Slope: Aspect Time: Wind **Animal actions:**
Observed Crawling Exposed Feeding Hidden Mating Undergrnd Drinking In veg Response In rocks Captured Coiled Weighed Extended Bled **Conditions:**	Observed Crawling Exposed Feeding Hidden Mating Undergrnd Drinking In veg Response In rocks Captured Coiled Weighed Extended Bled **Conditions:**	Observed Crawling Exposed Feeding Hidden Mating Undergrnd Drinking In veg Response In rocks Captured Coiled Weighed Extended Bled **Conditions:**	Observed Crawling Exposed Feeding Hidden Mating Undergrnd Drinking In veg Response In rocks Captured Coiled Weighed Extended Bled **Conditions:**	Observed Crawling Exposed Feeding Hidden Mating Undergrnd Drinking In veg Response In rocks Captured Coiled Weighed Extended Bled **Conditions:**
Clear Overcast Hazy Sprinkling P. cloudy Raining M. cloudy Slt/snow **Substrate:**	Clear Overcast Hazy Sprinkling P. cloudy Raining M. cloudy Slt/snow **Substrate:**	Clear Overcast Hazy Sprinkling P. cloudy Raining M. cloudy Slt/snow **Substrate:**	Clear Overcast Hazy Sprinkling P. cloudy Raining M. cloudy Slt/snow **Substrate:**	Clear Overcast Hazy Sprinkling P. cloudy Raining M. cloudy Slt/snow **Substrate:**
Soil A'a lava Sand Pahoehoe Cinders Outcrop Cobble Brkdwn pit Rocks Crack Talus Cave **Vegetation:**	Soil A'a lava Sand Pahoehoe Cinders Outcrop Cobble Brkdwn pit Rocks Crack Talus Cave **Vegetation:**	Soil A'a lava Sand Pahoehoe Cinders Outcrop Cobble Brkdwn pit Rocks Crack Talus Cave **Vegetation:**	Soil A'a lava Sand Pahoehoe Cinders Outcrop Cobble Brkdwn pit Rocks Crack Talus Cave **Vegetation:**	Soil A'a lava Sand Pahoehoe Cinders Outcrop Cobble Brkdwn pit Rocks Crack Talus Cave **Vegetation:**
Aspen Doug. fir Cottonwd Limb. pine Willow Oth. trees GB Wildrye Oth. grass Sage Chokechry Snowberry Ant.Bitt.br. Snowbrsh Green R.b. Gray R.B. Tansy Currant Oth. shrbs Balsamrt Parsnip Nettle Parsley Buckwht Lupine Monkeyflr Oth. forbs **Notes:**	Aspen Doug. fir Cottonwd Limb. pine Willow Oth. trees GB Wildrye Oth. grass Sage Chokechry Snowberry Ant.Bitt.br. Snowbrsh Green R.b. Gray R.B. Tansy Currant Oth. shrbs Balsamrt Parsnip Nettle Parsley Buckwht Lupine Monkeyflr Oth. forbs **Notes:**	Aspen Doug. fir Cottonwd Limb. pine Willow Oth. trees GB Wildrye Oth. grass Sage Chokechry Snowberry Ant.Bitt.br. Snowbrsh Green R.b. Gray R.B. Tansy Currant Oth. shrbs Balsamrt Parsnip Nettle Parsley Buckwht Lupine Monkeyflr Oth. forbs **Notes:**	Aspen Doug. fir Cottonwd Limb. pine Willow Oth. trees GB Wildrye Oth. grass Sage Chokechry Snowberry Ant.Bitt.br. Snowbrsh Green R.b. Gray R.B. Tansy Currant Oth. shrbs Balsamrt Parsnip Nettle Parsley Buckwht Lupine Monkeyflr Oth. forbs **Notes:**	Aspen Doug. fir Cottonwd Limb. pine Willow Oth. trees GB Wildrye Oth. grass Sage Chokechry Snowberry Ant.Bitt.br. Snowbrsh Green R.b. Gray R.B. Tansy Currant Oth. shrbs Balsamrt Parsnip Nettle Parsley Buckwht Lupine Monkeyflr Oth. forbs **Notes:**

Appendix H. Explanations of NPSpecies Codes.

PARK STATUS

- **Present:** *Species occurrence in park is documented and assumed extant.*
- **Historic:** *Species historical occurrence in the park is documented, but recent investigations indicate that the species is now probably absent.*
- **Probably Present:** *Park is within species range and contains appropriate habitat. Documented occurrences of the species in the adjoining region of the park give reason to suspect that it probably occurs within the park. The degree of probability may vary within this category, including species that range from common to rare.*
- **Encroaching:** *The species is not documented in the park, but is documented as being adjacent to the park and has potential to occur in the park.*
- **Unconfirmed:** *Included for the park based on weak (unconfirmed) record or no evidence, giving nminimal indication of the species occurrence in the park.*
- **False Report:** *Species previously reported to occur within the park, but current evidence indicates that the report was based on a misidentification, a taxonomic concept no longer accepted, or some other similar problem of interpretation.*

SPECIES ABUNDANCE

- **Abundant:** *May be seen daily, in suitable habitat and season, and counted in relatively large numbers.*
- **Common:** *May be seen daily, in suitable habitat and season, but not in large numbers.*
- **Uncommon:** *Likely to be seen monthly in appropriate season/habitat. May be locally common.*
- **Rare:** *Present, but usually seen only a few times each year.*
- **Occasional:** *Occurs in the park at least once every few years, but not necessarily every year.*
- **Unknown:** *Abundance unknown.*

RESIDENCY

- **Breeder:** *Population reproduces in the park.*
- **Resident:** *A significant population is maintained in the park for more than two months each year, but it is not known to breed there.*
- **Migratory:** *Migratory species that occurs in park approximately two months or less each year and does not breed there.*
- **Vagrant:** *Park is outside of the species usual range.*
- **Unknown:** *Residency status in park is unknown.*

SPECIES NATIVITY

- **Native:** *The species is native to the park (either endemic or indigenous), or if the Park Status is Probably Present as defined above, the species would be native to the park if it were eventually confirmed in the park.*
- **Non-Native (Exotic):** *The species is not native to the park (neither endemic nor indigenous), or if the Park Status is Probably Present as defined above, the species would not be native to the park if it were eventually confirmed in the park.*
- **Unknown:** *Nativity classification in park is unknown.*

SPECIES OF MANAGEMENT PRIORITY

Yes or No
IF YES: Explain management priorities.

SPECIES OF EXPLOITATION CONCERN

Yes or No
IF YES: Explain exploitation concerns

Appendix I. Information for voucher specimens.

Temporary ID #	Date Collected	Species	Sex	SVL (cm)	Tail (cm)	Location	Collectors
CRMO-04	16-Jun-99	Chbo	F	57.4	7.6	Northend road at group campsite turnoff	Lee, J. R. and B. I. Mosier
CRMO-13	22-Jun-00	Chbo	J	23.8	2.7	Herpetological array H1, north trap	Weekley, T. M.
CRMO-23	31-Aug-00	Chbo	M	44.7	6.4	Herpetological array WC6-S	Lee, J. R.
CRMO-15	23-Jul-00	Coco	F	72.7	23.8	Herpetological array H1, west trap	Weekley, T. M.
CRMO-14	22-Jun-00	Crvi	M	80.5	5.5	100 m from the road at herp array H1	Weekley, T. M.
CRMO-18	9-Jul-00	Crvi	F	78	4.3	Northend road at group campsite turnoff	Lee, J. R.
CRMO-02	26-Jul-99	Eusk	F	5.7	10.2	Herpetological array LC3, east trap	Welch, J. and A. Eighmy
CRMO-06	30-Jul-99	Eusk	F	6.4	10.4	Herpetological array DO, east trap	Welch, J. and A. Eighmy
CRMO-12	20-Jun-00	Phdo	F	4.5	1.8	Just n. of boundary 2.1 km N of Round Knoll	Lee, J. R and T. M. Weekley
CRMO-10	13-Aug-00	Phdo	M	6.5	2.7	Near parking area for EC3	Lee, J. R.
CRMO-20	13-Aug-00	Phdo	J	2.8	1.1	Near parking area for EC3	Lee, J. R.
CRMO-08	15-May-00	Pica	M	89	16.8	Road at Broken Top picnic table	Morris, M.
CRMO-03	29-May-00	Pica	M	62.5	10.5	Hairpin curve to the northwest of Broken Top	Morris, M.
CRMO-07	11-Jun-00	Pica	M	96	17	Hairpin curve to the northwest of Broken Top	Morris, M.
CRMO-16	6-Jul-00	Pica	J	33.7	6	Herpetological array SELR, east trap	Weekley, T. M.
CRMO-09	18-Jun-99	Scgr	F	5.9	7.4	Northend gate	Lee, J. R.
CRMO-11	20-Jun-00	Scgr	J	4.2	5	Herpetological array EC1, east trap	Lee, J. R.
CRMO-19	27-Jul-00	Scgr	M	6	8.1	Herpetological array LC6, west trap	Lee, J. R.
CRMO-01	14-Jun-93	Thel	F	59.4	17.8	Northend road near group campsite	Schneider, R.
CRMO-17	11-Jul-00	Thel	F	68.5	16.4	LCC road at Herpetological array LC6	Lee, J. R.
CRMO-05	29-Jul-00	Thel	J	25.5	3.4	Herpetological array LC6, south trap	Lee, J. R.
CRMO-21	25-Aug-00	Thel	M	48.5	14.6	Herpetological array RC2, south trap	Lee, J. R.
CRMO-22	28-Aug-00	Thel	J	26	7.6	In N. trap of SSC2	Colket, E. C.

Appendix I (continued). Information for voucher specimens.

Temporary ID #	Notes	UTM Zone	UTM Northing	UTM Easting	Location Acc. (m)	Date preserved	IMNH number
CRMO-04	Found dead in the road at 1250h	12T	4816351	292632	20	12-Jun-00	pending
CRMO-13	Sacrificed	12T	4816742	294622	10	31-Jul-00	pending
CRMO-23	Sacrificed	12T	4815735	291372	10	pending	pending
CRMO-15	Sacrificed	12T	4816742	294622	10	31-Jul-00	pending
CRMO-14	Sacrificed	12T	4816752	294481	30	31-Jul-00	pending
CRMO-18	Sacrificed	12T	4816401	292636	30	31-Jul-00	pending
CRMO-02	Found dead in the trap at 0940h	12T	4817602	290730	10	12-Jun-00	pending
CRMO-06	Dead in trap	12T	4814198	294530	10	12-Jun-00	pending
CRMO-12	Sacrificed	12T	4817988	298852	200	31-Jul-00	pending
CRMO-10	Sacrificed	12T	4817266	292764	10	24-Aug-00	pending
CRMO-20	Sacrificed	12T	4817261	292827	10	24-Aug-00	pending
CRMO-08	Found dead in the road	12T	4811713	294176	50	12-Jun-00	pending
CRMO-03	Found dead in the road at 1830h	12T	4811722	293881	100	12-Jun-00	pending
CRMO-07	Found dead in the road at 1220h	12T	4811722	293881	100	12-Jun-00	pending
CRMO-16	Sacrificed	12T	4812954	294502	10	31-Jul-00	pending
CRMO-09	Was basking on a rock	12T	4815629	293389	10	12-Jun-00	pending
CRMO-11	Sacrificed	12T	4817101	292291	30	31-Jul-00	pending
CRMO-19	Sacrificed	12T	4817231	290746	10	31-Jul-00	pending
CRMO-01	Found dead in the road at 0830h	12T	4816377	292673	200	12-Jun-00	pending
CRMO-17	Sacrificed	12T	4817260	290775	10	31-Jul-00	pending
CRMO-05	Killed by ants in trap	12T	4817231	290746	10	31-Jul-00	pending
CRMO-21	Sacrificed	12T	4816751	290789	10	28-Aug-00	pending
CRMO22	Found dead in trap	12T	4815450	292845	10	pending	pending

Appendix J. Inventory field work photographs

Photo J-1: Looking southward along the Great Rift from the LC1 array at the head of Little Cottonwood Canyon

Photo J-2: Field crew

Photo J-3: Field crew installing a trapping array

The Department of the Interior protects and manages the nation’s natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 131/101586, March 2010

National Park Service
U.S. Department of the Interior

Natural Resource Program Center
1201 Oakridge Drive, Suite 150
Fort Collins, Colorado 80525

www.nature.nps.gov

EXPERIENCE YOUR AMERICA ™