Factors Influencing Pika Foraging Behavior in North Cascades National Park Service Complex, Washington

Final Report

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Photo by Rachel Richardson

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Factors influencing pika foraging behavior in North Cascades National Park Service Complex, Washington

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Abstract. The American pika (*Ochotona princeps*) is a small lagomorph physically and biologically restricted to talus slopes at higher elevations or latitudes in mountainous regions. Pikas will consume, collect, and store vegetation as an adaptive response to seasonal fluctuations in food availability. Pikas are extremely sensitive to heat and relatively isolated because of specific habitat and narrow range requirements; therefore, pikas are considered to be a climate change indicator species for alpine ecosystems. No historical baseline data exists on pika behavioral responses to climate or habitat use in North Cascades National Park Service Complex in Washington. My objective was to provide data to understand potential implications of climate change on pika populations by collecting observations on foraging behavior across this region. I studied pikas during summer 2009 throughout the park complex. I collected 69 observations of pika behavior between June 25 and September 27, 2009 to investigate the relationship between date, elevation, and temperature on pika foraging methods by documenting the proportion of time pikas spent grazing and haying. Pika grazing behavior decreased through summer, supporting my hypothesis that grazing behavior would be negatively correlated with increasing date. Pika haying behavior increased as the season advanced, also supporting my hypothesis that haying behavior would be positively correlated with increasing date. My prediction that the proportion of time pikas spent haying would be positively correlated with elevation was supported by my results. Pikas spent less time grazing at higher elevations as the proportion of time spent grazing was negatively correlated with elevation. Temperature was a significant effect in logistic regression models, and was positively correlated with time spent grazing and negatively correlated with time spent haying. These preliminary data demonstrate the importance of considering how multiple interacting factors may affect pika foraging behavior.

INTRODUCTION

Rapidly increasing temperatures due to global climate change have significant impacts on the dynamics of wildlife populations (Root et al. 2003). Species with specific habitat requirements may exhibit certain behavioral responses under extreme climatic conditions, which can ultimately affect a population's distribution, dispersal, and survival (Smith 1974b). Climate-induced changes in the range and distribution of species are well documented in sensitive ecosystems including, but not limited to, alpine and polar regions (Parmesan 2006). Studies of these ecosystems suggest that organisms that live in variable environments, and are relatively isolated because of restricted habitat and narrow range requirements are exceedingly susceptible to rising temperatures (Krajick 2004). The potential consequences of ecological change from a warming climate are apparent and, therefore, studies should be undertaken to assess the risk of species extinctions and loss of biological diversity.

The American pika (*Ochotona princeps*) is a small lagomorph generally restricted to talus slopes at higher elevations or latitudes in mountainous regions. Pikas are heavily insulated with fur, well adapted to life in cool, moist climates, and are physiologically capable of maintaining a stable body temperature under a variety of environmental conditions (i.e., thermoregulation). However, pikas are extremely sensitive to heat (Smith 1974b; Beever et al. 2003; Grayson 2005) and behaviorally restricted to talus slopes that allow them to retreat underneath the rocks to avoid stressful daytime temperatures (Smith 1974b). High temperatures negatively affect pika survival and limit activity (Smith 1974b). In some regions, climate warming raises the lower elevation limits of pika distributions, resulting in the extirpation of lower elevation populations (Beever et al. 2003; Grayson 2005). As a result of their sensitivity to high temperatures and restricted habitat requirements, pikas are considered to be a climate change indicator species for alpine ecosystems (Beever et al. 2003; Smith et al. 2004).

Pika foraging behavior consists of two distinct methods of using and collecting available vegetation: (1) grazing plants for immediate consumption, and (2) gathering vegetation from adjacent meadows and shrubs to store in haypiles for use in the winter (Smith and Weston 1990). Pikas are central-place foragers and will feed and gather vegetation from meadows surrounding talus edges (Roach et al. 2001). Seasonal fluctuation in food availability is largely responsible for pikas caching vegetation in haypiles during the short summer growing season. This adaptive food hoarding behavior enables pikas to manage their resources in the winter months because they do not hibernate and live beneath the talus the entire winter (Vander Wall 1990). Consequently, the over-winter survival of pikas may depend on their ability to accumulate adequate forage in haypiles (Dearing 1997), which may also provide material to insulate nesting sites from extreme temperatures, and additional predator protection (Krear 1965; Ivins 1984). A study on the relationship between the initiation of haying behavior and over-winter survival in collared pikas (*Ochotona collaris*) showed that haypile mass provided a minimum of three to six months of winter food reserves (Morrison et al. 2009). Further, pika survival was greatest when haying began prior to peak vegetation biomass (Morrison et al. 2009). The timing of peak biomass varies, however, depending on the year of observation and other variables independent of haypile mass, such as spring snowmelt patterns or extreme temperatures (Morrison et. al 2009).

The distance pikas travel from the talus edge when haying is greater than during feeding, depending on plant quality and abundance throughout and surrounding the talus-meadow interface (Roach et al. 2001). The summer growing season (June-August) is relatively short in alpine areas, and restricts the amount of time pikas have to construct haypiles (Huntly et al. 1986). Pika haying rates and midday activities increase during peak vegetation biomass (Conner 1983; Morrison et al. 2009). However, thermal stress from extreme daytime temperatures may constrain the time available for pika surface activities, including haying and grazing. Because pikas are sensitive to high temperatures (MacArthur and Wang 1974; Smith 1974b) the implications of a warmer environment may have adverse effects on pika foraging behavior by directly influencing daily activities and efforts to accumulate vegetation, ultimately impacting over-winter survival. Climate change may also affect pika foraging patterns, thereby causing potential shifts in pika abundance and distribution.

Before 2009, no data existed on pika ecology in North Cascades National Park Service Complex in Washington. Therefore, the need to collect relevant data to help understand how pikas may alter their behavior in response to climate warming in this region is important. To help address this need for information, I observed foraging pikas from late June through September 2009 throughout the North Cascades ecosystem to document the proportion of time pikas spent grazing and haying. I then evaluated the relationship between pika foraging behavior and temperature, elevation, and date. Specifically, I evaluated multiple hypotheses regarding pika foraging activity. First, I hypothesized that the proportion of time spent grazing by pikas would be negatively correlated with temperature, positively correlated with elevation, and negatively correlated with date. Second, I hypothesized that the proportion of time spent haying by pikas would be negatively correlated with temperature, positively correlated with elevation, and positively correlated with date. Summer temperatures should be lower at higher elevations and, therefore, pikas may be better suited for thermoregulation in these areas (MacArthur and Wang 1974). At lower elevations, pikas decrease the amount of time active in relation to increasing summer temperatures (Smith 1974b). At higher elevations, pikas may remain active throughout the day; however, increasing summer temperatures negatively affect the percentage of time pikas engage in surface activity (Smith 1974b). Pikas decrease the percentage of time spent grazing and the duration of their feeding trips between the months of July and August (Conner 1983). Morrison et al. (2009) reported that collared pikas increased their haying activity in the months of July and August compared to the month of June, while Huntly et al. (1986) also showed that pika haying activity increased in late summer.

METHODS

Study Area

The North Cascades National Park Service Complex (NOCA) encompasses 275,684 ha in north central Washington with elevations ranging between 300 and 2,800 m (Figure 1). The complex is divided into three management units, the North Cascades National Park, Ross Lake National Recreation Area, and the Lake Chelan National Recreation area, with the land managed as the federally designated Stephen Mather Wilderness across 93% of these units. Climate varies annually in NOCA, and the average maximum daily temperature for July and August 2009 was 68.7˚F as indicated by a SNOTEL station located at Thunder Basin (elevation 1,317 m; Natural Resources Conservation Service [NRCS 2009]). The average maximum daily temperature between 1989 and 2009 ranged from 61.7 to 73.9˚F (NRCS 2009). Precipitation and snowpack also varies annually; see Bruggeman (2010) for more details. This study was conducted in 30 1-km^2 survey areas throughout NOCA with survey areas selected using a stratified random sampling method (Figure 2; Bruggeman 2010). Within the 30 survey areas, 115 patches were examined with talus patch area ranging from 0.003 to 41.9 ha, and talus patch perimeter ranging from 0.22 to 9.5 km (Bruggeman 2010). Pika presence was documented in 27 of the 30 areas, and behavioral observations occurred in 15 of the selected sites (Figures 2 and 3).

Deep, isolated valleys carved by montane glaciers are prominent features spanning the east and west sides of the Cascade and Picket mountain ranges. The North Cascades ecosystem encompasses a variety of habitats including diverse, lowland forests and expansive subalpine and alpine regions. At low elevations, forests are dominated by Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), and western redcedar (*Thuja plicata*). Silver fir (*Abies amablis*) and lodgepole pine (*Pinus contorta*) become more common in mid-elevation forests. Mountain hemlock (*Tsuga mertensiana*) and subalpine fir (*Abies lasiocarpa*) are characteristic of the transition zone between closed canopy forest (forest line) and the subalpine parkland. Above forest line, the alpine zone includes treeless, sparsely vegetated habitats interspersed among extensive icefields and glaciers (Pojar and MacKinnon 2004). Mammalian herbivores that were commonly observed in talus patches with pikas included hoary marmots (*Marmota caligata*), and cascade golden-mantled ground squirrels (*Spermophilus saturatus*). Predators observed in the study area included golden eagles (*Aquila chrysaetos*), and long-tailed weasels (*Mustela frenata*).

Data Collection

From late June through late September 2009, I surveyed potential pika habitat (i.e., talus with surrounding meadows) within 30 1-km^2 survey areas to determine the presence or absence of pikas in talus patches (Figure 2). Pika presence was established in a talus patch by direct observations, audible vocalizations, or active haypiles with freshly clipped vegetation. When foraging pikas (i.e., those that were grazing or haying) were in view, I used focal animal sampling (Altmann 1974) to conduct intensive five-minute individual observations on up to five pikas found in the patch. For patches that had fewer than five pikas, all visible, foraging pikas were included in the sample.

Pikas quickly habituate to the presence of human observers (Ivins and Smith 1983; Huntly et al. 1986; Holmes 1991). I observed pikas through binoculars from vantage points that allowed maximum visibility of foraging activities. During each individual 5-minute observation, I recorded pika activities and categorized them as: (1) grazing; (2) haying; (3) scanning (including perching and vocalizing); (4) resting; (5) running, and (6) intraspecific interactions (including territory defense and socializing). I used a Timex Ironman stopwatch with split and lap functions to record the amount of time spent at each behavior. At the time of each observation, I recorded the following environmental covariates: (1) temperature; (2) cloud cover (sunny, partly cloudy, mostly cloudy, cloudy, or rain); and (3) wind speed according to the Beaufort scale (calm, light breeze [<10 mph], windy [10-20 mph], or gusting [>20 mph]). I recorded the date of the observation and each pika's location in latitude/longitude coordinates using a Global Positioning System (GPS). After surveys were completed, I used a Geographic Information System (GIS) elevation layer to determine the elevation of each pika location.

When foraging pikas were in view, I used direct observations to identify fresh vegetation selected by pikas for immediate consumption and vegetation actively clipped by pikas for storage in haypiles. When haypiles were located within talus habitat, I also examined contents and identified vegetation. If possible, I classified all plants by common and scientific names, and grouped them into shrubs, forbs, cushion plants, grasses, ferns, trees, lichens, bryophytes, and leaf litter. Cushion plants are low growing forbs characteristic of alpine environments (Huntly et al. 1986).

Statistical Analyses

For each observation, I calculated the proportion of time spent by pikas in each behavior. I conducted regression modeling analyses to examine how the proportion of time spent grazing and the proportion of time spent haying were correlated with temperature, elevation, and date. I developed competing hypotheses expressed as five logistic regression models (Hosmer and Lemeshow 2000) for each response variable. I used logistic regression methods because the response variable was a proportion constrained between zero and one. I used logistic regression techniques in R (R Development Core Team 2008) to fit models and estimate parameter coefficients. I calculated a corrected Akaike's Information Criterion (AIC_c) value for each model, and ranked and selected the top approximating models for each response variable using ΔAIC_c values (Burnham and Anderson 2002).

RESULTS

Pika Observations and Foraging Behavior

I collected 69 5-minute observations of individual pika foraging behavior between June 25 and September 27, 2009. Of the 69 observations, 61 were recorded within assigned 1-km^2 survey areas and 8 were opportunistically recorded in talus patches outside of the survey areas (Figures 4 and 5). Pikas were observed in patches ranging in elevation between 878 m and 2,156 m (mean = 1,548; SE = 37.2). I defined low elevation as <1,219 m, middle elevation as between 1,219 m and 1,828 m, and high elevation as >1,828 m, and documented the number of observations within each strata (Table 1). The ambient temperature recorded at the time of each observation varied between 39.1 and 87.5ºF (mean = 62.9; SE = 1.4). During observations, I documented pikas primarily in grazing, haying, and scanning behavioral states (Figure 6).

Pikas preferred shrubs and forbs when grazing in higher elevation meadows located adjacent to talus patches, and were often seen consuming entire leaves of plants during a single foraging bout (Table 2). At lower elevations where talus was surrounded by dense forest, I observed pikas feeding on lichens and bryophytes directly within the patch (Table 2). Pikas also preferred to clip shrubs and forbs when haying, and carried larger clumps of vegetation extending out of both sides of the mouth to deposit onto haypiles (Table 3). Haypile contents were diverse, but also reflected this overall vegetation preference (Table 4).

Factors Influencing Pika Foraging Behavior

The top model for the proportion of time pikas spent grazing included elevation and date covariates, and had an AIC_c value of 5332.8 and a $\Delta AIC_c = 0$. The top model included negative, significant elevation and date covariates (Figure 7; Table 5). The temperature covariate was not included in the top model. Temperature was a significant effect in other models, however, and was positively correlated with time spent grazing (Table 5). The second best model for the proportion of time pikas spent grazing had a $\Delta AIC_c = 112.7$, and included a negative, significant date covariate (Table 5).

The top model for the proportion of time pikas spent haying also included elevation and date covariates, and had an AIC_c value of 5466.0 and an $\Delta AIC_c = 0$. The top model included positive, significant elevation and date covariates (Figure 8; Table 6). The temperature covariate was not included in the top model. Temperature was a significant effect in other models, however, and was negatively correlated with time spent haying (Table 6). The second best model had a $\Delta AIC_c = 32.9$, and included a positive, significant date covariate (Table 6).

DISCUSSION

My results support my prediction that the proportion of time spent grazing by pikas is negatively correlated with date. The amount of time pikas spend grazing has been documented to decrease into late summer (Conner 1983) and may be attributed to multiple factors. The emergence of new vegetation is related to the timing of snowmelt, and pikas likely use this as a cue to begin major grazing activity in the spring. Specifically, female pikas will time the initiation of first litters with the arrival of spring vegetation (Smith 1978). The high energetic demands of weaning a litter may result in an increased rate of foraging (Huntly et al. 1986) where females spend more time at the beginning of the season directly consuming fresh vegetation. Given that the timing of peak vegetation biomass, which may affect haying behavior, can vary depending on snowmelt patterns (Morrison et al. 2009), pika grazing behavior should reflect this relationship because the time for grazing throughout summer may be more limited in areas with later snowmelt. Therefore, pikas would be expected to graze more intensely in these late snowmelt areas shortly after the melt and before the need to begin haying that occurs later in summer.

Pikas can meet their nutritional requirements by grazing throughout the year (Conner 1983), but will increase the amount of time spent haying depending on when plant quality and abundance provide maximum harvesting benefits (Huntly et al. 1986). My results also reflect this behavioral trade-off driven by time and energetic considerations, and support my prediction that the proportion of time spent haying by pikas is positively correlated with date. Because the summer growing season is short, pikas should invest more time and energy into collecting plants as vegetation peaks in quantity and quality. For female pikas, the costs associated with reproductive activities may also preclude intensive haying behavior until the young become independent later in the season (Conner 1983).

Contrary to my prediction, pikas spent less time grazing at higher elevations as the proportion of time spent grazing was negatively correlated with elevation. The reasons for this result are not well understood because at higher elevations pikas may remain active and graze throughout the day (Smith 1974b). Changes in climate can differ among elevations, thereby affecting the phenological growing season of plants which may influence nutritional quality of available forage. Plant senescence could be delayed or accelerated depending on seasonal weather patterns, also affecting the potential amount of time available for pika foraging activities. If high altitude environments provide more favorable habitat characteristics, pikas at higher elevations should exhibit an increase in foraging behavior. The majority of high elevation patches in the study area were surveyed later in the season when snowpack was gone. Although snowpack accumulation during winter was not measured in this study, grazing behavior observed in some high elevation patches early in the summer may have been affected by lingering snowpack. The availability of food resources in most environments can be unpredictable every year, and may affect how and when an animal makes a decision to sample and harvest an area. Temporal variation in resource abundance and quality may differ among elevations, and could also contribute to variation in the daily foraging patterns of pikas, which may help explain my result.

My prediction that the proportion of time pikas spent haying would be positively correlated with elevation was supported by my results. In the study area, vegetation composition was markedly different among elevations. In patches surveyed at lower elevations, intra-talus habitat consisted primarily of lichens and bryophytes, while middle and higher elevation patches supported greater vegetation diversity. At higher elevations, new vegetative growth can be delayed by lingering snowpack into summer (Conner 1983), which could minimize the amount of time pikas invest in foraging activities. Factors such as environmental conditions and population density likely contribute to this variation in haying behavior across elevations. Earlier snowmelt at middle elevation sites may have permitted longer periods of harvesting activity, with higher quality vegetation becoming available for pikas earlier than in other areas. Although the growing season begins earlier at lower elevations (Smith 1974b), the presence of preferred plant species across the study site during periods of peak above ground biomass may have been greater in higher elevation patches. Vegetation data collected in NOCA in 2009 showed an increase in the frequency of occurrence of cushion plants and graminoids with elevation, and a decrease in the frequency of bryophytes and lichens with elevation (Bruggeman 2010). An increase in availability of preferred species with elevation may have contributed to the observed haying behavior, with pikas spending more time at higher elevations harvesting higher quality plants for winter food storage. Dearing (1997) showed that pikas harvested plants high in secondary compounds that delayed decomposition of haypile contents and preserved stored food throughout the winter season. Pikas can preferentially select plants with beneficial compounds (Dearing 1997), suggesting that the quality of vegetation may influence this adaptive, food-hoarding behavior.

The temperature covariate was not included in the top models, and models that included temperature were not highly supported by the data. However, it is worth noting that temperature was a significant effect in less supported models, and was positively correlated with time spent grazing and negatively correlated with time spent haying. The ability of a pika to maintain a core body temperature in an unpredictable environment can be an energetic cost associated with foraging effort (MacArthur and Wang 1974). Extreme temperatures constrain the amount of time pikas remain exposed on the surface (Smith 1974b), with variable temperatures likely occurring among low, middle and high elevation populations. I observed pika foraging activity over a wide range of temperatures (39.1 to 87.5˚F); however, because pikas would often disappear from view during an observation, the calculated total amount of time spent foraging may not have been indicative of all activity at the time the temperature was recorded. Cooler temperatures below the talus surface provide refugia for pika behavioral thermoregulation, but it was unknown during observations whether pikas went under the talus for thermoregulation purposes. During individual observations, pikas would often disappear under talus, move quickly under talus, and reappear in a different location nearby. Because pikas are territorial during the foraging season, and home ranges are approximately separated by a 25 m radius (Barash 1973; Smith 1974a) the same individual was able to be followed in each documented observation. These quick retreats underneath the rocks may have provided thermoregulation benefits and protection from predators. If pikas are physiologically deprived of the ability to regulate their body temperatures, they experience thermal stress and die (Smith 1974b). During this study, however, I primarily observed pikas foraging within the talus-meadow interface where rockslide shelters were available for retreat.

Understanding the limitations of collecting, analyzing, and interpreting observational data is necessary when considering the reliability of information presented in biological studies. In this study, I used data from one summer to begin to identify factors that may influence pika foraging behavior in NOCA. My data included only observations when foraging pikas were in view, and this study was not designed to include observations throughout an entire day. My sample size was small (69 total observations), and the majority of my observations occurred at middle elevation sites. My results, however, demonstrate the importance of considering multiple interacting factors affecting pika behavior. Longer-term field studies could provide more insight on pika foraging behavior and these interactions by incorporating additional analyses of habitat, climate, and anthropogenic factors (i.e., trails and campsites).

The potential consequences of global climate change on multiple aspects of biodiversity continue to be evaluated through ongoing ecological studies, thereby increasing understanding of species' responses to changing environments. Biological impacts are often examined in small scale, local communities with collective studies being integrated using quantitative analyses for assessing global climate trends (Parmesan and Yohe 2003). Shifts toward extreme weather events have been predicted to occur in high alpine environments (ACIA 2005) and may change the current mechanisms regarding how plant and animal species adapt to environmental fluctuations. Temperature dynamics affected pika behavior in other areas of the western United States (Smith 1974b), and negatively influenced the persistence of populations in lower elevation areas (Beever et al. 2003). Pikas in NOCA are a model species for studying influences of climate on behavioral strategies because they are currently widely distributed in talus patches throughout this ecosystem and across the majority of elevations in the park.

MANAGEMENT RECOMMENDATIONS

Given that my analyses of factors influencing pika foraging behavior throughout NOCA were limited due to the number of observations collected at low and high elevations, I recommend that future studies continue to focus on comparing environmental variables across all elevations that may affect the time available for foraging and foraging behavior. Pika observations should be conducted in patches at low (< 1,219 m), middle (1,219 – 1,828 m), and high (> 1,828 m) elevations in order for data to be extrapolated over the entire study area. Within each elevation category, observations should be conducted at various times throughout the day to better understand temperature variability, and whether pikas are altering their behavior in response to temperature. These studies should not focus exclusively on temperature effects, and should evaluate changes in plant communities within each elevation zone on an annual basis to better understand how vegetation availability may also affect pika foraging behavior. Finally, the 2009 estimates of pika population sizes at low elevations in NOCA were small in comparison to those at middle and high elevations (Bruggeman 2010). Therefore, monitoring pika populations on an annual basis would provide consistent results for predicting whether abundance and distribution will be significantly affected by a changing climate.

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FIGURES

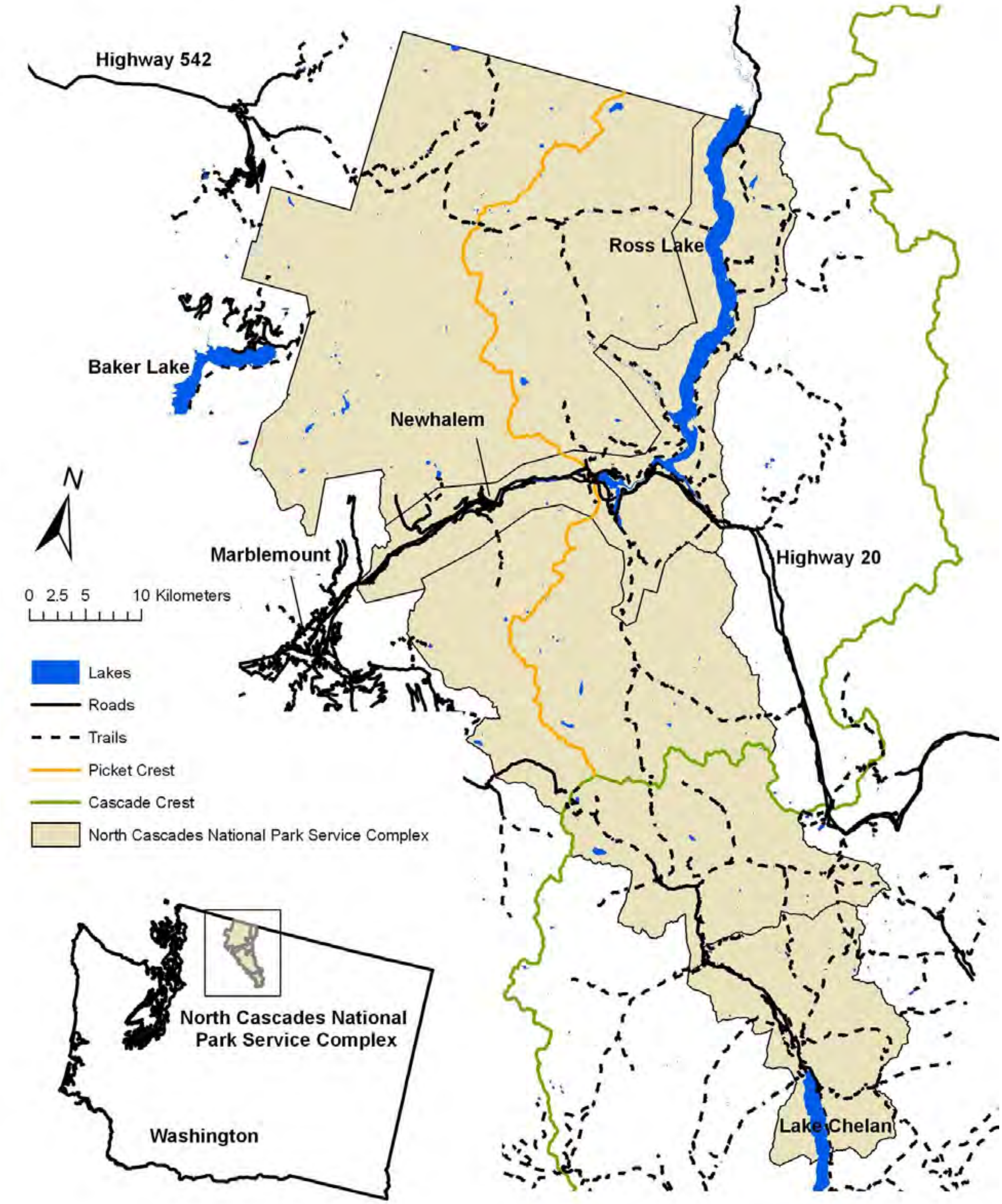

Figure 1. The study area in the North Cascades National Park Service Complex located in north central Washington

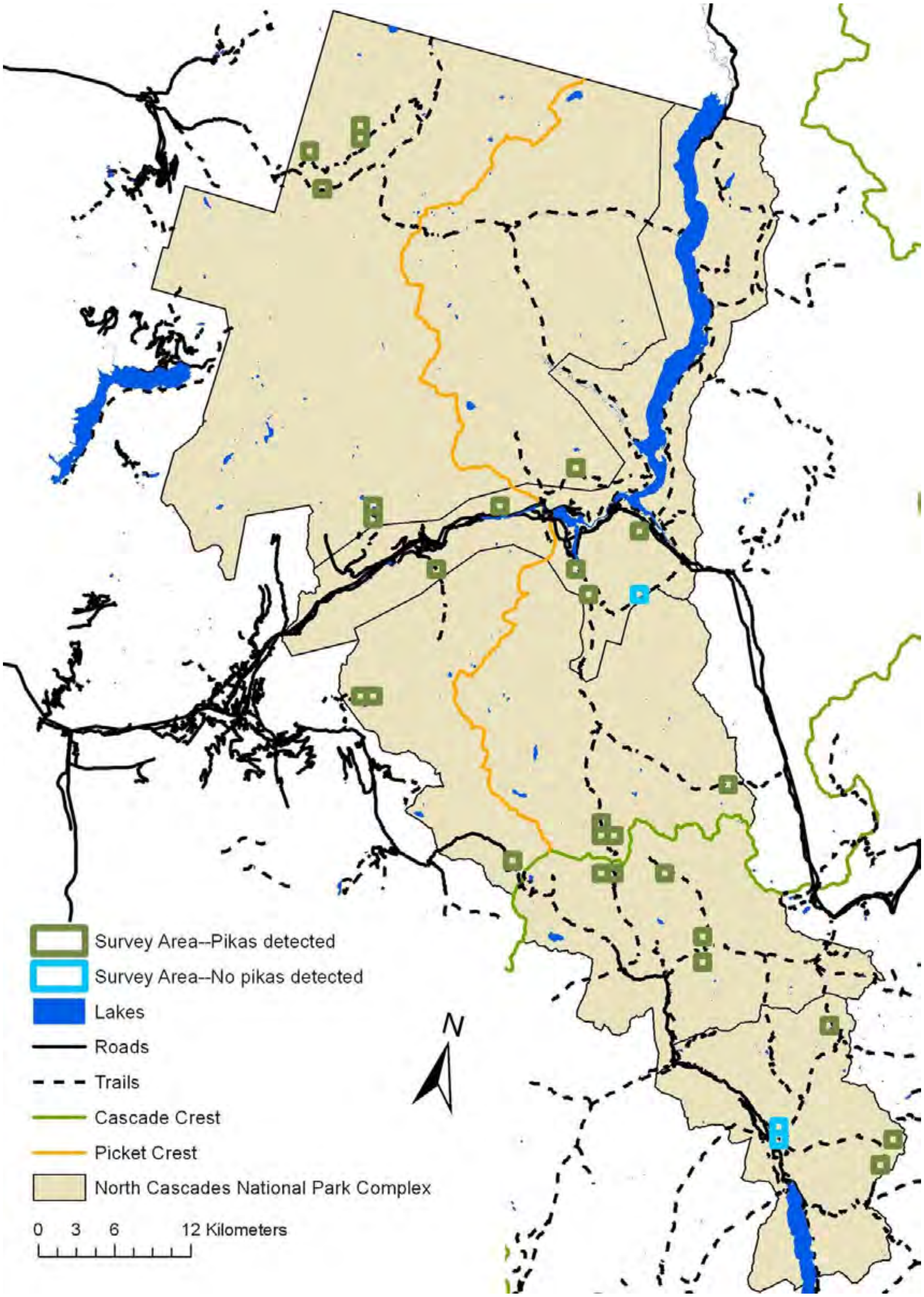

Figure 2. The 30 1-km^2 survey areas that were examined for pika presence during 2009 in North Cascades National Park Service Complex.

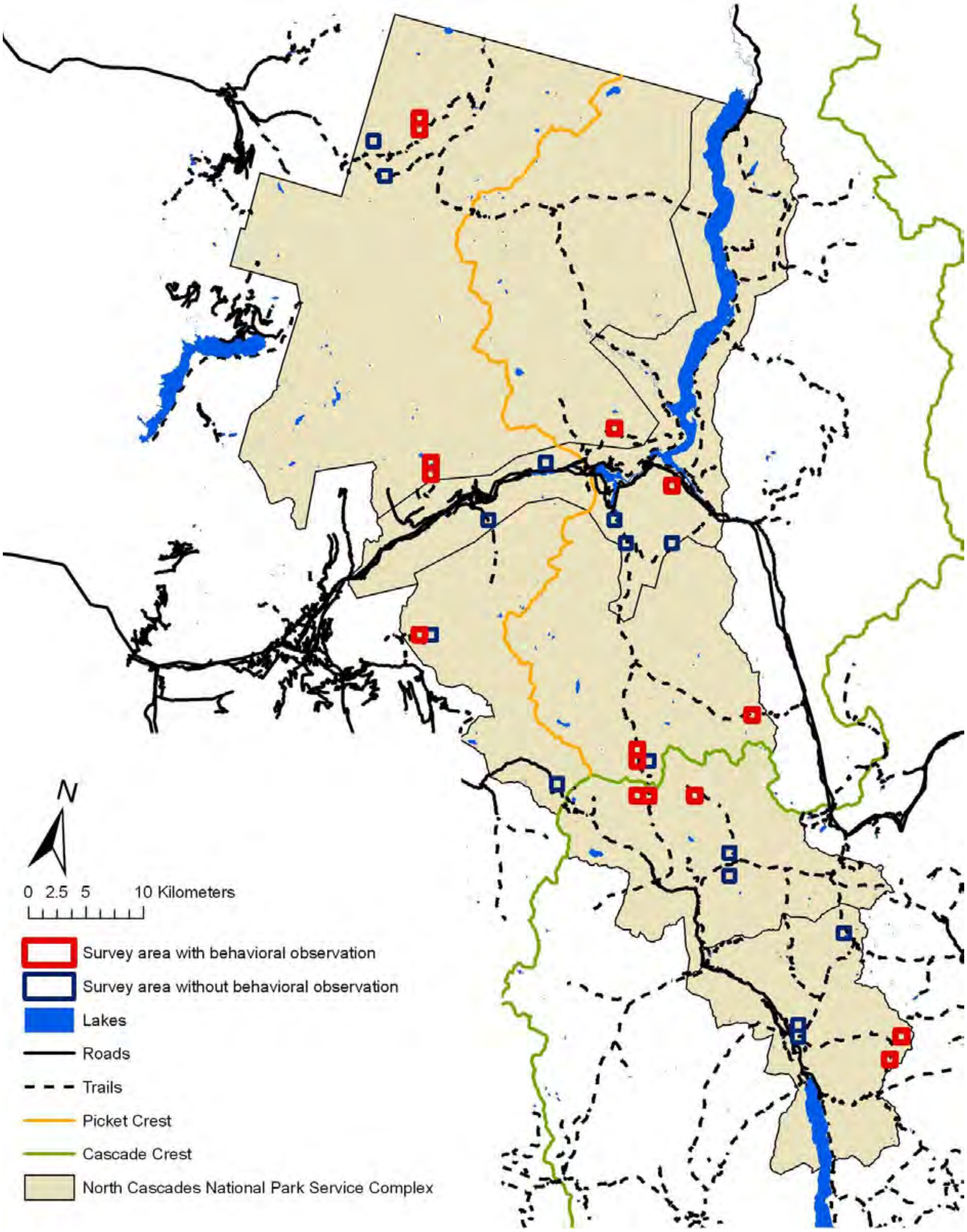

Figure 3. The 15 1-km^2 survey areas where pika behavioral observations were conducted during 2009 in North Cascades National Park Service Complex.

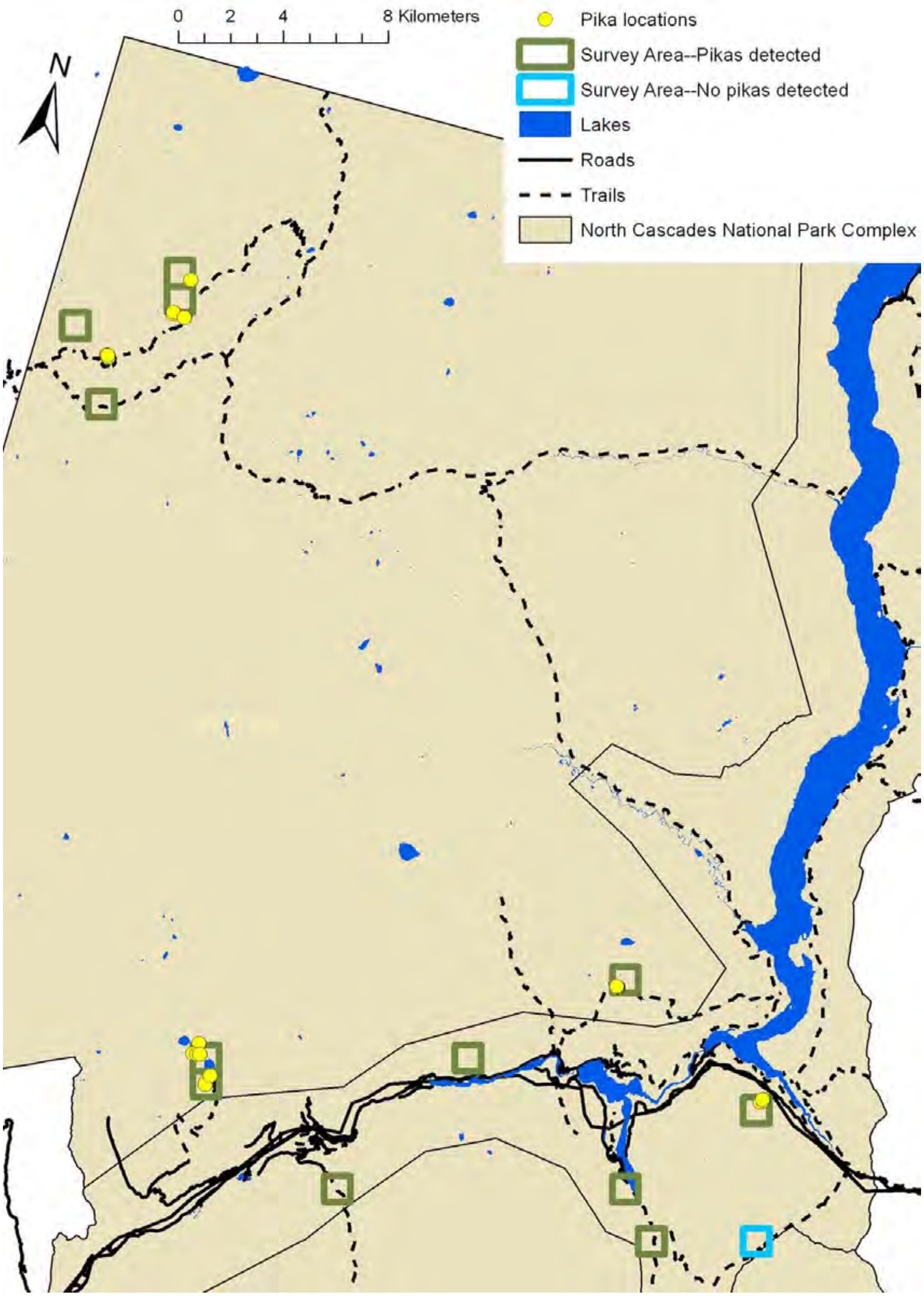

Figure 4. Locations of pika foraging observations obtained during 2009 surveys in the northern section of North Cascades National Park Service Complex.

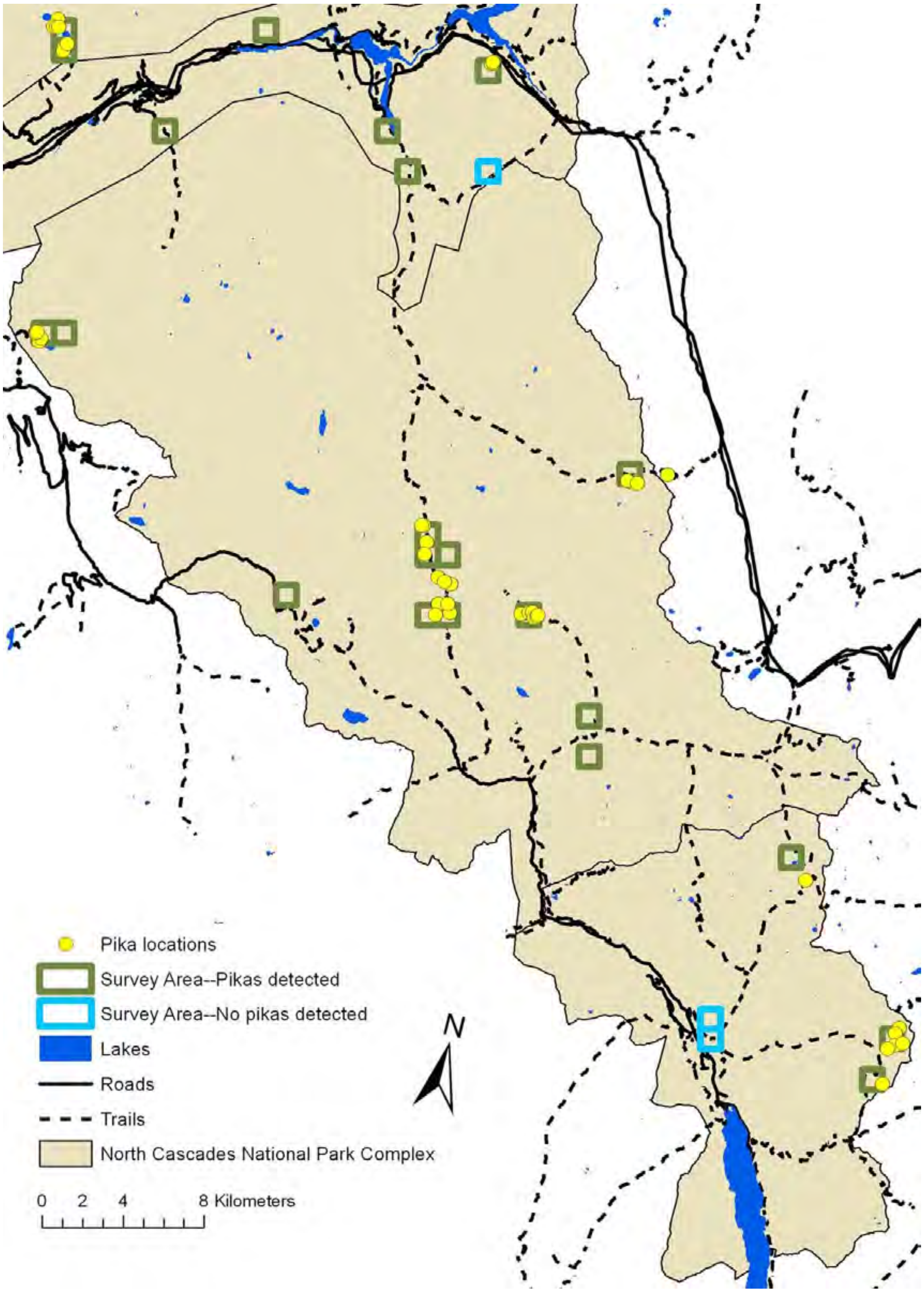

Figure 5. Locations of pika foraging observations obtained during 2009 surveys in the southern section of North Cascades National Park Service Complex.

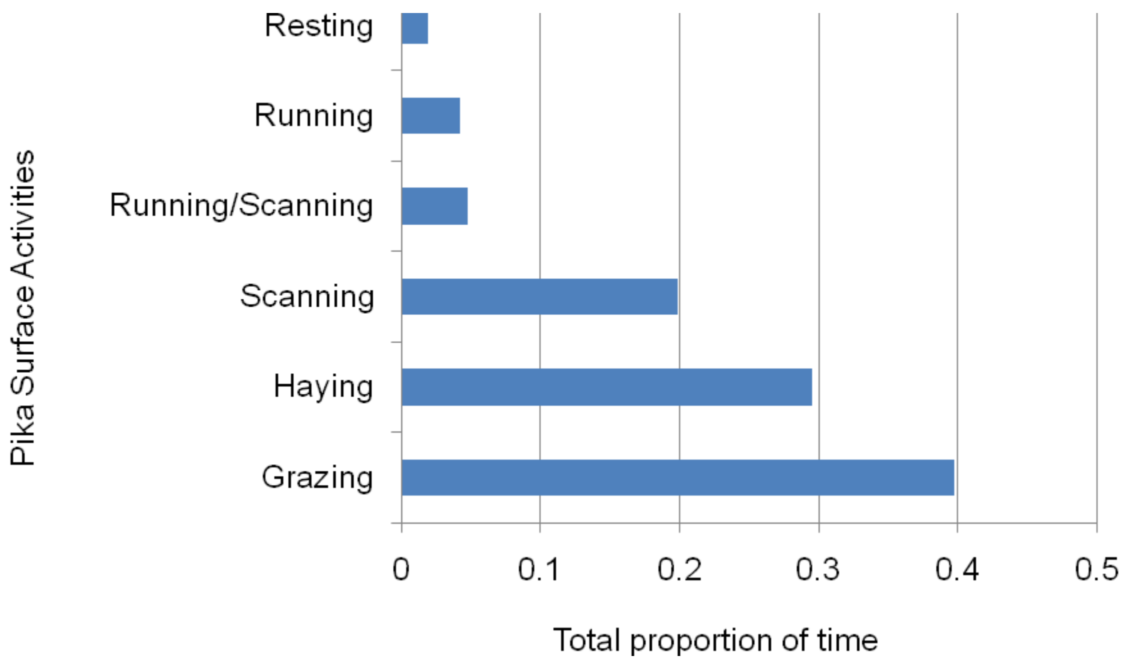

Figure 6. The total proportion of time calculated from 69 observations of pika surface activities during 2009 surveys in North Cascades National Park Service Complex. Intraspecific interactions were omitted from the chart because the total activity time represented a small proportion (0.0002).

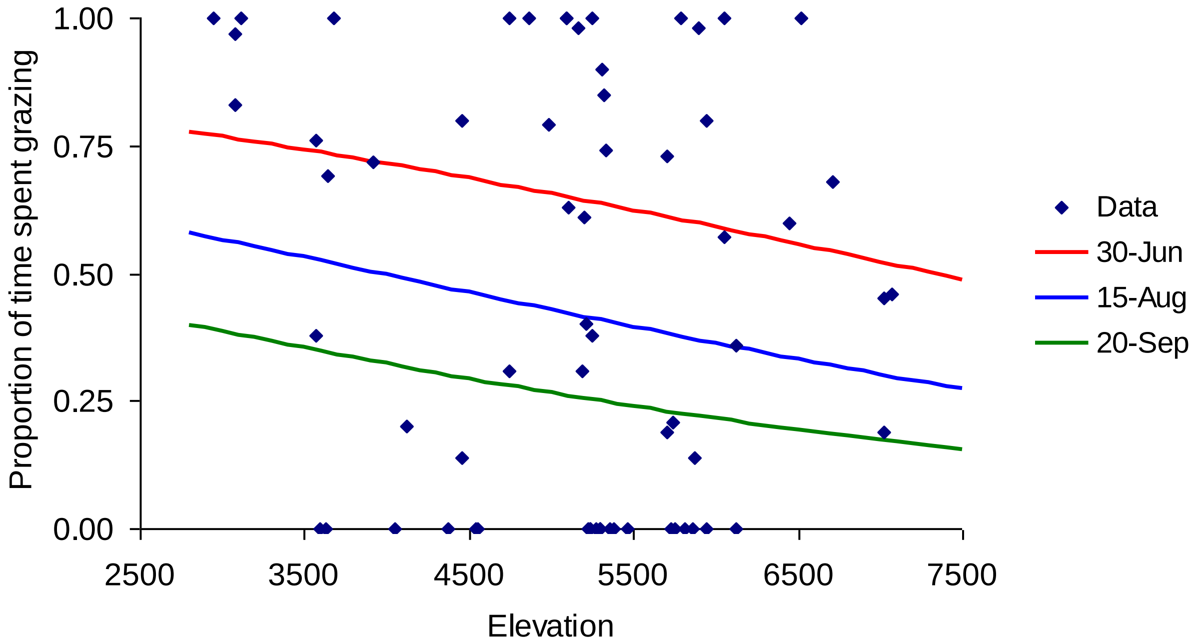

Figure 7. The relationship between the proportion of time pikas spent grazing and elevation during 2009 surveys in North Cascades National Park Service Complex, with original data depicted with diamonds. The curves represent predictions from the top model of how the proportion of time spent grazing varies with elevation for three different dates (June 30, August 15, and September 20).

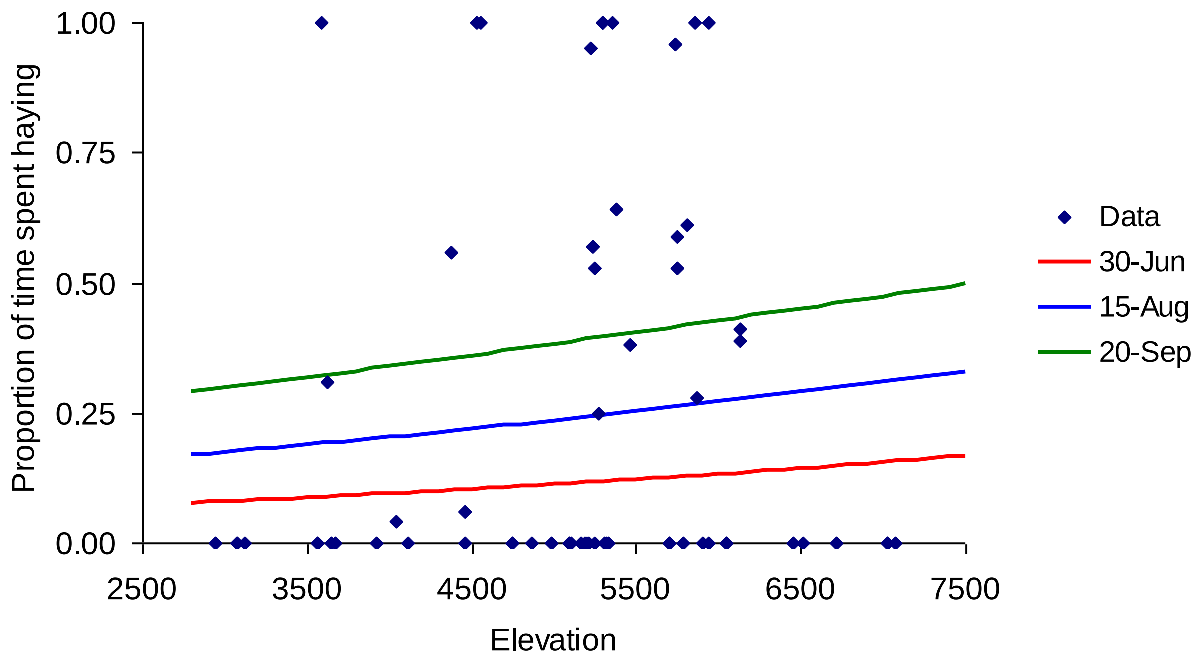

Figure 8. The relationship between the proportion of time pikas spent haying and elevation during 2009 surveys in North Cascades National Park Service Complex, with original data depicted with diamonds. The curves represent predictions from the top model of how the proportion of time spent haying varies with elevation for three different dates (June 30, August 15, and September 20).

TABLES

Table 1. The number of pika foraging observations per elevation strata, and the corresponding mean elevation and standard error (SE) of the observations. The 69 total pika observations were obtained during summer 2009 surveys in North Cascades National Park Service Complex.

Elevation strata	Number of Observations	Mean Elevation of Observations (m)	Standard Error of the Elevation of Observations
Low (<1,219 m)	12	1,033	30.4
Middle (1,219-1,828 m)	47	1,587	21.9
High (>1,828 m)	10	1,985	40.8

Table 2. Plants selected and directly consumed by pikas during opportunistic observations of foraging behavior during 2009 surveys in North Cascades National Park Service Complex.

Species	Plant Type
Black huckleberry (*Vaccinium membranaceum*)	Shrub
Saskatoon (*Amelanchier alnifolia*)	Shrub
False azalea (*Menziesia ferruginea*)	Shrub
Goat's beard (*Aruncus dioicus*)	Shrub
Lupine (*Lupinus spp.)*	Forb
Leatherleaf saxifrage (*Leptarrhena pyrolifolia*)	Forb
Spreading dogbane (*Apocynum androsaemifolium*)	Forb
Corn lily (*Veratrum viride*)	Forb
Valerian (*Valeriana spp.)*	Forb
Fragile fern (*Cystopteris fragilis*)	Fern
Partridgefoot (*Luetkea pectinata*)	Cushion plant
Phlox (*Phlox spp.)*	Cushion plant
False pixie cup (*Cladonia chlorophaea*)	Lichen
Unidentified grasses	Grass
Unidentified bryophytes	Bryophyte

Table 3. Plants selected and stored in haypiles by pikas during opportunistic observations of foraging behavior during 2009 surveys in North Cascades National Park Service Complex.

Species	**Plant Type**
Stinging nettle (*Urtica dioica*)	Shrub
Thimbleberry (*Rubus parviflorus*)	Shrub
Red elderberry (*Sambucus racemosa pubens*)	Shrub
False azalea (*Menziesia ferruginea*)	Shrub
Mountain ash (*Sorbus spp.)*	Shrub
Pink mountain-heather (*Phyllodoce empetriformis*)	Shrub
Black huckleberry (*Vaccinium membranaceum*)	Shrub
False solomon's-seal (*Smilacina racemosa*)	Forb
Strawberry (*Fragaria spp.)*	Forb
Pearly everlasting (*Anaphalis margaritacea*)	Forb
Lupine (*Lupinus spp.)*	Forb
Fragile fern (*Cystopteris fragilis*)	Fern
Partridgefoot *(Luetkea pectinata*)	Cushion plant
Unidentified grasses	Grass
Dry leaves	Leaf litter

Table 4. Plants identified in pika haypiles by opportunistic discoveries of cache locations during 2009 surveys in North Cascades National Park Service Complex.

Species	Plant Type
Stinging nettle (*Urtica dioica*)	Shrub
Thimbleberry (*Rubus parviflorus*)	Shrub
Goat's beard (*Aruncus dioicus)*	Shrub
Red elderberry (*Sambucus racemosa pubens*)	Shrub
False azalea (*Menziesia ferruginea*)	Shrub
Mountain ash (*Sorbus spp.)*	Shrub
Pink mountain-heather (*Phyllodoce empetriformis*)	Shrub
Black huckleberry (*Vaccinium membranaceum*)	Shrub
Lingonberry (*Vaccinium spp.*)	Shrub
Salmonberry (*Rubus spectabilis*)	Shrub
Vine maple (*Acer circinatum*)	Shrub
Thimbleberry (*Rubus parviflorus*)	Shrub
Saskatoon (*Amalanchier alnifolia*)	Shrub
Willow (*Salix spp.)*	Shrub
Raspberry (*Rubus spp.)*	Shrub
Slide alder (*Alnus viridis*)	Shrub
Valerian (*Valeriana spp.)*	Forb
Red columbine (*Aquilegia formosa*)	Forb
False solomon's-seal (*Smilacina racemosa*)	Forb
Violet (*Viola spp.)*	Forb
Gentian (*Gentiana spp.)*	Forb
Corn lily (*Veratrum viride*)	Forb
Miner's-lettuce (*Claytonia sibirica*)	Forb
Strawberry (*Fragaria spp.)*	Forb
Pearly everlasting (*Anaphalis margaritacea*)	Forb
Lupine (*Lupinus spp.)*	Forb
Fireweed (*Epilobium angustifolium*)	Forb
Bracken fern (*Pteridium aquilinum*)	Fern

Table 4 continued. Plants identified in pika haypiles by opportunistic discoveries of cache locations during 2009 surveys in North Cascades National Park Service Complex.

Fragile fern (*Cystopteris fragilis*)	Fern
Partridgefoot *(Luetkea pectinata*)	Cushion plant
Trembling aspen (*Populus tremuloides*)	Tree
Yellow cedar (*Chamaecyparis nootkatensis)*	Tree
Unidentified conifer needles	Tree
Unidentified bryophytes	Bryophyte
Unidentified grasses	Grass
Dry leaves	Leaf litter

Table 5. Coefficient estimates and standard errors (SE) for covariates contained in each of the five models evaluated as part of the modeling analysis examining temperature, elevation, and date effects on the proportion of time spent grazing by pikas during 2009 surveys in North Cascades National Park Service Complex. Covariates with estimates that are significant at $\alpha = 0.05$ are denoted with bold. An "N/A" denotes the covariate was not included in the model. Covariates are defined in the text.

Model No.	Covariate ΔAIC_c	Date Estimate (SE)	Elevation Estimate (SE)	Temperature Estimate (SE)
5	0.00	**-0.020 (0.001)**	**-0.00028 (0.00003)**	N/A
3	112.70	**-0.019 (0.001)**	N/A	N/A
4	262.38	N/A	**-0.00027 (0.00003)**	**0.020 (0.002)**
2	342.83	N/A	**-0.00025 (0.00003)**	N/A
1	371.07	N/A	N/A	**0.018 (0.002)**

Table 6. Coefficient estimates and standard errors (SE) for covariates contained in each of the five models evaluated as part of the modeling analysis examining temperature, elevation, and date effects on the proportion of time spent haying by pikas during 2009 surveys in North Cascades National Park Service Complex. Covariates with estimates that are significant at $\alpha = 0.05$ are denoted with bold. An "N/A" denotes the covariate was not included in the model. Covariates are defined in the text.

Model No.	Covariate ΔAIC_c	Date Estimate (SE)	Elevation Estimate (SE)	Temperature Estimate (SE)
5	0.00	**0.020 (0.001)**	**0.00019 (0.00003)**	N/A
3	32.90	**0.020 (0.001)**	N/A	N/A
4	247.80	N/A	**0.00017 (0.00003)**	**-0.008 (0.002)**
2	255.26	N/A	**0.00016 (0.00003)**	N/A
1	279.92	N/A	N/A	**-0.006 (0.002)**