BEFORE THE CALIFORNIA FISH AND GAME COMMISSION

PETITION TO LIST THE AMERICAN PIKA (*OCHOTONA PRINCEPS*) AS THREATENED UNDER THE CALIFORNIA ENDANGERED SPECIES ACT

American pika © John C. Mosesso

CENTER FOR BIOLOGICAL DIVERSITY, PETITIONER

AUGUST 21, 2007

Notice of Petition

The Center for Biological Diversity submits this petition to list the American pika (*Ochotona princeps*) as threatened throughout its range in California, under the California Endangered Species Act (California Fish and Game Code §§ 2050 *et seq.*, "CESA"). In the alternative, Petitioner requests that the Fish and Game Commission list the five California subspecies of the American pika as threatened or endangered as follows: the Taylor pika (*O. p. taylori*) as threatened, the Gray-headed pika (*O. p. schisticeps*) as threatened, the Yosemite pika (*O. p. muiri*) as endangered, the Mt. Whitney pika (*O. p. albata*) as threatened, and the White Mountain pika (*O. p. sheltoni*) as endangered. This petition demonstrates that the American pika clearly warrants listing under CESA based on the factors specified in the statute.

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I. Executive Summary

The Center for Biological Diversity submits this petition to list the American pika (*Ochotona princeps*) as threatened throughout its range in California, under the California Endangered Species Act (California Fish and Game Code §§ 2050 *et seq.*, "CESA"). In the alternative, Petitioner requests that the Fish and Game Commission list the five California subspecies of the American pika as threatened or endangered as follows: the Taylor pika (*O. p. taylori*) as threatened, the Gray-headed pika (*O. p. schisticeps*) as threatened, the Yosemite pika (*O. p. muiri*) as endangered, the Mt. Whitney pika (*O. p. albata*) as threatened, and the White Mountain pika (*O. p. sheltoni*) as endangered. This petition demonstrates that the American pika clearly warrants listing under CESA based on the factors specified in the statute.

The American pika is a small mammal related to rabbits and hares that inhabits rocky talus fields in alpine areas throughout western North America. Of the 36 recognized American pika subspecies in North America, five occur entirely or partly in California, primarily in the Sierra Nevada and Cascades mountain ranges in the eastern portion of the state. Pikas are extremely temperature-sensitive and are restricted to cool, moist microhabitats on higher peaks. Elevations of historic populations in California range from 1,370 m to 3,700 m (4495 to 12140 ft), with most populations above 2500 m (8202 ft).

Global warming represents the gravest threat to the long-term survival of the American pika in California. In the western United States, temperatures have already increased by 1.1–2.8°C (2.0-5.0°F) during the past century. In California, the Grinnell Resurvey Project resurveyed the terrestrial vertebrate fauna at 21 sites in Yosemite National Park between 2003-2006 that were originally surveyed by Grinnell and colleagues between 1911-1920 (Moritz 2007). Temperatures in Yosemite National Park have increased by 3°C (5.4°C) over 100 years, more than the mean increase in California or western United States temperatures over the same period (Moritz 2007). The pika showed an upward range shift and substantial range contractions on both eastern and western slopes. The pika range contracted by 349 m (1145 ft) on dry eastern slopes and by 497 m (1631 ft) on western slopes (Moritz 2007). Moritz (2007) attributes the range shift in the pika and other high elevation species to these temperature increases:

> The most likely cause of contractions of the high elevation species and at least some of the upwards expansions of formerly lower elevation taxa, is effect of increased temperatures (Moritz 2007: 36).

In a similar study, Beever et al. (2003) documented the extirpation of six of twenty-five pika populations in the Great Basin during the 20th century and found significant evidence that global warming has caused or contributed to these extirpations. Between 2003-2007, Beever resurveyed Great Basin pika populations and found additional population extirpations and an increased pace of population loss since the 1990s (Erik Beever, personal communication, 8/10/07).

The impacts of global warming on pika populations in California include the following: (1) rising summer temperatures may exceed the low thermal limits of the pika and make the talus habitat inhabited by pikas so hot that they can no longer survive; (2) higher summer temperatures may inhibit successful juvenile dispersal and preclude midday foraging, preventing pikas from gaining sufficient body mass and collecting enough vegetation to successfully overwinter; (3) diminished snowpack is lowering the protective insulation for the pika during the coldest winter conditions; (4) temperature and precipitation changes may alter the composition and relative abundance of vegetation in and around talus areas to a mix of plant species which are less favorable for pikas; (5) reductions in alpine permafrost may lead to degradation and eventual loss of talus habitats; and (6) changing climate conditions may make pikas more susceptible to predators and disease.

Temperatures in California will continue to increase throughout this century under all climate scenarios. The amount of warming experienced will depend upon how much additional greenhouse gas pollution society pumps into the atmosphere. Additional warming projections range from 1.7-5.8°C (3.0-10.4°F) for California as a whole. However, temperatures will increase even more in the high elevation alpine areas inhabited by the American pika. One regional climate model predicts high elevation Sierra Nevada temperatures increases of as much as 6.3 °C (11.3°F) in April and 9.2°C (16.5°F) in May (Snyder 2002).

Along with the projected warming will come decreased precipitation in the Sierra Nevada, reduced snowpack, and earlier spring snowmelt, all of which will no doubt cause further extirpations of American pika populations. Under high warming scenarios, the species could become extinct in California by the end of this century. Overall, the pika's high sensitivity to temperature, obligate association with talus habitat, tendency toward philopatry, and low dispersal ability make the species an early sentinel of global warming and place them at extreme risk of extinction from anthropogenic climate change.

For these reasons the Commission should act promptly to protect the American pika under the California Endangered Species Act. Recommended management actions include implementing immediate greenhouse gas reductions at the state and federal level, facilitating pika adaptation to climate change, and monitoring pika populations and their habitat.

II. The CESA Listing Process

Recognizing that certain species of plants and animals have become extinct "as a consequence of man's activities, untempered by adequate concern for conservation," (Fish & G. Code § 2051 (a)) that other species are in danger of extinction, and that "[t]hese species of fish, wildlife, and plants are of ecological, educational, historical, recreational, esthetic, economic, and scientific value to the people of this state, and the conservation, protection, and enhancement of these species and their habitat is of statewide concern." (Fish & G. Code § 2051 (c)) the California Legislature enacted the California Endangered Species Act ("CESA").

The purpose of CESA is to "conserve, protect, restore, and enhance any endangered species or any threatened species and its habitat...." Fish & G. Code § 2052. To this end, CESA provides for the listing of species as "threatened" and "endangered." "Threatened species" refers to a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts. Fish & G. Code § 2067. "Endangered species" refers to a "native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease." Fish & G. Code § 2062.

The Fish and Game Commission ("Commission") is the administrative body that makes all final decisions as to which species shall be listed under CESA, while the Department of Fish and Game ("Department") is the expert agency that makes recommendations as to which species warrant listing. The listing process may be set in motion in two ways: "any person" may petition the Commission to list a species, or the Department may on its own initiative put forward a species for consideration. "Petitions shall include information regarding the population trend, range, distribution, abundance, and life history of a species**,** the factors affecting the ability of the population to survive and reproduce, the degree and immediacy of the threat, the impact of existing management efforts, suggestions for future management, and the availability and sources of information. The petition shall also include information regarding the kind of habitat necessary for species survival, a detailed distribution map, and any other factors that the petitioner deems relevant." Fish & G. Code § 2072.3. In the case of a citizen proposal, CESA sets forth a process for listing that contains several discrete steps.

Upon receipt of a petition to list a species, a 90-day review period ensues during which the Commission refers the petition to the Department, as the relevant expert agency, to prepare a detailed report. The Department's report must determine whether the petition, along with other relevant information possessed or received by the Department, contains sufficient information indicating that listing may be warranted. Fish & G. Code § 2073.5.

During this period interested persons are notified of the petition and public comments are accepted by the Commission. Fish & G. Code § 2073.3. After receipt of the Department's report, the Commission considers the petition at a public hearing. Fish & G. Code § 2074. At this time the Commission is charged with its first substantive decision: determining whether the Petition, together with the Department's written report, and comments and testimony received, present sufficient information to indicate that listing of the species "may be warranted." Fish & G. Code § 2074.2. This standard has been interpreted as the amount of information sufficient to "lead a reasonable person to conclude there is a substantial possibility the requested listing could occur." *Natural Resources Defense Council v. California Fish and Game Comm*. 28 Cal.App.4th at 1125, 1129.

If the petition, together with the Department's report and comments received, indicates that listing "may be warranted," then the Commission must accept the petition and designate the species as a "candidate species." Fish & G. Code § 2074.2. "Candidate species" means a "native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant that the commission has formally noticed as being under review by the department for addition to either the list of endangered species or the list of threatened species, or a species for which the commission has published a notice of proposed regulation to add the species to either list." Fish & G. Code § 2068.

Once the petition is accepted by the Commission, then a more exacting level of review commences. The Department has twelve months from the date of the petition's acceptance to complete a full status review of the species and recommend whether such listing "is warranted." Following receipt of the Departments status review, the Commission holds an additional public hearing and determines whether listing of the species "is warranted." If the Commission finds that the species is faced with extinction throughout all or a significant portion of its range, it must list the species as endangered. Fish & G. Code § 2062. If the Commission finds that the species is likely to become an endangered species in the foreseeable future, it must list the species as threatened. Fish & G. Code § 2067.

Notwithstanding these listing procedures, the Commission may adopt a regulation that adds a species to the list of threatened or endangered species at any time if the Commission finds that there is any emergency posing a significant threat to the continued existence of the species. Fish & G. Code § 2076.5.

III. Species Description

The American pika, *Ochotona princeps*, is a small, furry, diurnal, herbivorous mammal related to rabbits and hares (Grayson 2005). Overall body form is egg-shaped, with no visible tail, short legs, and rounded ears (Smith and Weston 1990). Pikas actually have a "buried" tail that is longer relative to length of body than any other lagomorph (Smith and Weston 1990). Their moderately large suborbicular ears are haired on both surfaces and normally dark in color with white margins (Smith and Weston 1990). The hind limbs are not appreciably longer than the forelimbs, and the hind feet are relatively short among lagomorphs (Smith and Weston 1990). There are five toes on the front feet and four on the hind feet (Smith and Weston 1990). Soles of the feet are densely furred except for small black naked pads at the end of the toes (Smith and Weston 1990). The skull is slightly rounded in profile, and the interorbital region is broad and flat (Smith and Weston 1990). The dental formula is I 2/1, c 0/0, p 3/2, m 2/3, total 26 (Smith and Weston 1990).

Compared to other *Ochotona* species, the American pika is intermediate in size, and there is considerable variation in size among populations (Smith and Weston 1990). Body length ranges from 162 to 216 millimeters (Smith and Weston 1990). Average body mass ranges from 121 to 176 grams (Smith and Weston 1990). When sexual dimorphism in size occurs within populations, males are slightly larger than females (Smith and Weston 1990).

American pika fur coloration is similar between the sexes, but varies among subspecies and by season (Smith and Weston 1990). In summer, dorsal fur ranges from grayish to cinnamon-brown, often richly colored with tawny or ochraceous hues (Smith and Weston 1990). In winter, fur is grayer and nearly twice as long as the summer fur (Smith and Weston 1990). The dense underfur is usually slate-gray or lead colored (Smith and Weston 1990). Ventral fur is usually whitish with a buffy wash (Smith and Weston 1990).

IV. Taxonomy

In the order *Lagomorpha*, family *Ochotonidae*, the genus *Ochotona* includes 14 to 18 species worldwide (Smith and Weston 1990). American pikas have historically also been referred to by the common names cony, rock rabbit, mouse hare, whistling hare, and piping hare (Wilson and Ruff 1999) under a variety of species names (Hall 1981). Some subspecies of American pika were previously known by other species names (e.g. *schisticeps*), and sometimes under the genus *Lagomys*, but were all eventually revised into the single species *Ochotona princeps,* as explained in Hall (1981).

Of the two pika species in North America, the American pika *Ochotona princeps* is taxonomically and geographically distinct from the collared pika *Ochotona collaris.* The range of *O. princeps* extends from New Mexico and California, north through central British

Columbia; the range of *O. collaris* includes extreme northwest Canada and western Alaska (Hall 1981). The American pika is physically distinct from the collared pika, which is grayer, with a distinct gray patch on the nape and shoulders (Anthony 1928).

The American pika has a discontinuous distribution in mountain ranges throughout much of western North America (Smith and Weston 1990). There are 36 recognized American pika subspecies in North America (Wilson and Ruff 1999). The five subspecies that occur in California are described by Hall (1981) as follows:

Taylor pika (*Ochotona princeps taylori*)

1912. *Ochotona taylori* Grinnell, Proc. Biol. Soc. Washington, 25:129, July 31, type from 9000 ft., Warrant Peak, Warner mts., Modoc Co., California.

1951. *Ochotona princeps taylori*, Hall, Univ. Kansas Publ., Mus. Nat. Hist., 5:133, December 15.

Gray-headed pika (*Ochotona princeps schisticeps*)

1889. *Lagomys schisticeps*, Merriam, N. Amer. Fauna, 2:11, October 30, type from Donner [=Summit], Placer Co., California.

1936. *Ochotona princeps schisticeps*, A.H. Miller, Jour. Mamm., 17:175, May 18 (princeps and schisticeps regarded as conspecific by Borell, Jour. Mamm., 12:307-308, August 24, 1931).

Yosemite pika (*Ochotona princeps muiri*)

1916. *Ochotona schisticeps muiri* Grinnell and Storer, Univ. California Publ. Zool., 17:6, August 23, type from 9300 ft., near Ten Lakes, Yosemite National Park, Tuolumne Co., California.

1934. *Ochotona princips muiri*, Hall, Proc. Biol. Soc. Washington, 47:103, June 13.

Mt. Whitney pika (*Ochotona princeps albata*)

1912. *Ochotona albatus*, Grinnell, Univ. of California Publ. Zool., 10:125, January 31, type from 11,000 feet near Cottonwood Lakes, Sierra Nevada Mountains, Inyo County, California."

1951. *Ochotona princeps albata*, Hall Univ. Kansas Publ., Mus. Nat. Hist., 5:127, December 15.

White Mountain pika (*Ochotona princeps sheltoni*)

1918. *O. schisticeps sheltoni*. Grinnell, Univ. California Publ. Zool., 17:429, April 25, type from 11,000 ft., "near" Big Prospector Meadow, White Mountains, Mono County, California.

1946. *Ochotona princeps sheltoni*, Hall, Mammals of Nevada, p. 593, July 1.

V. Habitat Necessary for Survival

The American pika inhabits talus fields fringed by suitable vegetation on rocky slopes of alpine areas throughout western North America (Smith and Weston 1990). Although it is primarily found in talus fields, American pika has also been known to inhabit piles of broken rock (Smith and Weston 1990, Hafner 1993). They occasionally inhabit man-made substrate such as mine tailings or piles of scrap lumber (Smith and Weston 1990). Pikas are most often seen near the talus-meadow interface, although they are frequently found on barren expanses of talus (Smith and Weston 1990). Smith and Weston (1990) propose that of all North American montane mammals, American pikas are the most obligate residents of talus habitat. Throughout most of western North America, talus habitat has a patchy distribution, resulting in island-like population structure or metapopulation structure (Smith and Weston 1990).

American pikas do not dig burrows, and rely on existing spaces beneath the talus for den and nest sites (Smith and Weston 1990). However, they may be capable of enlarging den and nests sites beneath the talus by digging (Smith and Weston 1990). Pikas prefer to locate their dens and nest sites below rocks approximately 0.2 to 1 m in diameter, but they will often sit on larger, prominent rocks, and will also cache haypiles under large boulders (Smith and Weston 1990).

Pikas are restricted to cool, moist microhabitats on higher peaks or along watercourses (Hafner 1993). Pikas live in regions with short summers of less than 20 days per year above 35°C (82% of 50 patches), long winters with greater than 180 days per year below 0°C (94%), a freeze-free period of less than 90 days (86%), and annual precipitation of more than 300 mm (96%) (Hafner 1993). All extant pika populations are restricted to regions of <30 days/year above 35°C, >150 days/year below 0°C, a freeze-free period of <120 days, and annual precipitation of >200 mm (Hafner 1993). In the northern portions of its range, American pika is found at elevations ranging from sea level to 3,000 m; near the southern limits of its range it is uncommon to find American pika at elevations lower than 2,500 m (Smith and Weston 1990). Hafner (1993) concluded that American pika range generally decreased by 56.6 m in elevation for each degree of latitude North.

American pikas commonly occur in habitat occupied by marmots (*Marmota* spp.), chipmunks (*Tamias* spp.), ground squirrels (*Spermophilus* spp.), and woodrats (*Neotoma* spp.) (Smith and Weston 1990). There is no evidence of interspecific competition between the pika and any of these species (Smith and Weston 1990).

VI. Biology, Ecology, and Life History

A. Behavior

Pikas are diurnal and relatively easy to detect based on sightings, vocal calls, haypiles, or feces (Beever et al. 2003). American pikas have four pronounced behaviors: (1) surveillance (or “musing”) from a prominent rock, which may account for up to half of the time an animal is surface active; (2) haying or feeding; (3) vocalizing; and (4) engaging in activities related directly to territory establishment or maintenance, including vocalizing, cheek rubbing, aggression, and social tolerance (Smith and Weston 1990).

The American pika has two characteristic vocalizations, the short call and the long call or song, as well as several other distinct acoustic signals (Smith and Weston 1990). Social cohesion is maintained by exhibiting social tolerance and engaging in short call duets (Smith and Weston 1990).

Both sexes have a porcine gland complex in the lower cheek, from which they frequently deposit scent marks by rubbing the gland area on rocks (Smith and Weston 1990). American pikas are able to differentiate between individuals by the odors emitted from the scent marks (Smith and Weston 1990). Scent marking occurs throughout the home range, but more frequently in areas of overlap with the opposite sex (Smith and Weston 1990). Pikas cheek-rub throughout their active season, apparently with elevated frequency during the breeding season or upon colonization of a new territory (Smith and Weston 1990). This behavior may serve a dual function: territory advertisement or maintenance and sexual advertisement leading to mating (Smith and Weston 1990).

American pikas do not hibernate, and remain active through the winter (Smith and Weston 1990). They maintain access to haypiles and meadows through the use of tunnels through the snow (Smith and Weston 1990).

B. Diet, Feeding, and Foraging

American pikas are generalist herbivores (Smith and Weston 1990). Most water needs are met through consumed plant material, but available drinking water is also used (Martin 1982, Harris 2005). Pikas have higher energetic demands than other montane mammals, in part because they do not hibernate, and in part because they make up to 13 trips per hour to collect vegetation during the haying season (Beever et al. 2003). Their daily caloric intake is equivalent to filling their stomachs nine times each day (Smith and Weston 1990). Food intake is increased during pregnancy and lactation (Smith and Weston 1990).

American pikas employ two different modes of foraging: direct consumption of food (feeding) and the caching of vegetation in haypiles as a food source through the winter months (haying) (Smith and Weston 1990). Whereas feeding occurs throughout the year, haying is confined to the summer months following the breeding season (Smith and Weston 1990). (Smith 1974b) found that timing of haying is correlated to amount of precipitation during the previous winter—pikas began and terminated haying earlier in years following little snow and early spring. At low-elevation sites, haying begins before the snow has melted at high altitudes; at high elevation sites, haying continues after haying has ceased at lower altitudes (Smith 1974b).

Different plant species are harvested based on the composition of the plant community; some plants are selected over others, and some are not harvested at all (Smith and Weston 1990). Selected plants are commonly harvested in a deliberate sequence that generally corresponds to their seasonal phenology (Smith and Weston 1990). Apparently, American pikas assess the nutritional value of available food and harvest accordingly (Smith and Weston 1990). Selected plants have a significantly higher caloric, protein, lipid, and water content than non-selected plants (Smith and Weston 1990). Pikas may also avoid some abundant plants that contain toxic chemicals (Smith and Weston 1990). More forbs and tall grasses are hayed than eaten directly; the most common plant type eaten is short alpine grasses (Smith and Weston 1990). Pikas have also been observed to cache plants with high toxic concentrations in their haypiles, which tend to be resistant to decomposition, and delay eating these plants until the toxins decay (Dearing 1997).

Most haypiles are constructed in dens beneath the talus near the talus-meadow interface, but may also be constructed on the surface of the talus (Smith and Weston 1990). Males tend to store more vegetation than females, and adults tend to store more than juveniles (Smith et al. 1990). Food storage is positively associated with the amount of vegetation available, and is negatively associated with the distance vegetation has to be transported from the meadow to the haypile (Smith et al. 1990). In one Colorado population, the average haypile size was 28 kg of fresh vegetation per pika which represents 14,000 foraging trips during 8-10 weeks of the summer (Dearing 1997).

The adaptive significance of haypiles is apparently related to the need to serve as a potential winter food supply during years when the winter season is unusually harsh or prolonged (Smith and Weston 1990). Although American pikas appear to collect as much vegetation as possible during the haying season, this amount apparently may be insufficient to provide an exclusive source of food during winter (Smith and Weston 1990). Cushion plants may form an important food for American pikas foraging during winter in snow tunnels, and lichens may also be an important winter food source (Smith and Weston 1990).

American pikas deposit two types of fecal droppings, a hard brown round pellet and caecal pellets, soft black shiny strings of material formed in the caecum (Smith and Weston 1990). Caecal pellets have a higher energy value and protein content than plant food stored in haypiles (Smith and Weston 1990). American pikas may either ingest the caecal pellets directly or store them for later consumption (Smith and Weston 1990).

C. Territory and Home Range

The territory of an American pika is the area the animal defends from intruders; the home range is the total area used (Smith and Weston 1990). The size of a territory is typically about 55% of that of the home range, although territory size varies seasonally and is significantly larger in early summer than in late summer (Smith and Weston 1990). Measurements of territory size vary from 410 m^2 to 709 m^2 (Smith and Weston 1990). Measurements of home range vary from 861m^2 to 2,182 m^2 (Smith and Weston 1990). Territory size and shape may vary based on configuration of habitat, distance from the territory to vegetation, and quality of vegetation (Smith and Weston 1990). Three estimates of population density are 2.2 to 7.4/ha, 3.4 to 9.9/ha, and 4.0 to 8.6/ha (Smith and Weston 1990).

Adult American pikas are individually territorial, with equivalent average territory sizes for males and females, but overlap of home ranges is greater and nearest-neighbor distances are smaller between members of a mating pair than between nearest-neighbors of the same sex (Smith and Weston 1990). Spatial overlap between paired adults is greatest in early to mid-summer and much reduced in late summer and early autumn (Smith and Weston 1990).

Territories are defended primarily by acts of aggression such as chases and fights (Smith and Weston 1990). These aggressive acts are rare, and normally occur between individuals of the same sex, and most frequently during encounters between animals unfamiliar with each other, such as a resident and an immigrant (Smith and Weston 1990). Individuals will intrude upon another's territory, but usually when the resident is inactive (Smith and Weston 1990). Territorial behavior increases with increased haying activity (Martin 1982).

Haypile sites appear to be traditional (Smith et al. 1990). Haypile sites are maintained in the territory when the territory ownership changes (Peacock 1997).

D. Reproduction and Development

The mating system is classified as facultatively monogamous based on the paired configuration, its persistence in time, and the interplay of aggression and social tolerance behaviors (Smith and Weston 1990). Pikas form mated pairs with adults from adjacent territories (Smith and Weston 1990). Females may exhibit mate choice when more than one potential mate is available (Smith and Weston 1990).

Adult females have two litters per year; average litter size ranges from 2.34 to 3.68 (Smith and Weston 1990). American pikas are reflex ovulators and are seasonally polyestrus; they first breed as yearlings, with a gestation period of 30 days (Smith and Weston 1990). Females typically only wean one of the two litters they initiate, weaning the second litter only when the first litter is lost to predation or due to poor physiological condition of the mother (Smith and Weston 1990). As a result, less than 10% of weaned juveniles in most populations are the result of second litters (Smith and Weston 1990). Resorption of entire litters may occur under conditions of extremely adverse weather conditions (Smith and Weston 1990).

First litters tend to be conceived one month before snowmelt so that the spring flush of alpine vegetation is available to lactating females (Smith and Weston 1990). Parturition occurs as early as March at some low-elevation sites, but first occurs in May with a peak in June throughout most of the range (Smith and Weston 1990). Breeding before snowmelt is possible because American pikas do not hibernate and have access to food stored in their haypiles and on nearby meadows through the use of snow tunnels (Smith and Weston 1990). The timing of parturition reflects a compromise between weaning young early enough to give them a fitness advantage in obtaining territories and meeting the female's energetic demands during weaning (Smith 1978). Juveniles that emerge first have an advantage in gaining territories of individuals that have succumbed to over-wintering mortality (Smith 1978). However, because weaning is energetically taxing for females and depletes her fat stores, weaning must also be well-timed with snowmelt and the emergence of new spring vegetation (Smith 1978).

Timing of parturition is not based on the snow melt that year, but on the average snow melt for that location (Smith and Weston 1990). Breeding seasons at higher elevations were found to lag behind lower elevations by about six weeks (Smith 1974b). The variance of initiation of first litters is directly related to the long-term variance of snowmelt at a locality; phenology of reproduction is more synchronous where snowmelt is predictable than at comparatively unpredictable sites (Smith and Weston 1990).

American pikas are born slightly haired, with eyes closed and fully erupted teeth, at an average mass of 10 to 12 g (Smith and Weston 1990). Eyes open at an average of 9 days of age (Smith and Weston 1990). American pikas are among the fastest growing of all lagomorph species, and may reach minimum adult mass within 3 months of birth (Smith and Weston 1990). Mothers are away from the nest for extended periods, but return about every 2 hours and nurse for an average of 10 minutes (Smith and Weston 1990). Captive young cannot survive independently of their mother until about 18 days of age (Smith and Weston 1990).

The first adult behaviors to develop are those related to aggression and territoriality, such as agonistic behavior, scent-marking, and alarm-calling (Smith and Weston 1990). Young are weaned as early as 3-4 weeks (Smith and Weston 1990). By the fourth week of age the young are intolerant of and spend little time in contact with their siblings and mother (Smith and Weston 1990).

E. Dispersal and Migration

Adult pikas are individually territorial and rarely disperse (Peacock 1997). Juveniles are born into the relatively permanent and static social organization of adult territory holders (Smith and Weston 1990). Adult females become intolerant of their young soon after weaning and attempt to exclude them from their territory (Smith 1974b). Other adults apprehend and chase unfamiliar juveniles from their territories (Smith and Gilpin 1996). Thus, the juvenile's survival is directly contingent on its finding a vacant territory to occupy (Smith and Weston 1990).

Most young are philopatric, remaining on their natal or an adjoining home range (Smith and Weston 1990). While living on their natal home range, juveniles occupy areas as widely separated as possible from their mother, putative father, and siblings (Smith and Weston 1990). In addition, philopatric juveniles are most likely to be active when their parents are inactive (Smith and Weston 1990).

Dispersal appears to be caused by competition for territories, primarily by resident juveniles (Peacock 1997). Juveniles will disperse if no territory is available (Golian 1985). Approximately 25% of all juvenile American pikas may attempt to disperse (Smith and Weston 1990). Juveniles generally must obtain a territory in the summer after their birth (Smith and Ivins 1987). Immigration of juveniles to new locations and populations generally occurs during the late summer and fall or spring months (Smith 1987).

Temperature appears to be the primary environmental factor controlling the initial success of dispersing juveniles (Smith 1974a). Because juvenile dispersal occurs within months of birth, juveniles at low-altitude sites generally disperse during the summer, when temperatures are high, leading to low dispersal success (Smith 1974a). Following a dry winter or early spring, the period for gathering hay may end before juveniles disperse, greatly reducing success of dispersing juveniles (Smith 1974a). At higher elevations, temperature and seasonality have little effect on dispersing juveniles (Smith 1974a).

Dispersals of up to 3 km have been indicated, with the vast majority of dispersals at shorter distances (Beever et al 2003). Peacock (1997) found evidence of occasional dispersal between populations separated by 2 km. Pikas can disperse across non-rocky habitat over distances of 3 km in cooler regions (Hafner 1993). However, dispersal over non-rocky habitat may have a low success rate (Beever et al 2003). Longer dispersals (2 km) are likely more successful across mesic, high-elevation habitat (Hafner 1994, Beever et al 2003). Peacock (1997) found that an average of 34% of the individuals at one California population were replaced each year by immigrants from another population 2 km away.

There is evidence of extremely few dispersals over distances greater than 20 km over the past 6,000 years (Hafner 1994). Subspecies are separated by 10 to 100 km (Hafner and Sullivan 1995). Various studies show and many scientists believe that migration of pikas between mountaintop islands is not currently occurring (Beever et al. 2003).

F. Temperature Limits and Thermoregulation

American pikas have an average body temperature of 40.1°C (104.2°F) and a relatively low lethal body temperature of 43.1°C (109.6°F) (MacArthur and Wang 1973, Smith and Weston 1990). Pikas have low thermal conductance that favors overwinter survival, because resting metabolism at ambient temperatures below 21°C (69.8°F) uses less energy (MacArthur and Wang 1973, Smith and Weston 1990). The thick fur that insulates pikas during the winter also prevents evaporative cooling during the summer (Beever 2002). The average body temperature of the American pika is generally 2-3°C higher than other small mammals inhabiting the same rockslide habitat, due to high basal metabolic rate and low thermal conductance (MacArthur and Wang 1973).

Hyperthermia and death may occur after brief exposures to ambient temperatures above 25.5-29.4°C (77.9-84.9°F) (Smith and Weston 1990). Most thermoregulation in response to high ambient temperatures is behavioral rather than physiological (Smith and Weston 1990). American pikas are relatively inactive on warm days. Near the lower altitudinal range of the species where temperatures may be hot, they shun activity throughout the midday hours and are surface active about 30% of daylight hours (Smith and Weston 1990). In an experiment with captive pikas, Smith (1974b) found that pikas died within 6 hours if confined in the sun at lower elevation sites.

High temperatures appear to constitute a major stress on pikas at lower elevations (Smith 1974b). Smith (1974b) found that pikas at cooler high altitude (3350-3400 m) sites in the Sierra Nevada were active throughout the day, but pikas at warmer lower altitude sites (2300-2550 m) in the Sierra Nevada were active primarily in morning and late afternoon (Smith 1974b). Similarly, at a warmer site in Nevada, Hall (1946) found that pikas were most active from sunrise until 11:00 a.m.; relatively inactive between 11:00 a.m. and 4:30 p.m.; and then active until sunset, but less so than in the morning. Smith (1974b) also found that pikas at low altitudes generally foraged less than 20 m from their haypiles, but at higher altitudes foraged regularly up to 400 m from the haypile. Additionally, at high elevation sites, pikas were more wide ranging and occupied a greater proportion of available sites, whereas suitable habitat patches were always undersaturated at low elevation sites (Smith 1974b).

Smith (1978) also found that pika populations in the Sierra Nevada, California, were susceptible to higher mortality in years of early snowmelt because they lost the protective insulation of the snow cover and experienced thermal stress during winter.

G. Mortality and Population Turnover

American pikas attain a maximum age of 7 years, and age-specific mortality rates are greatest in the birth to one year and five to seven year age groups (Millar and Zwickel 1972, Smith and Weston 1990). Smith (1978) measured age-specific mortality of populations in two sites in California as well as in Colorado and Alberta and found the average mortality rates for age group 1-4 was 37% , 45%, 44%, and 45% respectively. Peacock (1997) reported an average mortality rate in pika populations of 37-53% each year, and found that very few pikas survived at the study population for the four years of the study.

Smith (1980) described the metapopulation-like structure of pikas at Bodie, California, where pika populations on discrete talus habitat patches were connected by colonization and extinction dynamics. For example, at Bodie, eleven habitat islands occupied in 1972 were unoccupied in 1977, and eight sites unoccupied in 1972 were occupied in 1977 (Smith 1980). Smith (1980) also found that 53% of 77 islands changed in territory saturation over the five years, with extinction and recolonization associated with small island size and increased isolation.

Golian (1985) found in four years of data at a site in Colorado that mortality increased and reproductive success decreased with increased snow accumulation (snow pack) and late date of melt, presumably because spring vegetation growth was delayed. Smith (1978) found that pika mortality increased in the Sierra Nevada, California, in years of early snowmelt due to the loss of the protective insulation of snow cover and in years of late snowmelt due to the delay in the growth of spring vegetation.

Potential predators include coyote (*Canis latrans*), longtail weasels (*Mustela frenata*), shorttail weasels (*M. erminea*), pine martens (*Martes americana*), bobcat (*Lynx rufus*), and red fox (*Vulpes vulpes*) (Krear 1965, Smith and Weston 1990), and these predators differ in their ability to capture pikas (Ivins and Smith 1983). Weasels are more effective hunters of pika since they are able to hunt in the talus interstices (Ivins and Smith 1983). Coyotes and martens appear to succeed primarily in ambushing pikas in meadows, when pikas are surface-active on the talus, or when juveniles are dispersing outside the talus (Ivins and Smith 1983, Smith and Weston 1990). Predatory birds that occur in the same habitat, including the Northern goshawk (*Accipiter gentilis*), golden eagle (*Aquila chrysaetos*), red-tailed hawk (*Buteo jamaicensis*), marsh hawk (*Circus cyaneus*), prairie falcon (*Falco mexicanus*), and common raven (*Corvus corax*), are not believed to kill many pikas (Krear 1965, Smith and Weston 1990).

VII. Range and Distribution

A. Pre-Historic Distribution

Fossil evidence suggests that ochotonid lineages have persisted in North America for at least 500,000 years (Beever et al. 2003, Smith and Weston 1990). Commonality of some ectoparasites between the American pika, collared pika, and *O. hyperborean* in Asia lead researchers to believe that the American pika is derived from one ancestral species that migrated across Beringia (Smith and Weston 1990).

Separation of the American pika and the collared pika to the north is likely the result of the Wisconsinian glaciation (Smith and Weston 1990). It is likely that the range of the American pika was pushed south with the advancing ice and cold temperatures, while the collared pika remained in the Bering refugium (Smith and Weston 1990). Fossil remains from the Wisconsinian indicate that the American pika reached its maximum distribution during this period, when its ranged extended 100 km south of its present distribution, and it also occurred at elevations lower than where it is currently found (Smith and Weston, 1990, Beever et al. 2003). The southernmost fossil remain of the pika from this period is from Kokoweef cave, California, 100 km south of its current distribution (Mead 1987).

Some authors report that the fossil record indicates that the American pika did not always live in rocky or talus habitats (Smith and Weston 1990, Grayson 2005). These authors believe that during much of the Quaternary, pikas apparently lived in valley-bottoms in steppe or grassland habitat, similar to pika species in Asia today (Smith and Weston 1990). Analyses of pika remains from ancient woodrat (*Neotoma* spp.) middens in western North America show that pikas were living at elevations less than 2000 m (6,561 ft) in areas without talus around 12,000 years ago (Grayson 2005). This is disputed by Hafner (1993) who found no evidence in the fossil record to dispute that the American pika is a rock-dwelling species, and should be considered a biogeographic indicator species of cool, mesic, rocky habitat or microhabitat.

Throughout the late Wisconsinian (20,000 to 10,000 years ago) and into the recent era, summer temperatures increased and American pikas became isolated on suitable montane areas (Smith and Weston 1990). Continued warming and catastrophic events coupled with the demographic consequences of decreasing population sizes on mountaintop islands extirpated many populations, and these conditions also prevented the re-colonization of these habitats (Smith and Weston 1990). By about 7,500 years ago, American pika populations had apparently retreated up slope on isolated mountains and had become specific to talus habitats (Grayson 1987, Smith and Weston 1990).

The American pika became extinct in the lower elevations of the northern half of the Great Basin about 7,000 years ago (Grayson 1987). Scientists believe that during this period of history the Great Basin saw an increase in summer temperatures and precipitation and a decrease in winter precipitation (Grayson, 1987). Such an event might have decreased or eliminated pika habitat in lower elevations of the Great Basin. By about 4,500 years ago, the distribution of pikas in the Great Basin had become much as it was during historic times (Grayson 2005). Grayson (2005) found the average elevation of American pika populations in the Great Basin increased from 1750 m 7,500 years ago, to 2,168 m currently. The current patchy, high-elevation distribution in the Great Basin is the result of loss of lower elevation populations (Grayson 2005).

Biogeographic perspectives on montane mammals of the Great Basin have followed the traditional island biogeography model, viewing mountaintops as islands isolated from mainland populations in the Sierra Nevada or Rocky Mountains by a sea of inhospitable low-elevation valleys (Beever et al. 2003). Isolation on mountaintops has prohibited re-colonization under current climatic conditions. Subspecies differentiation within the American pika may be due to this isolation (Smith and Weston 1990).

B. Historic Distribution

The American pika is distributed discontinuously in mountainous areas throughout western North America (Smith and Weston 1990). In the northern part of its range it is found at elevations from sea level to 3,000 meters (Smith and Weston 1990). To the south the lower elevational limit of its range becomes progressively higher, as American pikas cannot tolerate high diurnal temperatures found at lower elevations (Smith and Weston 1990). Near the southern limits of its distributional range it is uncommon to find American pika at elevations lower than 2,500 m (Smith and Weston 1990). In California, elevations of historic populations ranged from 1370 m to 3700 m (see subspecies descriptions below).

Historic distribution information for the five California subspecies is described below and illustrated in Figure 1. The range map for the five American pika subspecies in California (Figure 1) was produced by overlaying the range map of extant American pika populations depicted by Hafner (1993: 374) with the locations of collections of individuals from each pika subspecies as specified by museum records provided by the Global Biodiversity Information Facility database (http://www.asia.gbif.net/portal/download_input.jsp?taxonKey=241662&countryKey=0&resourceKey=0&georeferencedOnly=true&nextTask=ecat_browser.jsp)

Taylor pika (*Ochotona princeps taylori*)

The type locality of *O. p. taylori*, also known as the Warner Mountain or Taylor's Cony, was collected at 9,000 ft. in elevation on Warren Peak by W.P. Taylor on July 18, 1910 (Howell 1924, Bailey 1936). Maillard (1927) reports *O. p. taylori* from Quaking Asp Spring, at 4500 feet in elevation, 12 miles west of Happy Camp Forest Service Station in Modoc County. Also:

> [the pika] is more numerous and more widely distributed in [Modoc] county than was at first supposed...Fresh sign was found in several places along the Warner Range…from 5000 feet upward, one small colony being in the rocky bottom of Eagle [Canyon], just before the [canyon] opens abruptly into the rolling plain, about a mile westerly from Eagleville. Another colony of conies was noted by Gilmore on a hill above the Pit River Forest Service Station in September, 1926…A large colony exists near the top of the Warner Range, a little southeast of Eagle Peak, at close to 9000 feet elevation….(Maillard 1927:356).

In 1936 the range of *O. p. taylori* was reported as the dark-colored lava fields of southeastern Oregon and northeastern California, from 5,000 to 9,000 feet in elevation, wherever suitable cover and talus rock occurred (Bailey 1936). In California, there are specimens from 5 locations: Warren Peak, Sugar Hill, 5 miles NW of Eagle Peak in Modoc County, 2 mi N. of Medicine Lake in Siskiyou County, and 4 mi SW of McDonald Peak in Lassen County (MVZ database; Bailey 1936). In Oregon, specimens are available from northern end of the Warner Mountains, Adel, Jack Lake, Fort Warner Creek, Guano Valley, and the northern end of the Steens Mountains (Bailey 1936). This subspecies has also been reported from Lower Klamath Lake, Drews Creek, and the lava beds near the head of the Owyhee River (Bailey 1936).

Gray-headed pika (*Ochotona princeps schisticeps*)

The type locality of *O. p. schisticeps* was collected at Donner [Summit] California, by Charles A. Allen on June 9, 1888 (Howell 1924). Also known as the gray-headed pika, *O. p. schisticeps* was distributed in the boreal zones of the northern Sierra Nevada, from Mount Shasta south to Donner Pass at elevations from 5,000 to 9,000 feet (Howell 1924).

Orr (1949) reported pikas as "fairly common in the Tahoe region but limited to rock slides largely above the 7500-foot level" and states "[n]o doubt many persons on the way to Mt. Tallac, the Velma Lakes or on the slopes of Mt. Rose, Ward Peak, even on the talus slopes above Eagle Falls, have heard the calls of these little animals…" (Orr 1949:110-111).

Yosemite pika (*Ochotona princeps muiri*)

This type locality is known from Ten Lakes, Yosemite National Park, Tuolumne County, California, at 9,300 feet in elvation on October 11, 1915, by W.P. Tylor (Howell 1924).

Grinnel and Storer (1924) describe this subspecies in the Yosemite region as a "[c]ommon resident of the Hudsonian Zone, extending down locally into part of the Canadian Zone and up into Arctic-Alpine. Recorded from Ten Lakes, Tenaya Lake, and Washburn Lake eastward to Bloody [Canyon] to Ellery Lake"[1] (Grinnell and Storer 1924:218). Further:

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[1] The Canadian Zone refers to areas from approximately 6,000- 8,000 feet in elevation, the Hudsonian Zone to areas from approximately 8,000-11,000 feet in elevation, and the Arctic Zone to areas from approximately 11,000-13,000 feet in elevation. For a fuller description of these life zones, see Grinnell and Storer (1924:4-12).

> The Yosemite Cony is an alpine species, found only in the higher parts of the mountains above the fir belt, chiefly in the zone occupied by the alpine hemlock, white-bark pine, Sierran heather, and cassiope. Even within this narrow area it does not live everywhere, but is restricted to a single type of habitat, that comprised in moraines or taluses of broken granite….Altitudinally, the cony is found, in the Yosemite National Park, as low as 7700 feet, for example, near Glen Aulin, on the Tuolumne River; upward it ranges to about 12,000 feet, as on the slopes of Mount Dana and on the very summit of Parsons Peak, 12,120 feet.
>
> In one typical rock slide, at the head of Lyell [Canyon], our estimates indicated a population of at least one cony for every 750 square yards. This would mean a population of about six to an acre (Grinnell and Storer 1924:218)….

Hall (1981) described marginal records from Nevada at 8500 ft., 3 mi. south of Mt. Rose, and from California at Markleeville, mountains west of Bishop Creek, Washburn Lake, and at latitude 39°N, summit of Sierra.

<u>Mt. Whitney pika (*Ochotona princeps albata*)</u>

This type locality is known from Cottonwood Lakes, near Mount Whitney, at 11,000 feet in elevation, Inyo County, California, September 3, 1911 by Joseph Grinnell (Grinnell 1912, Howell 1924).

> In our field work in the vicinity of Mount Whitney we found plentiful evidence of the presence of conies close to timber-line, from the immediate slopes of Mount Whitney south to Cottonwood Pass. None were seen above 12,000 feet altitude nor below 10,600, except at one point on the Inyo side of the mountains near Little Cottonwood Creek, where unmistakable sign was seen and the characteristic bleat of the animals heard at about 9500 feet (Grinnell 1912:127).

Howell (1924:44) notes the geographic distribution as the “[s]outhern part of the high Sierra Nevada, from Kearsarge Pass south to the headwaters of the Tule and Kern Rivers; altitudinal range from 8,500 feet to 13,000 feet.”

Sumner and Dixon (1953) report *O.p. albata* as “common throughout the higher rocky basins and talus rock piles both below and above timber line.” “It has been observed near Mt. Whitney at an elevation of 13,000 ft.; it probably occurs at least several hundred feet higher (Sumner and Dixon 1953:431).” Observations were also made just below Tokopah Falls in Tokopah Valley at 7,000 feet on August 10 and 11, 1933 (Sumner and Dixon 1953). Pikas were observed for the first time in a new rockside at Twin Lakes in Tulare County in July, 1906, and this colony subsequently grew to one of the largest in the state by August, 1922 (Sumner and Dixon 1953).

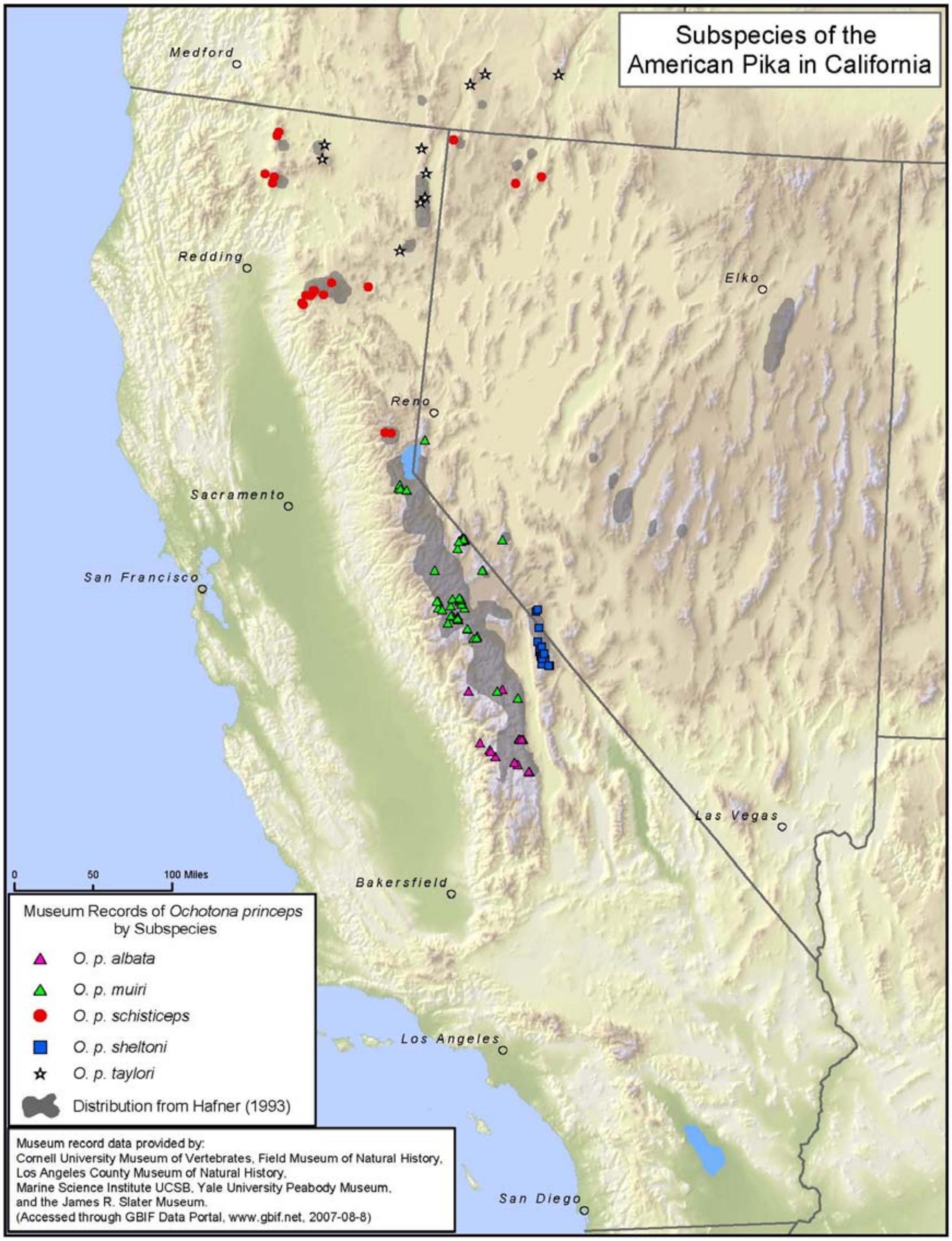
Hall (1981) lists marginal records from Bullfrog Lake and at 10,000 ft. at Independence Creek. Grinnell (1912) notes that *O.p. albatus* differs from *O.p. schisticeps* in its larger ears and much paler coloration throughout, being creamy whitish above instead of brown and slate.

<u>White Mountain pika (*Ochotona princeps sheltoni*)</u>

This type locality is known from the White Mountains, 11,000 feet in elevation, near Big Prospector Meadow, Mono County, California, on July 29, 1917 by A.C. Shelton (Howell 1924). Howell (1924) lists the geographic distribution as the “White Mountains of California and

Nevada at 8,000-13,000 feet in elevation." Records indicate that this species occurred near Pinchot Creek, California (Hall 1981), and on the northern end of White Mountains in Mineral County, Nevada (Hall, 1946). Hall (1981) lists a "marginal record" from Pinchot Creek in Nevada, at 8700 feet.

Figure 1. Range map of five American pika subspecies in California.



Subspecies of the American Pika in California

Museum record data provided by:
Cornell University Museum of Vertebrates, Field Museum of Natural History,
Los Angeles County Museum of Natural History,
Marine Science Institute UCSB, Yale University Peabody Museum,
and the James R. Slater Museum.
(Accessed through GBIF Data Portal, www.gbif.net, 2007-08-8)

VIII. Population Status, Trend and Abundance

Scientists believe that climatic changes during the past 10,000 years led to extirpation of most low-elevation pika populations, producing the modern distribution and isolation of pikas on mountain islands (Smith and Weston 1990). Population loss occurred throughout the Pleistocene and Holocene as climate conditions became warmer and drier (Grayson 2005). However, the pace of population loss has greatly accelerated in the last century in parallel with global warming (Grayson 1993).

In California, pika populations have been lost from multiple low-elevation sites in Yosemite National Park during the past 90 years as mean air temperatures in Yosemite rose by 3°C (5.4°F) (Moritz 2007). Overall, the pika range contracted upslope 349 m (1145 ft) on dry eastern slopes and 497 m (1631 ft) on western slopes (Moritz 2007). A study of pikas at Bodie, California, at the lower edge of the altitudinal range of pika in the region (2,500 m, 8202 ft) found that these populations were more prone to extinction due to thermal stress (Smith 1974a). Pika colonizations were unable to offset extinctions because dispersal to suitable habitat was so impaired by the higher temperature of the local climate, leaving large patches of suitable pika habitat unoccupied (Smith 1974a). This study suggests that pika populations in California that are subjected to warmer, drier conditions will experience increased rates of extinction.

Parallel trends of pika population extirpations at low elevation have been found in the Great Basin. Six low-elevation Great Basin pika populations have been recorded as extirpated over the span of just a few decades (55-86 years) during the 20th century (Beever et al. 2003). At three of these sites (Ruby, Desatoya, and Hart Mountains), pika populations were extirpated from low-elevation areas but remained extant in high elevation areas that were in close proximity (Beever et al. 2003). For example, in the Ruby Mountains, Nevada, pikas recorded at 2,375 m (7792 ft) in 1956 could only be found at higher elevations above 2,743 m (8999 ft) in the 1990s (Beever et al. 2003). At least three additional Great Basin pika populations have gone extinct in the past decade (Krajick 2004, Schwarz 2005, Erik Beever, personal communication 8/10/07). This totals a loss of at least 32% of interior Great Basin populations in the past 100 years. Studies further indicate that loss of pika populations at study sites in the interior Great Basin occurred where climate conditions averaged 20% drier and 8-10% warmer than those at which populations persisted (Beever 2002), suggesting that climate conditions are a primary mechanism driving population extirpations.

In addition, Beever et al (2003) found greater rates of extirpation of lower elevation populations at *higher* latitudes in the Great Basin, presumably because the lower elevation populations at the lower latitudes have already been extirpated. Beever et al. (2003) suggest that these northern populations may be “on the steeper part of the exponential curve of extinction rate over time” and have a greater extinction debt. The extinction debt is a well-known phenomenon of time-delayed extinctions of populations after their habitat has been lost or diminished (Tilman et al. 1994), also known as faunal relaxation. For pika populations, habitat is currently being lost because its climatic suitability is being degraded by global warming (i.e. temperature rise, loss of snowpack, changes in precipitation). As described in detail in Section IXA, even if greenhouse gas emissions were to level off now, the climate is committed to at least a 0.6°C rise in temperatures over approximately the next 100 years. Pika populations in many regions across California may be already committed to extinction due the loss of climatically suitable habitat.

The American pika's obligate association with talus habitat, vulnerability to warmer weather, tendency toward philopatry, and low dispersal ability have isolated pika populations, placing them in jeopardy. These characteristics have made the pika more isolated within and between ranges than any other montane mammal (Beever et al. 2003). This isolation has increased the genetic distinctiveness of many population, so that the extirpation of individual populations increases the risk of losing a genetically unique population (Hafner and Sullivan 1995). This isolation combined with the restricted range and small size of many pika populations also increases their likelihood of extinction (Beever 2002).

Of the 5 subspecies of American pika in California, the White Mountains pika (*O. p. sheltoni*) has been listed by the IUCN as VU-D1 signifying that subspecies is vulnerable with less than 1000 mature individuals in the wild (IUCN 2006). The IUCN assessment of the American pika is based on the 1996 evaluation which does not appear to have included an analysis of threats from global warming.

In light of the observed population contractions in the Sierra Nevada and the Great Basin, and the projected impacts of global warming on the species, all populations of the American pika in California must be considered at high risk of extinction in the immediate or foreseeable future.

IX. Nature and Degree of Threat

This section describes in detail the nature and degree of threat to the American pika, as well as the factors affecting its ability to survive and reproduce.

A. Global Climate Change

Global warming represents the gravest threat to the long-term survival of the American pika. This section provides an annotated overview of the scientific basis of global climate change, the contribution of greenhouse gases to global warming, the changes in climate conditions that have occurred to date, and how these changes have impacted the American pika in California. We then provide a detailed review of climate projections for California in this century, and how these changes will affect American pika population persistence and its high elevation montane habitat.

1. The Climate System, Greenhouse Gas Concentrations, the Greenhouse Effect, and Global Warming

That global warming as a result of anthropogenic greenhouse gas emissions is occurring, and will continue to occur, is no longer subject to credible scientific dispute. There is an international scientific consensus that most of the warming observed has been caused by human activities, and that it is "very likely" that it is largely due to emissions of greenhouse gases (Solomon et al. 2007). The Fourth Assessment Report from the Intergovernmental Panel on Climate Change (IPCC)[2] has recently synthesized the best available science on global warming.

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[2] The IPCC was established by the World Meteorological Organization and the United Nations Environment Programme in 1988 (IPCC 2001). The IPCC's mission is to assess available scientific and socio-economic

The basic physics underlying global warming are as well established as any phenomena in the planetary sciences. The earth absorbs heat in the form of radiation from the sun, which is then redistributed by atmospheric and oceanic circulations and also radiated back to space (Le Treut et al. 2007). The earth's climate is the result of a state in which the amount of incoming and outgoing radiation is approximately in balance (Le Treut et al. 2007). Changes in the earth's climate can be caused by any factor that alters the amount of radiation that reaches the earth or the amount that is lost back into space, or that alters the redistribution of energy within the atmosphere and between the atmosphere, land, and ocean (Le Treut et al. 2007). A change in the net radiative energy available to the global earth-atmosphere system is called "radiative forcing" (Le Treut et al. 2007). Positive radiative forcings tend to warm the earth's surface while negative radiative forcings tend to cool it (Albritton et al. 2001).

Radiative forcings are caused by both natural and anthropogenic factors (Albritton et al. 2001, ACIA 2004, Le Treut et al. 2007). The level of scientific understanding of these different forcings varies widely, and the forcings themselves and interactions between them are complex (Le Treut et al. 2007). The primary cause of global warming, however, is society's production of massive amounts of "greenhouse gases" such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and halocarbons that cause positive radiative forcings (Forster et al. 2007, Le Treut et al. 2007). Greenhouse gases are, in fact, the radiative forcing mechanism that is currently best understood (Albritton et al. 2001).

The Enhanced Greenhouse Effect is caused by increasing concentrations of these greenhouse gases in the earth's atmosphere. As greenhouse gas concentrations increase, more heat reflected from the earth's surface is absorbed by these greenhouse gases and radiated back into the atmosphere and to the earth's surface. Increases in the concentrations of greenhouse gases slow the rate of heat loss back into space and warm the climate, much like the effect of a common garden greenhouse (Forster et al. 2007, Le Treut et al. 2007). The higher the level of greenhouse gas concentrations, the larger the degree of warming experienced. Carbon dioxide is by far the most important greenhouse gas because anthropogenic emissions of carbon dioxide dwarf those of all other compounds (Forster et al. 2007). While much smaller amounts of other greenhouse gases are emitted, these other gases can still make an important contribution to climate change because they have global warming potentials many times that of carbon dioxide (Forster et al. 2007). Increases in major greenhouse gas concentrations and their contribution to global warming are reviewed below.

By the time of the Fourth Assessment Report of the IPCC in 2007, the atmospheric concentration of carbon dioxide had increased by 36% since 1750 to a level that has not been exceeded during the past 650,000 years and likely not during the past 20 million years (Denman et al. 2007). About three fourths of manmade carbon dioxide emissions come from fossil fuel burning, and most of the remaining emissions are due to land-use changes, primarily deforestation (Denman et al. 2007). Carbon dioxide is considered the most important

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information on climate change and its impacts and the options for mitigating climate change and to provide, on request, scientific and technical advice to the Conference of the Parties to the United Nations Framework Convention on Climate Change (IPCC 2001). Since 1990, the IPCC has produced a series of reports, papers, methodologies, and other products that have become the standard works of reference on climate change (IPCC 2001). The IPCC's comprehensive Assessment Reports are produced approximately every seven years and build upon and expand past IPCC products. The *Fourth Assessment Report* was released in 2007.

greenhouse gas overall because the volumes emitted dwarf those of all the other greenhouse gases combined. Not surprisingly, the rate of increase of total atmospheric carbon dioxide concentrations is speeding up as well. Carbon dioxide emissions increased during 2000 to 2005 (4.1 ± 0.1 GtC yr–1) compared to emissions during the 1990s (3.2 ± 0.1 GtC yr–1) (Denman et al. 2007). As of March, 2006, the atmospheric carbon dioxide concentration was 381 ppm, and rising at over 2 ppm per year (Shukman 2006).

The atmospheric concentration of methane, another important greenhouse gas, has increased by about 150% since 1750, continues to increase, and has not been exceeded during the past 650,000 years (Forster et al. 2007). About 60% of current methane emissions come from human activities, and there is also evidence that current carbon monoxide (CO) emissions are a cause of increasing methane concentrations (Denman et al. 2007). Over a 100-year period, methane will trap about 23 times more heat than an equal amount of carbon dioxide (Albritton et al. 2001).

The atmospheric concentration of nitrous oxide has increased by about 18% since 1750, continues to increase, and has not been exceeded during at least the last 2000 years (Forster et al. 2007). About half of the nitrous oxide emissions to the atmosphere come from human activities (Denman et al. 2007). Over a 100-year period, nitrous oxide will trap about 296 times more heat than an equal amount of carbon dioxide (Albritton et al. 2001).

Halocarbons are carbon compounds that contain fluorine, chlorine, bromine, or iodine (Forster et al. 2007). Most types of halocarbons are produced exclusively by human activities (Forster et al. 2007). Halocarbons that contain chlorine, like chlorofluorocarbons, ("CFCs") also cause depletion of the stratospheric ozone layer and are regulated under the Montreal Protocol (Forster et al. 2007). The combined tropospheric abundance of ozone-depleting gases peaked in 1994 and is now declining slowly (Forster et al. 2007). However, some compounds which have been promoted as substitutes for now-regulated CFCs are themselves greenhouse gases, and concentrations of these gases, such as hydrochloroflurocarbons ("HCFCs") and hydroflurocarbons ("HFCs") are now increasing (Forster et al. 2007). There are many different types of halocarbons, which have global warming potentials that vary between 12 and 12,000 times that of carbon dioxide (Forster et al. 2007).

Many other natural and human caused factors that are less understood than greenhouse gases contribute to positive or negative radiative forcing, including aerosol emissions, land-use changes, and changes in solar and volcanic activity, water vapor, and cloud cover (Le Treut et al. 2007). Nevertheless, scientists now know that greenhouse gases are the most important force driving global warming, and that carbon dioxide is in turn the most important of the greenhouse gases (Forster et al. 2007, Solomon et al. 2007). Carbon dioxide emissions from fossil fuel burning are virtually certain to remain the dominant control over trends in atmospheric carbon dioxide concentrations during this century (Forster et al. 2007).

2. Climate and Environmental Change Observed to Date

Global average temperatures have risen by approximately 0.74° C ± 0.18° C (1.33° F ± 0.32° F) during the past 100 years (1906-2005) (Trenberth et al. 2007), and the rate of warming is accelerating. Over the past 50 years, the rate of warming was almost double than that observed over the past century (0.13°C (0.23°F) per decade versus 0.7°C (1.26°F) per decade) (Trenberth et al. 2007). Eleven of the last 12 years (1995 to 2006, except 1996) were the warmest years on record (Trenberth et al. 2007). In addition to increased average warming, heat waves have increased in frequency and duration, there are fewer frost days in mid-latitudes, and warm extremes (warmest 10% of days or nights) has increased while cold extremes (coldest 10% of days or nights) has decreased (Trenberth et al. 2007).

Global climate has changed in other ways as well. For example, precipitation has increased in the 20th century over most mid- and high latitudes (above 30°N) of the Northern Hemisphere continents, but has decreased in tropical and subtropical regions, such as the Sahel, the Mediterranean, southern Africa and parts of southern Asia, where droughts have become more common (Trenberth et al. 2007). Heavy precipitation events (e.g., above the 95th percentile) has increased in most regions since 1950, even where mean precipitation is lower (Trenberth et al. 2007). Mountain snow in temperate zones is particularly sensitive to small increases in warming because temperatures are often just slightly below freezing. In the Northern Hemisphere snow cover observed by satellite from 1966-2005 decreased in every month except November and December (Trenberth et al. 2007).

Specifically, throughout the American pika range in the western U.S., air temperature, precipitation, snowpack, and snowmelt timing have significantly changed, all of which are important climate variables of immediate concern for the pika. In the western United States, temperatures have increased by 1.1–2.8 °C (1.9-5.0°F) during the past century (Smith et al. 2001), exceeding global average temperature increases by more than double in most western regions. While precipitation has generally increased at mid-to-upper latitudes, annual precipitation in the southwest has decreased over the past century by 1-2% per decade (Trenberth et al. 2007). Snowpack has decreased in the later half of the 20th century in most snowmelt basins throughout the western U.S. in response to rising temperatures (Vicuna and Dracup 2007). Warming is also resulting in earlier seasonal runoff of mountain snowpack (Christensen et al. 2007, Vicuna and Dracup 2007). Streamflow timing (measured as CT or center of timing) advanced 10-30 days from 1948-2000, with the greatest change in the Pacific Northwest, Canada, Alaska, and the mountain plateaus of Washington, Oregon, and Idaho (Vicuna and Dracup 2007). In California, America pika habitat in the Sierra Nevada has become significantly warmer and drier, with lower snowpack, while the southern Cascades has become warmer with lower snowpack.

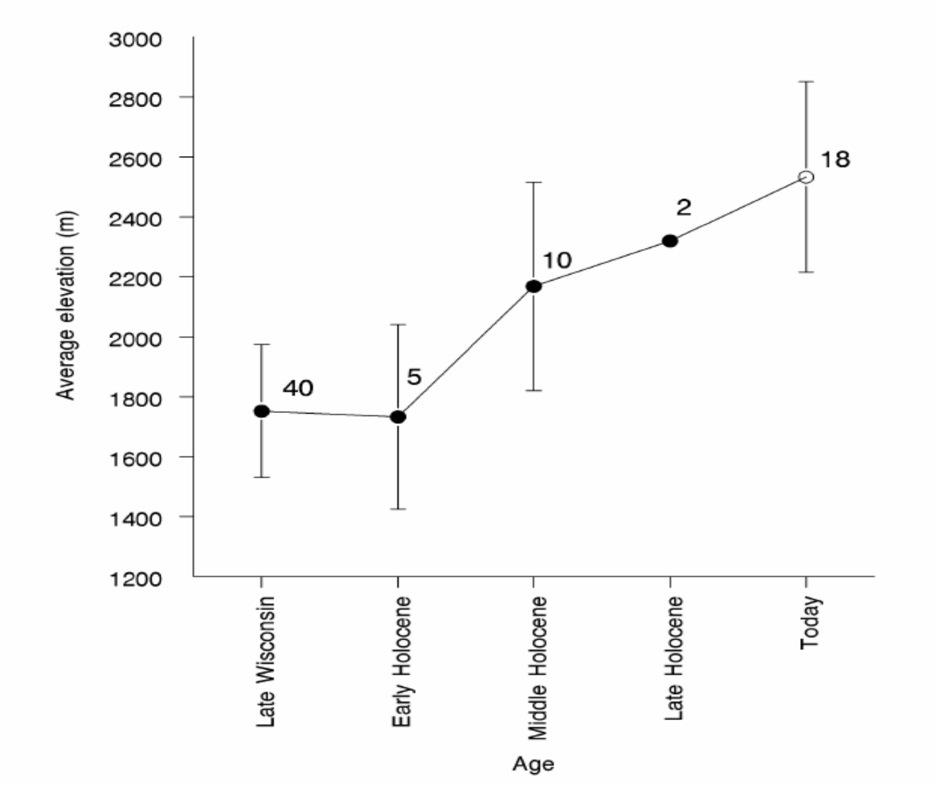
3. Observed Impacts to the American Pika from Global Warming

Because of the high thermal sensitivity of pikas, temperature appears to be one of the most important climate variables affecting pika distributions and population persistence. Pika scientists have attributed pika population extirpations in the past century to rising temperatures due to global warming, and therefore, continuing warming poses a significant threat to the American pika. Because average temperatures decrease with increasing elevation and latitude, many changes in American pika distributions have been documented at low elevations and at the southern boundaries of the American pika range. In California, ongoing work in Yosemite National Park has recorded the recent disappearance of low-elevation pika populations. The most detailed work completed to date on the impact of global warming on the American pika is from the Great Basin. Because studies have been conducted on both the impacts of pre-historic climate shifts on pika distribution and persistence (Grayson 2005) and on the ongoing impacts of climate changes over the past few decades (Beever et al. 2003), the Great Basin research provides an informative context for understanding how climate change impacts the American pika.

Historic Population Extirpations and Climate Change

Grayson (2005) examined pre-historic pika specimens including bones, teeth, and fecal pellets from archaeological and paleontological sites and woodrat middens within the Great Basin and extracted the location, elevation, and age of all such specimens from the literature. Using this data from 72 pika populations, Grayson (2005) calculated the average elevation of Great Basin pika populations through time as illustrated in Figure 2: "[i]n sum, the history of Great Basin pikas during the last 8000 years or so can be seen in part as a relentless loss of lower elevation populations, creating the extremely patchy, and generally high elevation, distribution seen today (Grayson 2005: 2107)."

Figure 2: Changing elevations of pika populations in the Great Basin through time. Solid circles represent now-extinct pika population data and open circle represents minimum elevations for extant populations reported in Beever et al. (2003).[3] Source: Grayson (2005: 2109).



Between 40,000-7,500 years ago, the average elevation of pika populations was 1,750 meters (5741 ft) (Grayson et al. 2005). During the Middle Holocene from *c.* 7,500-4,500 years ago, the climate became hotter and drier, and the average elevation of these populations rose 435 meters to 2168 m (7,112 ft). This increase in elevation reflects the extinction of the remaining

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[3] Dates for time periods used in Grayson (2005) are as follows: late Wisconsinian *c.* 40,000-10,000 radiocarbon years ago; early Holocene *c.* 10,000-7,500 years ago; middle Holocene *c.* 7,500-4,500 years ago; late Holocene *c.* 4,500-200 years ago.

low-lying pika populations across much of the Great Basin (Grayson 1993, 2000, 2005). The average elevation of the 25 pika populations that survived into the 20th century (as reported by Beever et al. (2003)) was 2,381 m (7,812 ft), and the average elevation of the 18 populations that survived into the 1990s was 2,533 m (8,310 ft) (Grayson 2005). Beever subsequently re-surveyed and reported the extirpation of three additional Great Basin pika populations in the 2000s (Krajick 2004), resulting in an increase in elevation of remaining extant populations to 2665 m (8743 ft) (Shwarz 2005). Grayson (2005) concluded that increasing temperatures have caused the range of pika populations to move up-slope, as occupied habitat became unsuitable.

Grayson (2005) also calculated the distance between now-extinct pika populations and extant populations as a measure of pika range constriction due to climate change. During the late Wisconsinian, now-extinct pika populations were located an average of 170 km (105 miles) from the nearest extant population, but by the late Holocene, this distance had declined to about 30 km (18 miles):

> These results join analyses of very different sorts (McDonald & Brown, 1992; Beever et al., 2003) to suggest that the future of pikas in the Great Basin under conditions of global warming is markedly insecure. In addition to providing this subjective lesson, however, they provide a deeper historical context for the important analysis of pika extirpation provided by Beever et al. (2003)….Instead, combined with the results of their important work, the prehistory of pikas in the Great Basin makes it fairly clear that their conclusion that "current anthropogenic influences…may have combined with factors operating over longer timescales (e.g. climate, habitat area) to produce fairly rapid extirpations of pikas in the Great Basin (Beever et al., 2003, p. 50) is in need of some minor modification. The prehistoric record of these animals leaves no doubt that anthropogenic influences have combined with these other variables to produce the diminished distribution that marks Great Basin pikas today. The impact that prehistoric non-anthropogenic factors have had on those animals makes controlling our current impacts on them all that more important (Grayson 2005: 2108).

Recent Population Extirpations and Global Warming

Two recent studies of pika population persistence in California and the Great Basin have found that pika populations have been extirpated from lower elevation sites over the past century, resulting in an upslope range shift in both regions. Both studies conclude that increased temperatures provide the best explanation for low-elevation population extirpations.

In California, the Grinnell Resurvey Project resurveyed the terrestrial vertebrate fauna at 21 sites in Yosemite National Park between 2003-2006 that were originally surveyed by Grinnell and colleagues between 1911-1920 (Moritz 2007). These surveys resulted in sufficient data to statistically detect elevational shifts for 36 small mammal species over the ~90 year period and to compare shifts on both eastern and western mountain slopes for 14 species, including the American pika. The pika was one of several high-elevation species to show an upward range shift and one of four species to show substantial range contractions on *both* eastern and western slopes. The pika range contracted by 349 m (1145 ft) on dry eastern slopes by 497 m (1631 ft) on western slopes (Moritz 2007). Temperatures in Yosemite National Park have increased by 3°C (5.4°C) over 100 years, which is much greater than the mean increase in California temperatures over the same period (Moritz 2007). Moritz (2007) attributes the range shift in the pika and other high elevation species to these temperature increases:

> The most likely cause of contractions of the high elevation species and at least some of the upwards expansions of formerly lower elevation taxa, is effect of increased temperatures (Moritz 2007: 36).

Strikingly, range contractions involved mostly mid- to high-elevation mammal species like the pika. Range contractions were also more numerous (17 of 24 cases) and of higher magnitude than were range expansions (7 of 24 cases) which involved mostly low-elevation species (Moritz 2007). Fourteen species lost over 30% of their range and eight species lost over 50% of their elevational range (Moritz 2007). Overall, mammal species' ranges in Yosemite National Park increased in their lower and upper elevation limits by 500-600 m (1640-1969 ft) in the past 90 years which is roughly as expected given the 3°C (5.4°F) temperature increase (Moritz 2007).

In a similar study, Beever et al. (2003) documented the extirpation of six of twenty-five pika populations (24%) in the Great Basin during the 20th century and found significant evidence that global warming has caused or contributed to these extirpations. Beever et al. (2003) conducted exhaustive surveys between 1994-1999 at 25 sites where pika populations had been recorded in the early to mid-20th century (55-86 years ago), and collected data on climatic, biogeographic, and human disturbance factors that might explain population persistence. At three of the six extirpated sites (Ruby, Desatoya, and Hart Mountains), pika populations were extirpated from low-elevation areas but remained extant in high elevation areas that were in close proximity (Beever et al. 2003). For example, in the Ruby Mountains, Nevada, pikas recorded at 2,375 m (7792 ft) in 1956 could only be found at higher elevations above 2,743 m (8999 ft) in the 1990s (Beever et al. 2003).

The elevation of talus habitat, total habitat area in the mountain range, and the distance to primary roads were the best predictors of pika population persistence (Beever et al. 2003). The maximum elevation of talus habitat at each site predicted pika persistence better than any other climate-related variable (Beever et al. 2003). Population persistence was greatest at sites with high-elevation talus habitat, presumably because high-elevation sites are cooler and facilitate upward migration of pika populations. In contrast, extirpated populations were located at significantly lower elevations and were associated with drier, hotter climate conditions. Extirpated sites received 19.6% less annual precipitation and had average daily maximum temperatures 7.7-10.2% higher than those of extant sites during June, July, and August (Beever et al. 2003). The effects of temperature on pika population persistence are highlighted by Beever et al. (2003: 48):

> Our finding that maximum elevation of talus habitat occurred in all of the 9 highest-ranking (yet none of the 8 lowest-ranking) models for persistence in information-theoretic analyses … suggests that thermal effects have influenced recent persistence trajectories of Great Basin populations of pikas. Thus, warmer temperatures seem likely to be contributing to apparent losses that have occurred at a pace significantly more rapid than that suggested by paleontological records. Maximum elevation of talus at local and mountain-range scales relates to climatic influence because it denotes how far up-slope pikas can migrate in relatively contiguous taluses under increased temperatures. Importance of thermal biology

> is supported more forcefully by the fact that extirpations occurred in 3 low-elevation areas in close proximity to high-elevation populations that remained extant…

Amount of talus habitat in the range was also a strong predictor of population persistence. Pika populations in mountain ranges having moderate or large amounts of talus survived in 17 out of 18 instances (Beever et al. 2003). Beever et al. (2003) suggest that pika populations that are restricted to mountain ranges with minimal habitat have lower persistence because rescue (i.e. recolonization) from nearby populations is less likely and because these populations are more likely to be small and hence vulnerable to stochastic events and small-population risks. Small, declining populations are prone to entering an "extinction vortex" where losses of genetic diversity, environmental and demographic stochasticity, and Allee effects interact to prompt further declines (Gilpin and Soulé 1986). In support, Smith (1980) found that pika population extinctions in the California Sierra Nevada occurred in small or medium-sized patches. Unfortunately, rising temperatures from global warming are likely to reduce areas of habitable talus, further diminishing the size of pika populations and increasing their vulnerability to extinction.

Beever et al. (2003) warn that global warming may also operate in cumulative and synergistic ways with anthropogenic influences, such as grazing pressure and human disturbance, to accelerate pika population declines:

> Pikas in the Great Basin appear to have undergone significant losses (>25% of historic sites) during the last half century. The inclusion of some anthropogenic as well as natural variables in models selected using AIC methods in this exploratory analysis suggests that current anthropogenic influences (i.e., grazing status, proximity to roads) may have combined with factors acting over longer timescales (e.g., climate, habitat area) to produce fairly rapid apparent extirpations of pikas in the Great Basin (Beever et al. 2003:50).

Finally, the fact that isolation from Sierra Nevada or Rocky Mountain "mainland" pika populations did not appear to be important in pika extirpations suggests that migration of pikas between mountaintop islands is not currently happening (Beever et al. 2003; Beever 2002). This suggests that, at least for Great Basin populations, metapopulations may be more vulnerable to extinction due to the absence of movement among habitat patches.

Between 2003-2007, Beever resurveyed Great Basin pika populations and found additional population extirpations and an increased pace of population loss since the 1990s (Erik Beever, personal communication, 8/10/07). As of 2004, nine of the 25 (36%) Great Basin populations were extirpated (Krajick 2004). These population extirpations have increased the pika elevational limit by at least another 132 m (433 ft) (Shwarz 2005).

In a second study, Beever (2002) provides further insights on the relationships between pika population persistence and climate conditions in lower elevation regions. Beever (2002) conducted pika population surveys at Craters of the Moon Monument in central Idaho and Lava Beds National Monument in northeastern California ("Craters," and "Lava Beds," respectively), where pikas have historically occurred at lower elevations than predicted by the latitude-elevation relationship found among historic pika population sites in the Great Basin. Elevations at Craters range from 1,590-1,990 meters (5,217-6,529 ft) and elevations at Lava Beds from 1,230-1,650 meters (4,036-5,414 ft), and climate conditions are relatively hot and dry. Beever (2002) re-surveyed locations in Craters and Lava Beds in July, 1995 where pikas had been observed in previous decades to determine if pikas still persisted, and if so, to explore potential mechanisms which have allowed them to do so in unusually harsh conditions. Beever (2002) searched 15 locations of historic and potential pika habitat in Lava Beds, eight of which had historic occupation records, and 12 locations in Craters, four of which had historic occupation records.

At Lava Beds, Beever (2002) found pikas at five of the eight localities where they had previously been reported, and at four of seven localities where no historic records existed. At Craters, Beever (2002) found pikas at three of four localities at which they had previously been reported, and at six of eight sites for which no historic records existed. Beever (2002) reported that the occupied habitats at Craters and Lava Beds experience climate conditions that were an estimated 18-24% drier annually and 5-11% warmer during the hottest months of the year than were climates at sites where pikas have been extirpated from the Great Basin.

Beever (2002) explains the persistence of pika populations in these hotter, drier low-elevation sites largely as a function of the complex physical structure of the habitat, the large habitat extent, and accessibility of food resources. In both monuments, the rocky volcanic habitat is interlaced with tubes, caves, and deep, complex lava formations that provide pikas with relatively cool refugia during the hottest times of the year (Beever 2002). At a fine scale, pikas were associated with microtopography such as rocks large enough to provide space for subsurface movement and tunneling. Second, pikas occupied large, continuous areas of volcanic habitat that were interconnected as opposed to isolated habitat pockets, allowing for easier movement. Third, pikas disproportionately used areas with average or greater-than-average amounts of vegetation within distances comparable to the dimensions of the home range, meaning that food resources were relatively close. Overall, the unique microclimate and habitat characteristics of these low elevation sites appear to allow pika population persistence. Beever (2002) notes that measuring the temperature regimes that pikas experience throughout the day and year may provide further insights into their persistence (Beever 2002).

Beever (2002) suggests that the close proximity of occupied sites to population strongholds (facilitating population rescue) and the relative inaccessibility of the volcanic habitat to humans (low human disturbance) may further support pika population persistence at these monuments. While Beever (2002) notes that this research does not provide conclusive understanding of the degree to which multiple factors influence pika persistence, he highlights the importance of the interactions between climate change, habitat degradation, and human disturbance:

> Persistence of pikas, at least in the interior Great Basin, appears to be a function of extent of habitat, distance to primary roads, and maximum elevation of habitat to which pikas can migrate (which should dictate pikas’ ability to respond to climate change). Additionally, pika population size relates to the presence of livestock grazing in some cases. Therefore, management actions may hold great importance for pika persistence. For most species, persistence depends critically on the amount, spatial distribution, and quality of appropriate habitat. Although removal or physical degradation of lava and talus habitats are not likely over

> ecological time scales, habitat quality for pikas may be compromised by the following: consistently higher ambient temperatures (e.g., due to climate change); altered composition of forbs and grasses in and adjacent to lava flows (e.g., because of altered fire regimes, exotic species, or uncharacteristically intense levels of grazing at flow margins); and significant fragmentation of lava habitats (e.g., road construction). Pika persistence at low-elevation sites may also be affected by disturbance or alteration of pika habitats by humans or livestock (e.g. nutrient deposition by livestock in large caves, human disturbance of hay piles)….(Beever 2002: 29).

4. Projected Changes in Climate Conditions in the Pika Range

Because hard data are not available for events that have not yet occurred, the future level of society's greenhouse gas emissions and the consequences for our climate must be projected. Since the Third Assessment Report, the IPCC has performed an unprecedented internationally coordinated climate change experiment using 23 models by 14 modelling groups from 10 countries to project future climate conditions. This large number of models that range from simple to complex, running the same experiments, provides more accurate quantification of future climate conditions, the importance of different model parameters, and the uncertainty in the results. For projecting future climate change, the model experiments used an array of different emission scenarios. These include three of the six Special Report on Emissions Scenarios ("SRES'), B1, A1B, and A2, that represent low, medium and high greenhouse gas growth scenarios during this century, respectively. In addition, experiments included scenarios with CO_2 doubling and quadrupling and scenarios with different levels of greenhouse gas mitigation, including (1) constant composition commitment scenarios in which greenhouse gas concentrations are fixed at year 2000 levels, (2) zero emission commitment scenarios in which emissions are set to zero in the year 2100 and (3) overshoot scenarios in which greenhouse gas concentrations are reduced after year 2150 (Meehl et al. 2007).

The IPCC has projected an average of 1.1-6.4°C (2-11.5° F) of additional warming by the end of this century based on the SRES scenarios of future greenhouse gas emissions (Solomon et al. 2007). Specifically, in the pika range in the western United States, average temperatures are projected to rise by 4.9–7.1°C (8.6-12.7°F) during the winter and by 2.7–4.3°C (4.8-7.7°F) during the summer by the end of the 21st century (Smith et al. 2001). Heat waves will be more common, more intense, and longer lasting with some of the greatest increases in intensity occurring in the western U.S. (Christensen et al. 2007). In addition, precipitation, snowpack, and snowmelt are predicted to change in ways that will impact the American pika and the vegetation it depends on.

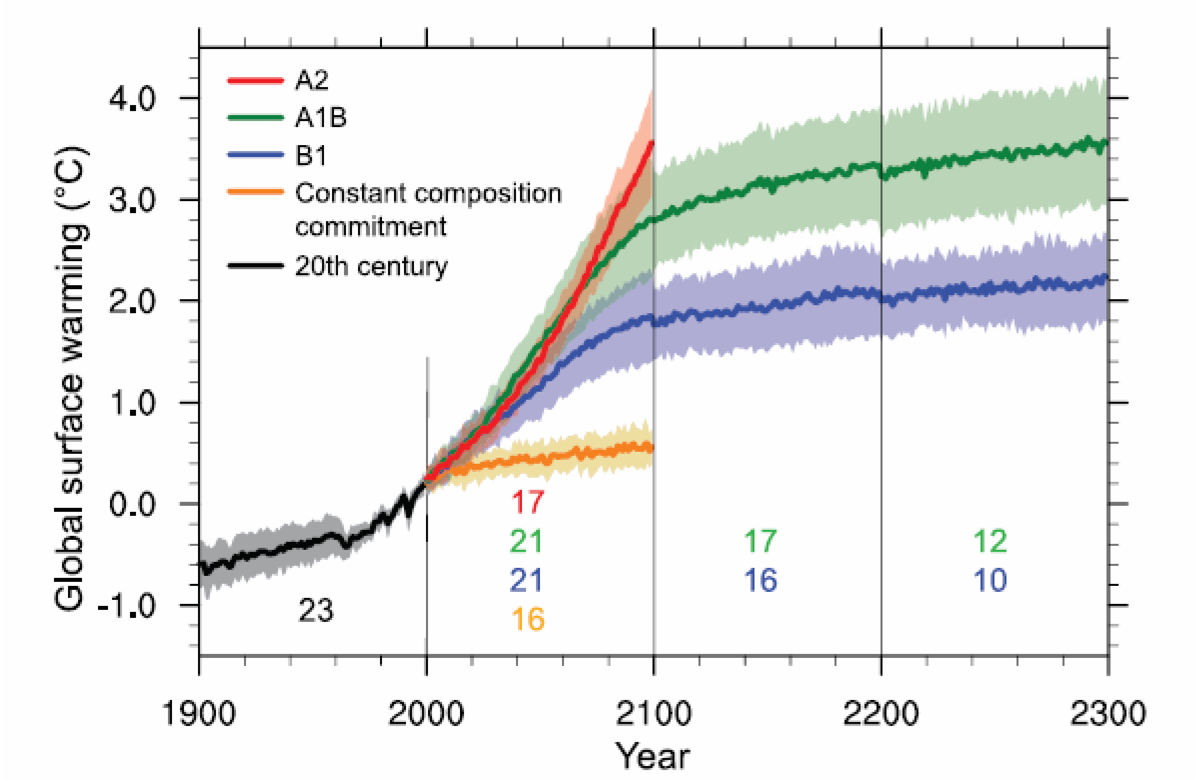
Changes in precipitation in the western U.S. are projected to differ across regions and seasons (Christensen et al. 2007). Precipitation is predicted to decrease during the summer in the southwest and increase during the winter in the northwest (Christensen et al. 2007). Although mean precipitation in the southwestern U.S. is projected to be reduced (Christensen et al. 2007), the intensity of precipitation events and flooding will increase throughout the west due to the higher water-holding capacity of warmer air. For example, Leung et al. (2004) found that extreme precipitation events during the winter will increase in the Cascades, Sierra Nevada, northern Rockies, and British Columbia by 10-20% by 2040-2060. Overall, longer dry periods will be interspersed with heavy precipitation events, and droughts will increase in frequency. Of importance for the pika, droughts could result in broad, regional vegetation die-offs and through a positive feedback mechanism, increase the present-day land area experiencing severe droughts from 1% to 30% by the end of the century (Christensen et al. 2007).

Snowpack is thought to be critical in providing pikas insulation against cold weather during the winter months (Smith 1978). Although forecasting climate change in mountainous regions is challenging because of complex topography, general climate models and finer-scale regional models have consistently predicted the continued reduction in snowpack in the mountainous areas of the western U.S. (Christensen et al. 2007). Snowpack will continue to decrease because autumn snowfall will be delayed and more winter precipitation will be delivered as rain instead of snow (Christensen et al. 2007). On average, the snowline is predicted to rise by 150 m (492 ft) for each 1 ºC (1.8°F) increase in temperature, and these rises are likely to be greater at lower elevations (Christensen et al. 2007).

Warming will also continue to cause earlier seasonal runoff of mountain snowpack in the western U.S. (Christensen et al. 2007, Vicuna and Dracup 2007). Using a regional model, Leung and Ghan (1999) found that rivers and streams in western North America will continue to shift to earlier snowmelt timing. Earlier runoff is likely to produce increased winter flooding, lower summer moisture, and reduced summer river flows (Christensen et al. 2007), all of which will affect vegetation. Of importance for pikas, lower summer moisture may cause the earlier dessication and die-off of mountain plants. Because plants in Mediterranean climates such as California's are highly sensitive to drought, the overall summer productivity of plants is likely to decrease, lowering food resources during the critical pika haying period (Cayan et al. 2006).

Finally, of importance to the persistence of the American pika, global temperatures will continue to rise in the 21st century regardless of the mitigation measures adopted (Figure 3) (Meehl et al. 2007). Past anthropogenic greenhouse gas emissions have altered the energy balance of the earth and committed us to future warming even if greenhouse gas emissions were stabilized immediately. Due to the lag time in the climate system, this warming commitment equates to additional warming of 0.6° C (1° F) that is already "in the pipeline," even absent additional greenhouse gas emissions (Hansen et al. 2005). In concordance, the IPCC multi-model climate change commitment experiments indicate that if greenhouse gases were stabilized for 100 years at year 2000, a further warming of 0.5°C (0.9°F) would occur in the 20th century (Meehl et al. 2007). Even the model that uses the lowest emissions scenario and predicts the lowest levels of warming in response to greenhouse gas concentrations (the SRES B1 scenario) projects a 1.79°C (3.2°F) temperature rise in by the end of this century, which is more than double the warming that occurred in the last century (Meehl et al. 2007).

Figure 3. Multi-model means of surface warming (relative to 1980-1999) for the scenarios A2, A1B, and BI, shown as continuations of the 20th century simulation. Values beyond 2100 are the stabilization scenarios. Source: Meehl et al. (2007: 762).



Climate Change in California: the Sierra Nevada and Cascades Pika Habitat

Regional climate models embedded in the global climate models better capture climate conditions in topographically complex areas such as California and have allowed the prediction of climate change at finer scales, permitting more accurate forecasting of how climate change will affect the American pika. These regional models indicate that changes in temperature and precipitation will be heterogeneous by season and region in California, with some of the greatest changes occurring in the montane pika habitat of the Sierra Nevada. Depending on the emission scenarios used, general circulation models project increases in temperature of 1.7-5.8 °C (3-10.4°F) (Cayan et al. 2006) and 2.5-9 °C (4.5-16.2°F) (Vicuna and Dracup 2007) by 2100 in California. Using a regional climate model under a doubling of pre-industrial CO_2 concentrations (280 to 560 ppm), Snyder et al. (2002) found that, annual temperatures across California would increase by 1.4-3.8°C (2.5-6.8°F) and annual precipitation would increase by 23% in northwest California with little or no change in precipitation to the south, similar to projections for the western U.S. One of the most important findings of this regional model for the American pika in California was that temperatures were projected to increase the most in the higher elevations of Sierra Nevada, rising by as much as 6.3 °C (11.3°F) in April and 9.2°C (16.5°F) in May. In addition, the central Sierra Nevada would become significantly drier and accumulate significantly less snowpack. Specifically, while spring precipitation was not expected to change in the southern Cascades, spring precipitation was projected to decrease by

67% in the central Sierra Nevada (Snyder et al. 2002). Snow accumulation was projected to decrease by nearly 100% in April in the central Sierra Nevada (Snyder et al. 2002). Bell et al. (2004) also used a regional climate model to project climate change in California under doubled CO_2 concentrations and projected increases in extreme temperature events, more prolonged hot spells, and increased minimum and maximum diurnal temperatures.

In the Sierra Nevada and southern Cascades, warmer temperatures will reduce the annual snowpack and result in increased winter runoff and earlier spring snowmelt, similar to projections for the western U.S. (Vicuna and Dracup 2007). Snowpack in the Sierra Nevada is expected to decrease by 30-90% by the end of the century (California Climate Change Center 2006). Spring and summer streamflows are projected to decline by as much as 25% by 2050 and 55% by the end of the century (duVair 2003). Although earlier studies suggested that the mid-altitude basins of the northern Sierra Nevada would be most affected by climate change, more recent studies indicate that the higher elevations of the southern Sierra Nevada will also be heavily impacted by the combined effects of increasing temperatures and decreasing precipitation (Vicuna and Dracup 2007).

5. Future Impacts of Global Warming on the American Pika

The American pika is extremely sensitive to changes in temperature which is reflected in its restricted distribution principally in upper-elevation talus fields. Because it does not hibernate but depends on its haypile for over-winter survival, the pika is also extremely sensitive to changes in the abundance and composition of vegetation surrounding its talus habitat. In the following section, we discuss the ways that projected changes in climate conditions will affect the American pika in California, including both direct effects from thermal stress and indirect effects from changes in vegetation, talus habitat, interactions with predators, and disease prevalence.

For the American pika in California, global warming has resulted in temperature increases that appear to be exceeding the thermal limits of pika at lower elevations and that are projected to be particularly severe in montane regions in the coming decades, committing the pika to further population declines and an upslope retreat. Additionally, the acceleration in snowpack loss in the Sierra Nevada and southern Cascades is removing the protective insulation of snow cover, leaving the pika more vulnerable to thermal stress during winter. Smith (1978) and Beever et al. (2003) discuss four ways by which thermal stress impacts pika populations:

- Increasing summer temperatures projected for the Sierra Nevada and Cascades may make talus habitat inhabited by pikas so hot that the species can no longer survive (Beever et al. 2003). Summer temperatures may increase more than 4.3°C (7.7°F) in California during this century (Smith et al. 2001) and may be even more extreme at high elevations (Snyder et al. 2002). Given the pikas's low lethal temperature limit of just 3°C (5.4°F) above its core body temperature, the pika may no longer be able to thermoregulate during summer by seeking out cool, moist refuges amongst the rocks. This is particularly likely where the talus is composed of small, similarly sized rocks that provide fewer cool crevices (Beever et al. 2003). Furthermore, predicted increases in the frequency and duration of heat waves will place the pika under more thermal stress during the critical summer haying period.

- Increasing summer temperatures and heat-wave events may reduce the pika's ability to forage midday, perhaps preventing pikas from gaining sufficient body mass and storing enough vegetation in their haypiles to successfully overwinter (Beever et al. 2003). Pikas have higher energetic demands than other montane mammals, in part because they do not hibernate. They require enough time to forage to fill their stomachs 9 times per day and must make up to 13 haying trips per hour to create sufficiently large haypiles to survive the winter. Since pikas curtail their foraging activities during midday in hotter regions (Smith and Weston 1990), it is likely that increasing temperatures will reduce the pika's diurnal foraging abilities.

- Temperature appears to be the primary environmental factor determining initial success of dispersing juveniles (Smith 1978). Warmer temperatures may affect the dispersal success of juveniles during the summer (1) if they are not able to move far enough to access suitable habitat patches due to thermal stress or (2) if they cannot make adequate winter haypiles at their newly colonized site because higher temperatures lead to earlier dessication of vegetation (Smith 1978). Since juveniles are the primary age group that disperses, they are responsible for recolonization of habitat patches. Lower success of juvenile dispersers may place pika metapopulations at higher risk of extinction when patches are not recolonized or when patches experiencing population declines are not rescued. For example, a study of pikas at Bodie, California, at the lower edge of the altitudinal range of pika in that area (2,500 m, 8202 ft) found that warmer temperatures severely limited successful juvenile dispersal (Smith 1974a). Even short distances (<300 m, 984 ft) appeared to effectively inhibit successful colonization of suitable habitat patches (Smith 1974a).

- Because pikas are active throughout the winter, they are sensitive to changes in snow cover. Snowpack appears to provide protective insulation for the American pika during the coldest winter conditions, and years of early snowmelt have been associated with higher over-wintering mortality in California (Smith 1978). Snowpack may decrease by up to 90% in the Sierra Nevada by the end of the century (Cayan et al. 2006) and snowmelt has already shifted up to a month earlier (Vicuna and Dracup 2007). These shifts to ever-reduced snowpack and earlier snowmelt may result in higher pika mortality during winter (Smith 1978).

Overall, higher temperatures, heat waves, lower snowpack, and earlier snowmelt, all of which are currently occurring and which are predicted to increase, will make currently occupied pika habitat climatically unsuitable in the future. Even if the area of talus habitat does not change, pikas will lose habitat as it becomes thermally unsuitable for supporting pika populations. In addition to increasing thermal stress, global warming may impact pika populations by altering the abundance and composition of the plant species they depends on, reducing the extent of alpine meadow and talus habitat, and changing interactions with predators and disease. Below we discuss each of these threats:

Vegetation change

Of foremost concern for the American pika in California, the hotter and drier conditions projected for montane regions could change the relative abundance and composition of plants surrounding the talus areas inhabited by pikas to a mix of plant species with which pikas did not co-evolve, to species which are less favorable for pikas, or which cannot support the pika at all (Beever et al. 2003). Montane plants species will respond individually to changing climate conditions, and projected increases in temperatures, droughts and floods, reduced snowpack leading to ‘false spring’ conditions, and earlier seasonal runoff may significantly alter the composition, biomass, water content, reliability, and phenology of vegetation in alpine habitat. Pikas appear to select plants that have a significantly higher caloric, protein, lipid, and water content than non-selected plants (Smith and Weston 1990), and it is possible that alpine plant community could shift to a suite that is less suited to pika nutritional needs. Additionally, rising summer temperatures coupled with increasing summer dryness may lead to the earlier dessication of vegetation and curtail the pika’s ability to accumulate a sufficient summer haypile for surviving winter months (Hafner 1994). In hot, low-elevation environments in California, summer dessication already limits the length of the summer season when hay can be collected (Smith 1974b).

Secondly, the abundance of pika forage plants is likely to decline with the loss of the alpine and subalpine meadows that pika depend on. Average annual temperature is a key variable that determines plant community composition across the elevation gradient of the Sierra Nevada and Cascades (Bunn et al. 2005). As temperatures rise, alpine and sub-alpine plant communities will shrink as the timberline moves up and meadows are replaced by the upward expansion of mixed conifer forests (Bunn et al. 2005). Alarmingly, pine and sub-alpine plant communities could decline by up to 40-50% by mid-century (Bunn et al. 2005). The range of potential pika habitat will become increasingly smaller in area and restricting pika populations to ever-more isolated mountain-top habitat islands (Peters and Darling 1985).

A model developed by McDonald and Brown (1992) to predict extinctions in the Great Basin under changing climate and vegetation conditions provides some insight on the losses of pika populations that might be expected as a result of temperature rise and associated habitat shifts in California. This quantitative model predicts both the number and identity of montane species that would become extinct under an assumed scenario of changing climate and vegetation. The model is based on the fact that the isolated montane mammal faunas of the Great Basin are highly predictable in two respects: (1) there is a high, positive correlation between number of species and the area of the mountaintop above 2280 m (7480 ft) elevation, which is the approximate lower limit of woodland habitat, and (2) the faunas of the different mountain ranges comprise nearly perfect nested subsets with respect to species composition in that each fauna of successively higher species richness tends to contain virtually all of the species in more species-poor faunas plus one or more additional species (McDonald and Brown 1992). McDonald and Brown (1992) made the following four assumptions: (1) a 3°C (5.4°F) increase in temperature and no change in precipitation; (2) a 500 m (1640 ft) upward shift in vegetation zones on Great Basin mountains will be caused by this temperature increase; (3) the response of each boreal mammal species to climate and vegetation can be predicted from its present ecological associations and geographic distributions; and (4) there is no migration by boreal species across the desert valleys separating mountain ranges, which is an assumption that almost certainly holds for pikas. Based on these assumptions, McDonald and Brown (1992) estimated that the lower border of the piñon-juniper woodland would shift upward by 500 m (1,640 ft), and they used the resulting amount of remaining habitable area to predict the remaining species richness. The predicted species richness was then rounded off to the nearest integer, and this value was used, along with the highly ordered structure of the species-by-mountain matrix, to predict the identity of the species most likely to go extinct (McDonald and Brown 1992).

Using this model, McDonald and Brown (1992) predict that individual mountain ranges will lose 35-96% of the area of montane habitat, 9-62% of montane mammal species by mountain range in the Great Basin, and three to fourteen species regionally. Of great concern, the pika would disappear from five of six mountain ranges where it existed as of 1992 (McDonald and Brown 1992). The 3°C (5.4°F) increase in temperature used in the model is well within the range of the 1.1 to 6.4°C (1.9-11.5°F) of temperature rise within this century projected by the IPCC in the 2007 Fourth Assessment Report (Solomon et al. 2007), indicating that potentially catastrophic losses of pika populations could occur within the foreseeable future.

Grayson (2005) concludes that findings for the Great Basin populations indicate that future of pikas under conditions of global warming is "markedly insecure." As stated by Grayson (2005): "Prehistoric alterations in the distribution of pika populations in the Great Basin were driven by climate change and attendant impacts on vegetation. Today, Great Basin pikas contend with both climate change and anthropogenic impacts and thus may be on the brink of extinction." Grayson (2006) concluded:

> We know that the Holocene history of pikas in the Great Basin has been characterized by ever-increasing lower altitudinal limits and thus of ever-decreasing population numbers, trends undoubtedly caused by climate change. Given that this trend has continued in recent decades, it is very possible that these animals—the global warming canaries of western North America—are facing extinction unless strong action is taken to reduce anthropogenic impacts on them (Grayson 2006: 2986).

Talus area declines

Climate change may affect the formation and maintenance of the talus habitat that pikas depend on by diminishing the prevalence of permafrost in alpine regions. Through freeze-thaw dynamics, alpine permafrost is an important force driving the creation of most talus habitats and their maintenance by discouraging plant invasions into talus fields (Hafner 1994). Permafrost will continue to decline in the alpine areas throughout the pika range as winter temperatures increase, and the quality of the talus habitat may decline as vegetation encroaches and fills the talus interstices with soil and plant matter (Hafner 1994). Therefore, pika habitat may not only be lost at lower elevations due to thermal unsuitability, but its obligate talus habitat may be degraded at high elevations due to the loss of permafrost.

Interactions with predators

Changing climate conditions may also affect pika interactions with its predators. Weasels are the most effective pika predators because they are able to hunt pika within the talus (Ivins and Smith 1983). Decreased snowpack and earlier snowmelt might allow these predators to access the talus piles more easily during the winter and spring and increase pika mortality.

The predicted shift from montane meadows to woodlands may also give American pikas a disadvantage in detecting its predators. Pikas visually detect predators hunting in their talus and meadow habitats and give a series of alarm calls to alert conspecifics to the presence of these predators (Ivins and Smith 1983). As treelines encroach upward into mountain meadows, saplings may reduce the pikas' ability to visibly detect coyotes and martens that hunt by ambushing pikas foraging in mountain meadows and by targeting dispersing juveniles (Ivins and Smith 1983). Changes in visibility in meadow habitats due to modern industrial forestry practices have been implicated in the high predation rates and dramatic declines of the endangered Vancouver Island marmot (*Marmota vancouverensis*) that also uses montane meadows for summer foraging (Bryant and Page 2005). Bryant and Page (2005) found that marmots occupied clearcuts next to mountain meadows and that the visibility in clearcuts was subsequently reduced by tree succession, leaving marmots more vulnerable to attacks from wolf and cougar predators.

Disease

Projected changes in temperature and humidity may increase disease prevalence and severity in the American pika and its forage plants. Many wildlife and plant pathogens are sensitive to temperature, rainfall, and humidity (Harvell et al. 2002). As the climate has warmed, these pathogens, in many cases, have expanded their ranges northward and upslope because warmer temperatures (1) have allowed their survival and development in areas that were previously below their temperature threshold, (2) increased their rates of development, (3) increased rates of reproduction and biting of their tick, midge, and mosquito vectors, and (4) lowered the resistance of their hosts (Harvell et al. 2002, Parmesan 2006). Of concern for pikas, warming temperatures at higher elevations may increase the prevalence of diseases and disease vectors (ticks, midges, mosquitos), exposing pikas to new diseases or increasing the transmission of existing diseases.

In summary, the pika's high sensitivity to temperature, obligate association with talus habitat, tendency toward philopatry, and low dispersal ability make the species an early sentinel of global warming and place them at extreme risk of extinction from anthropogenic climate change. Under a high warming scenario, the American pika could be extinct in California by the end of this century.

B. Overexploitation

We found no information to suggest that overexploitation is significantly affecting American pika populations at this time.

C. Predation

Potential predators of American pikas include coyotes (*Canis latrans*), longtail weasels (*Mustela fermata*), shorttail weasels (*M. erminea*), and pine martens (*Martes americana*) (Smith and Weston 1990). Weasels are more successful predators than the larger animals because they can follow pikas into crevices among the talus where the larger animals cannot go (Smith and Weston 1990). All American pika skulls found in coyote scats were juveniles, indicating that these young animals are more vulnerable to predation and may be caught while trying to disperse between patches of talus (Smith and Weston 1990). Several predatory birds also co-occur with American pikas, but probably do not take many individuals (Smith and Weston 1990). Although predator dynamics may be altered due to changes in temperature and snowfall, there is currently no evidence of increasing pressure from predation.

D. Other Natural Events or Human-Related Activities

Livestock grazing in the meadows that surround the pika's talus habitat may negatively affect pika by browsing and trampling vegetation important for pika foraging and haying. Beever et al. (2003) found evidence that livestock grazing may impact pika populations. All six extirpated sites were grazed, indicating that there is a significant negative correlation between grazing and population persistence (Beever et al. 2003). Although the grazing variable was absent in the two highest-ranking models explaining the results, the third-ranked model that included grazing still received a considerable amount of support (Beever et al. 2003). However, grazed areas tended to occur at lower elevations where talus habitat was sparser, making it to difficult to the importance of grazing in relation to lower elevation and talus area. Beever et al. (2003) conclude that cattle and horse grazing within 20-50 m of talus may negatively influence pikas. Pikas are central-place foragers that graze most intensely nearer to talus to reduce energetic costs and predation risk, and therefore, the vegetation in the radius around talus is particularly important.

However, these researchers state that the potential threat from grazing should be cautiously interpreted, for several reasons. First, the solid nature of talus rock may prevent direct interaction between large herbivores and pikas on the talus. Outside the talus, steep terrain or rock formations may largely prevent livestock or feral horses from accessing the talus margins so that grazing of very broad areas may correspond only loosely with grazing pressure within 50 m of talus habitat (Beever et al. 2003). Cattle and horses eat mostly graminoids (i.e. grasses and grasslike plants such as sedges and rushes) and pikas are generalist herbivores (Beever et al. 2003). Finally, pika population persistence was not correlated with the number of cattle, ungulate, or horse defecations observed at the sites (Beever et al. 2003).

Despite these caveats, grazing should be considered a potential threat to pikas that can interact in cumulative and synergistic ways with global warming: "Current anthropogenic influences (i.e., grazing status, proximity to roads) may have combined with factors acting over longer timescales (e.g., climate, habitat area) to produce fairly rapid apparent extirpations of pikas in the Great Basin." (Beever et al 2003). In support, researchers in China have attributed the recent dramatic declines of another talus-dwelling pika, the Ili pika (*Ochotona iliensis*), to the interaction between increasing grazing pressure in alpine pika habitats and the loss of low-elevation habitat from rising temperatures due to global warming (Wei-Dong and Smith 2005).

In California, grazing over the past 150 years has been characterized as "excessive," "unsustainable," and detrimental to mountain meadows in the Sierra Nevada, southern Cascades, and the Modoc Plateau, although numbers of sheep and cattle have been reduced (Bunn et al. 2005). Of particular concern, the high mountain meadows used by the pika evolved without the type of grazing pressure caused by livestock (Bunn et al. 2005). The 1996 Sierra Nevada Ecosystem Project (SNEP) found that "over-grazing in mountain meadows is a threat to many rare species that are restricted to these habitats" (Bunn et al. 2005). According to the Forest Service, grazing heavily impacts mountain meadow ecosystems in the Sierra Nevada:

> the riparian and meadow systems are the key livestock forage areas within allotments above 4,000-foot elevations. Studies have shown that 50 percent to 80 percent of the herbage used comes from these meadow systems, which constitute a small percentage (generally less than 5 percent) of the allotment area. In the Sierra Nevada forests, the meadow systems cover an estimated 2 percent of the allotment areas (Bunn et al. 2005: 297).

In addition to grazing, exotic species and altered fire regimes may also alter the composition of forbs and grasses that are important to pika (Beever et al. 2003).

Human disturbance also impacts pika populations. Beever et al. (2003) found that population persistence was negatively correlated with the distance to roads (associated with higher accessibility and human disturbance) and positively correlated with wilderness areas (associated with lower human disturbance). Specifically, this study found a correlation between persistence and greater distances from the nearest road of any type, and the correlation was significantly stronger with greater distance from the nearest primary road (Beever et al. 2003). Additionally, 4 out of 6 sites managed by the Bureau of Land Management were extirpated, compared with 2 out of 8 managed by the U.S. Forest Service and only 1 out of 11 in wilderness areas. However, wilderness area sites had greater habitat availability, making it difficult to distinguish between the importance of wilderness or talus area.

Beever et al. (2003) also found “abundant evidence of direct human influence” at three of six sites that have been extirpated:

> At 1 site, about half of the talus area was excavated and used as a "borrow pit" for road maintenance. At another site, the talus area apparently was used extensively as a dump site. Carvings in aspen tree trunks suggested extensive human use of Smith Creek since at least the 1930's, and we found numerous gun shells on taluses there. (Beever et al. 2003: 45).

Of concern for the pika, the alpine and subalpine habitats inhabited by the pika are sensitive to disturbance and are difficult to restore once they have been degraded by grazing and human disturbance:

> The short growing season, variable precipitation, relatively low primary productivity, temperature fluctuations, high wind speeds, and shallow, weakly developed soils of alpine and subalpine systems can compound the effects of disturbance and make these ecosystems among the most difficult to restore (Beever et al. (2003): 49).

X. Effect of Current Management and Recommended Management Actions

Current management has been inadequate to prevent the decline of the American pika in California, and is inadequate to ensure this animal’s survival in the wild. Management actions for the pika in California are needed in the following areas: mitigating greenhouse gas pollution, facilitating adaptation to climate change, and monitoring pika populations and their habitat. Mitigation of greenhouse gases is essential to slow global warming and ultimately stabilize the climate system while there is still suitable pika habitat remaining. Adaptation actions are necessary to improve existing management and remove threats other than climate change to give the pika a better chance of surviving the period of rapid warming to which we are already committed. Finally, monitoring activities are critical to build upon existing knowledge and track the status of pika populations.

A. Mitigation

In order to limit future warming and preserve suitable pika habitat, the growth of anthropogenic greenhouse gas emissions must be slowed and then reversed, with global emissions ultimately falling to a small fraction of 1990 levels. Because the United States is by far the world's largest greenhouse gas polluter on a cumulative basis, its participation in international efforts is needed in order for such efforts to fully succeed. Unfortunately, the current federal Administration has opposed all mandatory greenhouse gas reductions, and has actively blocked international progress. The U.S. Congress has also not enacted mandatory greenhouse gas reduction legislation. In the absence of federal leadership, state and local governments have taken the lead, and their actions have assumed even greater importance.

California is the world's sixth largest economy and the twelfth largest polluter in its own right, and is also a leader in climate change policy. Many laws and policies adopted first in California are later adopted by other states. As such, greenhouse gas reductions achieved by California and/or California agencies are highly significant, and may lead directly to additional reductions elsewhere. Below we discuss recommended management actions to be taken by the Fish and Game Commission, Department of Fish and Game, the State of California, and the federal government to reduce greenhouse gas pollution. While no single entity can solve global warming on its own, if each jurisdiction does its part, it is not too late to stabilize the climate system and prevent the extinction of the American pika in California.

California Fish and Game Commission Recommended Actions

- Enact a policy pursuant to Fish and Game Code §703 or other authority requiring a quantitative analysis of the greenhouse gas implications of all project reviews submitted to the Fish and Game Commission pursuant to the California Environmental Quality Act or other statutory authority. Require projects' greenhouse gas emissions to be avoided, reduced, or mitigated to the maximum extent practicable.

- Enact a policy pursuant to Fish and Game Code §703 or other authority requiring a quantitative analysis of the greenhouse gas implications of all Fish and Game Commission regulations. Require greenhouse gas emissions to be avoided, reduced, or mitigated to the maximum extent practicable.

- Enact a policy pursuant to Fish and Game Code §703 or other authority to reduce greenhouse gas emissions from Fish and Game Commission activities. Measures could include holding all hearings in locations accessible by public transportation, considering the greenhouse gas implications of all Commission purchases, retrofitting commission offices for the maximum possible energy conservation, installing solar power or purchasing renewable energy for all Commission facilities, allowing telecommuting for Commission staff, and providing solar-powered vehicle charging stations at Commission facilities.

California Department of Fish and Game

- Enact a policy requiring a quantitative analysis of the greenhouse gas implications of all project reviews submitted to the Department of Fish and Game pursuant to the California Environmental Quality Act or other statutory authority. Require projects' greenhouse gas emissions to be avoided, reduced, or mitigated to the maximum extent practicable.
- Enact a policy requiring a quantitative analysis of the greenhouse gas implications of all Department of Fish and Game regulations. Require greenhouse gas emissions to be avoided, reduced, or mitigated to the maximum extent practicable.
- Enact a policy to reduce greenhouse gas emissions from all Department of Fish and Game activities. Measures could include considering the greenhouse gas implications of all Department purchases, including converting Department vehicle fleets to hybrid, plug-in hybrid, and alternative fuels vehicles, retrofitting Departmentoffices for the maximum possible energy conservation, installing solar power or purchasing renewable energy for all Department facilities, allowing telecommuting for Department staff, and providing solar-powered vehicle charging stations at Department facilities.
- Initiate programs to educate the public about the impact of greenhouse gas emissions and global warming on wildlife, and encourage and facilitate greenhouse gas reductions.

California Resources Agency

As a member of the California Climate Action Team, the Resources agency is actively engaged in proactive planning efforts to meet the goals of Governor Schwarzenegger's Executive Order S-3-05, which sets a goal of reducing greenhouse gas emissions as follows: by 2010, reduce emissions to 2000 levels; by 2020, reduce emissions to 1990 levels; and by 2050, reduce GHG emissions to 80 percent below 1990 levels. To date the Resources Agency has identified five management actions within the Department of Forestry, one within the Department of Water Resources, and eleven within the California Energy Commission to reduce greenhouse gas emissions (California Environmental Protection Agency (CalEPA) 2006). The Resources Agency should continue with implementation of all the measures identified. The Resources Agency should also develop additional measures within other Resources Agency Departments, Boards, and Commissions, such as the policies recommended above.

State of California

The State of California has long been a champion of environmental protection and a leader in climate change policy nationally. California has a number of laws and policies that address the critical challenge of slashing California's greenhouse gas emissions. Ongoing efforts as of March, 2006 were summarized by CalEPA (2006:17) and are given in Table 1. Continued implementation of each of these measures, along with all discrete early action measures identified by both the Climate Action Team (California Environmental Protection Agency 2007) and CARB (California Air Resources Board 2007) is recommended, because full implementation of these measures will significantly reduce greenhouse gas emissions and help ameliorate the threat to the American pika.

Table 1. Greenhouse gas emission reduction strategies underway in California. Source: CalEPA (2006:17).

Agency Responsible	**Climate Change Emission Reductions (Million Tons CO_2 Equivalent Gases)**	
Strategies	**2010**	**2020**
Air Resources Board		
Vehicle Climate Change Standards	1	30
Diesel Anti-idling	1	1.2
Public Utilities Commission		
Accelerated Renewable Portfolio Std to 33% by 2020	5	11
California Solar Initiative	0.4	3
Investor Owned Utility Energy Efficiency Programs	4	8.8
Integrated Waste Management Board		
Achieve 50% Statewide Recycling Goal	3	3
Energy Commission		
Building Energy Efficiency Standards	1	2
Appliance Energy Efficiency Standards	3	5
Fuel-efficient Replacement Tires & Inflation Programs	1.5	1.5
State and Consumer Services and Cal/EPA		
Green Buildings Initiative	0.5	1.8
Air Resources Board andCal/EPA		
Hydrogen Highway	Included*	
Total Potential Emission Reductions	**22**	**68**

The California Global Warming Solutions Act of 2006 was signed into law in September, 2006, and is the nation's first mandatory cap on a state's overall greenhouse gas emissions. The California Legislature declared:

> *Global warming poses a serious threat to the economic well-being, public health, natural resources, and the environment of California. The potential adverse impacts of global warming include the exacerbation of air quality problems, a reduction in the quality and supply of water to the state from the Sierra snowpack, a rise in sea levels resulting in the displacement of thousands of coastal businesses and residences, damage to marine ecosystems and the natural environment, and an increase in the incidences of infectious diseases, asthma, and other human health-related problems.* (Cal. Health and Safety Code § 38501(a))

The Global Warming Solutions Act requires the reduction of greenhouse gas emissions to 1990 levels by the year 2020.[4] *Id.* at § 38550. The law will be implemented through a series of California Air Resources Board (CARB) rulemakings including establishing emission source monitoring and reporting requirements, discrete early action emission reduction measures, and finally greenhouse gas emission limits and measures to achieve the maximum feasible and cost-effective reductions in furtherance of the greenhouse gas emission cap. *Id.* at § 38550. Timely promulgation and adoption of the Global Warming Solutions Act rulemakings is a recommended management action because meeting the Act's reduction targets will significantly reduce greenhouse gas emissions, very likely spur similar reductions in other states or nationally, and help reduce the threat of climate change to the American pika.

Prominent among California's existing laws addressing greenhouse gases, yet to date little utilized, is California's flagship environmental protection statute, the California Environmental Quality Act (California Public Resources Code §21000 et seq., "CEQA"). CEQA requires state and local agencies to assess and reduce to the extent feasible all significant environmental impacts from new project approvals. The CEQA environmental review process is fully established throughout the state, with a proven track record of ameliorating impacts relating to air pollution, water quality and availability, land use, endangered species, and many other aspects of California's environment. This process represents an important opportunity, and also a legal mandate, for cities, counties, and other agencies to consider the greenhouse gas emissions from new projects they approve and then to adopt the many measures available to reduce those emissions. We include full implementation of CEQA with regard to the greenhouse gas emissions from new projects and development as a recommended management action because doing so would significantly reduce greenhouse gas emissions, very likely spur similar reductions in other states or nationally, and help reduce the threat of climate change to the American pika. A blueprint for full CEQA compliance is provided in Nowicki et al. (2007).

United States

As the world's largest greenhouse gas polluter, the participation of the United States is a key component of any successful plan to reduce global greenhouse gas emissions sufficiently to stabilize the climate system and minimize future warming so that the American pika can survive. Recommended management actions at the federal level include the following:

- The United States should immediately ratify the Kyoto Protocol and rejoin international negotiations in support of more ambitious reductions in the post-2012 compliance period.
- The United States Congress should pass, and the President should sign, comprehensive federal legislation capping and then rapidly reducing total U.S. greenhouse gas emissions, such that total emissions fall to 80% or more below 1990 levels by 2050.

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[4] The Global Warming Solutions Act states that "[n]othing in this division shall relieve any person, entity, or public agency of compliance with other applicable federal, state, or local laws or regulations, including state air and water quality requirements, and other requirements for protecting public health or the environment." Cal. Health and Safety Code § 38592(b); *see also* "Nothing in this division shall limit the existing authority of a state entity to adopt and implement greenhouse gas emissions reduction measures. Nothing in this division shall relieve any state entity of its legal obligations to comply with existing law or regulation." *Id.* at § 38598.

While there is still time to save the American pika, these mitigation activities must begin immediately. Scientists warn that we are approaching a tipping point beyond which climate feedbacks will greatly amplify the warming from anthropogenic emissions, leading to rapid additional temperature increases and catastrophic climate impacts. Warming of more than 1° C (1.8° F) above year 2000 levels has been defined as "dangerous climate change," with particular reference to species extinction and sea level rise (Hansen et al. 2006, Hansen et al. 2007). The atmospheric greenhouse gas level "ceiling" that must not be exceeded in order to prevent additional warming of more than 1° C (1.8° F) above year 2000 levels is 450-475 ppm of carbon dioxide (Hansen et al. 2006). With atmospheric carbon dioxide levels already over 380 ppm and increasing at over 2 ppm per year, and worldwide emissions continuing to increase each year, rapid and substantial reductions are needed to stay below this ceiling.

One path to achieving these substantial emissions reductions is known as the "alternative," as opposed to the "business as usual," greenhouse gas emissions scenario (Hansen 2006, Hansen et al. 2006, Hansen et al. 2007). In the business as usual scenario, carbon dioxide emissions continue to grow at about 2% per year, and other greenhouse gases such as methane and nitrous oxide also continue to increase. In the alternative scenario, by contrast, carbon dioxide emissions decline moderately between now and 2050, and much more steeply after 2050, so that atmospheric carbon dioxide never exceeds 475 parts per million. The alternative scenario would limit global warming to less than an additional 1°C in this century (Hansen et al. 2006, Hansen et al. 2007).[5]

Since the year 2000, however, society has not followed the alternative scenario. Instead, carbon dioxide emissions have continued to increase by 2% per year since 2000 (Hansen et al. 2006, Hansen et al. 2007). This rate of increase itself appears to be increasing (Denman et al. 2007). If this growth continues for just ten more years, the 35% increase in CO_2 emissions between 2000 and 2015 will make it impractical if not impossible to achieve the alternative scenario (Hansen et al. 2006, Hansen et al. 2007). For this reason, it is essential that mitigation activities begin immediately.

B. Adaptation

It is also important to eliminate other threats to pikas that may operate in cumulative or synergistic ways with global warming. Because researchers have found that pika population persistence was negatively correlated with the distance to the nearest road, one recommended management action is to maintain roadless areas within the range of the American pika in California. This action is consistent with California's position on the protection of National Forest System Inventoried Roadless Areas in the State of California (Schwarzenegger 2006). Not only are roadless areas beneficial to pikas, but California has concluded that "[t]he preservation of roadless areas protects both economic and intrinsic values for current and future generations of Californians" (Schwarzenegger 2006). For this reason, California already has an overall goal of ensuring no net loss of Inventoried Roadless Areas acreage within the state

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[5] The "tripwire" between keeping global warming to less than 1°C, as opposed to having a warming that approaches the range of 2-3° C, may depend upon a relatively small difference in anthropogenic greenhouse gas emissions (Hansen et al. 2006, Hansen et al. 2007). This is because warming of greater than 1 °C would likely induce positive climate feedbacks, such as the release of large amounts of methane from thawing arctic permafrost, that will further amplify the warming (Hansen et al. 2006, Hansen et al. 2007).

(Schwarzenegger 2006). Existing wilderness areas should also be maintained, and additional areas designated within the range of the pika in California.

C. Monitoring

Long term studies should be initiated for each of the five subspecies of American pika in California. The Grinnell project and Beever et al. (2003) serve as models for such studies. In order to fully evaluate the relative utility of management actions for restoration or conservation of vulnerable populations in the Great Basin, Beever et al. (2003) suggest manipulative experiments to partition natural variability more clearly from anthropogenic influence. Such studies should be considered in California as well. Moritz et al. (2007) gave detailed suggestions for further monitoring and research:

> The changes of greatest concern relate to the substantial contractions of elevational ranges of the mid-high elevation taxa….A few rather simple continuing surveys, which could easily be implement by Park staff, should be undertaken. For example, all talus between the elevations of 7800 and 9000 feet elevation could be regularly searched (each year or at somewhat longer intervals) for sign of pika (visual sightings, listening for their distinctive calls, searches for active hay piles in the fall, detailed searches for fresh whitewashing on boulders and fecal pellets), especially those historic sites (such as at Glen Aulin) where pika appear to have disappeared. If possible, pika surveys should use the standardized protocol developed by Erik Beever (NPS Great Lakes Netork; erik_beever@nps.gov) so as to contribute quantitative information to the larger picture of the apparent decline of this species throughout its range in the Great Basin….
>
> The extent to which vegetation change at high elevation is affecting alpine species is not clear, but the Park could extend its program of vegetation monitoring to representative habitats for these species using standardized quadrat protocols.
>
> We do not yet understand why some species are fluctuating more than others, but an obvious place to start is to examine physiological traits in free-ranging populations for signs of temperature-related stress. Physiologically-informed spatial modeling could yield useful predictions of change from the Grinnell period to the present, and then potential responses to future climate change. This could then be used to identify critical habitats and to inform future vegetation and fire management in the Park. This is obviously not work that Park biologists would, or could undertake, except in conjunction with partners at academic institutions.
>
> Finally, we would recommend that similar, site-specific resurveys of the small mammal fauna of the Park be undertaken at regular intervals (every 20 years?) so that trend lines can be more clearly delineated and future predictions made with the Grinnell and current data can be tested directly. Because each modern trapline has been georeferenced and a standardized trap effort has been employed, both location of specific sites and use of a common protocol will enhance the

comparisons of future surveys with those we have undertaken, and describe herein (Moritz et al. 2007).

XI. Conclusion

For all the reasons discussed above, Petitioner Center for Biological Diversity requests that the Commission list the American pika as threatened under the California Endangered Species Act ("CESA") throughout its range in California. In the alternative, Petitioner requests that the Commission list the five California subspecies of the American pika as threatened or endangered as follows: the Taylor pika (*O. p. taylori*) as threatened, the Gray-headed pika (*O. p. schisticeps*) as threatened, the Yosemite pika (*O. p. muiri*) as endangered, the Mt. Whitney pika (*O. p. albata*) as threatened, and the White Mountain pika (*O. p. sheltoni*) as endangered.

XII. Availability and Sources of Information

A. Literature Cited[6]

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[6] All references are provided in pdf format on the accompanying compact disk except for those denoted with an asterisk.

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B. Personal Communication Sources

Beever, E., personal communication, 8/10/07, U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, 3200 SW Jefferson Way, Corvallis, OR 97331.

C. Individuals Supporting Petitioned Action

This Petition is submitted on behalf of the Center for Biological Diversity and is supported by our staff, including the authors, and our over 35,000 members.