Describing Habitat Suitability for American Pika (*Ochotona princeps)* in the Cascade-Siskiyou National Monument

Alec Bayarsky
Neil Clayton

Southern Oregon University

In collaboration with:
Dr. Jamie Trammell
Dr. Michael Parker

Abstract

It has been suggested that the American pika may be present within the Cascade-Siskiyou National Monument. Pikas are a thermal specific species usually found in high-elevation habitats. Recent research has described populations of American pika within low-elevation habitats, including in Oregon, where average temperatures are higher than expected tolerance level for pikas. Habitat within the monument has been analyzed in comparison with gathered data of current persisting pika populations in similar environments in the Southern Cascades region, as well as literature on traditionally understood habitat requirements for American pikas. Utilizing Geographic Information Systems software in order to determine suitability of habitat within the monument allowed for the identification of specific locations that may present the possibility of pika population occurrence. The results of these suitability models have suggested possible occupancy. Field surveys have been undertaken at sites suggested by the models to determine current and historical occupation. Pikas are sedentary, do not disperse over large distances, and require talus slopes for refuge and denning. Selection of survey sites was restricted to these factors. The approach to surveying for and monitoring pika populations in the study area will be based on detection of haypiles, scat, or individuals, utilizing the habitat. Field survey has concluded that a small population of American pika is currently occupying habitat within the Monument, and plentiful evidence suggests widespread occupation historically. Further field survey is necessary to make conclusive determinations about the extent of current occupation by American pika.

I. Introduction

This research focuses on determining the suitability of available habitat within the Cascade-Siskiyou National Monument in regard to the American pika (*Ochotona princeps*). The American pika is considered to be an indicator species, important in the

interpretation of climatic changes and the effects of these changes on representative species within an area. Pikas are typically discussed as being limited to high-elevation, moist, rocky habitats with specific foraging patterns and behaviors and have been considered to have zero tolerance for slight changes in temperature. Recent research suggests that not only are American pika surviving and possibly thriving in lower elevation habitat than ever studied before (<2,500m) but that they are also doing so in environments with climatic trends previously thought to be unsuitable for pika survival. A study completed on American pika in the Northwestern Great Basin has identified new sites containing pika that are within areas not suspected to provide support for persistence of pika populations (Jefress 2017). Researchers identified 238 new sites with evidence of past and/or current occupancy by pikas. These sites previously thought to be unsuitable for pika survival show a shift in pika behavior and ability to utilize habitat.

Some researchers have attempted to explain this shift in the behavior of pika occurrence through the study of subsurface habitat acting as microrefuges. Some sites of pika occurrence researched were shown to moderate surface temperature within talus habitat based on subsurface characteristics. The moderation of surface temperatures by subsurface habitat was found to be the most effective predictor for pika occurrence, independent of other critical habitat characteristics, such as ambient temperature. This research suggests that microrefuges may provide thermal specialist species, such as the American pika, with a critical buffer against otherwise intolerable extremes (Chalfoun 2016). Current studies suggest that American pikas have employed a suite of behavioral responses to climatic variability including changes in foraging strategy, habitat use, and thermoregulation (Beever 2017). Recently, American pikas have been documented utilizing new habitat types including downed logs, snags, slash piles, and coniferous forests, though still maintaining close proximity to talus habitat, foraging and creating haypiles in coniferous forests up to 100m from the nearest talus patch (Beever 2017). This disbursement of pikas from traditional habitat expectancy provides the opportunity for study of behavioral change in the face of changing climate.

Species distribution models often fail to capture the complexity of species niches. Even so, species distribution models can be effective in describing species distribution based on numerous factors, and these models are being used to describe American pika populations within 8 National Park Service units, as part of a long-term monitoring project currently underway. Two of these study sites, Mount Lassen, in California and Crater Lake, in Oregon, are found along the Cascade Range and are located relatively close to the Cascade-Siskiyou National Monument, where the focus of this study lies (see figure 1).

Figure 1. The Cascade-Siskiyou National Monument in Oregon and California

The elevation range of these populations currently being researched by the National Parks Service is between 1206m – 3151m above sea level. This adds some of these populations to pika populations which are currently utilizing habitat thought to be below the elevation threshold for American pika persistence, making them acceptable for comparison with the Cascade-Siskiyou National Monument, which is also a potential low elevation site for pika occurrence. American pika are currently being monitored by the United States National Park Service in order to establish baseline data of pika distribution and habitat use so that it can be utilized in comparison of continued monitoring to relate changes in behavior and distribution to climatic changes (Jefress 2011). Current studies are producing results that contradict past research efforts, suggesting more research is necessary to better understand American pika and their capability to change their behavior and habitat use as climate changes. This continued research can lead to better understanding of the capabilities of other thermal specific species to adapt to a changing climate.

This research effort could provide potentially useful information to be considered in any continued or future research of the distribution of American pika within Southern Oregon and will also contribute to the value of the Cascade-Siskiyou National Monument as its ecological importance continues to be understood. This study aims to answer the question of whether or not it is reasonable to expect pika populations to be using the monument as a refuge and will apply well-used conservation biology and ecology techniques, such as deductive and inductive habitat modeling, to determine the areas in the monument most likely to contain American Pika populations. It will also

provide a description of the potential distribution of pikas within the Cascade-Siskiyou National Monument based on the initial habitat-suitability modeling and resulting field survey.

The Cascade-Siskiyou National Monument area in Southern Oregon may contain all of the critical elements needed for pikas to persist. Applying these models in Southern Oregon will help to guide future researchers in determining whether or not pikas may be found in microrefugia in Oregon. The hypothesis of this research project is that the Cascade-Siskiyou National Monument will contain habitat characteristics matching those from pre-existing low elevation sites known to contain American pika, as well as from traditionally understood habitat characteristics required by pika as stated in literature from previous studies.

This study asks two related research questions. First off, does the Cascade-Siskiyou National Monument contain suitable habitat for American pika? If so, what is the potential distribution, and what is the actual distribution of American pika within the Monument? To answer these questions, this research effort began by using inductive and deductive habitat modeling to determine the suitability of the habitat within the Cascade-Siskiyou National Monument (CSNM). The deductive modeling effort will attempt to determine whether there is suitable habitat within the monument based on traditionally understood habitat requirements held by American pikas. The inductive modeling effort will attempt to determine whether there is suitable habitat contained within the monument based on habitat characteristics associated with known pika populations currently being studied by the National Parks Service. The habitat characteristics being collected in these surveys are aspect, elevation, and slope.

Completion of the two types of habitat suitability modeling and the combination of those results will suggest whether or not the CSNM contains habitat considered suitable for American pika use. If the CSNM does contain suitable habitat, the next steps of the project will be to determine if suitable habitat is being utilized currently, or if historical occupations have taken place. Upon completion and analysis of the models, this study will attempt to quantify the distribution and number of individuals in the population(s) within the Cascade-Siskiyou National Monument based on evidence of habitat use (presence-absence).

II. Project Design and Methods

Deductive Habitat Model

A review of scientific journal articles and natural history books was conducted and these were used to determine all of the critical habitat elements required by American pikas (*Ochotona princeps*). In recent years, many articles have been published that refute the traditional narrative regarding habitat elements required by

American pikas, particularly in the areas of nesting, foraging, and elevation. For example, American pikas have been found at elevations much lower than previously thought (Beever et al. 2017), they have been shown to inhabit dens not made of talus piles of rock (Manning and Hagar 2011), or to inhabit areas that have an average temperature above what was previously thought to be acceptable (Simpson 2009). These novel behaviors may exhibit flexibility in the face of climate change (Beever et al. 2017).

In this study, all of the variables chosen for inclusion, both climatic and environmental, as well as the limits on those variables, were determined by taking a traditional view on the natural history of the American pika. The literature review was also used to determine the characteristic values of these variables in order to create maps in GIS that represent the values necessary for inclusion and exclusion. Data that would be able to represent the variables chosen from the literature review was collected for use in ArcMap 10.5. The variables deemed necessary to determine suitable pika habitat included slope, aspect, temperature, elevation, precipitation, and vegetation.

Pikas den in talus, a pile of rocks that form at the base of a cliff or slope. Slope, in degrees, was determined using the angle of repose that would create the appropriate talus size that American pikas prefer for denning. The angle of repose is different for each type of material (Sæter 2008), however, most geologic material forms talus piles when the angle of repose is ~30° (Lerner 2003). Therefore, an angle of 30° or more was selected as suitable. Digital Elevation Models (DEMs) for California and Oregon were used to isolate the study area. The Slope tool in ArcMap was used to calculate slope for California and Oregon. Next, the Reclassify tool was used to assign new values to each slope angle. Any angle of 30° or above was assigned a “1”, while any angle below was assigned a “0”. In this way, all slopes at or above the critical marker for creating talus piles were isolated and visualized on the map. This layer was then used as the input for the Extract by Mask tool. This enabled the specified values to be restricted to the study site, the Cascade-Siskiyou National Monument.

Aspect, or the compass direction of a particular slope, affects temperature. Pikas are temperature sensitive and are most often found on slopes with a northerly aspect, where it is cooler (Verts and Carraway 1998, Barbour 1999, Jeffress et al. 2011, 2017). The Aspect tool was run on the original DEMs and a layer representing aspect was produced. Using the Reclassify tool in ArcMap, all northerly facing aspects, including northeast and northwest, were assigned a value of “1” and all other aspects were assigned a “0”. All slopes with a northerly aspect were demarcated and represented visually on the map. This layer was then applied via the Extract by Mask tool to the Monument boundary.

The American pika is considered a montane mammal and is mostly found residing above 1500 meters in elevation (Verts and Carraway 1998, Jeffress et al. 2011,

2017, Erb 2013). The Reclassify tool was used to calculate and isolate elevation values from the California and Oregon DEMs. Any pixel assigned a value of 1500 meters or above was reclassified as a “1”, meaning that it represents suitable pika habitat. Any pixel assigned a value of fewer than 1500 meters was reclassified as a “0”, therefore representing unsuitable pika habitat. The result was represented visually on a map layer and then pinned to the Monument boundary using Extract by Mask.

Temperature plays an important role in pika distribution, as it has been previously shown that being exposed to temperatures at or above 25.5° Celsius for extended periods of time can result in pika expiration (Smith 1974). This value was used as the upper limit of temperature. PRISM monthly temperature data was retrieved from Oregon State University (Ecological 2018). The average July temperatures over a 30-year period were used. The Reclassify tool was used in ArcMap to classify an average July temperature of 25.5° or above as a “0” and anything below as a “1”. The resultant map layers represented this reclassification visually and the layer was restricted to the study site.

Precipitation, per se, is not usually considered a critical habitat factor for American pikas. However, a study conducted by Jeffress, et al. (2017) found that, across the Great Basin, annual precipitation was greater at occupied, as opposed to relict sites. Other studies have revealed the same trend. In the Rocky Mountains, the mean average annual precipitation at occupied sites was 884mm (Erb 2013). This is the value point that was used in ArcMap to determine habitat suitability. The precipitation data used was acquired from PRISM and any value that was previously assigned as 884mm or above was reclassified as a “1”, while any value below that was reclassified as a “0”. Using the Reclassify tool resulted in a map layer with only the preferred values represented. This layer was then Extracted by Mask to the monument boundary.

Pikas in North America may be found in a variety of habitats, from the high Rockies to the lava beds of Craters of the Moon National Monument and Preserve (Jeffress et al. 2011, Erb 2013). Pikas are generalist herbivores that also cache vegetative material in hay piles (Verts and Carraway 1998). They feed mostly on forbs and graminoids. At various sites in Washington and others in Utah, as many as 23 different species of plants were found cached in hay piles (Verts and Carraway 1998, Fowler et al. 2014). Landfire vegetation data was used to determine suitable individual vegetation types. The Reclassify tool was used in ArcMap to reassign values. Any vegetation type that certainly would not be used by pikas, for example, Coastal Wetlands or Agricultural Areas, were reclassified to have a value of “0”. Special attention was given to attributes such as Barren Land, Snowpack, or Bare Earth. These vegetation types possibly represent talus piles and therefore were given a value of “2” to signify their importance. All other suitable vegetation types, such as Alpine or Montane Meadows, were reassigned a value of “1”. These three values formed a new layer which

was Extracted by Mask to the Cascade-Siskiyou National Monument boundary layer (Table 1).

Finally, Raster Calculator was used to combine the multiple map layers produced. This process combined all of the variables as well, and a final map was created. This map represented visually all of the areas containing the variables that make up preferable pika habitat. Very few areas contained all 6 of the critical habitat elements. Therefore, only areas that contained a combination of at least 5 variables were considered as potential pika habitat and represented accordingly.

Vegetation Type Classified “0”	Vegetation Type Classified “1”	Vegetation Type Classified “2”
Agricultual-All Types	Alpine Dwarf-Shrubland	Barren
Big Sagebrush Shrubland and Steppe	Aspen-Mixed Conifer Forest and Woodland	Quarries-Strip Mines-Gravel Pits
Deciduous Shrubland	California Mixed Evergreen Forest and Woodland	Snow-Ice
Desert Scrub	Chaparral-All Types	
Developed-All Types	Conifer-Oak Forest and Woodland	
Introduced-All Types	Douglas-fir Dominant-All Types	
Greasewood Shrubland	Grassland-All Types	
Low Sagebrush Shrubland and Steppe	Juniper Woodland and Savanna	
Open Water	Lodgepole Pine Forest and Woodland	
Pacific Coastal Marsh and Pacific Coastal Scrub	Mountain Hemlock Forest and Woodland	
Salt Desert Scrub	Mountain Mahogany Woodland and Shrubland	
Sparse Vegetation	Pinyon-Juniper Woodland	
Wetlands and Riparian Areas-All Types	Ponderosa Pine Forest, Woodland and Savanna	
	Red Alder Forest and Woodland	
	Red Fir Forest and Woodland	
	Redwood Forest and Woodland	
	Sitka Spruce Forest	
	Spruce-Fir Forest and Woodland	
	Subalpine Woodland	
	Western Oak Woodlands	
	Western Hemlock-Silver Fir Forest	
	Western Red-cedar-Western Hemlock Forest	

Table 1. Vegetation types in the CSNM classified by suitability.

Inductive Habitat Model

In order to create an inductive model, information must be gathered of known locations for the species of interest. The National Park Service is currently conducting a long-term monitoring effort focused on American pikas, with locations of study in Crater Lake National Park, Lava Beds National Monument, Lassen Volcanic National park, and Craters of the Moon National Monument and Preserve. These locations are all found near the western coast of North America, aside from Craters of the Moon National Monument and Preserve, which is located in Boise, Idaho. All of these known locations of pika populations contain habitat characteristics similar to the CSNM, based on geographic location.

Location information for known observations of pikas was downloaded from the National Parks Service from this monitoring effort, providing 3,869 data points to be used in the creation of this model. National Elevation Dataset Digital Elevation Models (DEMs) were downloaded in large sections, completely encompassing each study area and all location points of pikas, from the online EarthExplorer platform. This data was uploaded into ArcGIS, plotted on to a base map, and transformed into a common UTM projection for more accurate analyses.

Once a raster layer of elevation was processed, slope and aspect were calculated for all pika location points. Mean annual temperature data was downloaded in the form of “30-year normal” data layers from the PRISM online database (prism.oregonstate.edu). For all habitat characteristics, values were attached for aspect, elevation, slope, and temperature to each individual locational point for pika occurrence on the map. The attribute table for all pika locations, and now their corresponding habitat characteristics, was then uploaded into Microsoft Excel, and descriptive statistics were run on this data.

This process produced an average value for each habitat characteristic, as well as a standard deviation value. From this information, parameters for suitable habitat were created for the American pika. The parameters were determined using the mean values for each characteristic, and one standard deviation above and below this value. This created a window of prediction for what corresponding habitat characteristics would be acceptable for pika presence to be observed, referred to from here forward as “parameters of suitability”.

At this point, these parameters of suitability needed to be applied to the Cascade-Siskiyou National Monument. A boundary of the CSNM was downloaded from the BLM website and uploaded to ArcGIS. Raster layers for each habitat characteristic were then clipped to the boundary. In order to create a final map highlighting only the suitable areas of the monument, the data layers needed to be reclassified. This reclassification was done using the first and third quartile values for each characteristic (Table 2).

Statistic	1st Quartile	3rd Quartile	Mean	Standard Deviation
Aspect	75.964	256.293	170.825	105.661
Slope	2.688	20.946	12.519	11.161
Elevation	1637.000	2318.000	1963.887	429.892
Temperature	5.150	7.050	6.233	1.403

Table 2. Descriptive statistics for all habitat characteristics.

Using aspect as an example, the 1st quartile value for aspect (Table 1) that was calculated in descriptive statistics was 75.964 and the third quartile value was 256.293. Accordingly, everything below 75.964 and above 256.293 was assigned a “0”, and everything within these limits was assigned a “1”. Using this format, the same process was repeated for each habitat characteristic being evaluated, reclassifying all values between the first and third quartile values to a value of “1”, and anything outside of these limits to a “0.” By setting all “0” values to appear with no color on the map, and all “1” values to appear in black on the map, each raster data layer now only portrayed those areas within the CSNM boundary that met our parameters.

At this step of the process, an important decision had to be made regarding the use of temperature in the parameters of suitability. Based on the parameters of suitability calculated for temperature, only a small area of the CSNM in the northeast would be considered possible habitat. The inclusion of this map layer in the production of the final map would significantly lessen the area within the monument that could be considered suitable habitat. This lessening is not necessarily negative, however the accuracy of this prediction needed to be considered before inclusion. In recent studies done on the American pika, ambient temperature has increasingly been discounted as a valid measurement of habitat suitability because of the ability and tendency of pikas to utilize underground talus habitat as a refuge from the heat. Because of this, it was determined that the use of temperature within the model would result in an invalid representation of all possible locations within the monument that could provide suitable habitat for American pikas. With temperature removed from the model, the final map of habitat suitability for the CSNM includes aspect, elevation, and slope. The final step of this process was the combination of all three map layers together to create one final map representing suitable habitat, where all highlighted area within the Monument represents habitat that falls within the parameters of suitability for each habitat characteristic being evaluated.

Field Survey

The approach to surveying for, and monitoring pika populations in our study area, will be based on both direct (aural and visual) and indirect (scat and haypile) detection. Detection of current occupancy will be verified through visual, aural, or haypile identifications. Historical occupancy will be determined through location of old scat, without the presence of hay piles or sighting/aural detection of individuals. Based on local knowledge and previous studies, sites were mostly contained in and around Surveyor Ridge, including Surveyor Mountain, areas within the Monument that contain significant talus habitat.

The Cascade-Siskiyou National Monument lies, geographically speaking, within range of the National Parks Service existing monitoring program and therefore is particularly well suited for a survey such as this one. Pikas are territorial, conspicuous, and easy to detect, however, they are relatively difficult to capture and mark (Smith 1974, British Columbia Resources Inventory Committee 1998, Smith and Gilpin 1997, Beever et al. 2003). That procedure would not be suitable for a population such as this, given that the number of individuals is uncertain and there is concern regarding a probable small population size. Once an individual has been identified, an area of 12m^2 will be calculated from that point, which will allow for estimation of the number of individuals present in the study site. This measurement is based upon territorial range and is recommended by the National Parks Service protocol (Jeffress et al. 2011). Any individual found outside of the 12m^2 radius will be documented as a new individual.

Haypiles are an important aspect of pika behavior. They are created and maintained in order to store excess food. These piles are usually placed in the dens of individuals inside the talus. However, recent studies have suggested that pikas may be making haypiles on the edge of, or deep within forests (Beever et al. 2017). This unique behavior may be a reaction to changing or extreme conditions and a crucial aspect of this study will be to locate haypiles within the talus and beyond and to identify the contents. GPS points will be tagged to each haypile for future data analysis of individuals and ranges. Vegetation cover data will also be measured and recorded, in order to try to understand the grazing behavior of the pika population.

Pikas usually graze for plant material close to their territorial talus piles (Beever et al. 2017). Evidence of grazing and collecting of plant materials may be observed. Pika diets usually consist of forbs and graminoids. High forb cover has been shown to correlate with pika abundancy (Moyer, et al. 2016), therefore observation and collection of data around the pika home range to survey for forbs and graminoids that would be typically found in pika diets (and haypiles) will be undertaken, as well as observations for unique grazing behaviors.

III. Results and Discussion

Deductive habitat model results

Each variable was visually applied to a boundary that made up the study area, the CSNM. The preferred value of each element was shaded as black, while the unwanted value was given no color. Therefore, the darker areas on each individual map, as well as the final map, represented suitable pika habitat and predicted where they may be found in the CSNM.

Much of the topography of the study area lies at a northerly aspect, so a majority of the map of the study area is shaded black to represent this (Figure 2). The resulting slope map was very nearly colorless, which represents the limited area inside the monument which lies at an angle that might represent talus piles. This was expected as the nature of the study area implied this. Roughly half of the study area was shaded black for elevation. This is significant as, in comparison with other locations known to contain pika populations nearby, the CSNM lies at relatively low elevation (Figure 3).

At first, it appears that the map that represents vegetation is almost 100% shaded, however, there are a few smaller areas that are shaded even darker black. This represents possible talus locations based upon the variable selection of “bare earth” or “snowpack.” All other suitable vegetation resulted in a grey shading. This result is also not surprising, given the wide variety of vegetation pikas have been observed foraging and caching (Figure 4). The precipitation map layer results were quite similar to elevation and this correlation was expected as well, due to snowpack.

The final map produced from a combination of at least 5 of the 6 factors clearly identifies a small portion of the CSNM that contains habitat that is suitable for the American pika, totaling 7162.65 hectares of the 69,011 hectares in the monument (10.38 %). This represents the areas in the CSNM that the model predicted pikas may be found (Figure 5).

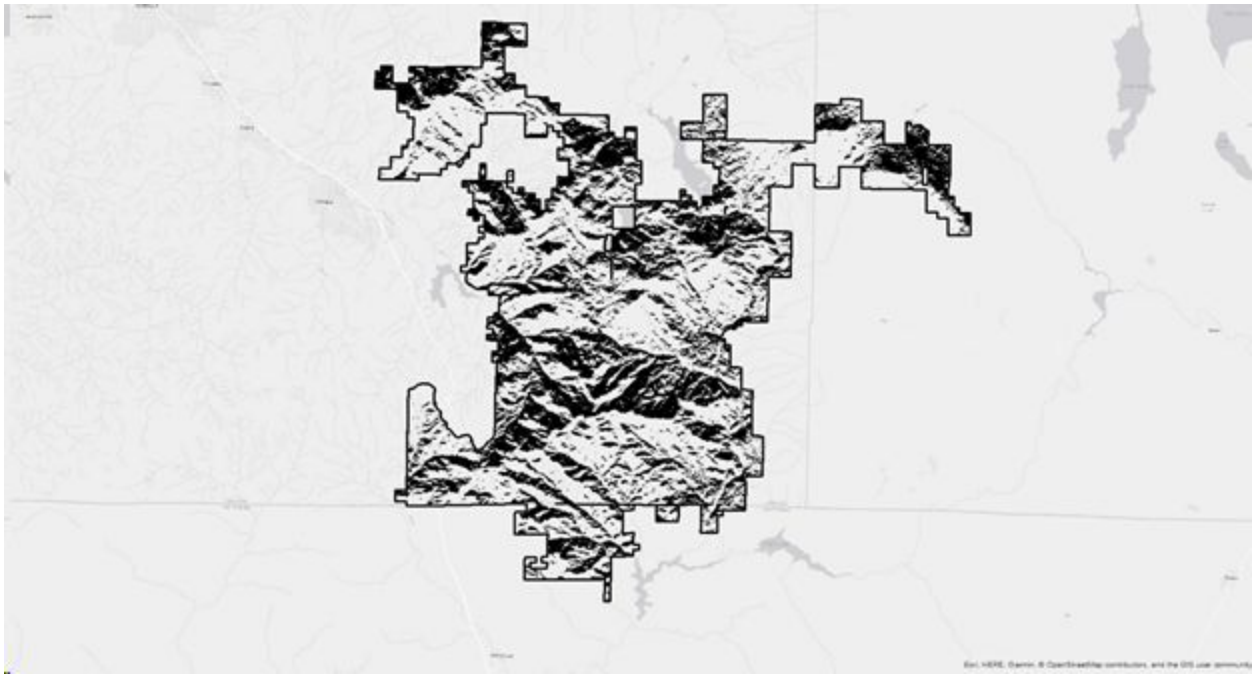

Figure 2. Aspect

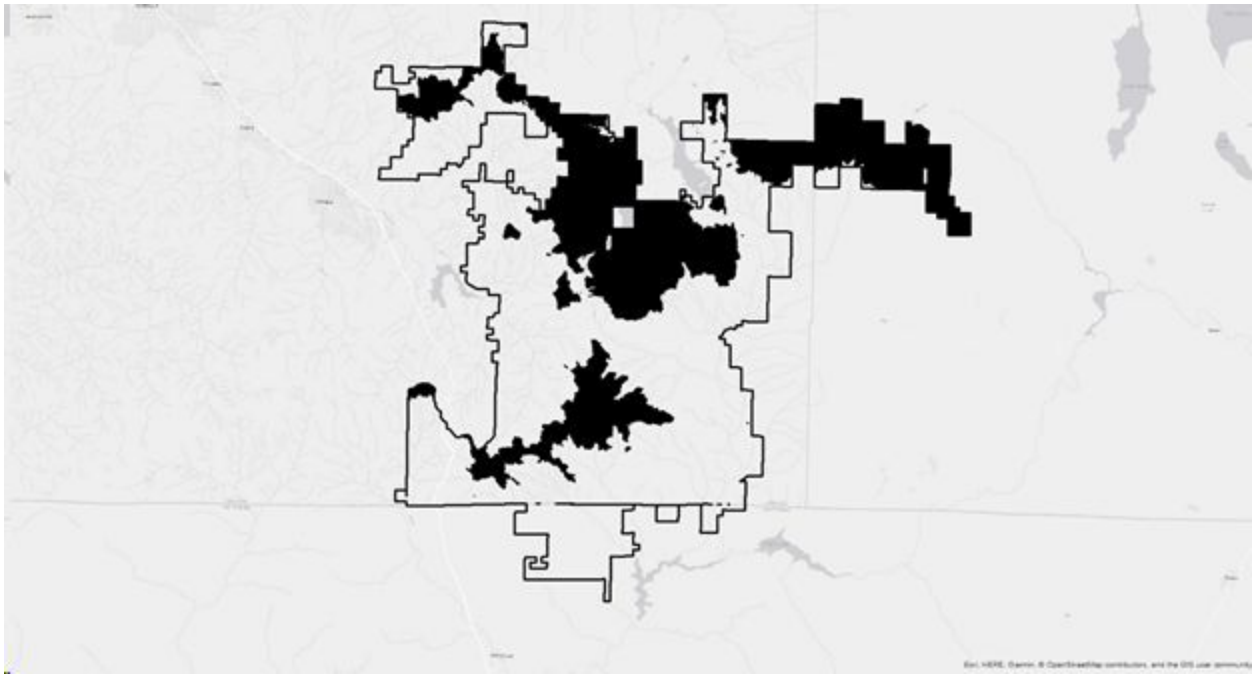

Figure 3. Elevation

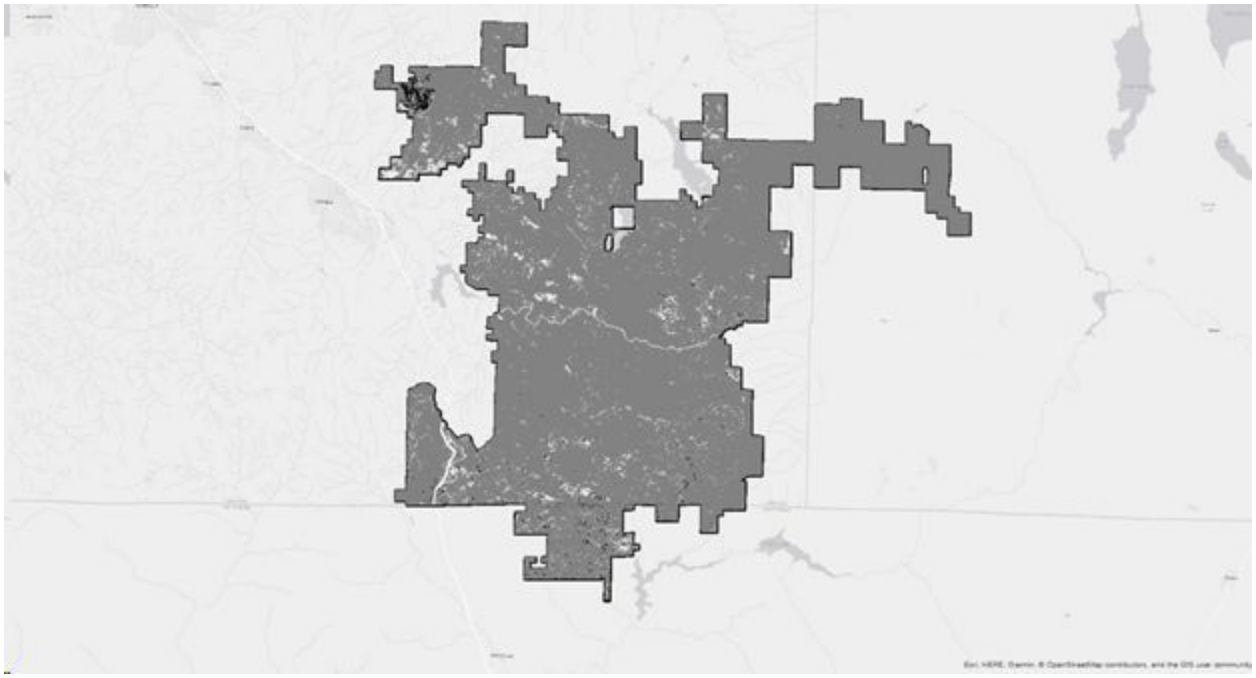

Figure 4. Vegetation. Note the black shaded areas that represent classification "2", which signify areas that may contain talus.

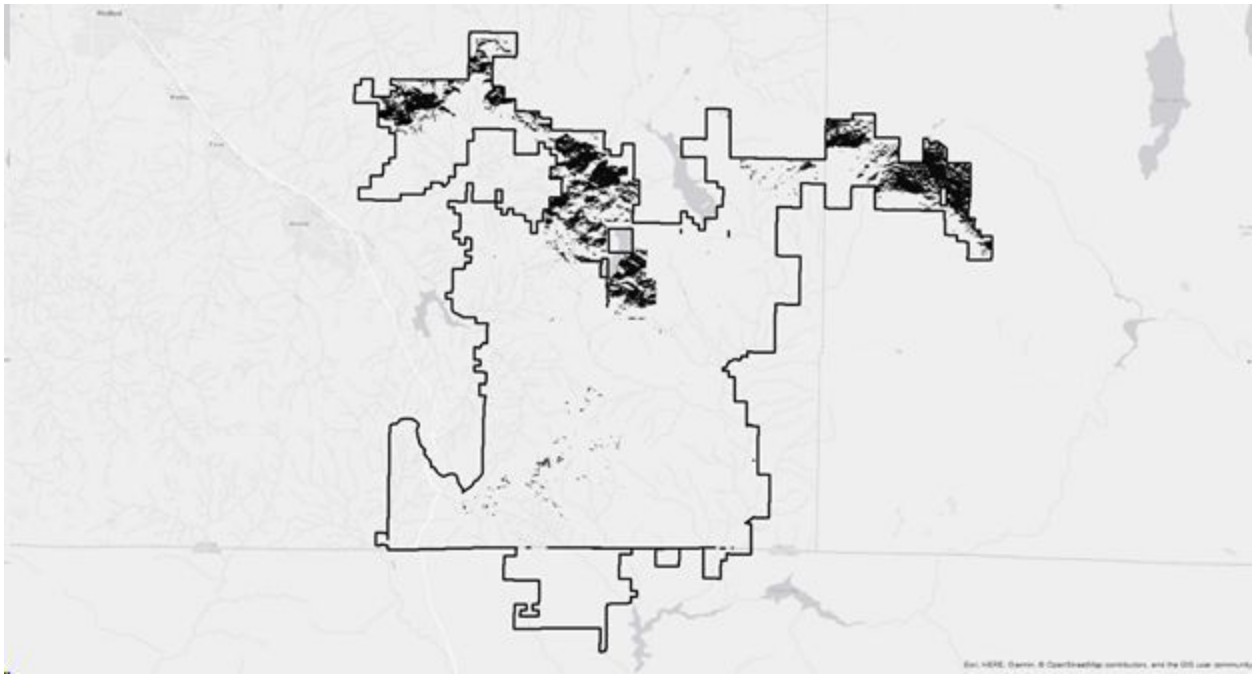

Figure 5. The final map that represents all suitable pika habitat within the boundaries of the CSNM.

Inductive Habitat Model Results

After combining and applying the parameters of suitability, the final map (Figure 6) identified a small portion of the CSNM to represent suitable habitat. A majority of the habitat identified as suitable is in the north section of the monument, split between center north and northeast. There are small areas considered suitable as well that are dispersed in the lower center region of the monument. The descriptive statistics run on the habitat characteristic data showed no clear trend in the data, with the values associated with each characteristic varying widely.

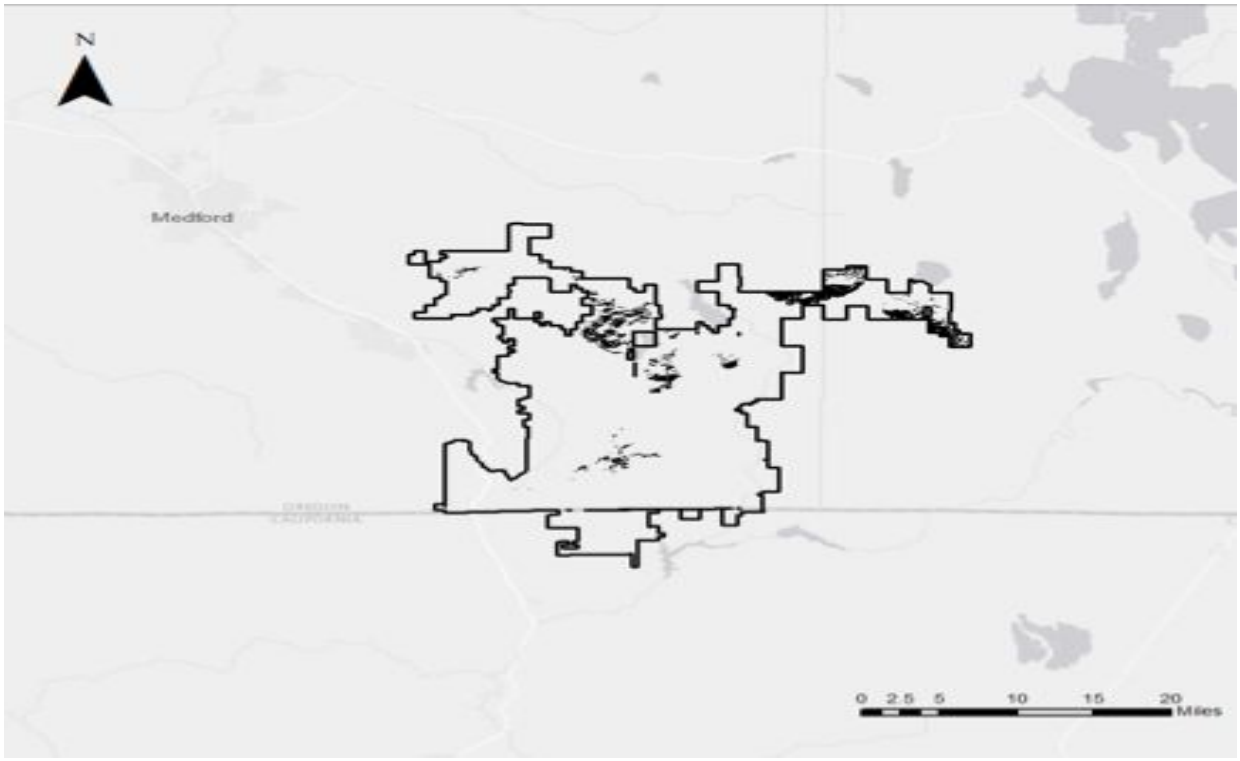

Figure 6. Suitable habitat within the CSNM.

Figure 7. Areas within the CSNM containing suitable aspect.

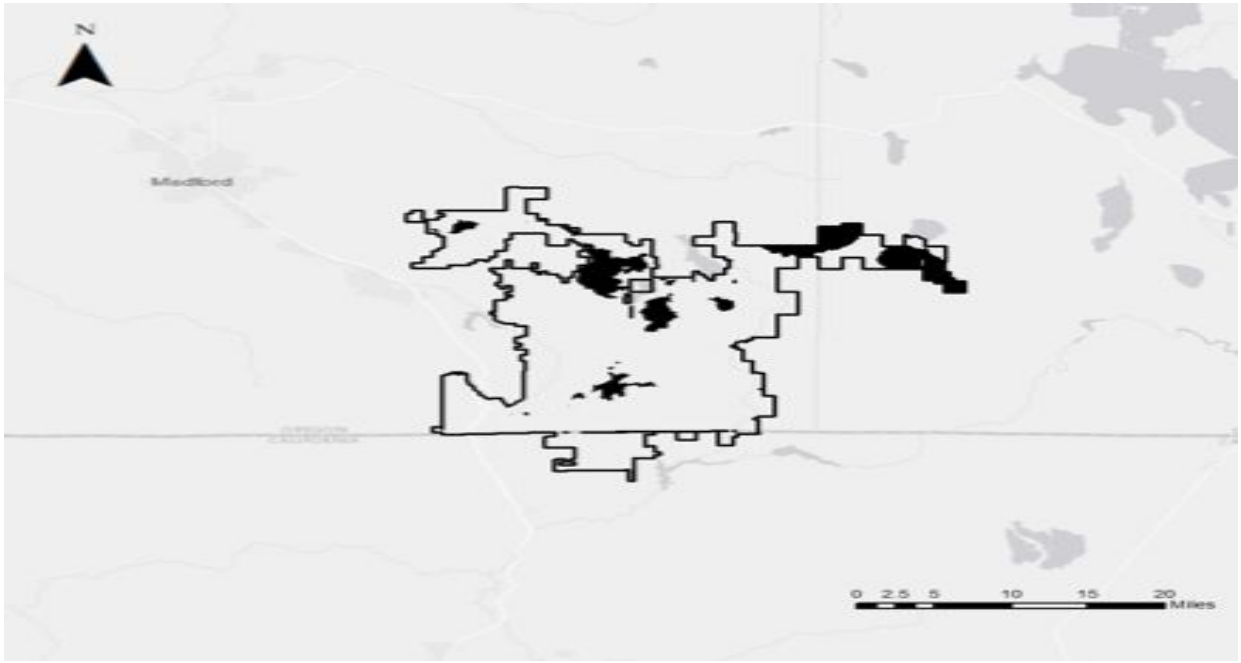

Figure 8. Areas within the CSNM containing suitable elevation.

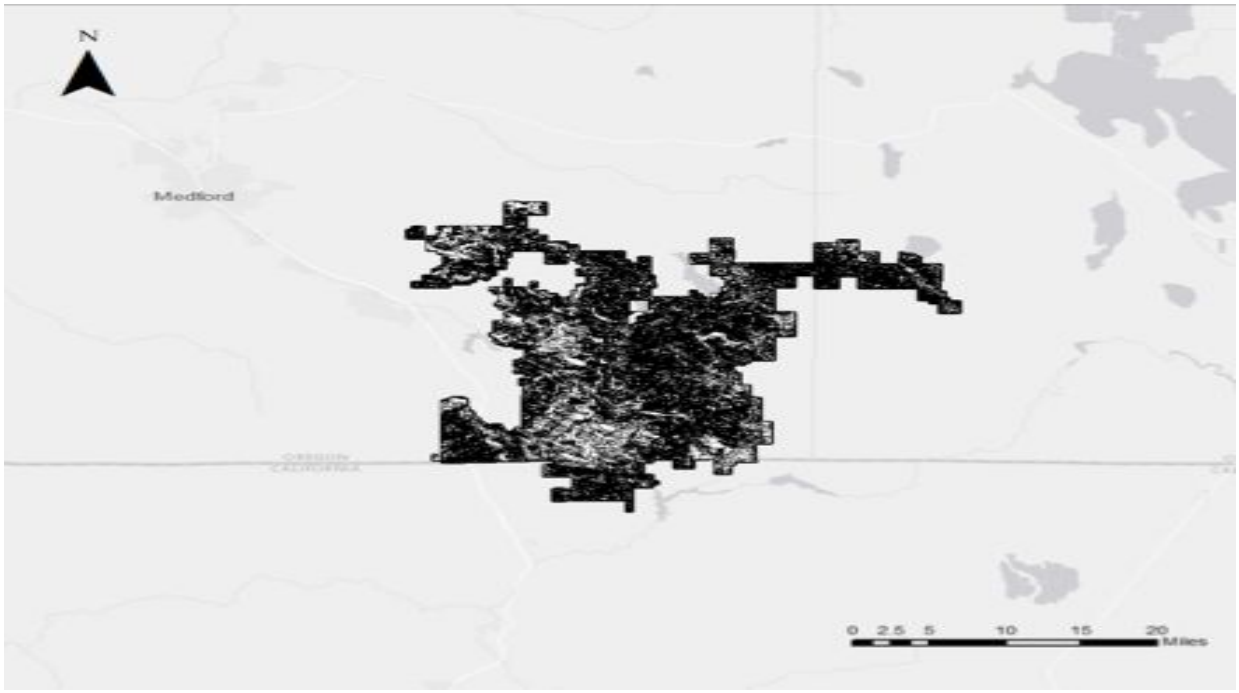

Figure 9. Areas within the CSNM containing suitable slope.

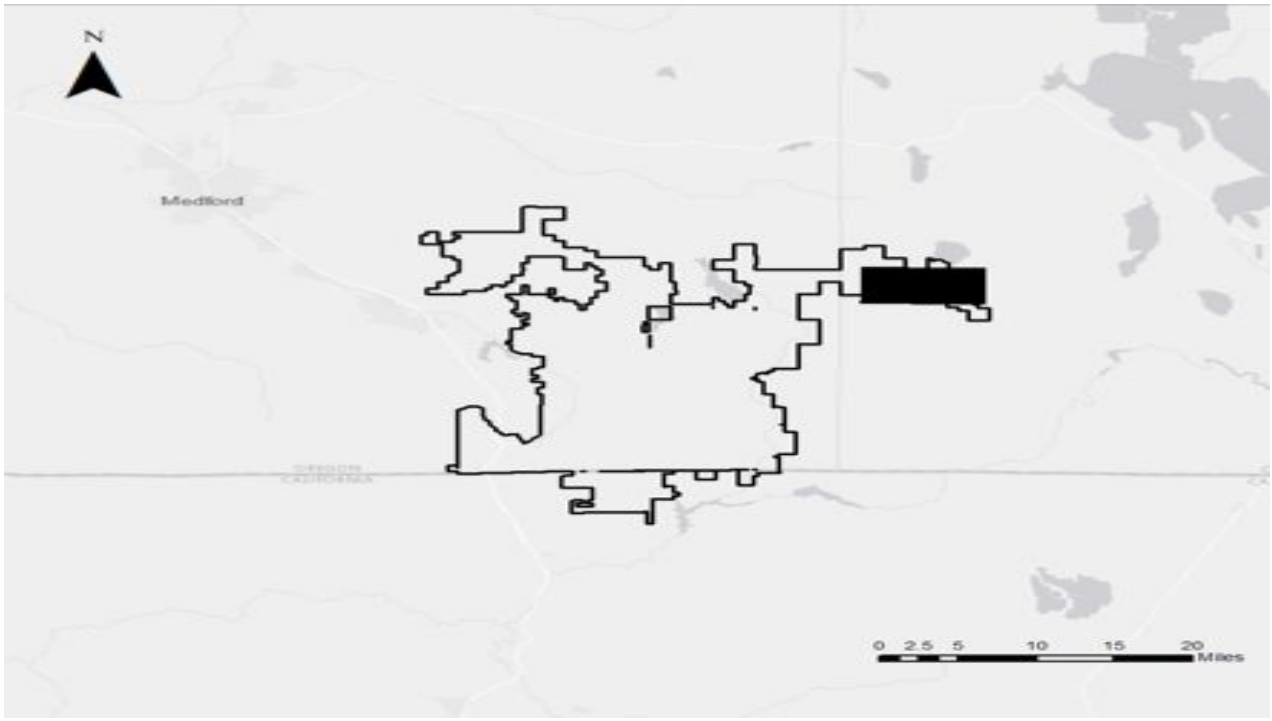

Figure 10. Areas within the CSNM containing suitable temperature. (Not included in final map)

Statistic	Minimum	Maximum	Range	1st Quartile	Median
Aspect	-1.000	359.170	360.170	75.964	174.719
Slope	0.000	56.332	56.332	2.688	9.158
Elevation	1206.000	3151.000	1945.000	1637.000	1881.000
Temperature	3.190	8.770	5.580	5.150	6.140

Table 3. Complete descriptive statistics for habitat characteristics (Part one of two).

Statistic	3rd Quartile	Mean	Variance (n-1)	Standard Deviation (n-1)
Aspect	256.293	170.825	11164.236	105.661
Slope	20.946	12.519	124.572	11.661
Elevation	2318.000	1963.887	184807.354	429.892
Temperature	7.050	6.233	1.967	1.403

Table 4. Complete descriptive statistics for habitat characteristics (Part two of two).

The CSNM in Southern Oregon and Northern California is the only national monument to be designated for its significant biodiversity. According to the results of the deductive and inductive habitat models, it is very possible that *Ochotona princeps* could be an addition to the biodiversity found therein. The final analysis, represented by Figure 5 and Figure 6 (deductive and inductive respectively), shows that the critical habitat elements required by American pikas are found within the CSNM boundary. Although the area that comprises the CSNM is relatively isolated in relation to other known pika populations, the model predicts that there are multiple sites within the monument that may sustain a population of American pikas.

Field Survey Results

The CSNM contains habitat characteristics that do not traditionally match understood requirements for American pika persistence in regard to temperature regimes and elevation, so further research is necessary to better understand the potential populations within the monument. Field survey of the identified suitable habitat provided more in-depth data and a better understanding of what this habitat actually looks like on the ground and has further validated this research effort by helping to determine if pikas are actually present within the monument. Our field survey efforts have confirmed the presence of at least one current population of American pika. This confirmation was concluded in the form of aural and visual identification of American

pika. While only one singular site surveyed in the monument confirmed current occupancy of American pika, each site surveyed within the CSNM contained evidence of historical pika occupancy (scat, old haypile evidence, and urine stain). Further field survey is necessary to determine if there is a greater extent of current pika occupation within the Monument.

IV. Conclusion

The results of both the deductive and inductive habitat models confirmed that there is suitable habitat within the Cascade-Siskiyou National Monument for use by American pikas. The resultant maps lead us into the field to specific areas within the CSNM that were considered suitable habitat for the American pika. Initial field survey efforts have yielded evidence of current and historical occupancy, however, further survey is necessary before conclusive statements can be made about the occupation of American pika in the CSNM.

Pika are sedentary and difficult to identify in the field, as they often remain underground in the talus slopes and are not always vocal. Because of this, many sites surveyed could be currently occupied by American pika without confirmation of this by the field researcher. Additionally, the Cascade-Siskiyou National Monument is a large expanse of land, which takes considerable time to navigate in the field. Only a portion of the identified suitable habitat within the CSNM was actually surveyed on foot, due to time and weather constraints, and further, more in depth field survey could add to the understanding of current and historic pika occupancy in the monument.

References

Barbour, et al. (1999) Terrestrial Plant Ecology, 3rd Ed. Benjamin/Cummings. Chapter 14. pp. 390-391

Beever, E. A., Hall, L. E., Varner, J.,
Loosen, A. E., Dunham, J. B., Gahl, M. K., . . . Lawler, J. J. (2017). Behavioral flexibility as a mechanism for coping with climate change. *Frontiers in Ecology and the Environment, 15*(6), 299-308. doi:10.1002/fee.1502

Beever, E. A., P. E. Brussard, and J.
Berger. 2003. Patterns of apparent extirpation among isolated populations of pikas (Ochotona princeps) in the Great Basin. Journal of Mammalogy 84:37-54.

British Columbia Resources Inventory
Committee. 1998. Inventory methods for pikas and sciurids. Standards for Components of British Columbia's Biodiversity No. 29. Version 2.0.

Ecological Systems and Vegetation Data Acquired through Oregon Spatial Data Library. Produced from Institute for Natural Resources, Oregon State University. http://spatialdata.oregonexplorer.info/geoportal/details

Erb, Liesl Peterson, (2013) "Climatic and Habitat Drivers of American Pika (Ochotona princeps) Occupancy and Population Density

Fitzgerald, M., Coulson, R., Lawing, A.
M., Matsuzawa, T., & Koops, K. (2018). Modeling habitat suitability for chimpanzees (pan troglodytes verus) in the greater nimba landscape, guinea, west africa. Primates, , 1-15. doi:http://dx.doi.org/10.1007/s10329-018-0657-8

Fowler, J., Overby, S., & Smith, B. (2014). Distance and Temperature Effects on Pika Forage (pp. 1-18, Rep.). U.S. Forest Service, Rocky Mountain Research Station

Jeffress, M. R., J.
Apel, L. K. Garrett, G. Holm, D. Larson, N. Nordensten, and T. J. Rodhouse. 2011. Monitoring the American pika (Ochotona princeps) in the Pacific West Region - Crater Lake National Park, Craters of the Moon National Monument and Preserve, Lassen Volcanic National Park, and Lava Beds National Monument: Narrative Version 1.0. Natural Resource Report NPS/UCBN/NRR—2011/336. National
Park Service, Fort Collins, Colorado.

Jeffress, M. R., Gunst, K. J., &
Millar, C. I. (2017). A Surprising Discovery of American Pika Sites in the Northwestern Great Basin. Western North American Naturalist, 77(2), 252-268. doi:10.3398/064.077.0213

L, E. H., Chalfoun, A. D., Beever, E.
A., & Loosen, A. E. (2016). Microrefuges and the occurrence of thermal specialists: Implications for wildlife persistence amidst changing temperatures. *Climate Change Responses, 3*doi:http://dx.doi.org/10.1186/s40665-016-0021-4

Lerner, K. L., & Lerner, B. W. (2003). World of earth science. Detroit: Gale.

Manning, T., & Hagar, J. C. (2011). Use of Nonalpine Anthropogenic Habitats by American Pikas (Ochotona princeps) in Western Oregon. Western North American Naturalist, 71(1), 106-112.

Moyer-Horner, L., Beever, E. A., Johnson, D. H., Biel, M., & Belt, J. (2016). Predictors of Current and Longer-Term Patterns of Abundance of American Pikas (Ochotona princeps) across a Leading-Edge Protected Area. *PloS one*, *11*(11), e0167051. doi:10.1371/journal.pone.0167051

PRISM Climate Group, Oregon State University, http://prism.oregonstate.edu, retrieved July 6, 2018

Sæter, M. B. (2008). Dynamics of talus formation (Master's thesis, Thesis / Dissertation ETD, 2008). Oslo: Univeristy of Oslo.

Simpson, W. G. (2009). American Pikas Inhabit Low-Elevation Sites Outside the Species Previously Described Bioclimatic Envelope. Western North American Naturalist, 69(2), 243-250. doi:10.3398/064.069.0213

Singh, R., Joshi, P.K., Kumar, M. et al. Environ Monit Assess (2009) 155: 555. https://doi.org/10.1007/s10661-008-0455-7

Smith, A. T. 1974. The distribution and dispersal of pikas: Influences of behavior and climate. Ecology 55:1368-1376.

Smith, A. T., and M. Gilpin. 1997. Spatially correlated dynamics in a pika metapopulation. Pages 407-428 in Metapopulation biology: Ecology, genetics, and evolution. Hanski, I. A., and M. E. Gilpin, editors. Academic Press.

Verts, B. J., & Carraway, L. N. (1998). Land Mammals of Oregon. University of California Pr