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Upper Columbia Basin Network

Pika Survey Report for Craters of the Moon National Monument and Preserve

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ON THE COVER
American pika (*Ochotona princeps*)
Photo from Craters of the Moon NM&P

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Executive Summary

Recent putative extirpations of the American pika (*Ochotona princeps*) in some Great Basin mountain ranges have led to concerns about the impacts of climate change and global warming on this heat intolerant species. The deep cracks and crevices in the lava flow environments found at Craters of the Moon National Monument and Preserve (CRMO) provide a unique and potentially critical habitat type for pikas. Consequently, CRMO could become a regionally significant refugia for pikas if warming over the next century occurs as predicted, and the need for establishing a baseline against which future population change can be detected is clear.

The Upper Columbia Basin Network (UCBN) recognizes this need and has identified pika monitoring as a future project. Pikas are well suited for presence-absence surveys and given the vast area of potential habitat at CRMO, this approach is highly efficient. In September 2007, observers surveyed 72 randomly selected sites in the northern portion of the Monument to detect both direct (visual and aural) and indirect (fresh scat and haypiles) pika sign. Surveys were conducted in 12 m plots for 20 minutes with two visits per site. Target surveys were conducted in southern low-elevation areas of the preserve to determine the extent of pika distribution, and numerous sites with historic pika observations were also surveyed. Additional targeted searches were also made in October 2007 along the northern and northeastern margins of lava flows adjacent to the Monument boundary. These efforts were designed to contribute to our understanding of the current southern/lower elevation limit of pika in CRMO, estimate the proportion of area occupied in the northern portion of the park, estimate pika site occupancy and pika detectability, allow for comparison with recent pika surveys conducted at Lava Beds National Monument, and provide recommendations for a long-term pika monitoring program in CRMO.

Pika detection probability was estimated to be very high (i.e. ~ 1), particularly when indirect sign was included. The proportion of area occupied in the Monument study area was estimated to be 0.20, and pahoehoe lava sites with high complexity and moderate forb cover were more likely to be occupied by pikas than unvegetated Aa lava sites. No pika sign was found during two days of targeted surveys in the southern Preserve area, but additional effort is required in 2008 before conclusions can be made about distributional limits in the park. Our results are similar to those recently obtained from the Lava Beds NM surveys, and a joint analytical effort is currently underway.

Acknowledgments

Many people contributed their ideas and hard work toward the development and implementation of this pika survey effort. Craters of the Moon NM&P resource manager John Apel and park wildlife biologist Mike Munts consulted on many of the phases of the project, facilitated logistics planning and coordination, and conducted pika surveys. Paige Wolken, Craters' botanist consulted on the design of vegetation sampling methods. We also thank Student Conservation Association Intern Erika Colaiacomo who was invaluable in assisting with field data collection and spent additional time sampling historic sites. UCBN Data Manager Gordon Dicus contributed his time and efforts in performing the surveys as well as provided advice regarding data management. Also, UCBN Coordinator Lisa Garrett oversaw the project staff, budget, and administration, consulted on all phases of the project, and reviewed the report and products. Finally, we would like to thank Erik Beever and Chris Ray for sharing information from their pika surveying efforts and conclusions at Lava Beds NM.

Background and Objectives

Rationale for Initiating a Pika Inventory at Craters of the Moon

The American pika (*Ochotona princeps*), a small mammal related to rabbits and hares (Order Lagomorpha), occurs in montane rocky environments of western North America from British Columbia south to the southern Great Basin (Hall 1981). The species is largely restricted to boulder-strewn talus fields and slopes where abundant crevices and cavities provide sufficient cover. It is sensitive to heat stress and is generally restricted to higher elevations (>1500 m or 5000'). Recently, localized extirpations of the species have been documented in isolated mountain ranges of the Great Basin (Beever et al. 2003). The hypothesized mechanism for these extirpations is increased warming resulting from accelerated climate change, and given the current predictions of climate change over the next century, the risk of extinction is now considerable (Beever et al. 2003, Wagner et al. 2003, Grayson 2005, Parmesan 2006).

The lava flow environments found at Craters of the Moon National Monument and Preserve (CRMO) provide a unique and potentially critical habitat type for pikas (Beever 2002). The cool microclimates in the deep cracks and crevices of the lava flows allow pikas to survive despite extreme summer surface temperatures. These flows are extensive, which presumably permits a much larger and more genetically diverse population to persist than those in highly fragmented montane environments. A recent pika survey in Lava Beds National Monument, an area with similar contiguous lava flow habitat, found that a large proportion (80%) of surveyed areas was occupied by pikas (Ray and Beever 2007). This is significant given the relatively low elevation (<1500 m) and hot climate of the Monument. CRMO contains an even larger area of lava flow habitats that range from approximately 1300-2300 m, making this an ideal setting for long-term monitoring of pikas along an elevational gradient. CRMO could become a regionally significant refugia for the species if warming over the next century occurs as predicted (*sensu* Wagner et al. 2003) and the need for establishing a baseline against which future population change can be detected is clear.

Pikas are territorial, conspicuous, and easy to detect, but difficult to capture and mark (British Columbia Resources Inventory Committee 1998, Ray and Beever 2007). They are well suited to presence-absence (i.e. detect-non detect) surveys, and given the vast area of potential habitat at CRMO, this approach is attractive for its efficiency. Mackenzie et al. (2002, 2006), drawing on methods originally developed for mark-recapture estimates of abundance, advanced an analytical approach for estimating occupancy by a species with imperfect detectability (i.e. probability of detection < 1). Their approach gives considerable model-based flexibility to sampling and naturally extends to the inclusion of environmental predictor variables, thus making an ideal framework for evaluating both status and trend of the pika population in CRMO, and for testing hypotheses about environmental drivers of pika populations. While occupancy is not a direct index for abundance, it is an appropriate status and trend metric for pikas because the species is highly territorial and a strong positive correlation is assumed to exist between site occupancy and abundance. The UCBN has not included pikas in its top tier of vital signs for immediate protocol development, but it recognizes the importance of establishing a long-term pika monitoring program. This baseline inventory will provide the information needed to evaluate the prospects of pika monitoring in CRMO, and will serve as an invaluable pilot study for protocol development (Garrett et al. 2007).

Objectives

For this first formal park survey in 2007, our objectives were as follows:

1) Establish the current southern/lower elevational limit of pikas in CRMO.

2) Provide a robust estimate of the proportion of area occupied for an approximately 2000 ha intensively surveyed pilot study area in the northern portion of the Monument (the "Monument study area"; Figure 1).

3) Provide robust model-based estimates of site occupancy probabilities for the Monument study area based on vegetation cover, lava flow type, and lava flow structural complexity.

4) Provide an estimate of pika detectability as a function of time of day, survey search time, and detection method (e.g. animal sighting vs. sign)

5) Collect sufficient data following common methods to support a formal comparison (e.g. model validation) of results from this survey and the 2005-2006 survey at Lava Beds National Monument.

6) Evaluate the candidate survey and analytical methods with data collected in 2007 and make recommendations for designing an efficient long-term monitoring program for pikas in CRMO.

Methods

Study Area

Craters of the Moon is located on the eastern Snake River Plain of Idaho, and encompasses parts of Lincoln, Minidoka, Blaine, Power, and Butte counties. The park was established in 1924 and originally included 21,626 ha (53,440 acres). In 2000 the Monument was expanded by the addition of 267,497 ha (661,000 acres) of federal public lands to include the entire Great Rift Volcanic Rift Zone. In 2002, 167,945 ha (415,000 acres) of this addition were legislatively designated as a National Preserve and are referred to as "the Preserve" throughout this report.

CRMO lava fields encompass over 182,000 ha (450,000 acres) of the Monument and Preserve, and include 60 lava flows and 25 cinder cones. Sagebrush-steppe makes up the approximately 121,406 remaining hectares, much of which exists as islands within the lava flows, known as "kipukas". CRMO extends south from the foothills of the Pioneer Mountains to the Snake River. The elevation rises from approximately 1305 m (4280 ft) in the southern tip near the Snake River to 2356 m (7729 ft) in the north. The climate is semiarid, with hot and dry summers and cold and wet winters. Winter snows comprise most of the annual precipitation in the Monument. Snow pack usually lasts most of the winter. The 30-year mean annual precipitation is 38.1 cm (15 inches) in the north (CRMO weather station data) and less than 25.4 cm (10 inches) in the south (Minidoka Dam, weather station data). The average July maximum temperature is 28.9°C (84°F) and average January minimum temperature is -12.2°C (10°F) (CRMO weather station data). Surface temperatures on the lava flows can reach 76.7°C (170°F) during summer heat and winter temperatures frequently remain below freezing for long periods.

CRMO supports several different vegetation types. The harsh and barren environment of the lava flows support an unusual variety of plant communities. Spring forbs include dwarf buckwheat (*Eriogonum. ovalifolium var. depressum*), silverleaf phacelia (*Phacelia hastata*), dwarf monkey flower (*Mimulus nanus*), dwarf onion (*Allium parvum*) and bitterroot (*Lewisia rediviva*). Common shrubs include tansy bush (*Chamaebatiaria millefolium*), ocean spray (*Holodiscus dumosus*), dwarf goldenweed (*Haplopappus nanus*), bitterbrush (*Purshia tridentata*), mock orange (*Philadelphia lewisii*), and mountain big sage (*Artemisia. tridentata ssp. vaseyana*). In the northern third of the Monument stands of limber pine (*Pinus flexilis*) are present. Sagebrush-steppe vegetation is the most widespread plant community in the Monument, growing almost everywhere outside of the lava flows, including the kipukas. Common plant species include three-tip sage (*Artemisia tripartita*), basin big sage (*Artemisia. tridentata ssp. tridentata*), bluebunch wheat grass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*) and prairie junegrass (*Koeleria nitida*). Scarlet paintbrush (*Castilleja miniata*) and silvery lupine (*Lupinus argenteus*) are common forbs. Surface water is extremely scarce in the Monument. Small ephemeral pools form during rainfall and subsurface ice lenses maintain small seeps and pools inside lava tubes and in the bottom of depressions in lava flows. The only riparian habitats in the Monument are those found near the northern boundary of the Monument where the lava flows and the foothills of the Pioneer Mountains meet.

The National Park Service (NPS) and the Bureau of Land Management (BLM) cooperatively manage CRMO although each agency retains primary management authority in different areas. In general, the areas of younger exposed lava fields are managed by the NPS and the older sagebrush-steppe dominated areas continue to be managed by the BLM. The BLM administered portion is a unit of the National Landscape Conservation System, while the original Monument and Preserve are administered as units of the National Park System. This inventory effort focused on NPS administered lands, particularly the original Monument in the northernmost portion of the park. The Monument contains the highest elevations of lava flow habitat in the park, and the pika survey was concentrated in areas ranging from 1739 m (5705 ft) to 1964 m (6444 ft), although searches were made in the southern portion of the Preserve that were < 1400 m.

Sampling Design

Historic and Target Search

Two non-probabilistic judgment samples were conducted in CRMO during September 2007. These were non-probabilistic targeted searches and are therefore not representative of overall pika occupancy in the park. Reliance on these samples for statistical inference would lead to positive biasing of estimates. However, these surveys were important to conduct and were invaluable in making a qualitative assessment of species status across the entire Preserve. First, a subset of historic locations provided by Beever (2002) and those obtained during recent vegetation mapping ground truthing surveys (John Erixson, Northwest Management, personal communication, July 2007; see Appendix D) were resurveyed. These historic locations were evaluated for current occupancy. Non-random targeted searches of the southern, low elevation areas of the Preserve portion of CRMO were also conducted. This survey attempted to add to our understanding of the elevational limit of pika distribution in CRMO. Additional targeted surveys were also conducted in late October outside the Monument boundary along Hwy 93 and along the edge of the 'Blue Dragon' flow approximately 12 miles east of the Monument boundary, but still within the elevational range of the intensively sampled Monument study area.

Occupancy Modeling

The primary focus of the inventory was an equal-probability generalized random tessellation stratified (GRTS) random sample of a 2000 ha focal study area located in the Monument portion of CRMO near the park headquarters (Figure 1) in order to model occupancy, detectability, and habitat associations. The spatially-balanced GRTS design offered considerable flexibility over simple random and systematic designs, and allowed for sample sites to be added or subtracted as necessary without compromising selection probabilities and sample site dispersion (Stevens and Olsen 2004). The GRTS sample permitted robust statistical inference to the entire 2000 ha Monument study area and can be integrated into future expanded or reduced sampling efforts. The Monument study area sampling frame included all land cover types designated as "lava" and "sparsely vegetated lava" within 1 km of a road or trail. The last 2 km section of the Wilderness Trail was excluded due to concerns about travel time. The land cover polygons were obtained from an existing park vegetation map produced by the Pacific Northwest National Laboratory with 2001 Landsat imagery. Accuracy of lava and sparely vegetated lava classifications was estimated to be 74% and 100%, respectively.

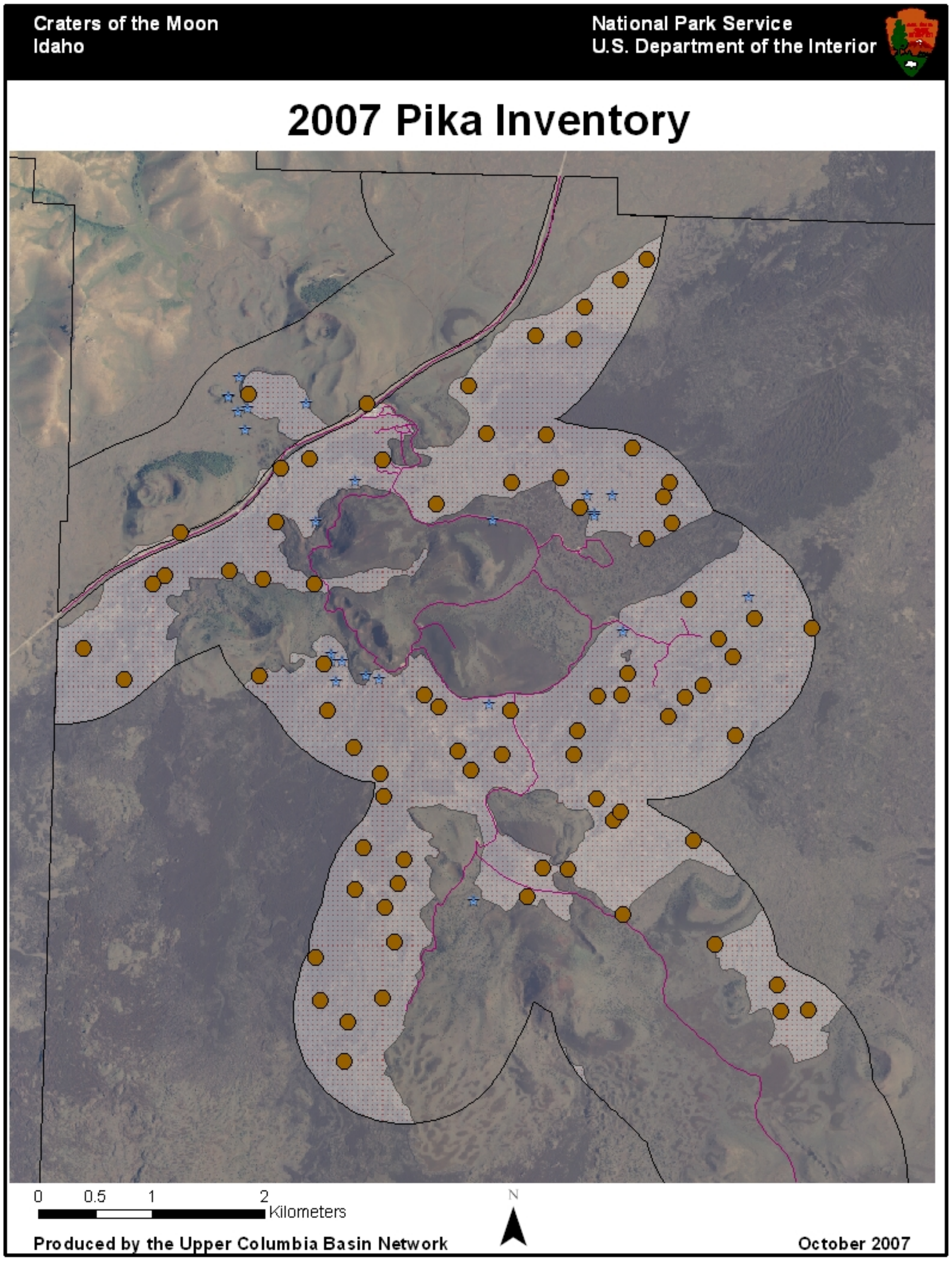

Figure 1. A map of the sampling frame (stippled), historic locations (blue) reported by Beever (2002), and 2007 sample locations (brown) in a 2000 ha study area in the original Monument portion of Craters of the Moon National Monument and Preserve.

Response Design

Following procedures established at Lava Beds National Monument (Ray and Beever 2007), surveys occurred at each sample location for 20 minutes. The core search radius was 12 m (452 m^2), but detections beyond this distance were also tallied between 12 m and 100 m and estimated to the nearest 5 m. A sample data sheet is included in Appendix A. Estimates were written in the detection distance field.

Following an approach developed by Ray and Beever (2007), our definition of occupancy was based on signs of site use. We classified the sites as occupied (alternatively "used") if the surveyor observed direct sign of visual or aural detections or indirect sign of fresh scat (and urine) or fresh hay within the 12 m plot. Detection methods, in order of confirmatory importance, were pika sightings (visual), pika alarm or social calls (aural), fresh haypiles, fresh scat, old haypiles, and old scat. When multiple detection types were made at a site, the site was classified, for analytical purposes, by the most important type. Type, time, and distance to first detection were also recorded to assess the efficiency of the 20 minute surveys.

Site environmental characteristics included weather observations, elevation, slope, aspect, lava type, lava structural complexity, and vegetation cover. One Kestrel Pocket Weather Monitor was available to collect weather observations such as temperature and wind speed for the day and time. Also, each technician was encouraged to note the weather descriptively, specifically cloud cover on a scale of 1-3 (1 being clear, 2 being partly cloudy, and 3 being complete cloud cover). Elevation was recorded in meters and obtained from a GPS unit. In most instances, slope and aspect were too subjective to measure due to microhabitat irregularities but they were measured in the few instances deemed appropriate by the technicians. In general, the lava flows are quite flat. Lava type was noted simply as Aa (rough and broken), Pahoehoe (smooth and ropy), cinder, other, or none (e.g. a point lands in deep-soiled vegetation), although most locations with high amounts of cinder, vegetation, or bare ground were dropped from the sample. Lava complexity was described simply along a scale from 1-3, with 1 representing smooth pavement-like Pahoehoe, a uniform cinder flat, or other structurally simple environment offering little cover to pikas, 2 representing a moderately complex environment where some cracks, crevices, and talus were present, and 3 representing highly complex structures where deep crevices, boulders, overhanging ledges, and broken lava features were abundant. Vegetation cover was visually estimated and recorded in percentage classes of the 12 m radius circle for each of 6 categories: rock (including all lava), bare ground (including dirt, mineral soil, and litter), forbs (all non graminoid flowering herbaceous plants), grasses (graminoids [grasses and sedges]), shrubs (woody plants), and trees. Cover estimates within each category could not exceed 100% but total estimates summed across all categories could exceed 100%. Table 1 presents the modified Daubenmire cover classes used for each category. Training and calibration of all field personnel involved in estimating vegetation and habitat variables were conducted at the start of the inventory, and a visual cover estimation guide was also used (Appendix B).

Table 1. Daubenmire's (modified with 'trace' and '100%' classes added) cover classes used for estimating vegetation cover in 12 m radius circular plots surrounding pika sample point centers at Craters of the Moon National Monument and Preserve.

Cover Class	Range	Midpoint
0	0%	0%
T	Trace <1%	0.5%
1	<5%	2.50%
2	5-25%	15%
3	25-50%	37.50%
4	50-75%	62.50%
5	75-95%	85%
6	95-100%	97.50%
7	100%	100%

The presence of a cave at the site was noted, although this was rare in the Monument study area random sample. Some of the historic sites were cave sites. Ray and Beever (2007) provided little evidence to warrant targeting cave habitats.

Sample Size and Sample Unit Locations

Based on occupancy and detectability estimates presented by Ray and Beever (2007), inventory objectives, consideration of time required to visit historic locations, and logistical constraints, the sample size drawn for the GRTS design was 80 point locations (Appendix C). This provided a similar sample size to that obtained in the Lava Beds study (for sites with 2 or more visits).

Only two full-time technicians were available for the 2-week survey to be conducted between September 10 and September 21. As many as four additional technical assistants were available on certain days of the project as well, depending on schedules. Each random sample location (GRTS design in the northern study area) was surveyed twice in order for detectability-explicit estimates of occupancy to be obtained. It took approximately 3 days for 2-3 people to complete surveys at all locations and, on average, one person could survey approximately 8-12 sites in an 8 hour day. This was a challenging schedule and future survey schedules should provide additional time. One day was dedicated to group training and calibration and two days were allocated to surveying the southern portion of the Preserve and visiting two southern 2007 detections reported by John Erixson along the Arco-Minidoka road. There were 27 historic sightings from Beever (2002) and 5 additional sightings obtained during the recent vegetation mapping ground truthing surveys (John Erixson, Northwest Management, personal communication, July 2007). Most of these sites were in the vicinity of the Monument study area and as time allowed, attempts were made to revisit all sites. In several instances, a few points were chosen from a cluster of proximal points to sample the area without spending excessive amounts of time surveying all historic points. Figure 1 displays the sites in and near the Monument and Appendix D contains the location coordinates for the historic sites and sites actually resurveyed in September 2007.

Personnel, Scheduling, and Equipment

Table 2. Outline of project personnel and their responsibilities for the September 2007 survey.

Role	Responsibilities	Name / Position
Project Lead	• Assisted in the study design • Acquired and maintained field equipment • Oversaw project operations and implementation • Oversaw data collection and entry, verified accurate data transcription into database • Maintained and archived project records • Certified 2007 data for quality and completeness • Assisted in data analysis • Completed reports, metadata, and other products according to schedule • Assisted data manager in database development • Updated protocol	Mackenzie Shardlow, UCBN Biological Technician
Technicians	• Reviewed design for logistical feasibility • Collected, recorded, entered and verified data • Provided guidance on southern park survey logistics	Mike Munts, CRMO Biological Technician; Other Park, Network, and SCA personnel as available
Data Manager	• Consulted on data management activities • Facilitated check-in, review and posting of data, metadata, reports • Worked with Project Lead and Ecologist to develop metadata and interim data storage strategy	Gordon Dicus, UCBN Data Manager
Ecologist	• Directed project design, implementation, analysis, and reporting • Trained field personnel • Assisted project lead in completion of reports, maps, metadata, and other products • Assisted data manager in completion of dm tasks	Tom Rodhouse, UCBN Ecologist
Network Coordinator	• Oversaw project staff • Oversaw administration and budget • Consulted on all phases of project • Reviewed and approved reports and products	Lisa Garrett, UCBN Coordinator
Park Resource Manager	• Consulted on all phases of project • Facilitated logistics planning and coordination • Served as park liaison to UCBN staff • Reviewed study design, reports, data and other project deliverables	John Apel, CRMO Park Resource Manager

Table 3. Weekly field schedule for the September 2007 pika inventory at Craters of the Moon National Monument and Preserve.

Week	Mon	Tue	Wed	Thu	Fri
1	Arrive and Prep	Training/historic site visits	Monument Survey (1st visit)	Monument Survey (1st visit)	Monument Survey (1^{st} & 2nd visit)
2	Southern Survey	Southern Survey	Monument Survey (2nd visit)	Monument Survey (2nd visit)	Wrap up/Historic Visits

This project required only a modest set of equipment, most of which was provided by the UCBN to field personnel. Personal equipment included water bottles and sun and rain protection. The UCBN provided 1 digital camera for use during the project. CRMO provided a second digital camera. The UCBN provided one vehicle and CRMO provided additional vehicles, depending on involvement of additional personnel. Table 4 details the equipment required for each independent surveyor or team.

Table 4. Equipment required for pika sampling. The UCBN supplied the first ten items on the list for up to 4 independent surveyors.

Equipment
Garmin Map 76 GPS units
Compasses w/inclinometer
Clipboards and data sheets
Ocular cover guides
GPS unit batteries (AA)
Mechanical pencils
Digital camera
2-way radios
First aid kits (2 available)
Binoculars (2 available)
Water bottle, sun, and rain protection
Day packs

Data Analysis

Analysis was only conducted on data collected from the randomly sampled 2000 ha Monument study area. The analytical framework followed modeling approaches outlined by Mackenzie et al. (2002, 2006) in which an estimate of occupancy (ψ) was obtained through maximum likelihood procedures after explicitly accounting for detectability (ρ). Site and sampling explanatory covariates were accounted for through use of the logit link of the form

$$\operatorname{logit}(\psi_i) = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_u x_{iu}$$

where logit(ψ_i) is the probability of site *i* being occupied (on the logit scale) as a function of *U* covariates associated with site i. The software program PRESENCE 2.x (Hines, USGS-Patuxent) was used to obtain estimates of overall proportion of area occupied by pikas and pika detectability within the study area. The R software and environment (R version 2.4.1, 2006 The R foundation for statistical computing) was used to fit standard logistic regression models and to evaluate the effect size of site-specific covariates following procedures outlined in Maindonald and Braun (2007). Detectability was high (near 1) and we therefore chose to evaluate the full suite of *a priori* habitat models in the R language and environment, as its numerical maximum likelihood routine is more stable than that used by PRESENCE, and it also offers a wider suite of evaluative tools. We used logistic regression (family=binomial [link="logit"]), to fit observed binary pika presence/absence data to models with site environmental attributes as predictors. We began with a full "global" model that included complexity (three ordinal levels), pahoehoe (coded 1, Aa coded 0), and each of the cover variables rock, bare, grass, forb, shrub, and tree (each with 9 possible ordinal levels, following the modified Daubenmire scale). A stepwise backwards model selection procedure was used in which the least significant (alpha $\geq$ 0.15) and lowest magnitude variable was removed for each subsequent model. Akaike's information criterion adjusted for small sample sizes (AICc) was used to rank models (Mackenzie et al. 2006, Maindonald and Braun 2007). AIC is a conservative approach that balances the number of model parameters (preventing overfitting) with the goodness-of-fit, and is generally regarded as a measure of the "best" or "preferred" model, given the observed data, from a discrete number of nested models of the same type. We also used the le Cessie-van Houwelingen goodness-of-fit test, increasingly preferred over the older Hosmer and Lemeshow test, as an additional "omnibus" measure of fit (le Cessie and van Houwelingen 1991, Hosmer et al. 1997, Vittinghoff et al. 2005). We used *k*-fold cross-validation to evaluate the predictive success of models as well (Maindonald and Braun 2007).

Results

Historic and Target Searches

Nineteen of the 32 CRMO historic sites were revisited in 2007. Of these 19 sites, detections (fresh sign including visual, aural, fresh hay, or fresh scat and urine) were made at six sites and a total of eight sites had either fresh or old sign (see Appendix D for table of historic sites and revisit results).

No detections were made during the targeted searches of the southern, low elevation areas of the Preserve portion of CRMO (see Appendix E). Three technicians spent two long days, with a majority of the time spent traveling to target search areas of the Wapi Flow and revisiting two historic sites south of the Monument. The crew started the surveys at the southern end of the Wapi flow, at the Baker Caves trailhead. They spent approximately half an hour to an hour searching probable places at each site for pika sign. Five areas were targeted on the Wapi flow, moving south to north. The second day of surveys started at the Wapi flow and moved north to the two historic points from 2006 that were located south of the Monument. These points landed off of the lava flows completely and the technicians found an abundance of marmot sign but no pika sign. Though in many ways the lava structure and complexity appeared similar at all of these sites, there were no pika detections. Pika sign was encountered in several of additional October targeted survey locations. All of these detections were within the elevational and latitudinal range of the Monument study area and are not included in further analyses.

Occupancy Modeling

Summary

Of the 80 random points drawn, 8 sites fell outside the target population (e.g. on a road, in a vegetated “kipuka”) leaving a total of 72 sites in the sample. Each site was surveyed two times over the course of the two week period. Of these 72 sites, 15 (20.8%) had fresh detections within 12 m. Detections within 100 m were made at six additional sites, for a total of 21 sites (29.2%).

For the site characteristics, pahoehoe was the most common lava type, comprising 43 (59.7%) of the 72 sites. Aa made up 27 (37.5%) of the sites and 2 (2.8%) sites were classified as other (i.e. mostly cinder). Thirty-three sites (45.8%) had a lava complexity of 3 (high), 28 (38.9%) a complexity of 2 (medium), and 11 (15.3%) a complexity of 1 (low). For the cover characteristics, the classification groups with the highest frequency over all sites were as follows: rock 75-95%, bare ground 0-1% (trace), forbs 1-5%, grasses 0%, shrubs 0%, and trees 0%. Average ranks for cover characteristics between sites with and without detections were 6.9 and 7.5 for rock, 2.1 and 2.0 for bare, 3.4 and 2.7 for forbs, 1.6 and 2.0 for grass, 3.3 and 2.5 for shrubs, and 1.1 and 1.4 for trees, respectively. Of the sites with fresh detections in the 12 m plot, 93.3% were pahoehoe and only 6.7% Aa. Also of significance, 66.7% of the sites with detections had a complexity level of 3. Only 6.7% and 33.3% of the sites with detections had complexity ratings of 1 or 2, respectively. The average time from sunrise for all surveys was 4.6 hours. The average time from sunrise for surveys with no detections was 4.7 hours. The average time from sunrise for surveys with detections was 4.0 hours. The average elevation for all sites was 1781 m and the average elevation for all sites with fresh detections was 1776 m.

Of sites where detections were made, time to first detection of any kind averaged 7 minutes (8 minute average for first visit and 6 minute average for second visit). The most frequent detection type was old scat (43.2% of detections), followed by new scat (31.8%), old hay (13.6%), fresh hay (6.8%), and aural (4.5%). Time to first detection during second visit was positively biased, particularly when the same observer conducted both visits. For first visits, 20 detections (old and new) were made within 12 m in 20 minutes. Eighteen (90%) of these detections were made within 15 minutes and only 14 detections (70%) were made within 10 minutes. One detection (6.7% of fresh detections) would have been missed if only a single visit was made to each site.

Model Results

Pika detectability was high, given that indirect fresh sign was used as a measure of presence. Estimates of detectability (ρ) for a range of models including a simple null model and a full model were approximately 0.92 (95% confidence interval approximately 0.74 to 0.98). The "naïve" proportion of area occupied (simple proportion of sites with detections) was 0.208, and the estimate of occupancy (ψ) after accounting for detectability was only slightly different at 0.209 (95% confidence interval 0.13 to 0.31). Given that detectability was so high and accounting for it contributed little to the overall information content of models, we modeled habitat predictors in R with standard logistic regression. Table 5 presents the full suite of logistic regression model results. We evaluated the goodness-of-fit and cross-validation performance of the full "global" model with all 9 parameters and also of the model with the lowest AICc (complex+pahoe+rock+grass+forb+tree). There was no evidence of lack-of-fit ($p > 0.5$, le Cessie-Houwelingen test). Cross-validation measures of prediction using 10 folds and five runs each averaged about 0.85 and 0.9 for the full and top models, respectively. The top three models were within 2 AICc values of one another, suggesting uncertainty regarding the "best" model. As a result, we used model averaging of parameter coefficients and their variances, weighted by each model's AICc weight, in order to account for this uncertainty (Mackenzie et al. 2006). Table 6 presents the averaged model parameters and table 7 presents parameters for the model with the lowest AICc value. The "shrub" parameter was not retained since it was only present in the second ranked model and appeared to contribute little to the model ($p = 0.28$). Figure 2 illustrates the predicted probabilities of site occupancy for each site, according to this averaged model. Overall predictive success was high. Using a standard 50% cutoff, only 1 of 15 occupied sites was incorrectly predicted with probability 0.18. Nine occupied sites were predicted with probability > 0.90. Four out of 57 unoccupied sites were misclassified with probabilities > 0.5. Lava complexity, lava type (e.g. Pahoehoe vs. Aa), and forb cover were all significant positive predictors of pika occupancy (Table 6). Sites with extensive rock cover, primarily associated with unvegetated Aa lava flows, were unlikely to be occupied. Grass cover, shrub cover, and tree cover were also negatively associated with pika occupancy, although to lesser and more variable extents. Figures 3 and 4 are photographs of typically "good" pika habitat and "poor" pika habitat, as demonstrated during the 2007 inventory.

Table 5. Model selection results using Akaike's information criterion, adjusted for small sample sizes (AICc).

Model	k	AICc	ΔAICc	AICc weight
complex+pahoe+rock+grass+forb+tree	7	35.774	0.000	0.387
complex+pahoe+rock+grass+forb+shrub+tree	8	36.643	0.869	0.251
complex+pahoe+rock+grass+forb	6	37.137	1.363	0.196
complex+pahoe+rock+bare+grass+forb+shrub+tree	9	38.112	2.338	0.120
complex+rock+grass+forb	5	40.659	4.885	0.034
complex+pahoe+grass+forb	5	42.585	6.811	0.013
complex+grass+forb	4	48.248	12.474	0.001
Pahoe+rock+grass+forb	5	51.431	15.657	0.000
rock+grass+forb	4	53.582	17.808	0.000
complex+forb	3	59.379	23.605	0.000

Table 6. Model averaging results for the first three models with ΔAIC < 2. These averaged parameter values were used to generate site occupancy probabilities.

Averaged Model	β coefficient	SE	z score	p value
(Intercept)	6.615	12.756	0.519	0.610
Complexity	3.299	1.540	2.141	0.032
Pahoehoe	2.781	1.585	1.755	0.079
Rock	-3.263	1.751	-1.864	0.062
Grass	-2.929	1.428	-2.052	0.040
Forb	4.337	2.162	2.006	0.045
Tree	-1.420	1.009	-1.408	0.159

Table 7. The "best" model with the lowest AICc score.

"Best" model	β coefficient	SE	z score	p value
(Intercept)	3.509	11.973	0.293	0.770
Complexity	3.686	1.624	2.269	0.023
Pahoehoe	2.960	1.507	1.964	0.050
Rock	-3.298	1.448	-2.277	0.023
Grass	-3.277	1.535	-2.135	0.033
Forb	5.086	2.364	2.151	0.032
Tree	-1.948	1.172	-1.662	0.096

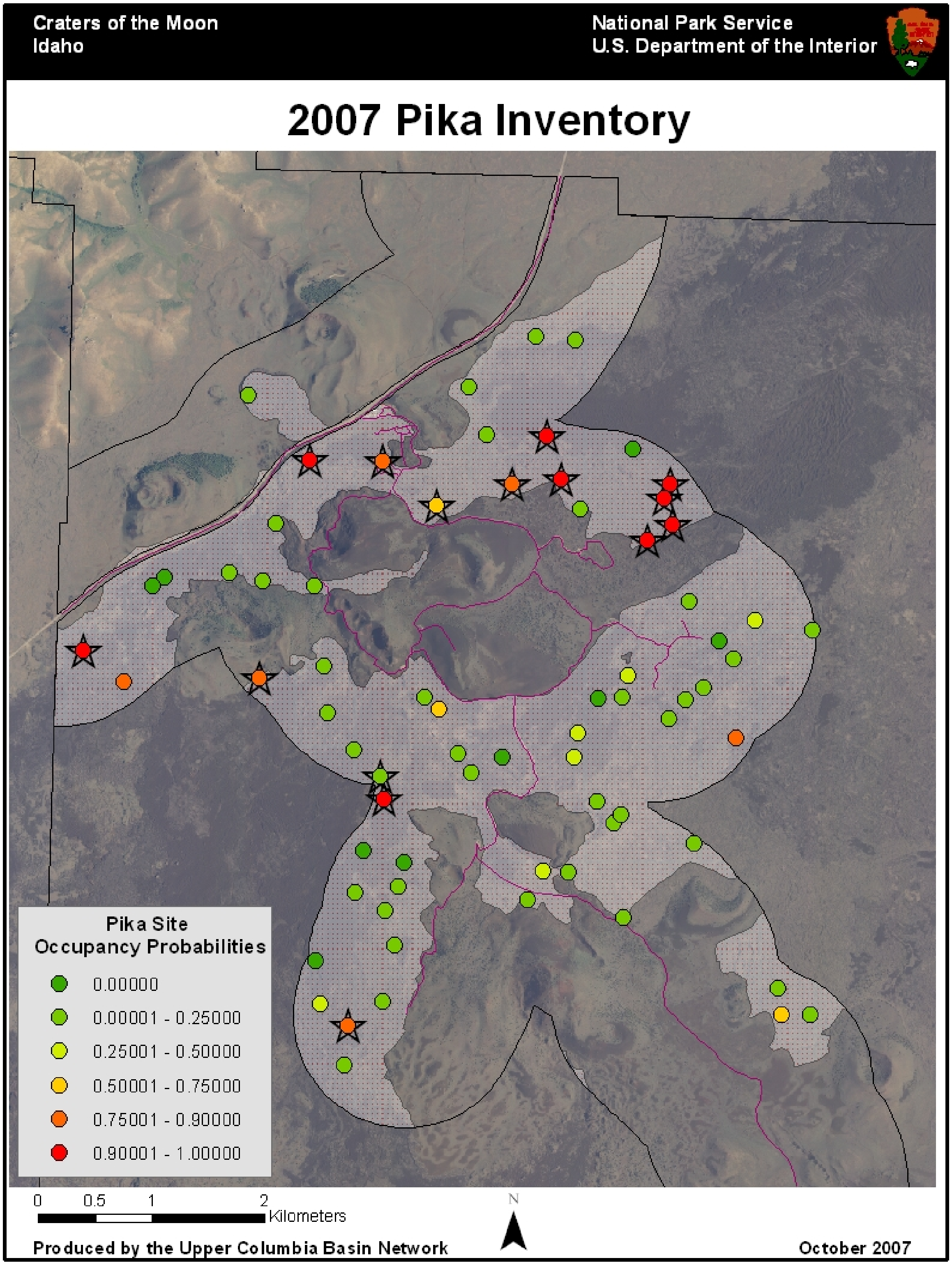

Figure 2. Occupancy probabilities for pika sites surveyed in 2007. Occupied sites, as observed during September 2007, are indicated with stars.

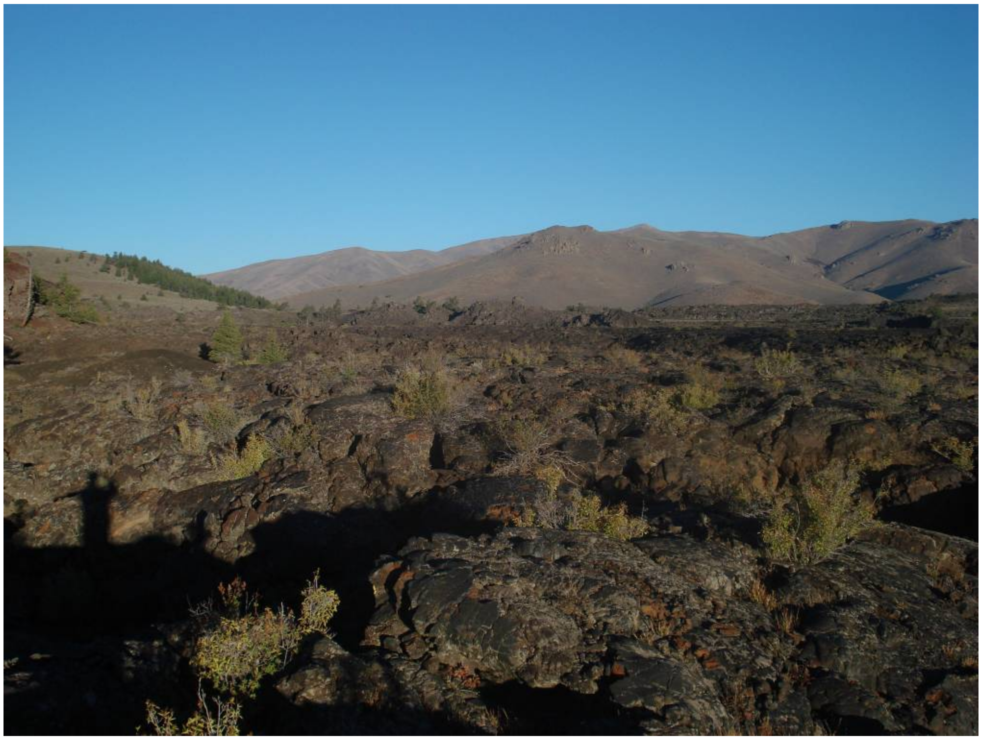

Figure 3. Sparsely vegetated, structurally complex pahoehoe representing “good” pika habitat.

Figure 4. Superficially complex but unvegetated Aa representing “poor” pika habitat.

Discussion and Recommendations for Future Surveys

Discussion

High lava complexity, the presence of pahoehoe lava, and moderate forb cover all appear to be strong positive predictors of pika occupancy while sites with high rock cover and correspondingly low overall vegetation cover appear to be less likely to support pikas. Increased lava complexity, particularly in pahoehoe sites, provides more microhabitat (i.e. deep cracks and crevices) that pikas seem to prefer and appears to support the amount of vegetation cover, particularly forbs, preferred by pikas. Anecdotally, pikas appeared to be particularly common in pahoehoe sites with overhanging ledges, although this characteristic was difficult to quantify. In many sites where pikas were not detected, lava complexity was high (e.g. Aa sites), but rock cover was also estimated to be extremely high (i.e. >90%) and the sites were often lacking vegetation. It also appeared that Aa structure was only superficially complex and that deep cracks and crevices, particularly with cool air flow, common in many pahoehoe sites, were often absent in Aa sites.

Both shrub and forb material was commonly found in haypiles, but shrub cover was a negative predictor (albeit largely insignificant) for pika occupancy. Our results were consistent with those reported by Ray and Beever (2007), in that pikas were more likely to use sites with lower grass cover and higher forb cover. They also reported that fernbush and sagebrush cover in the site was positively associated with pika presence. While we did not specifically consider the effect of individual shrub species, our results suggest that shrub cover may not have a strong effect on occupancy overall. Our study does not enable definitive conclusions regarding shrub cover, and could be addressed further in the future. It may be simply that shrub cover is similar in most sites sampled. It is noteworthy that though our surveys only descriptively documented dominant shrub and forb species composition of haypiles, it appears that fernbush, syringa, and bitterbrush are commonly used by pika at CRMO.

Old scat was the most common detection type. Though these detections were not included in analyses since they do not indicate current occupancy, it appears that sites with old scat frequently had fresh sign also. Ray and Beever (2007) also noted that very few surveys (3%) reported old scat in the absence of other signs. Consequently, observers should be encouraged to document all sign observed. The detection of old sign early in the survey may also stimulate more intensive searching, and could be addressed in the future as a component of detection variability.

Distance to edge was particularly difficult to discern, both in the field and using a GIS with high-resolution aerial photography and was therefore not retained for analysis. Future survey efforts should consider whether this metric is of interest and how best to consistently quantify it.

Many of our findings were similar to those reported by Ray and Beever (2007) at Lava Beds NM. They found that search effort (time spent) was positively related to the discovery of indirect signs of site use (i.e. scat and haypiles). They estimated the probability of detecting site use was 0.97, strikingly similar to our estimate of 0.92. Also similar to our findings was that they discovered few fresh haypiles and believe that this might indicate that pikas in Lava Beds NM (and possibly other similar sites) do not store large quantities of vegetation, or that they store hay at such a depth that it is not readily detected by survey crews.

Recommendations for Future Surveys

In all, we believe this "pilot" survey has provided a great deal of information and will contribute to further pika monitoring efforts, both in CRMO and outside of the park. As with any initial study, we have learned from our recent efforts and developed a list of recommendations and further questions for future surveys.

Regarding the historic visits and target search, it would still be very useful to determine the southern extent of pikas in the Preserve. A more intensive survey of the Wapi Flow and mid-latitude areas of the Preserve should be prioritized. Planning for this, should carefully factor in time of travel, as it takes almost half a day to drive to the Wapi flow from the park headquarters and many of the roads are unimproved roads requiring 4-wheel drive vehicles.

For the occupancy modeling, since pika probability of detection was determined to essentially equal 1, we recommend that sites only be surveyed once (1 visit) per season. This could mean that fewer technicians will be needed and that more sites could be surveyed. Consequently, by relying on only 1 visit to a site, it is extremely important that all observers are well trained and "calibrated" for pika surveys. Though a significant amount of sign was found outside of the 12 m plot, we suggest that this remain the plot size, as anything larger would take too much time per site and the costs appear to outweigh the benefits. Since 90% of the sign detection was in the first 15 minutes, it may be possible to shorten the time of each survey. We would suggest no shorter than 15 minutes or a significant amount of sign may be missed.

Though the influence of time of day of surveys on pika detectability was inconclusive, we still suggest that observers attempt to visit as many of these sites early in the morning and late evening as possible to try to obtain more aural and visual detections. Time of year may have also affected our detections, particularly aural and visual. Ray and Beever (2007) reported that date was the most important influence on the direct detection of pika, with detectability highest during early June surveys. Future surveys should be attempted in early summer to determine if increased calling behavior assists survey efforts. It may also be worthwhile to test the change in detectability using pika "callbacks." This method has been used often with territorial animals (particularly birds) to make the animal more vocal and thus more detectable.

Further efforts could also be made to determine the effects of other variables on pika detectability and occupancy. A high priority for subsequent survey and monitoring work should be to develop a more sophisticated approach to characterizing the differences in microhabitats and lava structure and can build on the previous efforts by Ray and Beever (2007). Ray and Beever (2007) looked more closely at geography, topography, and available forage than our efforts, and they found that these attributes affected site use by pikas. Proximity to lava flow edge may be important. However, determining where the lava-vegetation interface actually occurs is difficult. Often there is a fuzzy boundary across a gradient of increasing vegetation, particularly where cinders have accumulated. Future surveys may consider alternative approaches to this measure. Also, a better analysis of available forage could contribute to our understanding of pika habitat preferences. Though Ray and Beever (2007) could not determine or find any significance with variables such as microclimate (using data loggers), weather, moonlight, lunar cycles, woodrat presence, and cave or lava tube presence, further survey efforts by the UCBN could refine the methods behind measuring some of these variables and attempt to address these outstanding questions.

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Appendix A

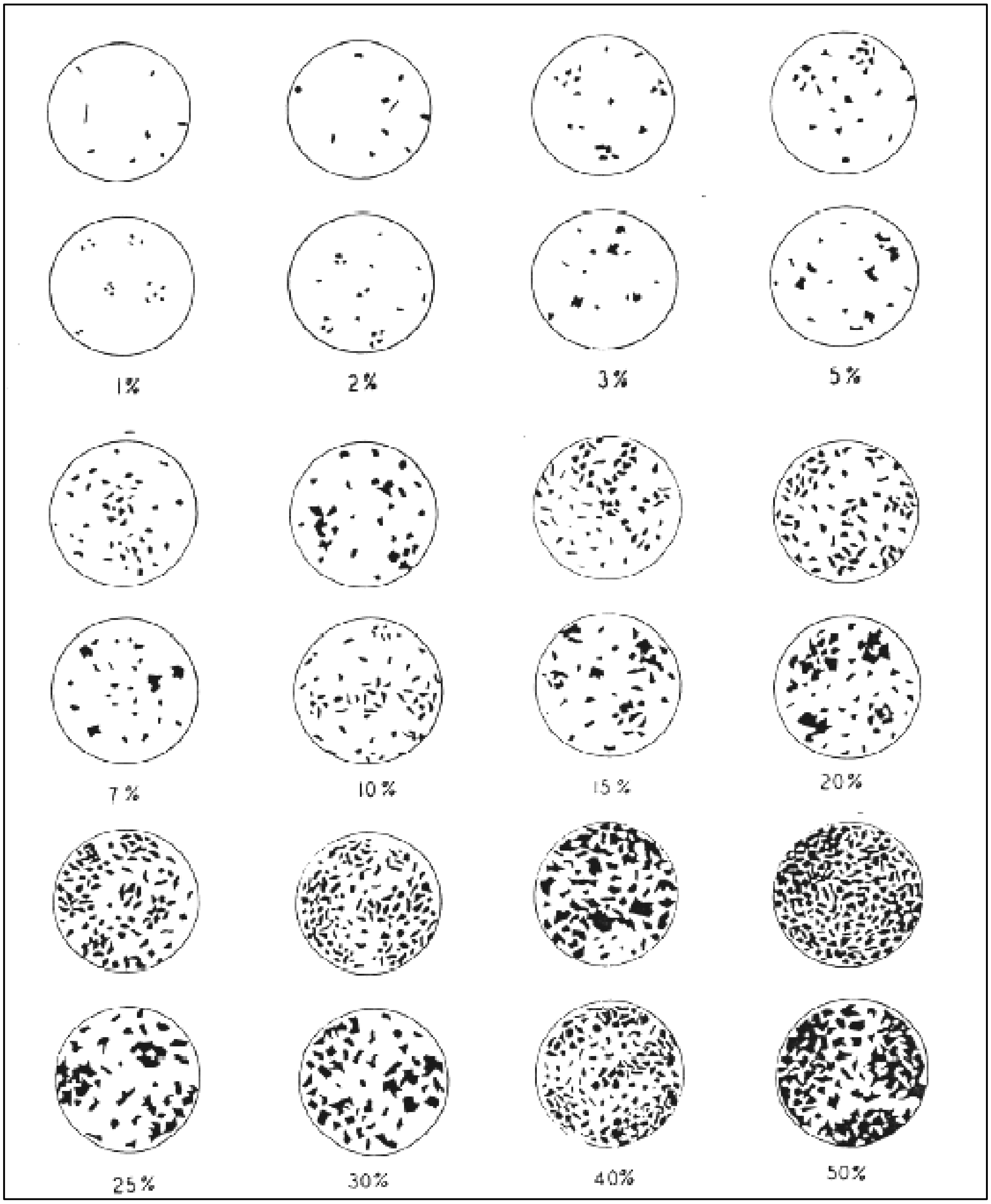
UCBN Pika Inventory Form – 2007 (not formatted for field – use Excel version available from UCBN)

<table>
<tr><td>Observer(s):</td><td>Date:</td><td>Site:</td><td>Visit:</td><td>Start time:</td><td>End time:</td><td colspan="3">Weather description:</td><td>Elevation (m):</td></tr>
<tr><td>Detect: Visual Aural NewHay FreshScat OldHay OldScat None</td><td colspan="2">First detect time/type:</td><td colspan="4">Distance to nearest detection (m): <12 <100 >100 Other</td><td>Slope (°)</td><td>Aspect (°)</td><td>Dist. to edge (m):</td></tr>
<tr><td>Lava type: None Cinder Aa Pahoehoe Other</td><td colspan="4">Lava complexity scale: 1 (flat/smooth) 2 3 (highly complex)</td><td colspan="2">Cave present: Yes No</td><td colspan="3" rowspan="2">Notes:</td></tr>
<tr><td>VEGETATION COVER (%)- 12 m radius</td><td>Rock:</td><td>Bare:</td><td>Forb:</td><td>Grass:</td><td>Shrub:</td><td>Tree:</td></tr>
</table>

<table>
<tr><td>Observer(s):</td><td>Date:</td><td>Site:</td><td>Visit:</td><td>Start time:</td><td>End time:</td><td colspan="3">Weather description:</td><td>Elevation (m):</td></tr>
<tr><td>Detect: Visual Aural NewHay FreshScat OldHay OldScat None</td><td colspan="2">First detect time/type:</td><td colspan="4">Distance to nearest detection (m): <12 <100 >100 Other</td><td>Slope (°)</td><td>Aspect (°)</td><td>Dist. to edge (m):</td></tr>
<tr><td>Lava type: None Cinder Aa Pahoehoe Other</td><td colspan="4">Lava complexity scale: 1 (flat/smooth) 2 3 (complex)</td><td colspan="2">Cave present: Yes No</td><td colspan="3" rowspan="2">Notes:</td></tr>
<tr><td>VEGETATION COVER (%)-</td><td>Rock:</td><td>Bare:</td><td>Forb:</td><td>Grass:</td><td>Shrub:</td><td>Tree:</td></tr>
<tr><td>Observer(s):</td><td>Date:</td><td>Site:</td><td>Visit:</td><td>Start time:</td><td>End time:</td><td colspan="3">Weather description:</td><td>Elevation (m):</td></tr>
<tr><td>Detect: Visual Aural NewHay FreshScat OldHay OldScat None</td><td colspan="2">First detect time/type:</td><td colspan="4">Distance to nearest detection (m): <12 <100 >100 Other</td><td>Slope (°)</td><td>Aspect (°)</td><td>Dist. to edge (m):</td></tr>
<tr><td>Lava type: None Cinder Aa Pahoehoe Other</td><td colspan="4">Lava complexity scale: 1 (flat/smooth) 2 3</td><td colspan="2">Cave present: Yes No</td><td colspan="3" rowspan="2">Notes:</td></tr>
<tr><td>VEGETATION COVER (%)-</td><td>Rock:</td><td>Bare:</td><td>Forb:</td><td>Grass:</td><td>Shrub:</td><td>Tree:</td></tr>
</table>

Appendix B

Ocular cover estimation guide for circular plots.



Appendix C

List of GRTS design pika sample point locations for the Monument study area, Craters of the Moon National Monument and Preserve. The coordinates are in UTM Zone 12, and the datum is WGS 84 in order to facilitate GPS data collection and waypoint navigation. Reported and mapped points will be presented in NAD 83 following NPS and UCBN spatial data requirements (Dicus 2007). Gray rows were points dropped from the sampling group.

Type	UTM X	UTM Y	Site ID
GRTS	291066	4814239	1
GRTS	292615	4811070	2
GRTS	292868	4810094	3
GRTS	294570	4815964	4
GRTS	296653	4809986	5
GRTS	292693	4811432	6
GRTS	294779	4812786	7
GRTS	292263	4813789	8
GRTS	295419	4814688	9
GRTS	294292	4811256	10
GRTS	293366	4812686	11
GRTS	291767	4812967	12
GRTS	295847	4813297	13
GRTS	294918	4811681	14
GRTS	294013	4814686	15
GRTS	291671	4815475	16
GRTS	290925	4813864	17
GRTS	293005	4811113	18
GRTS	292314	4810079	19
GRTS	295088	4815002	20
GRTS	296399	4809981	21
GRTS	293054	4811328	22
GRTS	294991	4812795	23
GRTS	292340	4813070	24
GRTS	296165	4813475	25
GRTS	293647	4812129	26
GRTS	293999	4812656	27
GRTS	291800	4813830	28
GRTS	295716	4812884	29
GRTS	294564	4812270	30
GRTS	293338	4814493	31
GRTS	292864	4814888	32
GRTS	290824	4813783	33
GRTS	292884	4810902	34
GRTS	292555	4809887	35
GRTS	294446	4814736	36
GRTS	296368	4810216	37

Type	UTM X	UTM Y	Site ID
GRTS	292838	4812101	38
GRTS	295400	4812606	39
GRTS	292380	4812664	40
GRTS	295587	4813647	41
GRTS	294148	4811004	42
GRTS	293633	4815546	43
GRTS	291918	4814342	44
GRTS	295557	4812780	45
GRTS	294767	4811877	46
GRTS	294319	4815119	47
GRTS	292220	4814901	48
GRTS	290567	4812937	49
GRTS	292268	4810464	50
GRTS	295039	4812992	51
GRTS	294621	4814463	52
GRTS	295814	4810580	53
GRTS	292879	4811891	54
GRTS	295210	4814190	55
GRTS	292608	4812326	56
GRTS	295436	4814326	57
GRTS	294508	4811247	58
GRTS	294228	4815994	59
GRTS	291504	4813906	60
GRTS	295976	4813136	61
GRTS	294998	4810839	62
GRTS	294981	4816500	63
GRTS	292722	4815392	64
GRTS	290211	4813214	65
GRTS	292965	4810597	66
GRTS	294600	4812482	67
GRTS	295359	4814559	68
GRTS	295628	4811496	69
GRTS	293931	4812266	70
GRTS	293538	4812302	71
GRTS	293236	4812802	72
GRTS	296679	4813390	73
GRTS	294981	4811757	74
GRTS	293791	4815126	75
GRTS	291955	4814822	76
GRTS	295997	4812434	77
GRTS	292526	4809535	78
GRTS	294662	4816251	79
GRTS	295211	4816674	80

Appendix D

Historic pika locations and revisits in Craters of the Moon National Monument and Preserve (as reported by Beever (2002) and John Erickson (2007, personal communication)). Coordinates are UTM Zone 12, and the datum is WGS 84 in order to facilitate GPS data collection and waypoint navigation. Reported and mapped points will be presented in NAD 83 following NPS and UCBN spatial data requirements (Dicus 2007).

Date	Type	Source	Site	UTMX	UTMY	Elevation (ft)	Revisited	Highest Detection
7/14/1995	Historic	Beever	1	291639.86	4815172.47	5934	10/2/2007	New Hay
7/14/1995	Historic	Beever	2	292186.84	4815402.6	6344	No	
7/14/1995	Historic	Beever	4	291491.14	4815454.99	6230	No	
7/14/1995	Historic	Beever	5	291668.06	4815356.88	5654	10/2/2007	None
7/14/1995	Historic	Beever	6	291577.21	4815328.81	6206	10/2/2007	None
7/14/1995	Historic	Beever	7	291586.76	4815637.31	5728	No	
7/14/1995	Historic	Beever	8	291491.14	4815464.99	6230	No	
7/15/1995	Historic	Beever	9	293842.09	4814363.57	5746	10/9/2007	None
7/15/1995	Historic	Beever	10	292831.04	4812943.25	6034	10/9/2007	None
7/15/1995	Historic	Beever	11	292410.56	4813172.35	6353	No	
7/15/1995	Historic	Beever	12	292408.66	4813110.65	6131	9/13/2007	Old Hay
7/15/1995	Historic	Beever	13	292719.59	4812977.56	5436	No	
7/15/1995	Historic	Beever	14	292498.58	4813107.88	5624	9/13/2007	None
7/15/1995	Historic	Beever	15	292447.92	4812924.16	6304	No	
7/15/1995	Historic	Beever	16	293814.54	4812727.81	5613	9/11/2007	Fresh Scat
7/15/1995	Historic	Beever	17	293670.81	4810972.08	6029	10/4/2007	None
7/16/1995	Historic	Beever	18	294743.95	4814428.66	5781	9/12/2007	New Hay
7/16/1995	Historic	Beever	19	294743.01	4814397.81	5965	No	
7/16/1995	Historic	Beever	20	294681.23	4814584.97	5774	9/12/2007	New Hay
7/16/1995	Historic	Beever	21	294905.98	4814578.12	5648	No	
7/16/1995	Historic	Beever	22	294610.04	4814463.63	5661	No	
7/16/1995	Historic	Beever	23	295004.23	4813370.85	5940	9/14/2007	None
7/16/1995	Historic	Beever	24	292868.32	4814887.53	5868	No	
7/16/1995	Historic	Beever	25	292615.4	4814710.03	5922	9/13/2007	New Hay
7/16/1995	Historic	Beever	26	292266.86	4814350.22	5631	9/13/2007	New Hay
7/17/1995	Historic	Beever	27	296115.98	4813676.78	5753	9/12/2007	Old Hay
7/17/1995	Historic	Beever	28	297863.72	4813438.84	5983	10/4/2007	None
2006	Historic	Erickson	1018	276086	4802659	NA	No	
2006	Historic	Erickson	3	301391	4826304	1633	10/2/2007	None
2006	Historic	Erickson	413	292353	4814158	NA	No	
2006	Historic	Erickson	8026	314390	4782949	NA	9/18/2007	None
2006	Historic	Erickson	93	310421	4778462	NA	9/18/2007	None

Appendix E

Target search locations and findings as well as historic sites revisited that fell outside of the Monument.

Area name	Date	Time	UTMX	UTMY	Elevation	Detection	Comments
Baker Caves	9/17/2007	1149	311571	4735034	1342	No	Good structure - no pika sign, just rabbit
N. Baker Caves	9/17/2007	1326	312071	4737861	1367	No	Good structure - no pika sign, just rabbit
"Falcon" Crater	9/17/2007	1406	312461	4738591	1383	No	Good talus bowl (very loose) - forced to leave due to rattlesnake activity
King's Bowl	9/17/2007	1708	319055	4757847	1495	No	1-2 complexity pahoehoe - saw what looked like a bitterbrush haypile but found only cottontail droppings
N. Edge Wapi Flow	9/18/2007	720	317710	4751624	1520	No	Camped here last night - out at daybreak in hopes to hear pika, no sign
S. of the Monument	9/18/2007	1137	308796	4767691	1442	No	Recently burned (1-2 years), mostly sage and cheatrass, lots of veg., saw one small scat that we determined was juvenile cottontail
H93 – S. of the Monument, Veg Crew point	9/18/2007	1344	310421	4778462	NA	No	Rock pikes surrounded by cheatgrass/fescue/rye, not on flow. LOTS of marmot sign, not what we determined to be pika habitat
H8026 –S. of the Monument, Veg Crew point	9/18/2007	1526	314390	4782949	NA	No	Same as H93. Small rock structures surrounded by veg, not on flow. Cheatgrass, rye, and burned sage. LOTS of marmot sign.

National Park Service
U.S. Department of the Interior

Upper Columbia Basin Network

Upper Columbia Basin Network
Inventory and Monitoring Program Office
Department of Fish and Wildlife
University of Idaho
Moscow, Idaho 83844

http://www1.nature.nps.gov/im/units/ucbn/

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