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Pika Monitoring at Crater Lake National Park, Craters of the Moon National Monument and Preserve, Lassen Volcanic National Park, and Lava Beds National Monument

2010-2014 Report

Natural Resource Data Series NPS/UCBN/NRDS—2015/782

ON THE COVER
American pika in Craters of the Moon National Monument and Preserve
Photograph by: Michael Durham, www.durmphoto.com

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Abstract

Four park units in the Pacific West Region, Crater Lake National Park (CRLA), Craters of the Moon National Monument and Preserve (CRMO), Lassen Volcanic National Park (LAVO), and Lava Beds National Monument (LABE) have formed a partnership with the Upper Columbia Basin Network to monitor the occupancy dynamics of the American Pika (*Ochotona princeps*) using a shared protocol that supports comparative analyses. A customized relational database shared among the 4 parks is being used to store and analyze the data for all 4 parks. The pika is a charismatic climate-sensitive species in all of these parks and evidence of recent localized extirpations and range contractions in some areas, particularly in the southern portion of its range in the Great Basin, have led to concerns about the impact of climate change on this heat-intolerant species.

This report details the occupancy survey results obtained during the first five years of monitoring (2010-2014), with focus on the fifth year and the implications for future monitoring and analysis. This report highlights in particular the high year-to-year variability (turnover) in pika site occupancy at some parks. Occupancy of sites was determined by recording pika sightings, pika calls, fresh food caches (haypiles), and fresh fecal pellets within 12-m radius plots. In the fifth year of monitoring, a total of 406 randomly-selected sites were surveyed in the four parks from late-July until late-October 2014. The proportions of sites considered to be occupied were (by park, lowest to highest): 0.21 for CRMO, 0.43 for LAVO, 0.61 for LABE, and 0.71 for CRLA. Over the five years of study, occupancy was most stable in CRLA, and lowest and least stable in CRMO. No apparent declining trends were discernible, although patterns of very low site occupancy in CRMO during several of the study years may warrant concern. Low occupancy patterns in a species with limited dispersal capabilities coupled with the apparent isolation of the CRMO pika population from other potential source populations may indicate vulnerability to temporary (at least) extirpation. The five year data set will be used as a baseline for detecting changes with data provided by future monitoring efforts. A hiatus from monitoring has been planned in order to accommodate other park spending priorities, to be followed by a second 5-year monitoring period at all parks where funding and interest has been agreed upon. We conclude that five years are necessary to establish clear patterns because of the high rate of annual turnover in site occupancy.

Acknowledgments

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Introduction

This report describes results from five years (2010-2014) of site occupancy surveys using the American Pika Monitoring Protocol (Jeffress et al. 2011) for pika populations in Crater Lake National Park, Craters of the Moon National Monument and Preserve, Lassen Volcanic National Park, and Lava Beds National Monument.

The American Pika (*Ochotona princeps*), a small mammal related to rabbits and hares (Order Lagomorpha), inhabits rocky montane environments of western North America from British Columbia south to New Mexico (Hall 1981). Pikas have received increasing attention over concerns that the species is at risk of extinction due to global climate change, and several authors have proposed that it is a sensitive climate change indicator species (Smith 1974, McDonald and Brown 1992, Lawlor 1998, Beever et al. 2003, Krajick 2004, Smith et al. 2004, Grayson 2005, Beever et al. 2010). Localized extirpations of pika populations have been documented in the Great Basin (Beever et al. 2003, Grayson 2005, Beever et al. 2010). The species appears to have responded to climate change with rapid contractions during much of the Holocene including over the last century (Hafner 1994, Hafner and Sullivan 1995, Beever et al. 2003, Grayson 2005, Mortiz et al. 2008, Galbreath et al. 2009). Elevational range contractions in the Great Basin appear to be particularly pronounced (Beever et al. 2003, Grayson 2005). The hypothesized mechanism for these range contractions is elevated temperatures and decreased snowpack resulting from accelerated climate change (Smith et al. 2004, Grayson 2005). Recent habitat models (e.g., Calkins et al. 2012) predict that pikas may disappear from large portions of their current range by the turn of the century, although the pika continues to persist in low elevation sites outside of its predicted bioclimatic envelope (Rodhouse et al. 2010), providing conflicting evidence for extinction risk due to climate change. The American pika was recently considered for protection under the Endangered Species Act (USFWS 2009). At the same time, a taxonomic revision of the species (Hafner and Smith 2010) led to the aggregation of formerly recognized subspecies, including several that were endemic to NPS lands, into five large phylogenetic groupings. In its listing decision, the USFWS recognized that “climate change is a potential threat to the long-term survival of the American pika” but concluded that none of the newly recognized phylogenetic groups were in immediate risk of extinction. Notably, however, the USFWS called for further data on the status, trends, and determinants of pika distribution for future listings and management considerations (USFWS 2010).

Pikas may be directly impacted by climate change for several reasons. First, they have a relatively high metabolic rate and low thermal conductance, such that resting body temperature is only about 3°C lower than lethal body temperature (MacArthur and Wang 1973, MacArthur and Wang 1974, Smith 1974). Due to this low thermal tolerance, pikas primarily thermoregulate through behavioral adaptations and strategically time activity during the hot, summer months (MacArthur and Wang 1974, Smith 1974). Pikas are locally restricted to boulder-strewn talus fields and lava flows where abundant crevices and cavities provide sufficient cover and thermal refugia (Smith and Weston 1990, Millar and Westfall 2010, Rodhouse et al. 2010). This leads to pika occurrence patterns distributed along latitudinal and elevational gradients (Hafner 1993, Hafner 1994, Rodhouse et al. 2010). In the southern and more arid portions of the species’ range, such as in the Great Basin and Sierra Nevada

Mountains, it is uncommon to find pikas below 2,500 m (Grinnel 1917, Smith and Weston 1990, Beever et al. 2003, Mortiz et al. 2008, Beever et al. 2010, but see Millar and Westfall 2010 and Rodhouse et al. 2010), but pikas occur at elevations as low as 300 m in mesic, northern latitudes (Simpson 2009). Furthermore, since pikas do not hibernate, the snowpack serves as thermal insulation in cold winter months, which has been studied in the closely-related collared pika (*O. collaris*; Morrison and Hik 2007). Without this insulation, pikas may be exposed to freezing rain and prolonged freezing temperatures (Smith et al. 2004, Morrison and Hik 2007). Recent research suggests that pikas are being lost from sites that have higher average summer temperatures and that experience more extremely cold days, presumably due to reductions in the insulation provided by winter snowpack (Beever et al. 2010). Therefore, snowpack declines projected to occur in mountainous regions of the western United States as a result of warming temperatures and altered precipitation patterns (Wagner et al. 2003, Mote et al. 2005, Karl et al. 2009) may also increase the risk of local extinction, particularly at lower elevations (Smith et al. 2004, Morrison and Hik 2007, Beever et al. 2010).

Our approach for monitoring pika populations in NPS land is based on repeat presence-absence surveys of circular plots (hereafter “sites”) that permit detection of changes in site occupancy patterns over time. Site occupancy is an efficient and informative measure of change in animal populations, and occupancy models can be used to examine factors affecting site occupancy and rates of turnover in site occupancy (ie. local site “extinction” and local site “recolonization”; MacKenzie et al. 2006, Royle and Dorazio 2008). Presence-absence surveys were successfully used to inventory the species in CRMO from 2007-2009 (Rodhouse et al. 2010) and in LABE (Ray and Beever *unpublished report*), and occupancy models developed from these surveys have revealed important insights that have been useful in guiding the development of this program. Included as part of the “Pikas in Peril” project, occupancy modeling results from the first 2 years of monitoring in these 4 parks as well as in 4 additional parks revealed that elevation and climate relationships with site occupancy were highly context-dependent (Jeffress et al. 2013). Patterns of site occupancy appeared to follow elevation gradients in the driest and hottest parks, including CRMO (Rodhouse et al. 2010, Jeffress et al. 2013) but were counterintuitively negatively correlated with elevation in wet and cold parks like CRLA and Grand Teton National Park (GRTE), where cold stress may be a more important factor than heat stress (Jeffress et al. 2013). Although the Pikas in Peril project only supported 2 years of field work in the 4 additional parks, monitoring has continued through 2014 in the 4 parks reported on here, providing additional opportunities to examine the complex, context-dependent relationships between pika site occupancy and climate change.

Objectives

The monitoring questions being addressed by this program are:

- What are the current patterns in pika site occupancy?
- What are the trends in pika site occupancy patterns in the four parks?
- Does the status and trends of pika site occupancy patterns vary along the elevational gradient within and among the four parks?

Methods

Pika site occupancy was evaluated at randomly selected sampling sites in the four parks following monitoring methods described in the peer reviewed monitoring protocol developed by the Upper Columbia Basin Network (Jeffress et al. 2011). Pilot testing of the monitoring protocol was coordinated with the NPS Climate Change Response Program funded “Pikas in Peril” research project.

Sampling Frame and Site Selection

Survey site locations were drawn from GIS based models of predicted habitat using the generalized random-tessellation stratified (GRTS) spatially balanced sampling design described by Stevens and Olsen (2004). A GRTS sample design is a flexible, efficient, and statistically robust approach that accommodates many of the difficulties commonly encountered in field sampling (e.g., sample frame errors, inaccessibility), allows for inclusion of new sample locations in response to these difficulties, maintains spatial balance, and, through a modified variance estimator developed for GRTS samples, increases precision of status estimates (Stevens and Olsen 2003, 2004). These attributes help ensure that GRTS survey designs are representative of the target population of interest, may be efficiently implemented, and allow unbiased inference from sampled sites to un-sampled elements of the resource in interest. This last attribute of GRTS is possible because the design generates known inclusion probabilities (or “sample weights”) and can adjust for biases in the design and be used in design-based inference. The sampling design also accounted for accessibility and safety concerns, determined on a park-by-park basis. Sites were further evaluated for their potential as pika habitat during field visits. A site had to contain ≥ 10% target habitat, which included talus, lava, outcrops or other forms of creviced rock that can provide shelter for pikas. Sites that did not meet the criteria were dropped from the sampling list and replaced with a GRTS oversample from the same stratum. Once a site was established, it was marked for relocation purposes with a discrete aluminum tree tag marker wired to a rock. Given variation among parks in data available for construction of the sampling frame, slightly different design specifications were used to select survey locations in each park.

CRLA

In order to delineate a sampling frame for CRLA, a map of potential pika habitat was created using an automated process to define the boundaries of different habitat types in the park. NAIP imagery from 2007 was used as the base map. Polygons were delineated and then classified by habitat type. Those polygons containing potential pika habitat were identified and selected for inclusion in a map of potential pika habitat. As a final step, the potential pika habitat map was reviewed by a wildlife specialist at the park and edited where appropriate. For site accessibility considerations, the sampling frame only included areas within 1 km of roads. Furthermore, steep slopes (> 35°), identified using digital elevation models in GIS, and traversable areas isolated by these steep slopes were excluded from sampling. The pika sampling frame for CRLA was then stratified by four elevational quantiles, with spatially-balanced samples distributed equally across each stratum.

CRMO

Historical sightings, recent pilot data (Rodhouse et al. 2010), current vegetation maps (Bell et al. 2009), and geologic maps were used to develop the CRMO sampling frames. Sampling was limited to habitat within 1 km of roads or sections of the northern portions of the CRMO Monument, extending south into the Wilderness Trail and Tree Molds Trail. Given that the pilot analyses found pika distribution restricted to the northern portion of the Monument above 1600 m (Monument and Huddle's Hole frames from Rodhouse et al. 2010), these areas as well as additional areas with 1 km of Highway 93 and Minidoka-Arco road were combined into one primary sampling frame to be sampled at regular intervals. Furthermore, steep slopes (> 35°), identified using digital elevation models in GIS, and traversable areas isolated by these steep slopes were excluded from sampling. This frame captured > 400 m range in elevation and was stratified by two elevational strata, based on median elevation of the frame, and in two substrate strata (i.e., pahoehoe, and aa lava). This yielded a total of four strata with spatially-balanced samples distributed equally across each stratum.

LABE

A map of lava flows provided by the park was used to delineate available habitat for the LABE sampling frame. The sampling frame includes areas designated as wilderness and portions of the Callahan, Schonchin, Ross, and Devils Homestead Flows. This sampling frame also captured the majority of study area addressed by Ray and Beever (*unpublished report*). For site accessibility and safety considerations, the sampling frame only included areas within 1 km of roads and excluded steep slopes (> 35°), which were identified using digital elevation models in GIS. Samples were distributed across two elevational strata based on median elevation of the frame.

LAVO

In order to delineate a sampling frame for LAVO, a map of potential pika habitat was created using an automated process to define the boundaries of different habitat types in the park. NAIP imagery from 2007 was used as the base map. Polygons were delineated and then classified by habitat type. Those polygons containing potential pika habitat were identified and selected for inclusion in the map of potential pika habitat. As a final step, the potential pika habitat map was reviewed by the wildlife specialist at the park and edited where appropriate. Given the remoteness of a significant amount of potential habitat, the sampling frame included areas within a 1 km buffer of trail sections in addition to the habitat within 1 km of roads. Starting from the trailhead, 1 km of each trail was buffered, and in a couple of instances, > 1 km of trail (≤ 3 km of the Butte Lake trails and 2 km of the southern portion of Kings Creek Trail). Furthermore, steep slopes (> 35°), identified using digital elevation models in GIS, and traversable areas isolated by steep slopes were also excluded from the LAVO sampling frame. The pika sampling frame for LAVO was stratified by four elevational quantiles, with spatially-balanced samples distributed equally across each stratum.

Occupancy Surveys

A site was defined as a 12-m radius plot containing ≥ 10% target habitat. Although survey crews varied in size, survey effort was standardized among sites and parks, usually having one or two crew members survey each site. Surveys began with a 5-minute period of silent observation to allow for visual and aural detection. The surveyor/s then thoroughly examined the entire plot and recorded all evidence of pika activity detected, including pika sightings, calls, scat, and hay. Once the surveyor/s felt the survey was complete, ancillary data was collected, including vegetation cover, and substrate complexity, and the site was marked, or re-marked as necessary. Several sites were surveyed more than once either using independent observers or surveying the same site at different times (i.e., early versus late season) to estimate detection probabilities.

A site was considered occupied if either a pika was seen or heard within the plot and/or fresh scat or fresh hay was found within the plot. Occupancy modeling has not yet been conducted for this project (but see Rodhouse et al. 2010 and Jeffress et al. 2013), so all reports of occupied sites in this document refer to those sites at which fresh sign was detected (i.e., “naïve” occupancy). Detection probabilities have not yet been estimated and our estimates of the proportion of sites occupied are therefore preliminary and conservative. The proportion of sites occupied that are reported here vary widely by park. Because our results are preliminary we strongly caution that no inferences should be made that compare the proportions among parks; for example, by concluding that CRLA has more pikas than LAVO. There are fundamental differences in the distribution and characteristics of suitable habitat and the coming detailed data analyses should provide more insight into factors affecting pika site occupancy. Furthermore, complete reporting of detection and occupancy probabilities will follow in future reports.

Results

The pika occupancy surveys for 2014 began in late-July at LABE, the lowest elevation park, and continued through late-October in CRLA. Specific dates varied by park and were based on when pika were expected to be most active. Field training and calibration occurred in LABE in late-July for crew members working in LABE, CRMO, and CRLA, with calibration or training with individual park staff occurring at the subsequent parks. LAVO field crews were trained and led by long-time project lead M. Magnuson and additional CRLA field crews were trained by park terrestrial ecologist S. Mohren.

Status

A total of 406 sites were surveyed across the four parks in 2014, which is the same total number of sites surveyed from 2013. For the first three years of monitoring the total number of sites sampled fluctuated annually as mapping errors and access issues were resolved. For the last three years, all sites were well established, accessible, contain the target percentage of pika habitat (>10%), and provide an adequate sample size.

A total of 129 sites were revisited across the four parks in 2014. After achieving nearly 50 revisits per park in 2010, the goal per park became 30 revisits for the following years. A goal of 50 revisits was implemented in 2014 at LABE since an early start in late-July allowed for adequate time to complete the revisits, and past years' revisits at LABE fell short of the 30 site goal: revisiting 0 sites in 2011, and 14 sites in 2013. Adequate numbers of site revisits allow for more accurate calculation of detection probability, which factors into the overall occupancy modeling results.

The proportions of sites considered to be occupied in 2014 were (by park, lowest to highest): 0.21 for CRMO, 0.43 for LAVO, 0.61 for LABE, and 0.71 for CRLA. The proportions of sites considered to be occupied were higher in 2014 than any other year, and this was true for all four parks. With the exception of LABE, all parks had at least one year where a decrease in the proportion of occupied sites was documented.

Table 1. Summary of pika survey activity in the 4-park monitoring effort, 2010-2014.

Park	2010	2011	2012	2013	2014
	Total Number of Sites Surveyed				
CRLA	85	107	145	100	100
CRMO	56	135	146	103	103
LABE	101	102	100	100	100
LAVO	76	112	75	103	103
Park	**2010**	**2011**	**2012**	**2013**	**2014**
	Total Number of Sites Revisited				
CRLA	50	30	30	41	30
CRMO	50	35	30	20	29
LABE	50	0	30	14	50
LAVO	41	30	0	21	20
Park	**2010**	**2011**	**2012**	**2013**	**2014**
	Proportion of Sites With Fresh Sign (Detections)				
CRLA	0.65	0.63	0.54	0.60	0.71
CRMO	0.21	0.07	0.16	0.08	0.21
LABE	0.24	0.29	0.40	0.45	0.61
LAVO	0.14	0.42	0.21	0.43	0.43

Trends

Site turnover probabilities have not been calculated for this report, but raw ("naïve" without accounting for imperfect detection) site occupancy turnover patterns are shown in Table 2. The number of sites that apparently remained occupied from one year to the next (survival), number of sites that apparently transitioned from unoccupied to occupied (recolonization), and the number of sites that apparently transitioned from occupied to unoccupied (extinction), are all listed. Turnover within each year will be analyzed in conjunction with climate data (e.g., temperature, and snowpack) in order to determine relevant annual relationships, and average annual turnover will be calculated from these first five years of monitoring to serve as a baseline for future monitoring efforts.

Table 2. Summary of apparent (naïve, not accounting for imperfect detection) site occupancy turnover patterns in the 4 study parks, 2010-2014. Site survival (Φ) is the number of sites that remained apparently occupied (based on detections) from one year to the next. Site recolonization (γ) is the number of sites that apparently transitioned from unoccupied to occupied from one year to the next. Site extinction (ε) is the number of sites that apparently transitioned from occupied to unoccupied from one year to the next.

CRLA	**Φ**	**γ**	**ε**
2010-2011	23	3	3
2011-2012	49	4	15
2012-2013	48	11	3
2013-2014	54	15	3
CRMO	**Φ**	**γ**	**ε**
2010-2011	4	1	1
2011-2012	7	11	2
2012-2013	7	1	12
2013-2014	8	14	0
LABE	**Φ**	**γ**	**ε**
2010-2011	6	5	7
2011-2012	7	9	4
2012-2013	31	14	9
2013-2014	39	22	6
LAVO	**Φ**	**γ**	**ε**
2010-2011	3	6	2
2011-2012	11	3	17
2012-2013	11	21	5
2013-2014	23	16	17

Discussion

Data

Comparing the 2014 data with the previous four years one might initially conclude that pika population numbers at the four parks are stable, or increasing. Although 2014 appeared to be a "good" year for pika, there are still questions to address, such as, what accounts for the shifts in the proportion of occupied sites in previous years at CRMO and LAVO? Why does one park's proportion of occupied sites increase while another decreases in the same year? And why is LABE, located at the lowest elevation of the four, the only park to increase in the proportion of occupied sites every year? Perhaps analysis of climate data (forthcoming) will reveal evident correlations. However, recent models suggest that the limiting factors of pika occupancy may vary from park to park, with some pika populations being more susceptible to climate change than others (Jeffress et al. 2013). Furthermore, this five year collection of data should be viewed as a baseline for future monitoring efforts.

Protocol

Throughout five years of monitoring, the overall protocol has not changed significantly. However, collection of some ancillary data has been phased in and out. The 2014 protocol saw the return of substrate complexity, a metric used successfully in the original 2007-2009 pilot surveys at CRMO (Rodhouse et al. 2010), which ranks sites (from 1 to 3, 3 being the highest complexity) in terms of boulder size, change in elevation within the site (relief), and the quality of holes, crevices, and general areas of refuge for pika. Site vegetation cover estimation was retained, as in previous years, although this may be redundant, as vegetation changes in these environments (i.e. lava fields) tend to be relatively slow.

The quantity of pika scat found at each site was not recorded in 2013 or 2014, as it had been the previous years. Recording an estimate of the quantity of scat found at each occurrence within a site may help increase confidence in site occupancy, and give some idea as to how the site is utilized. However, this kind of data can be recorded in the site notes, and may be inconsequential at many sites.

Multiple observers (typically two) were used on the majority of site surveys in 2014. This allowed for quicker plot setup, more accurate surveys, a higher level of safety, and the ability for technicians to discuss the pika signs discovered at the site (e.g. if scat was fresh or old). This method appears to be most useful at sites with high substrate complexity, and low detection probability (i.e. occupied sites where pika sign is least abundant). At sites with low substrate complexity, or an abundance of sign, single observer surveys are equally effective.

Future Plans and Analysis

Forthcoming analysis will evaluate rates of turnover in pika occupancy with climate data, after accounting for detectability (Rodhouse et al. *in preparation*). Analysis of temperature data collected in a subset of survey sites in CRMO and CRLA is also underway (Hovland et al. *in preparation*). Currently, the plan is to allow for a hiatus on pika surveys. The established sites and protocol will remain in place until another five year series is agreed upon.

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