BEFORE THE SECRETARY OF INTERIOR PETITION TO LIST THE AMERICAN PIKA (*OCHOTONA PRINCEPS*) AS THREATENED OR ENDANGERED UNDER THE UNITED STATES ENDANGERED SPECIES ACT

American pika © Brian Crawford

CENTER FOR BIOLOGICAL DIVERSITY, PETITIONER

OCTOBER 1, 2007

NOTICE OF PETITION

Dirk Kempthorne, Secretary
Department of the Interior
1849 C Street, N.W.
Washington. D.C. 20240

Ren Lohoefener, Regional Director
U.S. Fish and Wildlife Service
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PETITIONER

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Date this 1st day of October, 2007

Pursuant to Section 4(b) of the Endangered Species Act ("ESA"), 16 U.S.C. §1533(b), Section 553(3) of the Administrative Procedures Act, 5 U.S.C. § 553(e), and 50 C.F.R. §424.14(a), the Center for Biological Diversity hereby petitions the Secretary of the Interior, through the United States Fish and Wildlife Service ("USFWS," or "Service"), to list the American pika (*Ochotona princeps*) as a threatened or endangered species because it is in danger of extinction or likely to become so in the foreseeable future in all or a significant portion of its range. We believe that the entire species currently qualifies for listing as threatened. However, because the American pika is comprised of thirty-six recognized subspecies, and several of these subspecies are more immediately imperiled than others, we also formally request that USFWS conduct a status review on each subspecies to determine if separately listing any subspecies as threatened or endangered is warranted. Specifically, we request that the five American pika subspecies that inhabit the Great Basin be listed as endangered due to their small population size, declining population trend, declining range extent, and the substantial long-term threat that global warming poses to their persistence: the Ruby Mountains pika (*O. p. nevadensis*), *O. p. tutelata*, the White Mountains pika (*O. p. sheltoni*), the Gray-headed pika (*O. p. schisticeps*), and the Taylor pika (*O. p. taylori*). In addition, we request that Lava-bed pika (*O. p. goldmani*) and Bighorn Mountain pika (*O. p. obscura*) be listed as endangered due to their small population size, isolation from mainland pika population sources, and substantial ongoing threats to their persistence. Finally, we request that the remaining subspecies be listed as threatened. This petition demonstrates that the American pika and its constituent subspecies clearly warrant listing under the Endangered Species Act based on the five listing factors specified in the statute.

The Center for Biological Diversity ("Center") is a non-profit, public interest environmental organization dedicated to the protection of native species and their habitats through science, policy, and environmental law. The Center has over 35,000 members throughout the United States. The Center and its members are concerned with the conservation of endangered species, including the American pika, and the effective implementation of the ESA.

USFWS has jurisdiction over this petition. This petition sets in motion a specific process, placing definite response requirements on USFWS. Specifically, USFWS must issue an initial finding as to whether the petition "presents substantial scientific or commercial information indicating that the petitioned action may be warranted." 16 U.S.C. §1533(b)(3)(A). USFWS must make this initial finding "[t]o the maximum extent practicable, within 90 days after receiving the petition." *Id.* Petitioners need not demonstrate that listing *is* warranted, rather, Petitioners must only present information demonstrating that such listing *may* be warranted. While Petitioners believe that the best available science demonstrates that listing the American pika as threatened or endangered *is* in fact warranted, there can be no reasonable dispute that the available information indicates that listing the species as threatened *may* be warranted. As such, USFWS must promptly make a positive initial finding on the petition an commence a status review as required by 16 U.S.C. § 1533(b)(3)(B).

TABLE OF CONTENTS

Introduction

The American pika is a small mammal related to rabbits and hares that inhabits high elevation talus fields in alpine and subalpine areas throughout western North America. There are 36 recognized American pika subspecies in North America, 31 of which occur in the United States. Pikas are extremely temperature-sensitive and are restricted to cool, moist microhabitats on higher peaks. In the northern part of its range, the pika is found at elevations from near 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 the high temperatures found at lower elevations (Smith and Weston, 1990). Therefore, near the southern limits of its distributional range, American pikas are rarely found at elevations lower than 2,500 meters (Smith and Weston 1990).

Global warming represents the gravest threat to the long-term survival of the American pika. In the western United States, temperatures have already increased by 1.1–2.8°C (2.0-5.0°F) during the past century (Smith et al. 2001). Beever et al. (2003) documented the extirpation of six of twenty-five pika populations in the Great Basin range of Nevada and Oregon over 55-86 years 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). Overall, in the past century, at least 9 of 25 (36%) of documented Great Basin pika populations have been extirpated and the pika range has shifted upslope by 900 feet. In parallel with trends in the Great Basin, the Grinnell Resurvey Project in the Sierra Nevada Mountains of Yosemite National Park, California, detected the loss of the lowest-elevation pika population in the ~90 years between the historic Grinnell survey and modern resurvey (Moritz 2007), suggesting an upslope range shift of 500 feet. 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). Moritz (2007) concludes that the most likely factor underlying the range shift in the pika and other high elevation species is temperature increases.

The impacts of global warming on pika populations 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) the pika's meadow foraging habitat is shrinking as timberlines move upslope due to rising temperatures; (6) reductions in alpine permafrost may lead to degradation and eventual loss of talus habitats; and (7) changing climate conditions may make pikas more susceptible to predators and disease.

Temperatures in the western United States will continue to increase throughout this century under all greenhouse gas emission scenarios. The amount of warming experienced will depend upon how much additional greenhouse gas pollution society pumps into the atmosphere. By the end of this century, temperatures in the western U.S. are expected to rise by twice the levels experienced in the 20th century--an average of 2.1-5.7°C (3.8-10.3°F)--under a "business-as-usual" A1B SRES emissions scenario (Christensen et al. 2007) which the world is currently on the path to exceeding (Raupach et al. 2007). Temperatures may 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 under a scenario of doubled CO_2 concentrations (Snyder 2002).

Along with projected warming, decreased precipitation in the southwestern United States and reduced snowpack and earlier spring snowmelt throughout the west will no doubt contribute to further extinctions of American pika populations. Under high warming scenarios, many pika populations could be extirpated 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 it at risk of extinction from anthropogenic climate change.

For these reasons the Department of the Interior should act promptly to protect the American pika under the U.S. 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.

Natural History and Biology of the American Pika

I. Species Description

The American pika, *Ochotona princeps*, is a small, furry, diurnal, herbivorous mammal related to rabbits and hares (Grayson 2005). Its overall body form is egg-shaped, with no visible tail, short legs, and rounded ears (Smith and Weston 1990). Pikas have a "buried" tail that is longer relative to body length 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 ocher 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).

II. Taxonomy

In the order *Lagomorpha*, family *Ochotonidae*, the genus *Ochotona* includes 14 to 18 species worldwide (Smith and Weston 1990). Of the two pika species in North America, the American pika *Ochotona princeps* is geographically and physically distinct from the collared pika *Ochotona collaris.* The range of *O. princeps* extends from New Mexico and California, north through central British Columbia from 35°N to 54°N while the range of *O. collaris* includes extreme northwest Canada and western Alaska from 59°N to 68° (Hall 1981, Franken and Hik 2004). The American pika physically differs from the collared pika, which is grayer, with a distinct gray patch on the nape and shoulders (Anthony 1928).

American pikas have historically 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*. However, the American pika is currently recognized as a single species, *Ochotona princeps*, as explained in Hall (1981). In a review of the taxonomic revisions to date, Hall (1981) recognized 36 American pika subspecies in North America, 31 of which occur in the United States. The descriptions below are from Hall (1981) and common names are from Anthony (1928).

Mount 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.

Ochotona princeps barnesi

1955. *O. princeps barnesi.* Durrant and Lee, Proc. Biol. Soc. Washington, 68:6, May 20, type from Johnson's Reservoir, 8800 ft., 15 mi. by road N Loa (Fishlake Plateau), Silver Co., Utah.

Shuswap pika *(Ochotona princeps brooksi*)

1924. *O. princeps brooksi.* A.H. Howell, N. Amer. Fauna, 47:30, September 23, type from Sicamous, British Columbia.

Cascade pika (*Ochotona princeps brunnescens*)

1919. *Ochotona fenisex brunnescens.* A.H. Howell, Proc. Biol. Soc. Washington, 32:108, May 20, type from Keechelus, Kittitas Co., Washington.
1924. *Ochotona princeps brunnescens.* A.H. Howell, N. Amer. Fauna, 47:31, September 23.

Beaver Mountains pika (*Ochotona princeps cinnamomea*)

1905. *Ochotona cinnamomea.* J.A. Allen, Mus. Brooklyn Inst. Arts and Sci., Sci. Bull., 1:121, March 31, type from 11,000 ft., Brigg's [=Britt's] Meadows, Beaver Range, Beaver Co., Utah (5 mi. by road W. Puffer Lake, according to Hardy, Jour. Mamm., 26:432, February 12, 1946.). Known from type locality only.
1934. *Ochotona princeps cinnamomea*. Hall, Proc. Biol. Soc. Washington, 47:103, June 13.

Ochotona princeps clamosa
1938. *Ochotona princeps clamosa.* Hall and Bowlus, Univ. California Publ. Zool., 42:335, October 12, type from 8400 ft., N. rim Copenhagen Basin, Bear Lake Co., Idaho.

Bangs pika (*Ochotona princeps cuppes*)
1899. *Ochotona cuppes*. Bangs, Proc. New England Zool. Club, 1:40, June 5, type from 4,000 ft., Monashee Divide, Gold Range, British Columbia.
1924. *Ochotona princeps cuppes*. A.H. Howell, N. Amer. Fauna, 47:27, September 23.

Ashnola pika (*Ochotona princeps fenisex*)
1863. *Lagomys minimus.* Lord, Proc. Zool. Soc. London, p. 98, lectotype from 7,000 ft., near head Ashnola River, Cascade Range, British Columbia. *Nec* Schinz, 1821.
1913. *Ochotona fenisex*. Osgood, Proc. Biol. Soc. Washington, 26:80, March 22, renaming of *L. minimus* Lord.
1924. *Ochotona princeps fenisex.* A.H. Howell, N. Amer. Fauna, 47:28, September 23.

Figgins pika (*Ochotona princeps figginsi*)
1912. *Ochotona figginsi.* J.A. Allen, Bull. Amer. Mus. Nat. Hist., 31:103, May 28, type from Pagoda Peak, Rio Blanco Co., Colorado.
1924. *Ochotona prionceps figginsi*. A.H. Howell, N. Amer. Fauna, 47:21, September 23.

Dusky pika (*Ochotona princeps fumosa*)
1919. *Ochotona fenisex fumosa.* A.H. Howell, Proc. Biol. Soc. Washington, 32:109, May 20, type from Permilia [= Pamelia?] Lake, W base Mt. Jefferson [Linn Co.?], Oregon.
1924. *Ochotona princeps fumosa*. A.H. Howell, N. Amer. Fauna, 47:33, September 23.

Parawan Mountains pika (*Ochotona princeps fuscipes*)
1919. *Ochotona schisticeps fuscipes.* A.H. Howell, Proc. Biol. Soc. Washington, 32:110, May 20, type from Brian Head, Parowan Mts., Iron Co., Utah.
1942. *Ochotona princeps fuscipes*. Hall and Hayward, The Great Basin Naturalist, 2:108, July 20.

Lava-bed pika (*Ochotona princeps goldmani*)
1924. *Ochotona schisticeps goldmani.* A.H. Howell, N. Amer. Fauna, 47:40, September 23, type from Echo Crater, Sanke River Desert, 20 mi. SW Arco, Butte Co., Idaho.
1938. *Ochotona princeps goldmani*. Hall and Bowlus, Univ. California Publ. Zool., 42:337, October 12.

Ochotona princeps howelli

1931. *Ochotona princeps howelli.* Borell, Jour. Mamm., 12:306, August 24, type from 7,500 ft., near head Bear Creek, summit Smith Mtn., S end Seven Devils Mts., Adams Co., Idaho.

New Mexico pika (*Ochotona princeps incana*)

1919. *Ochotona saxatilis incana.* A.H. Howell, Proc. Biol. Soc. Washington, 32:107, May 20, type from 12,000 ft., Pecos Baldy, Santa Fe Co., New Mexico.
1924. *Ochotona princeps incana.* A.H. Howell, N. Amer. Fauna, 47:25, September 23.

Blue Mountains pika (*Ochotona princeps jewetti*)

1919. *Ochotona schisticeps jewetti.* A.H. Howell, Proc. Biol. Soc. Washington, 32:109, May 20, type from head Pine Creek, near Cornucopia, S slope Wallowa Mts., Baker Co., Oregon.
1951. *Ochotona princeps jewetti.* Hall, Univ. Kansas Publ., Mus. Nat. Hist., 5:130, December 15.

Ochotona princeps lasalensis

1955. *Ochotona princeps lasalensis.* Durrant and Lee, Proc. Biol. Soc. Washington, 68:4, May 20, type from Warner Ranger Station, 9,750 ft., La Sal Mts., Grand Co., Utah.

Lemhi pika (*Ochotona princeps lemhi*)

1919. *Ochotona uinta lemhi.* A.H. Howell, Proc. Biol. Soc. Washington, 32:106, May 20, type from Lemhi Mountains, 10 mi. W Junction, Lemhi Co., Idaho.
1924. *Ochotona princeps lemhi.* A.H. Howell, N. Amer. Fauna, 47:16, September 23.

Ochotona princeps littoralis

1955. *Ochotona princeps littoralis.* Cowan, Murrelet, 35:22, August 27, type from Hagensborg, British Columbia.

Alberta pika (*Ochotona princeps lutescens*)

1919. *Ochotona princeps lutescens.* A.H. Howell, Proc. Biol. Soc. Washington, 32:105, May 20, type from approx. 8,000 ft., Mt. Inglesmaldie, near Banff, Alberta.

Ochotona princeps moorei

1950. *Ochotona princeips moorei.* Gardner, Jour. Washington Acad. Sci., 40:344, October 23, 1950, type from 10,000 ft., 1 mi. NE Baldy Ranger Station, Manti National Forest, Sanpete Co., Utah. Known from type locality only.

Yosemite pika (*Ochotona princeps muiri*)

1916. *Ochotona schisticeps muiri.* Grinnell and Storer, Univ. California Publ. Zool., 17:6, August 23, type from 9,300 ft., near Ten Lakes, Yosemite National Park, Tuolumne Co., California.
1934. *Ochotona princeps muiri.* Hall, Proc. Biol. Soc. Washington, 47:103, June 13.

Ruby Mountains pika (*Ochotona princeps nevadensis*)

1919. *Ochotona schisticeps nevadensis.* A.H. Howell, Proc. Biol. Soc. Washington, 32:107, May 20, type from 10,500 ft., Ruby Mts., SW Ruby Valley P.O., Elko Co., Nevada.

1924. *Ochotona princeps muiri*. Hall, Proc. Biol. Soc. Washington, 47:103, June 13.

Jemez Mountains pika (*Ochotona princeps nigrescens*)

1913. *Ochotona nigrescens.* V. Bailey, Proc. Biol. Soc. Washington, 26:133, May 21, type from Goat Peak, head Santa Clara Creek, 10,000 ft., Jemez Mountains, Sandoval Co., New Mexico. Known only from type locality.
1924. *Ochotona princeps nigrescens*. A.H. Howell, N. Amer. Fauna, 47:26, September 23.

Ochotona princeps obscura

1965. *Ochotona princeps obscura***.** Long, Univ. Kansas Publ., Mus. Nat. Hist., 14:538, July 6, type from Medicine Wheel Ranch, 28 mi. E Lovell, 9,000 ft., Big Horn Co., Wyoming.

Rocky Mountain or Hollister pika (*Ochotona princeps princeps*)

1828. *Lepus (Lagomys) princeps.* Richardson, Zool. Jour., 3:520, type from headwaters Athabaska River, near Athabaska Pass, Alberta.
1897. [*Ochotona*] *princeps*. Trouessart, Catalogus mammalium…, p. 648.
1912. *Ochotona levis.* Hollister, Proc. Biol. Soc. Washington, 25:57, April 13, type from Chief Mountain [= Waterton] Lake, Glacier Co., Montana. (Regarded as subspecifically inseparable from *O. p. princeps* by Cowan, Murrelet, 35:20, August 27, 1955.)

Ochotona princeps saturata

1955. *Ochotona princeps saturatus*. Cowan, Murrelet, 35:23, August 27, type from Mt. Huntley in Wells Gray National Park, British Columbia.

Colorado pika (*Ochotona princeps saxatilis*)

1899. *Ochotona saxatilis.* Bangs, Proc. New England Zool. Club, 1:41, June 5, type from Montgomery, "near" Mt. Lincoln, Park, Co., Colorado.
1924. *Ochotona princeps nigrescens*. A.H. Howell, N. Amer. Fauna, 47:26, September 23.

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).

Ochotona princeps septentrionalis

1947. *Ochotona princeps septentrionalis*. Cowan and Racey, Canadian Field-Nat., 60:102, April 22, type from 6500 ft., Itcha Mountains, lat. 52° 45' N, long. 125° W, British Columbia. Known from type locality only.

White Mountain pika (*Ochotona princeps sheltoni*)

1918. *Ochotona 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.

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.

Ochotona princeps taylori

1934. *Ochotona princeps tutelata.* Hall, Proc. Biol. Soc. Washington, 47: 103, June 13, type from 8150 ft., Greenmonster Canyon, Monitor Mts., Nye Co., Nevada.

Uinta pika (*Ochotona princeps uinta*)

1912. *Ochotona uinta.* Hollister, Proc. Biol. Soc. Washington, 25:58, April 13, type from near head E fork Bear River, Uinta Mts., Summit Co., Utah.

1924. *Ochotona princeps uinta*. A.H. Howell, N. Amer. Fauna, 47:19, September 23.

Ochotona princeps utahensis

1941. *Ochotona princeps utahensis.* Hall and Hayward, Great Basin Nat., 2:107, July 20, type from 2 mi. W Deer Lake, Garfield Co., Utah.

Wyoming pika (*Ochotona princeps ventorum*)

1919. *Ochotona uinta ventorum.* Hall, Proc. Biol. Soc. Washington, 32: 106, May 20, type from Fremont Peak, 11,500 ft., Wind River Mts., Fremont Co., Wyoming.

1924. *Ochotona princeps ventorum*. A.H. Howell, N. Amer. Fauna, 47:18, September 23.

Ochotona princeps wasatchensis

1955. *Ochotona princeps wasatchensis.* Durant and Lee, Proc. Biol. Soc. Washington, 68:2, May 20, type from 10 mi. above lower powerhouse, road to Cardiff Mine, Big Cottonwood Canyon, Salt Lake Co., Utah.

III. Distribution

The American pika is distributed discontinuously in mountainous areas throughout western North America (Smith and Weston 1990). The range of American pika extends from the southern Rocky Mountains of New Mexico and southern Sierra Nevada Mountains of California, north through central British Columbia (Grayson 2005). In the United States, pika populations are found in nine states: California, New Mexico, Nevada, Utah, Oregon, Idaho, Wyoming, Montana, and Washington. In the northern part of its range, the pika is found at elevations from near 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). Therefore, near the southern limits of its distributional range it is uncommon to find American pika at elevations lower than 2,500 meters (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.

Historic distribution information for the individual subspecies is described below and is illustrated in Figure 1. The distributional map (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 accessed at http://www.asia.gbif.net/portal/download_input.jsp?taxonKey=241662&countryKey=0&resourceKey=0&georeferencedOnly=true&nextTask=ecat_browser.jsp.

Mount Whitney Pika (*Ochotona princeps albata*)

Central California. The 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 9,500 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 rockslide 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.

Ochotona princeps barnesi

Central Utah. The type locality is known from Johnson's Reservoir, 8,800 feet, 15 miles by road north of Loa (Fishlake Plateau), Silver County, Utah (Hall 1981). Hall (1981) lists marginal records from 1 mile northwest of Mount Marvin (Seven Mile Valley) at 9,200 feet; and Seven Mile Canyon, 4 miles north of Johnson's Reservoir, at 8,800 feet.

Shuswap pika *(Ochotona princeps brooksi*)

Southern British Columbia. The type locality is known from Sicamous, British Columbia (Hall 1981). Howell (1924) describes the range as "interior of southern British Columbia from Shuswap Lake west to Mount McLean and McGillivary Creek, Lilloooet District; limits of range unknown." Hall (1981) lists marginal records from the Robbins Range, 20 miles southeast of Kamloops in British Columbia.

Figure 1. Distribution of American pika subspecies in the United States.

Museum record data provided by:
Field Museum of Natural History,
Los Angeles County Museum of Natural History,
Royal Ontario Museum,
Michigan State University Museum,
University of Kansas Biodiversity Research Center,
James R. Slater Museum,
Museum of Vertebrate Zoology,
Yale University Peabody Museum,
(Accessed through GBIF Data Portal, www.gbif.net, 2007-08-8)

Cascade pika (*Ochotona princeps brunnescens*)

Southern British Columbia; Washington; Oregon. The type locality is known from Keechelus, Kittitas County, Washington (Hall 1981). Howell (1924) describes the range as "Cascade Range from southwestern British Columbia south to vicinity of Crater Lake, Oregon; interrupted apparently in central Oregon (vicinity of Mount Jefferson and Three Sisters) by the range of *fumosa*." Hall (1981) lists marginal records from Alta Lake, at Hope, British Columbia; Whatcom Pass, Stevens Pass, and Cowlitz Pass in Washington; at 4,000 feet on Mount Hood, one-half mile west of Salt Creek Falls, Oregon; Crater Lake, McLoughlin, and Diamond Lake, Oregon; Tumtum Mountain, Mount Index, and Mount Baker at 4,800 feet, in Washington; Sumas and North Vancouver, in British Columbia.

Beaver Mountains pika (*Ochotona princeps cinnamomea*)

Central Utah. The type locality was collected at 11,000 feet, at Brigg's Meadows, in the Beaver Range, in Beaver County, Utah, in 1905. The known range includes the Beaver mountain range (Durrant 1952). Howell (1924) describes the range as "Beaver Range, Utah, and Toyabe Mountains, Nevada; altitudinal range from 8,000 to 11,000 feet."

Ochotona princeps clamosa

Southeastern Idaho. The type locality is known from 8,400 feet, on the north rim of Copenhagen Basin, Bear Lake County, Idaho (Hall 1981). Hall (1981) lists marginal records from Deep Lake, Idaho; Bear River Mountains, 2 miles east of Strawberry Creek Ranger Station in the Wasatch Mountains, Idaho.

Bangs pika (*Ochotona princeps cuppes*)

Southeastern British Columbia; northeastern Washington; northern Idaho. The type locality is known from 4,000 feet, at Monashee Divide, Gold Range, British Columbia (Hall 1981). Howell (1924) describes the range as "Southeastern British Columbia, northeastern Washington, and northern Idaho, from Glacier south to Cabinet Mountains; west to the Gold Range, British Columbia; exact limits unknown." Hall (1981) lists marginal records from Glacier, British Columbia; Toby Creek, 18 miles west of Invermere, British Columbia; the West Fork Yaak River in Idaho; the Cabinet Mountains in Idaho; Sullivan Lake in Washington; Kettle Valley and Mount Revelstoke in British Columbia.

Ashnola pika (*Ochotona princeps fenisex*)

Southern British Columbia; Washington. The type locality is known from 7,000 feet, near the head of the Ashnola River, Cascade Range, British Columbia (Hall 1981). Howell (1924) describes the range as "interior mountain ranges of northern Washington and southern British Columbia, from vicinity of Wenatchee, Washington, north to the upper end of Okanagan Lake." Hall (1981) lists marginal records from Kimsquit, Rainbow Mountains, Redstone, MacGillivray Creek, Lillooet, Okanagan, Hedley, and Ashnola River in British Columbia; Hanceville, British Columbia, 24 miles west of Williams Lake; Horseshoe Basin, near Mount Chopaka, Washington; near Wenatchee, Washington; Steamboat Mountain, Easton, Lyman Lake, Barron, Washington; Bethel Ridge, 30 miles east-southeast of Mount Rainier, Washington, 3 miles north of Tieton Reservoir, at 6,000 feet.

Figgins pika (*Ochotona princeps figginsi*)

Colorado; southern Wyoming. The type locality is known from Pagoda Peak, Rio Blanco County, Colorado (Hall 1981). In Colorado, the range includes high areas from the Park Range southward to the Elk and West Elk Mountains (Armstrong 1972). Howell (1924) describes the range as "Western Colorado, from Gunnison County north to eastern Routt County (Hahn Peak) and to Bridger Peak, Wyoming." Hall (1981) lists marginal records from Bridger Peak, and the west slope of Sierra Madre Mountains, Wyoming; Mount Zirkel, Trappers Lake, Crested Butte, Irwin, 6 miles east of Skyway, Sand Mountain, and 9 miles southwest of Hans Peak Post Office, Colorado; northeast of Savery, Wyoming.

Dusky pika (*Ochotona princeps fumosa*)

Central Oregon. The type locality is known from Permilia Lake, west of the base of Mount Jefferson, Oregon (Hall 1981). Howell (1924) describes the range as "western slopes of the Cascade Mountains in Oregon, from the upper Clackamas River south at least to Three Sisters; also mountains near Paulina Lake, Crook County." Hall (1981) lists marginal records from 900 feet, 15 miles above Escatada, Oregon; Lost Lake in Newberry Crater, Paulina Lake, Three Sister, Lava Butte, and Lost Creek Ranger Station, 10 miles southeast of McKenzie Bridge, Oregon.

Parawan Mountains pika (*Ochotona princeps fuscipes*)

Southwestern Utah. The type locality was collected at Brian Head, in the Parowan Mountains, in Iron County, Utah, in 1919 (Hall 1981). The known range is the Markagunt Plateau. Hall (1981) lists marginal records from 9,000 feet at Duck Creek, Kane County, Utah; 8094 feet at Kolob Reservoir, Utah; and 7,890 feet at Lava Point, Utah.

Lava-bed pika (*Ochotona princeps goldmani*)

Central Idaho. The type locality is known from Echo Crater, Snake River Desert, 20 miles southwest of Arco, Butte County, Idaho (Hall 1981). Hall (1981) lists marginal records from the south base of Grassy Cone, Idaho; Fissure Creek and Great Owl Cavern, Idaho.

Ochotona princeps howelli

West-Central Idaho. The type locality is known from 7,500 feet, near the head of Bear Creek, on the summit of Smith Mountain, at the south end of Seven Devils Mountains, in Adams County, Idaho (Hall 1981). Hall (1981) lists marginal records from one-half mile east of Black Lake, Idaho.

New Mexico pika (*Ochotona princeps incana*)

Southern Colorado; northern New Mexico. The type locality was collected on Pecos Baldy, New Mexico, at 12,000 feet (Bailey 1931). In Colorado, the range includes the Sangre de Cristo Range, Culebra Range, and Spanish Peaks (Armstrong 1972). Bailey (1931) reports the subspecies as "common on all the peaks of the Sangre de Cristo Range that reach to or above timber line." Also:

> They are found as low as 11,000 feet on some cold northeast slopes, but are more common from 12,000 feet to the summits of most of the peaks. In the Pecos River Mountains, they were abundant in the rock slides of the Hudsonian Zone over Pecos

> Baldy and Truchas peaks from 11,000 feet to the very summit at 12,600 and 13,300 feet. In the Taos Mountains they were common from the camp at 11,400 feet to near the top of Wheeler Peak at 13,600 feet, and the Culebra Mountains from timber line to the tops of the highest peaks (Bailey 1931:64).

Howell (1924) describes the range as "high mountains of northern New Mexico, from Pecos Baldy north to the Culebra Range and probably to Sierra Blanca, Colorado." Hall (1981) lists marginal records from 11,500 feet at North Crestone Trail, Colorado; Medano Creek, and 11,900 feet at West Spanish Creek, Colorado; Wheeler Peak and Santa Fe Ski Area, New Mexico; near Fort Garland, Colorado.

Blue Mountains pika (*Ochotona princeps jewetti*)

Northeastern Oregon. The type locality is known from the head of Pine Creek, near Cornucopia, on the south slope of the Wallowa Mountains, in Baker County, Oregon (Hall 1981). Howell (1924) describes the range as "Wallowa Mountains, Strawberry Mountains, and southern portion of Blue Mountains, northeastern Oregon; altitudinal range approximately from 5,000 to 10,000 feet." Hall (1981) lists marginal records from Wallowa Lake, Anthony, Strawberry Butte, Austin, and near the head of East Pine Creek, Oregon.

Ochotona princeps lasalensis

East-central Utah. The type locality is known from Warner Ranger Station, at 9,750 feet, in the La Sal Mountains, Grand County, Utah (Hall 1981). Hall (1981) lists marginal records from 9,000 feet, one-half mile north of Warner Ranger Station in the La Sal Mountains, Utah; Geyser Pass, 12,280 feet at Mount Mellithin, and at 9,700 feet, one-half mile south of Warner Ranger Station, Utah.

Lemhi pika (*Ochotona princeps lemhi*)

Central Idaho. The type locality is known from the Lemhi Mountains, 10 miles west of Junction, Lemhi County, Idaho (Hall 1981). Howell (1924) describes the range as "Mountains of south-central Idaho—the Lemhi, Lost River, Salmon River, and Sawtooth Mountain Ranges; eastward to the Beaverhead Mountains, east of Leadore; northern limits of range imperfectly known." Hall (1981) lists marginal records from Table Mountain, Silver Bow County, Montana; Anchor Lake and Mount Bradley in Madison County, Montana; mountains east of Birch Creek, Ketchum, and Stanley Lake, Idaho; five miles west of Cape Horn, Idaho; Elk Summit, 15 miles southeast of Warren, Idaho; Upper Miner Lake near Jackson, Montana.

Ochotona princeps littoralis

Southwestern British Columbia. The type locality is known from Hagensborg, British Columbia (Hall 1981). Hall (1981) lists marginal records from Purcell Point, Fawn Bluff, Arran Rapids, and the head of Rivers Inlet, British Columbia.

Alberta pika (*Ochotona princeps lutescens*)

Southwestern Alberta. The type locality is known from approximately 8,000 feet, at Mount Inglesmaldie, near Banff, Alberta (Hall 1981). The range extends from Mount Inglemaldie and nearby mountains, south to Mount Forget-me-not southwest of Calgary (Anthony 1928). Hall (1981) lists marginal records from Mistaya Creek near the Banff-Jasper

Highway, Alberta; the head of Dorimer River, Canmore, Mount Forget-me-not, and the head of Brewster Creek, Alberta.

Ochotona princeps moorei

Central Utah. The type locality is known from 10,000 feet, 1 mile northeast of Baldy Ranger Station, Manti National Forest, Sanpete County, Utah (Hall 1981). It is known from type locality only (Hall 1981).

Yosemite pika (*Ochotona princeps muiri*)

Central California; west-central Nevada. Type local locality is known from Ten Lakes, Yosemite National Park, Tuolumne County, California at 9,300 feet in elevation on October 11, 1915, by W.P. Tylor (Howell 1924). Grinnell 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" (Grinnell and Storer (1924:218)). Further:

> 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 7,700 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)).

Howell (1924) describes the range as "central portion of Sierra Nevada, from Mount Tallac south to Mammoth pass; altitudinal range, 7,800 to 12,800 feet." Hall (1981) described marginal records from Nevada at 8,500 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.

Ruby Mountains pika (*Ochotona princeps nevadensis*)

Northeastern Nevada. The type locality is known from the Ruby Mountains, southwest of Ruby Valley Post Office in Elko County, Nevada (Hall 1946). The known range is the restricted to the Ruby Mountains, Nevada (Hall 1946). Hall (1981) lists marginal records from 7,830 feet at Long Creek, Nevada.

Jemez Mountains pika (*Ochotona princeps nigrescens*)

Southern Colorado; northern New Mexico. The type locality is known from the Jemez Mountains, New Mexico, at 10,000 feet, on Goat Peak at the head of Santa Clara Creek (Bailey 1931). Howell (1924) describes the range as "Jemez Mountains, New Mexico, north to the southern end of the San Juan Mountains, Colorado."

Ochotona princeps obscura

North-central Wyoming. The type locality is known from 9,000 feet at Medicine Wheel Ranch, 28 miles east of Lovell, Big Horn County, Wyoming (Hall 1981). Hall (1981) lists marginal records from 4 ½ miles south and 19 miles east of Shell, Wyoming; head of Trappers Creek, Powder River Pass, and Big Horn Mountains, Wyoming.

Rocky Mountain or Hollister pika (*Ochotona princeps princeps*)

Southeastern British Columbia; southwestern Alberta; northern Idaho; western Montana. The type locality is known from the headwaters of the Athabaska River, near Athabaska Pass, Alberta (Hall 1981). The range includes the Rocky Mountains from eastern British Columbia (at the headwaters of the South Pine River) and western Alberta (at Muskeg Creek) south along the main divide to eastern Idaho and western Montana (Anthony 1928).

Hall (1981) lists marginal records from the headwaters of South Pine River, British Columbia; 60 miles north of Jasper House and Muskeg Creek, Alberta; Medicine Lake and Sunwapta Pass, British Columbia; Thompson Pass, British Columbia; Pipestone River and Baker Lake, Alberta; Assiniboine and Tornado Pass, British Columbia; Waterton Lake, Alberta; Chief Mountain Lake, Little Belt Mountains, Belt Mountains, Cutaway Pass in Granite County, Lake Como, Bitterroot Mountains, Montana; Coeur d'Alene National Forest, Idaho; Mount Evans, Spillamacheen River, Kinbasket Lake, and Mount Robson, British Columbia.

Ochotona princeps saturata

Central British Columbia. The type locality is known from Mount Huntley in Wells Gray National Park, British Columbia (Hall 1981). Hall (1981) lists marginal records from Indian Point Lake and Murtle Lake, British Columbia.

Colorado pika (*Ochotona princeps saxatilis*)

Colorado; southern Wyoming; southeastern Utah; northern New Mexico. The type locality is known from Montgomery, near Mount Lincoln, in Park County, Colorado (Hall 1981). In Colorado, the range includes the Front, Sawatch, and nearby ranges, and the San Juan Mountains (Armstrong 1952). In Utah it is known only in the La Sal Mountains (Barnes 1927). Howell (1924) describes the range as "easterly mountain ranges of middle Colorado from the Medicine Bow Range south to the Sangre de Cristo Range; northward to Medicine Peak, Wyoming; westward in southern Colorado to the San Juan Range and to the La Sal Mountains in eastern Utah; altitudinal range approximately from 9,000 to 13,500 feet."

Hall (1981) lists marginal records from 3 miles east of Browns Peak, Wyoming; one-half mile east of Medicine Bow Peak, Wyoming; Estes Park, 12,300 feet at Niwot Ridge, Pikes Peak, Osier, and Horse Spring Mountain near Dyke, Colorado; 39 ½ miles north of Durango at Lime Creek, Colorado; 5 miles west of Lake City at Crystal Lake, Colorado; Middle Brush Lash Creek, Ten Mile Creek, Berthoud Pass, Colorado; 12,100 feet at Rocky Cut in Rocky Mountain National Park, Colorado.

Gray-headed pika (*Ochotona princeps schisticeps*)

Northeastern California; northwestern Nevada. 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 7,500-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)). Howell (1924) describes the range as “boreal zones of the northern Sierra Nevada, from Mount Shasta south to Donner Pass; altitudinal range from about 5,000 feet (on Mill Creek, above Morgan, Tehama County) to at least 9,000 feet.”

Hall (1981) lists marginal records from 5,700 feet, 3 miles north and 12 miles east of Fort Bidwell, Nevada; 8,400 feet at Duffer Peak in Pine Forest Mountains, Nevada; Tahoe, Donner Pass, Lassen Peak, Mount Shasta, and 12 miles northeast of Prattville, California.

Ochotona princeps septentrionalis

Central British Columbia. The type locality is known from 6500 feet in the Itcha Mountains in British Columbia (Hall 1981).

White Mountain pika (*Ochotona princeps sheltoni*)

East-central California; west-central Nevada. The type locality is known from 11,000 feet in the White Mountains, near Big Prospector Meadow, Mono County, California. 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. Howell (1924) describes the range as “The White Mountains of California and Nevada (8,000 to 13,000 feet altitude).” Hall (1981) lists marginal records from 8,700 feet at Pinchot Creek, Nevada.

Taylor pika (*Ochotona princeps taylori*)

Southern Oregon; northern California. 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 9,000 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 Warren Peak, Sugar Hill, and 5 miles NW of Eagle Peak in Modoc County, from 2 mi N. of Medicine Lake in Siskiyou County, and from 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).

Ochotona princeps tutelata

Central Nevada. The type locality is known from 8,150 feet in Greenmonster Canyon in the Monitor Mountains of Nye County, Nevada (Hall 1946). The known range includes the Desatoya, Shoshone, Toyabe, Toquima, and Monitor mountain ranges in central Nevada (Hall 1946). Hall (1981) lists marginal records from 7,500 feet at Smiths Creek in the Desatoya Mountains, Nevada; 8,700 feet on the southwest and west slopes of Mount Jefferson in the Toquima Range, Nevada; South Twin River and Arc Dome, Nevada.

Uinta pika (*Ochotona princeps uinta*)

Northern Utah. The type locality is known from near the headwaters of the East fork of the Bear River, in the Uinta Mountains, in Summit County, Utah (Hall 1981). The known range includes the Uinta and Wasatch Mountains (Durrant 1952). Hall (1981) lists marginal records from Elk Park, Utah; 11,000 feet at the Nipple, Utah; 10,500 feet at the southwest slope of Bald Mountain, Utah; 8,500 feet at Morehouse Canyon, 5 miles above the Weber River River, Utah. Howell (1924) describes the range as "the Uinta, and Wasatch Ranges, in Utah, and the Salt River and Wyoming Ranges, in Western Wyoming."

Ochotona princeps utahensis

South-central Utah. The type locality is known from 2 miles west of Deer Lake, in Garfield County, Utah (Hall 1981). The known range includes the Aquarius Plateau and environs (Durrant 1952). Hall (1981) lists marginal records from 9,000 feet at Donkey Lake on Boulder Mountain, Utah.

Wyoming pika (*Ochotona princeps ventorum*)

South-Central Montana; western Wyoming; east-central Idaho. The type locality is known from 11,500 feet on Fremont Peak in the Wind River Mountains, in Fremont County, Wyoming (Hall 1981). Howell (1924) describes the range as "Wind River, Gros Ventre, Absaroka, and Teton Ranges, Wyoming, north to the Beartooth and Absaroka Ranges in southern Montana."

Hall (1981) lists marginal records from the head of Big Timber Creek, one mile south of Hellroaring Lakes, Montana; 30 miles north and 18 miles west of Cody, Wyoming; Pahaska, Wyoming; Needle Mountain, Wyoming; 14 miles south and 8 ½ miles west of Lander, Wyoming; 17 miles south and 6 ½ miles west of Lander, Wyoming; 19 miles west and 2 miles south of Big Piney, Wyoming; 5 miles south and 2 miles west of Fremont Peak, Wyoming; Middle Piney Lake, Wyoming; 2 miles north and 8 miles east of Alpine, Wyoming; Teton Pass, Wyoming; Teton Canyon, Idaho; South Cottonwood Canyon, Montana.

Ochotona princeps wasatchensis

Central Utah. The type locality is known from 10 miles above the lower powerhouse, on the road to Cardiff Mine, in Big Cottonwood Canyon, in Salt Lake County, Utah (Hall 1981). Hall (1981) lists marginal records from 9,000 feet near Lake Solitude at Silver Lake, Utah; Mount Timpanogos, Utah; 7,000 feet at Big Willow Canyon, Utah; 6 miles above Wasatch Boulevard at Little Cottonwood Canyon, Utah.

IV. Habitat

A. Breeding and Foraging Habitat

The American pika inhabits high-elevation talus fields fringed by suitable vegetation on rocky slopes of alpine and sub-alpine areas throughout western North America (Smith and Weston 1990). Although it is primarily found in talus fields, the American pika is occasionally found in piles of broken rock and man-made substrate such as mine tailings or piles of scrap lumber (Smith and Weston 1990, Hafner 1993). In a few locations, pikas inhabit lava beds or talus fields on north-facing slopes along watercourses in lower-elevation areas (i.e. Lava Beds National Monument in northeastern California and the Columbia River Gorge in northern Oregon). However, these pika habitats are characterized by microclimate conditions that are uniquely moist and cool for their lower elevation locations and provide the cooler thermal refugia that pika require (Beever 2002).

Smith and Weston (1990) propose that of all North American montane mammals, American pikas are the most obligate residents of talus habitat. American pikas rely on the protected spaces beneath talus boulders for den sites throughout the year, for nest sites in spring, and for cache sites for their haypiles that allow them to survive the winter. The talus interstices provide a cool, moist microclimate during the summer and insulation from cold extremes during the winter when the talus is covered by snow. In a review of the environmental conditions of 50 habitat patches inhabited by pikas across the range, Hafner (1993) found that most pikas live in regions with short summers of less than 20 days per year above 35°C (95°F) (82% of 50 patches), long winters with greater than 180 days per year below 0°C (32°F) (94% of patches), a freeze-free period of less than 90 days (86% of patches), and annual precipitation of more than 300 mm (96% patches) (Hafner 1993). All pika populations were restricted to regions of less than 30 days per year above 35°C (95°F), more than 150 days per year below 0°C (32°F), a freeze-free period of less than 120 days, and annual precipitation of more than 200 mm (Hafner 1993).

Pikas do not excavate their own burrows but rely on existing spaces below boulders in talus fields, although they may dig to enlarge den and nest sites (Smith and Weston 1990). Pikas prefer to locate their den and nest sites below rocks approximately 0.2 m to 1 m in diameter, but they will often sit on larger, prominent rocks and will also cache their haypiles under large boulders (Smith and Weston 1990). Pika foraging habitat consists of alpine meadows surrounding talus fields. During the winter, pikas maintain access to meadows and haypiles through the use of tunnels through the snow (Smith and Weston 1990).

American pikas commonly occur in habitats 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).

B. Territory and Home Range

American pikas are diurnally active and relatively easy to detect based on sightings, vocal calls, haypiles, or feces (Beever et al. 2003). Adult American pikas are individually territorial. The territory of an American pika is the area the animal defends from intruders while 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). Territory size and shape are based on the configuration of the talus habitat, distance from the territory to vegetation, and quality of vegetation (Smith and Weston 1990). Territory size varies from 410 m^2 to 709 m^2 and home range size varies from 861 m^2 to 2,182 m^2 (Smith and Weston 1990).

Average territory sizes are equivalent 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). Haypile sites are maintained in the territory when the territory ownership changes (Peacock 1997). 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).

American pikas have four pronounced behaviors on their home ranges: (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 cheek rubbing, aggression, vocalizing and social tolerance (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 and maintenance and sexual advertisement leading to mating (Smith and Weston 1990).

Pikas defend their territories 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).

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).

C. Dispersal

Adult pikas are territorial and rarely disperse (Peacock 1997). Juveniles are born into the relatively permanent and static social organization of adult territory holders, and the juvenile's survival is directly contingent on finding a vacant territory to occupy (Smith and Weston 1990). Juveniles face extremely aggressive behavior from unfamiliar adults when they attempt to disperse, and dispersal is risky across non-talus habitat (Smith and Weston 1990). Therefore, most juveniles are philopatric, remaining on their natal home range or an adjoining home range (Smith and Weston 1990).

Adult females become intolerant of their young soon after weaning and attempt to exclude them from their territory (Smith 1974b). However, adult female and male pikas do show some affiliative behaviors towards their offspring by permitting related young to spatially overlap their home ranges throughout the first summer (Smith and Ivins 1983). This tolerance gives juveniles an opportunity to establish residency in or near their home range if a territory opens up due to adult mortality (Smith and Ivins 1983). Smith and Ivins (1983) found that most juveniles that established residency settled within 50 m of their home range center. While living on their natal home range waiting for a settlement opportunity, 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 spurred by competition for territories, primarily by resident juveniles (Peacock 1997). Juveniles will disperse if no territory is available (Golian 1985), and approximately 25% of all juvenile American pikas may attempt to disperse (Smith and Weston 1990). At low elevation sites, 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 in the Sierra Nevada 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 may have little effect on dispersing juveniles (Smith 1974a).

Pikas appear to be very limited in the distances they can disperse. The maximum dispersal distance is thought to be 3 km, with the vast majority of dispersals at shorter distances (Beever et al. 2003). Smith (1974a) found that distances of less than 300 m were barriers to dispersal for low elevation pika populations (2,500 m, 8,200 ft) in the Sierra Nevada. Pikas may be more successful at longer dispersals in the mesic, higher elevation habitats of the Sierra Nevada or Rocky Mountains (Hafner 1994, Peacock 1997, Beever et al. 2003). Peacock (1997) found that an average of 34% of the adults in a high elevation Sierra Nevada population (3,170 m, 10,398 ft) were replaced each winter by immigrants, 5% of which made long-distance dispersals of 2 km, 67.5% of which made short or intermediate dispersals less than 2 km, and 27.5% of which recruited from within the population. Hafner and Sullivan (1995) reported that pika metapopulations are separated by 10 to 100 km and postulated that the maximum dispersal distance for individual pikas was likely between 10 to 20 km. Hafner (1994) found that recolonization of extirpated sites within 20 km of source populations over the past 6,000 years has been very rare (7.8% maximum), indicating that 20 km poses a barrier to successful dispersal.

V. Temperature Limits and Thermoregulation

American pikas have a high 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) which restricts them to cool microclimates. Their high body temperature, which is 2-3°C higher than other small mammals inhabiting the same rockslide habitat, results from their rapid basal metabolic rate (143% of the weight-predicted value) paired with their low thermal conductance (MacArthur and Wang 1973). The low thermal conductance appears to be an adaptation that favors overwinter survival (MacArthur and Wang 1973, Smith and Weston 1990). Pikas in ambient temperatures below their lower critical temperature of 21°C (69.8°F) are able to spend less energy on thermoregulation due to their thick coats (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) and makes pikas vulnerable to thermal stress. 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).

Pikas are also vulnerable to hypothermia during the winter months. Smith (1978) found that pika populations in the Sierra Nevada, California, were susceptible to higher mortality in years of early snowmelt and suggested that loss of the protective insulation of the snow cover exposed pikas to cold temperature extremes and accompanying thermal stress.

VI. Diet and Foraging Behavior

American pikas are generalist herbivores (Smith and Weston 1990). They meet most of their water needs through consumed plant material, but also use available drinking water (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 27 trips per hour to collect vegetation during the haying season (Dearing 1997a). 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 pikas delay eating these plants until the toxins decay (Dearing 1997b).

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 1997b).

The adaptive significance of haypiles is to serve as the primary source of sustenance for pikas during the winter (Dearing 1997a). Early observers suggested that the haypile was insufficient to provide an exclusive source of food during winter, that pikas foraged heavily outside the haypile in winter, and that the haypile served as an emergency food store during especially long, harsh winters (Smith and Weston 1990, Dearing 1997a). However, a detailed study of Colorado pika populations in addition to a re-analysis of earlier pika studies suggests that pikas store ample food to last the winter and that the haypile does serve as their primary winter food source (Dearing 1997a). In Colorado populations, pikas consumed at least 175 days-worth of food from their haypile in the winter of the study year and stored 350 days of food (Dearing 1997a). Pikas may augment their winter diet by foraging outside of the haypile on lichens, tree bark, evergreen trees, and shrubs (Dearing 1997a). However, pikas appear to forage outside of the haypile primarily during the autumn and early winter (October-January) when vegetation is still available and not during late winter and spring (February-June) (Smith and Weston 1990, Dearing 1997a).

Pikas also ingest their caecal pellets as a source of nutrition. American pikas deposit two types of fecal droppings: a hard brown round pellet and caecal pellets which are 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).

VII. Breeding Behavior

The American pika's 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, and 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). Reabsorption 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 the 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). Illustrating the importance of spring vegetation to reproductive success and survival, Golian (1985) found that, in four study years at a Colorado site, pika reproductive success decreased and mortality increased with increased snowpack and late date of snowmelt, presumably because the growth of spring vegetation was delayed.

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).

VIII. Population Turnover and Mortality

Throughout most of western North America, talus habitat has a patchy distribution, resulting in island-like population structure or metapopulation structure for the American pika (Smith and Weston 1990). 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. 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, and higher extinction and lower recolonization rates were associated with small island size and increased isolation.

American pikas attain a maximum age of 7 years, and age-specific mortality rates are greatest in the birth to one year and the 5 to 7 year age groups (Millar and Zwickel 1972, Smith and Weston 1990). Peacock (1997) found that only 40% of pika juveniles that settled a vacant territory in the summer of their birth year were observed as yearlings on those territories in the following summer. Smith (1978) reported average mortality rates for age group 1 to 4 as 37% and 45% for California populations, 44% for Colorado populations, and 45% for Alberta populations. 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.

Abundance and Population Trends of the American Pika

Scientists believe that climatic changes during the past 10,000 years led to extirpation of most low-elevation American pika populations in the western United States, producing the modern distribution and isolation of pikas on mountain islands (Smith and Weston 1990). Population losses 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.

I. Historic Population Trends

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). A small form of *Ochotona*, perhaps *O. princeps*, inhabited the eastern United States until the last glaciation as late as 30,000 years ago or more (Grayson 2005). By the end of the Wisconsonian glacial period, 12,000 years ago, the American pika appears to be restricted to the intermontane areas of western North America (Smith and Weston 1990, Grayson 2005).

Separation of the American pika and the collared pika to the north is likely the result of the Wisconsinian glaciation (Smith and Weston 1990). The range of the American pika was likely 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 range extended 100 km south of its present distribution and it occurred at elevations lower than where it is currently found (Smith and Weston, 1990, Beever et al. 2003). The southernmost fossil remains 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 suggest 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 disprove that the American pika is a rock-dwelling species. Hafner (1993) argues that the pika 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 in cooler, 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 upslope 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 the middle Holocene (8,000-5,000 years ago) the Great Basin experienced an increase in summer temperatures and a shift from winter to summer precipitation which decreased the effective precipitation of the region (Grayson 1987). These climate conditions are thought to have decreased or eliminated pika habitat in lower elevations of the Great Basin and provide the best explanation for the disappearance of lower elevation pika populations (Grayson 1987, Grayson 2005). 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. Thus, the current patchy, high-elevation distribution in the Great Basin is the result of loss of lower elevation populations (Grayson 2005).

II. Current Abundance and Population Trends

Although the American pika has been well-studied in some regions (i.e. Great Basin, Sierra Nevada, Montana Rocky Mountains), the number of populations and total number of individuals that comprise each of the American pika subspecies are not well-known throughout its range. However, detailed studies of pika populations in the Great Basin provide important information on recent population trends during the past century, which indicate that pika populations are being extirpated from low-elevation sites and the rate of loss is accelerating. In the Great Basin, six low-elevation pika populations were 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 (7,792 ft) in 1956 could only be found at higher elevations above 2,743 m (8,999 ft) in the 1990s (Beever et al. 2003). Based on surveys between 2003-2007, at least three more Great Basin pika populations have gone extinct in the past decade (Krajick 2004, Schwarz 2005) which suggests that there is an increasing pace of population loss since the 1990s (Erik Beever, personal communication, 8/10/07). Overall, at least 9 of 25 (36%) of interior Great Basin pika populations have been extirpated during the past 100 years. Beever (2002) reported that the 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.

The Great Basin research indicates that interior pika populations located well north of the southern margin of the pika range are experiencing rapid extinctions. Beever et al. (2003) found that the probability of pika population persistence in the Great Basin decreased with increasing latitude, meaning that northern populations are experiencing higher extirpation rates. Beever et al. (2003) suggest that marginal southern populations in the Great Basin have already been extirpated due to climatic unsuitability, while 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 ecological process of time-delayed extinctions of populations after their habitat has been lost or diminished (Tilman et al. 1994), also known as faunal relaxation. This trend suggests that low-elevation pika populations throughout the range are extremely vulnerable to extinction from the current effects of global warming. Furthermore, as described *supra*, the increasing impacts of global warming in this century, particularly from temperature rise, changes in precipitation, and loss of insulating snowpack, will accelerate the loss of pika habitat across the range as its climatic suitability is further degraded. Even if greenhouse gas emissions were to level off now, the climate is committed to at least a 0.5°C rise in temperatures over approximately the next 100 years (Meehl et al. 2007), and temperature increases of 1.1-6.4°C (2-11.5° F) are predicted during this century depending on the emissions scenario (Solomon et al. 2007). Therefore, some pika populations, especially at lower elevations and lower latitude regions across the range, may already be committed to extinction due the loss of climatically suitable habitat.

In parallel with trends in the Great Basin, the Grinnell Resurvey Project in the Sierra Nevada Mountains of Yosemite National Park, California, detected the loss of the lowest-elevation pika population in the ~90 years between the historic Grinnell survey and modern resurvey (Moritz 2007). Although based on a small sample of surveyed sites, this study suggests that the pika range shifted upward by 500 ft. as mean air temperatures in Yosemite Valley rose by 3°C (5.4°F) over the past century (Moritz 2007). Regular resurveys of pika populations in Yosemite National Park will provide important information on whether the loss of this low elevation population is the beginning of an upward range shift. The extension of resurvey studies to other historic elevational transects in California will provide critical insights into pika population trends across the elevational and latitudinal range of the Sierra Nevada Mountains. A study of pikas at Bodie, California, at the lower edge of the altitudinal range of pika in the region (2,500 m, 8200 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 that are subjected to warmer, drier conditions will experience increased rates of extinction.

Further information on population trends of the American pika is provided by the World Conservation Union through the IUCN Red List classification. As described further in Section II, the IUCN Red List has classified seven of the 36 American pika subspecies as Vulnerable due to a small global population size or a declining range extent (IUCN 2006). Five subspecies were listed as Vulnerable VU-D1 signifying that the subspecies has a small population size with less than 1000 mature individuals in the wild (IUCN 2006): the White Mountains pika (*O. p. sheltoni*), Lava-bed pika (*O. p. goldmani*), *O. p. lasalensis,* Ruby Mountains pika (*O. p. nevadensis*), and Jemez Mountains pika (*O. p. nigrescens*) (IUCN 2006). Two additional subspecies were IUCN-listed as Vulnerable VU-B1+2C which signifies that these populations are severely fragmented with a declining range extent: *O. p. tutelata* and the Bighorn Mountain pika (*O. p. obscura*) (IUCN 2006). In total, three of the five American pika subspecies that inhabit the Great Basin have been designated as vulnerable by the IUCN: the Ruby Mountains pika (*O. p. nevadensis*), *O. p. tutelata*, and the White Mountains pika (*O. p. sheltoni*). However, Beever et al. (2003) documented five population extirpations in the 20th century for two other pika subspecies that inhabit the Great Basin—the Gray-headed pika (*O. p. schisticeps*) and Taylor pika (*O. p. taylori*) (Beever et al. 2003:44)—which clearly indicates that these subspecies are also declining in population size and range extent and deserve increased protection.

Several states have listed the American pika as species of conservation concern because of their small and fragmented populations, loss of habitat, and impacts from global warming. The New Mexico or Goat Peak pika (*O. p. incana*), which inhabits the lowest latitude of any American pika subspecies, has been designated as a New Mexico "Species of Greatest Conservation Need" due to loss and conversion of its alpine-wet meadow habitat, climate change, and small population size (New Mexico Department of Game and Fish 2006). In Utah, the American pika has been designated as a Tier III "Species of Conservation Concern" because of the discontinuous distribution of the populations throughout the state, vulnerability to local extirpation, and lack of information on the status of pika populations and their habitat (Gorrell et al. 2005). In Nevada, the American pika is a "Species of Conservation Priority" because of its "fragmented and isolated populations, some of which have recently gone locally extinct" and because it "appears highly susceptible to global climate change" (Nevada Department of Wildlife 2005).

Finally, the American pika's obligate association with talus habitat, vulnerability to warmer weather, tendency toward philopatry, and low dispersal ability have isolated pika populations in many regions of its range. In the Great Basin, pika populations are more isolated within and between ranges than any other montane mammal (Beever et al. 2003). This isolation has increased the genetic distinctiveness of many populations, so that the extirpation of individual populations increases the risk of losing a genetically unique population (Hafner and Sullivan 1995). Combined with the restricted range and small size of many pika populations, this isolation also increases the likelihood of population extinction (Beever 2002). Given the observed population extirpations in the Great Basin and California and the projected impacts of global warming on the species, pika populations across the range must be considered as vulnerable to extinction in the immediate and foreseeable future.

The American Pika Warrants Listing Under the ESA

I. Criteria for Listing Species as Endangered or Threatened

Under the ESA, 16 U.S.C. § 1533(a)(1), USFWS is required to list a species for protection if it is in danger of extinction or threatened by possible extinction in all or a significant portion of its range. In making such a determination, USFWS must analyze the species' status in light of five statutory listing factors:

> (A) the present or threatened destruction, modification, or curtailment of its habitat or range;
> (B) overutilization for commercial, recreational, scientific, or educational purposes;
> (C) disease or predation;
> (D) the inadequacy of existing regulatory mechanisms;
> (E) other natural or manmade factors affecting its continued existence.

16 U.S.C. § 1533(a)(1)(A)-(E); 50 C.F.R. § 424.11(c)(1) - (5).

A species is "endangered" if it is "in danger of extinction throughout all or a significant portion of its range" due to one or more of the five listing factors. 16 U.S.C. § 1531(6). A species is "threatened" if it is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." 16 U.S.C. § 1531(20). While the ESA does not define the "foreseeable future," the FWS must use a definition that is reasonable, that ensures protection of the petitioned species, and that gives the benefit of the doubt regarding any scientific uncertainty to the species.

Because global warming is one of the foremost threats to American pika, the USFWS should consider the timeframes used in climate modeling. The minimum time period that meets these criteria is 100 years. Predictions of impacts in the next 100 years or more are routine in the climate literature, demonstrating that impacts within this timeframe are inherently "foreseeable." The IUCN threatened species classification system, described below, also uses a timeframe of 100 years. Moreover, in planning for species recovery, the USFWS (as well as its sister agency, the National Marine Fisheries Service) routinely considers a 75-200 year foreseeable future threshold (Suckling 2006). For example, the Alaska Region has previously stated in the Steller's Eider Recovery Plan:

> The Alaska-breeding population will be considered for delisting from threatened status when: The Alaska-breeding populations has <1% <u>probability of extinction in the next 100 years</u>; AND Subpopulations in each of the northern and western subpopulations have <10% probability of extinction in 100 years and are stable or increasing. The Alaska-breeding population will be considered for reclassification from Threatened to Endangered when: The populations has > 20% <u>probability of extinction in the next 100 years</u> for 3 consecutive years; OR The population has > 20% probability of extinction in the next 100 years and is decreasing in abundance (USFWS 2002 (emphasis added)).

With regard to the Mount Graham red squirrel, the FWS stated "At least 10 years will be needed to stabilize the Mt. Graham red squirrel population and at least 100 to 300 years will be needed to restore Mt. Graham red squirrel habitat" (Suckling 2006 (emphasis added)). With regard to the Utah prairie dog, the Service defined the delisting criteria as "[t]o establish and maintain the species as a self-sustaining, viable unit with retention of 90 percent of its genetic diversity for 200 years" (Sucking 2006 (emphasis added)). The National Marine Fisheries Service stated of the Northern right whale: "[g]iven the small size of the North Atlantic population, downlisting to threatened may take 150 years even in good conditions" (Suckling 2006 (emphasis added)).

Perhaps most importantly, the time period the USFWS uses in its listing decision must be long enough so that actions can be taken to ameliorate the threats to the petitioned species and prevent extinction. Slowing and reversing impacts from anthropogenic greenhouse gas emissions, a primary threat to the American pika, will be a long-term process for a number of reasons, including the long lived nature of carbon dioxide and other greenhouse gases and the lag time between emissions and climate changes. For all these reasons, Petitioner suggests a minimum of 100 years as the "foreseeable future" for analyzing the threats to the continued survival of the American pika. The use of less than 100 years as the "foreseeable future" in this rulemaking would be clearly be unreasonable, frustrate the intent of Congress to have imperiled species protected promptly and proactively, and fail to give the benefit of the doubt to the species as required by law. USFWS must include these considerations in its listing decision.

II. IUCN Status of American Pika Subspecies

The World Conservation Union, formerly the International Union for the Conservation of Nature ("IUCN"), is the world's foremost authority on the status of threatened species. The IUCN Red List classification system is widely regarded as the most authoritative list of globally threatened species (Rodrigues et al. 2006). It is intended to be an easily and widely understood system for classifying species at high risk of global extinction (IUCN 2001). The general aim of the system is to provide an explicit, objective framework for the classification of the broadest range of species according to their extinction risk (IUCN 2001). The current system ("Version 3.1") is the result of a comprehensive and continuing process of drafting, consultation and validation (IUCN 2001).

The IUCN Red List classifies species worldwide according to their extinction risk based on objective criteria. A species is listed based on (1) the rate of population decline of the species over three generations, (2) fragmentation or fluctuations in the geographic range of the species, and (3) probability of extinction based on the quantitative analysis of the species over a 10-20 year period (IUCN Red List Criteria at § 5).

Seven of the 36 American pika subspecies have been classified by the IUCN as Vulnerable. The White Mountains pika (*O. p. sheltoni*), Lava-bed pika (*O. p. goldmani*), *O. p. lasalensis,* Ruby Mountains pika (*O. p. nevadensis*), and Jemez Mountains pika (*O. p. nigrescens*) were listed as VU-D1 signifying that the subspecies is vulnerable with less than 1000 mature individuals in the wild (IUCN 2006). Two additional subspecies were IUCN-listed as VU-B1+2C which signifies that these populations are vulnerable and severely fragmented, with a declining range extent: *O. p. tutelata* and the Bighorn Mountain pika (*O. p. obscura*) (IUCN 2006).

However, the current IUCN Red List classification understates the threats to the American pika. The evaluation of the American pika was made in 1996 and does not appear to have included an analysis of global warming. Scientific understanding of global warming and scientists' abilities to predict future impacts have advanced very rapidly in recent years. Today's information on the degree of threat to the American pika from greenhouse gas emissions was simply not available in 1996 nor were the studies documenting on 20th century declines of American pika populations in the Great Basin.

III. The American Pika Qualifies for Listing Under the Endangered Species Act

A. The Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

1. Global Climate Change

Global warming represents the gravest threat to the long-term survival of the American pika. The American pika is not only threatened by thermal stress and the loss of its montane habitat due to rising temperatures and altered precipitation regimes, but it also faces the cumulative and synergistic impacts of global warming with livestock grazing, human disturbance, disease, and changing interactions with predators. 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. We then provide a detailed review of climate projections in the western United States for the 21st century and how changing climate conditions will affect American pika population persistence and its high elevation montane habitat.

a. 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 recent 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)[1] has recently synthesized the best available science on global warming.

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[1] 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 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,

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).

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 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 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 the most important greenhouse gas pollutants 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 greenhouse gas overall because the volume emitted is greater that of all the other greenhouse gases combined. Not surprisingly, the rate of increase of total atmospheric carbon dioxide

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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.

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).

b. 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) have increased while cold extremes (coldest 10% of days or nights) have decreased (Trenberth et al. 2007).

Global climate has changed in other ways as well. 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) have 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 (2-5.0°F) during the past century (Smith et al. 2001), exceeding the average global temperature rise by more than double in many western regions. While precipitation has generally increased in the Pacific northwest (by 11% on average) (Parson et al. 2001), 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 (Stewart et al. 2004, Christensen et al. 2007, Vicuna and Dracup 2007). Streamflow timing (measured as CT or timing of the center of mass flow) 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).

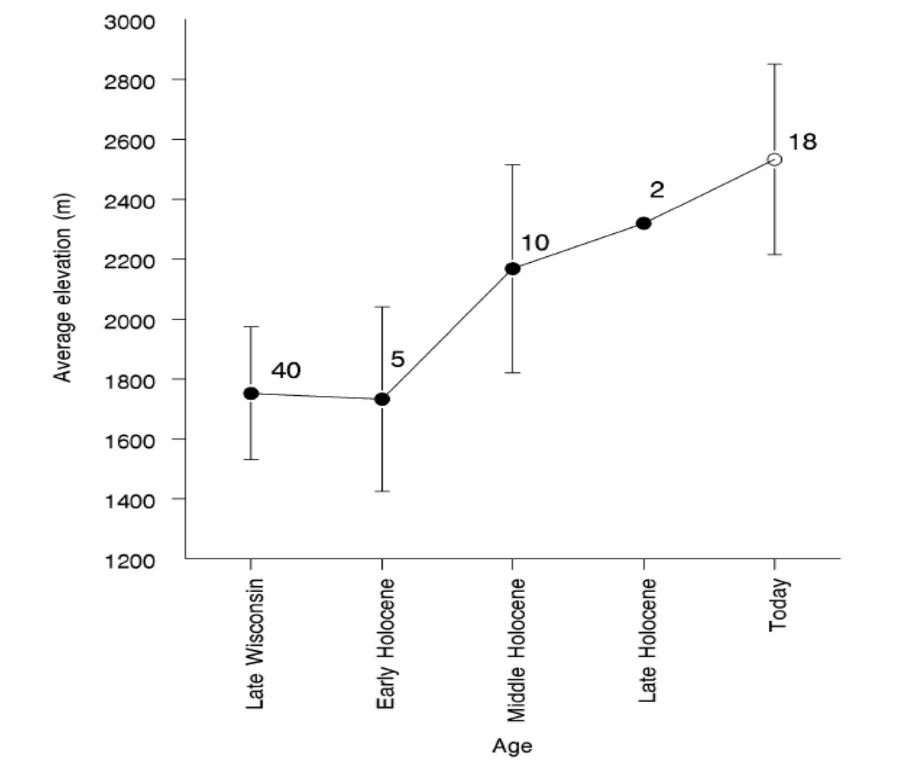
c. Observed Impacts to the American Pika from Global Warming

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. 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).[2]
Source: Grayson (2005: 2109).



Between 40,000-7,500 years ago, the average elevation of pika populations was 1,750 m (5,741 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 (1427 ft) to 2,168 m (7,112 ft). This increase in elevation reflects the extinction of the remaining low-lying pika populations across much of the Great Basin (Grayson 1993, 2000, 2005).

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[2] 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.

Grayson (2005) concluded that prehistoric pika population extirpations were driven by increasing temperatures, decreasing effective moisture and attendant changes in plant communities. 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 (40,000-10,000 radiocarbon years ago), now-extinct pika populations were located an average of 170 km (105 miles) from the nearest extant population, but by the late Holocene (4500-200 years ago), this distance had declined to about 30 km (18 miles) (Grayson 2005).

Recent Population Extirpations and Global Warming

Two recent studies of pika population persistence in Great Basin and California 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 most likely explanation for observed range shifts.

Beever et al. (2003) documented the extirpation of six of 25 pika populations (24%) in the Great Basin during the 20th century and found strong evidence that changing climate conditions have 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 (7,792 ft) in 1956 could only be found at higher elevations above 2,743 m (8,999 ft) in the 1990s (Beever et al. 2003).

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), whereas the average elevation of the 18 populations that survived into the 1990s was 2,533 m (8,310 ft) (Grayson 2005). In the early 2000s, Beever resurveyed Great Basin pika populations and reported the extirpation of three additional pika populations in the 2000s (Krajick 2004), resulting in an increase in elevation of remaining extant populations to 2,665 m (8,743 ft) (Schwarz 2005). As of 2004, at least nine of the 25 (36%) Great Basin populations were extirpated (Krajick 2004). Overall, these population extirpations have resulted in an upslope range contraction of 274 m (900 ft) in the Great Basin in less than a century.

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 climate change 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 2002, Beever et al. 2003). 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.

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 (Moritz 2007). The American pika was one of several high-elevation species to show an upward range shift (Moritz 2007). Pikas were not found at the lowest elevation Grinnell site of Glen Aulin at 7,800 ft, although they were detected at the next highest Grinnell site of 9,000 ft in Tuolumne Meadows (Jim Patton, personal communication, 8/30/07). Subsequent surveys have detected the next lowest extant pika population at a historic, non-Grinnell site at 8,300 ft (Jim Patton, personal communication, 8/30/07), suggesting that the pika range has contracted upslope by 500 ft during the past 90 years.

The Grinnell Resurvey Project's relatively small sample size of surveyed sites for the American pika highlights the importance of conducting regular resurveys of the Yosemite transect as well as extending Grinnell resurveys to other elevational transects in California (Lassen, White Mountains, and the southern Sierra) (Moritz 2007) in order to understand population trends of the American pika in California. However, the high proportion of range contractions detected by the Grinnell Resurvey Project among mid- to high-elevation mammal species like the pika (Moritz 2007) suggests that the absence of pika at the lowest-elevation survey site reflects a range shift rather than a random population extirpation. Range contractions were both more numerous (13 of 19 species) and of higher magnitude than were range expansions (6 of 19 species) which involved mostly low-elevation species (Moritz 2007, Table 4). 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) during the ~90 years in between surveys years (Moritz 2007).

Moritz (2007) offers three potential explanations for the observed range shifts of small mammal species in Yosemite National Park: stochastic fluctuations, fire-related vegetation change, and regional climate change. The strong directionality of the range shifts, totaling 19 upward versus 9 downward shifts (Moritz 2007), suggests that stochastic fluctuations are unlikely. Successional changes due to fire suppression in Yosemite National Park are most evident at mid-elevations (Moritz 2007), making this explanation implausible for the American pika which inhabits high elevations. Moritz (2007) concludes that the most likely cause of the range contractions for the American pika and other high elevation species is increased temperatures:

> 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).

Temperatures in Yosemite Valley have increased by 3°C (5.4°C) over the past 100 years, which is much greater than the mean increase in California temperatures over the same period (Moritz 2007). Future analyses of weather station data throughout the elevational range of Yosemite National Park will be important for examining the relationships between climate conditions and range shifts of high elevation species like the American pika.

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).

d. Projected Changes in Climate Conditions in the Pika Range

Since the Third Assessment Report, the IPCC has performed an unprecedented internationally coordinated climate change experiment using 23 models by 14 modeling 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 (30-75°N, 50-100°E), average temperatures are projected to rise by an average of 2.1-5.7°C (3.8-10.3°F) by the end of the 21st century under the A1B mid-level SRES emissions scenario (using a multi-model average from 21 models) with high projected warming during both the summer and winter: 1.6-5.8°C (2.9-10.4°F) during December-February and 2.3-5.7°C (4.1-10.3°F) during June-August (Christensen et al. 2007, Table 11.1). Warming during the winter could be even be higher than projected due to the snow-albedo feedback which is poorly captured in general circulation models (Christensen et al. 2007). 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.

Projected changes in precipitation in the western U.S. 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 important in providing pikas insulation against cold weather during the winter months (Smith 1978, Hik 2002). Although forecasting climate change in mountainous regions is challenging because of complex topography, general circulation 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). Furthermore, since less precipitation will be deposited as snow, the snow-albedo feedback will hasten declines in snowpack since surfaces without snow reflect less radiation than snow-covered surfaces (Leung et al. 2004). 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 and for coastal ranges where winter temperatures are close to freezing (Leung et al. 2004, Christensen et al. 2007). Leung et al. (2004) found that snowpack will decline significantly throughout the western mountains, with the biggest declines of 60-70% by mid-century (2040-2060) in the coastal ranges of the Sierra Nevada and Cascades where the snowpack is closer to the melting point and with smaller declines (20%) in the inland Rockies by mid-century (2040-2060). Overall, throughout the pika range, reduced snowpack will provide less insulative protection to pikas during cold weather extremes in winter.

Warming will also continue to cause earlier seasonal runoff of mountain snowpack in the western U.S. and result in lower summer moisture (Christensen et al. 2007, Vicuna and Dracup 2007) which will likely decrease vegetation available for pikas. Using a business-as-usual emissions scenario, Stewart et al. (2004) found that snowmelt (measured as CT, center of timing) would advance by 20-40 days by the end of this century in the Pacific Northwest, Sierra Nevada, and Rocky Mountain regions. Stewart et al. (2004) attributed earlier snowmelt to the dominant influence of warmer spring temperatures and cautioned that earlier snowmelt would lengthen the summer drought period throughout the western U.S. with "important consequences for water supply, ecosystem, and wildfire management". 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 desiccation and die-off of mountain plants. Because plants in Mediterranean climates that characterize the west coast of the United States are highly sensitive to drought, the overall summer productivity of plants is likely to decrease (Cayan et al. 2006), which could limit food resources throughout the summer and during the critical pika haying period.

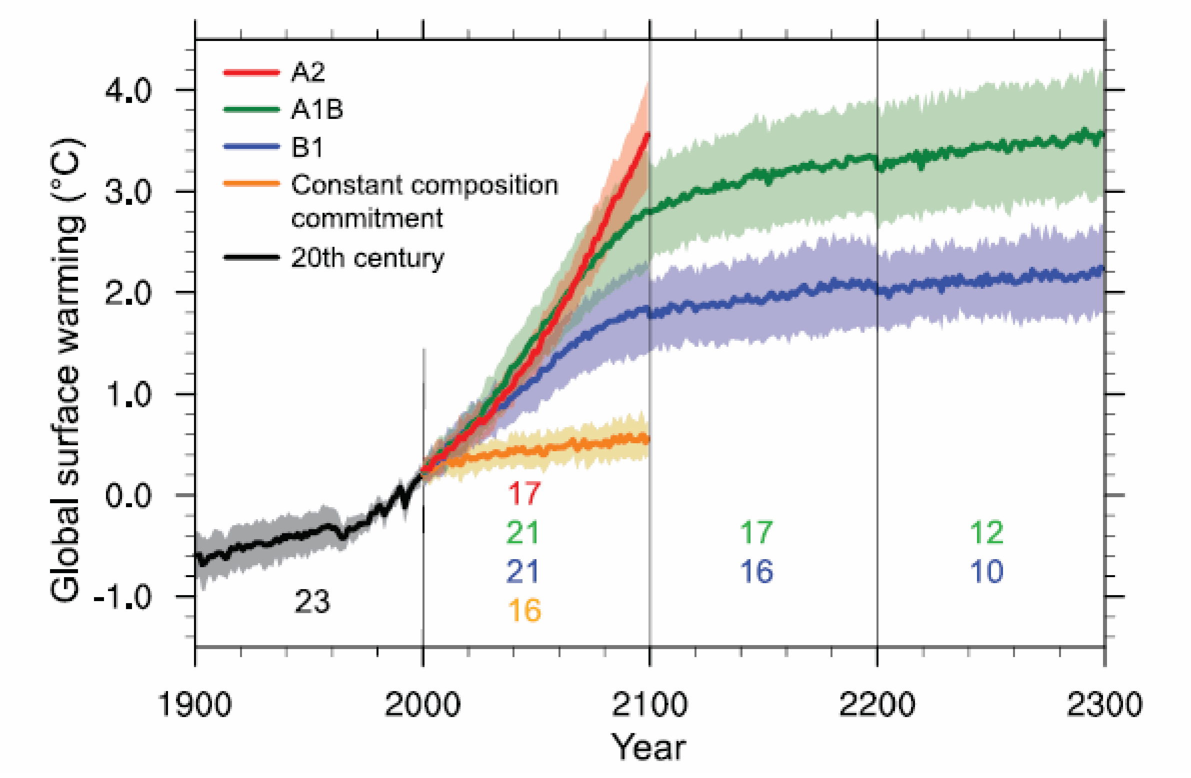
Finally, of importance to the persistence of the American pika, global temperatures will continue to rise in the 21st century regardless of the mitigation measures adopted (Figure 3) (Meehl et al. 2007). Past anthropogenic greenhouse gas emissions have altered the energy balance of the earth and committed 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).

Climate Change in the Western Mountain Ranges

Although modeling climate change in montane regions inhabited by the American pika is challenging due to complex topography, regional climate models and empirical and statistical downscaling techniques have proven useful for modeling changes in climate conditions at finer scales in topographically complex montane areas (Christensen et al. 2007). Some of the most detailed regional modeling completed to date has focused on forecasting climate change in the Sierra Nevada Mountains of California. Of relevance for the pika, three of the most important findings were that (1) temperatures are projected to increase the most at higher elevations, (2) hydrologic impacts on snowpack and streamflow are projected to heavily impact both higher and lower elevations of the Sierra Nevada, and (3) changes in temperature and precipitation will be heterogeneous by season and region. This section provides an overview of these studies.

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). One of the most important findings of this regional model for

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).



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.

Additionally, warmer temperatures are projected to continue reducing annual snowpack in the Sierra Nevada which will 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 an average of 32-59% under the B1 low emissions scenario and by 41-79% under the A2 high emissions scenario by the end of this century (2070-2099) when virtually no snow will remain below 1000 m (3280 feet) (Cayan et al. 2006). Maurer (2007) examined the confidence levels for projected hydrologic impacts on the Sierra Nevada at the end of the 21st century (2071-2100) under two SRES emissions scenarios, A2 (high emissions) and B1 (low emissions). Temperatures in the Sierra Nevada increased by 3.7°C under the high emissions A2 scenario and by 2.4°C under the low emissions B1 scenario. Two high confidence hydrologic impacts from these increased temperatures were increase in winter streamflow and a decrease in late spring and summer streamflow across four basins in the Sierra Nevada (Maurer 2007). In a review of studies assessing the impacts of climate change on hydrology, Vicuna and Dracup (2007) reported that, while earlier studies suggested that the low and 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.

e. 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 cooler, 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, including both direct effects from thermal stress and indirect effects from changes in vegetation, talus habitat, interactions with predators, and disease prevalence.

Thermal stress

Global warming has already resulted in temperature increases in the western U.S. which appear to be exceeding the thermal limits of the American pika for lower elevation populations. Average temperatures in the western U.S. rose by 1.1-2.8°C (2-5°F) during the 20th century (Smith et al. 2001) in parallel with a 36% reduction of pika populations in the Great Basin. By the end of this century, temperatures in the western U.S. are expected to rise by twice the levels experienced in the 20th century--an average of 2.1-5.7°C (3.8-10.3°F)--under a "business-as-usual" A1B SRES emissions scenario (Christensen et al. 2007) which the world is currently on the path to exceeding (Raupach et al. 2007). Temperature increases of this magnitude undoubtedly commit pika populations to an increased rate of extinction. Furthermore, massive loss of snowpack loss in the western mountains will continue to diminish the protective insulation of snow cover during the coldest winter weather, leaving the pika more vulnerable to thermal stress during winter. This section discusses four ways by which thermal stress will continue to impact the American pika.

- Increasing summer temperatures projected for the western mountains 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 5.7°C (10.3°F) in the western U.S. during this century (Christensen et al. 2007) and may be even more extreme at high elevations (Snyder et al. 2002). Given the pikas' 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 amidst talus boulders. 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 (Christensen et al. 2007) will place the pika and the vegetation it relies on 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 (Smith and Weston 1990). 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 desiccation 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 for that latitude (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). Loss of insulation from snow cover has also been implicated in population collapses of the collared pika in the Yukon (Hik 2002). 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 and by reducing the extent of alpine meadow and talus habitat.

Vegetation change

Of foremost concern for the American pika, the hotter, and in some areas 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, increased 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 the 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 desiccation of vegetation and curtail the pika's ability to accumulate a sufficient summer haypile for surviving winter months (Hafner 1994). In hotter, low-elevation environments of the pika range, summer desiccation 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 pikas depend on. The invasion of subalpine meadows by adjacent forests occurred extensively throughout montane regions in the western United States during the 20th century, especially since the 1930s, including pika habitat in the Rockies, Sierra Nevada, Cascades, Warner, Lemhi, Uinta, and Jemez Mountains and Lassen National Park (Dyer and Moffett 1999, Fagre et al. 2003). Average annual temperature and precipitation are key variables that determine plant community composition across montane elevation gradients (Miller and Halpern 1998, Fagre et al. 2003, Bunn et al. 2005). The widespread loss of alpine and sub-alpine plant communities as timberlines move up has been linked to rising temperatures and changes in precipitation due to global warming (Grabherr et al. 1994, Walther 2004, Walther et al. 2005). Meadows are being replaced by the upward expansion of mixed conifer forests (Bunn et al. 2005). In the northern Rocky Mountains, treelines have moved upward by 100-250 m in some areas since the 1930s (Fagre et al. 2003). 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. 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) predicted 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 the 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.

In summary, the pikas' 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 risk of extinction from anthropogenic climate change. Under a high warming scenario, pika populations, especially at lower elevations or lower latitude regions across the range, are extremely vulnerable to extinction.

2. Livestock Grazing

Livestock grazing in the meadows that surround the pikas' talus habitat may negatively affect pikas by browsing and trampling vegetation important for pika foraging and by facilitating the invasion of exotic plant species. Pikas are central-place foragers that graze most intensely nearer to talus fields to reduce the energetic costs of foraging and their predation risk (Huntly et al. 1986); therefore, the vegetation in the radius around talus is particularly important. Beever et al. (2003) found evidence that livestock grazing may impact pika populations in the Great Basin. All six sites where pika populations had been extirpated in the Great Basin were grazed, indicating a significant negative correlation between grazing and pika population persistence (Beever et al. 2003). However, grazed areas tended to occur at lower elevations where talus habitat was sparser, making it to difficult to distinguish between the importance of grazing relative to the importance of lower elevation and smaller talus area (Beever et al. 2003). Beever et al. (2003) concluded that cattle and horse grazing within 20-50 m of talus may negatively affect pikas.

However, Beever et al. (2003) 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 (Beever et al. 2003:5-):

> 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."

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).

The impacts of grazing on the alpine meadow foraging habitat that pikas rely on have been noted throughout the pika range in the western United States. 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).

Grazing has also been identified as a threat to the health of alpine-montane wet meadow ecosystems in New Mexico (New Mexico Department of Game and Fish 2006):

> Grazing practices. The wet meadows of the Southern Rocky Mountains Ecoregion provide some of the most attractive vegetation areas for grazing animals. Unconstrained access to the wet meadows may lead to loss of cover, mortality of plant species, increased erosion, and wetland drainage (p. 183).

Specifically in the Jemez Mountains, which is inhabited by the Jemez Mountains pika (*O. princeps nigrescens*), native vegetation has been replaced by non-native pasture species, which has significantly altered the species composition of alpine meadow communities (New Mexico Department of Game and Fish 2006):

> Historical manipulation of the meadow habitats through root plowing and reseeding with non-native tame pasture species has significantly altered the composition and hydrology of the montane meadows in the northern Jemez Mountains. Many of these wet meadows were converted to more xeric grazing lands and no longer maintain the necessary hydrology to support the characteristic vegetation of this type (p. 183).

3. Invasive Plant Species and Fire Suppression

In addition to grazing, the invasion of exotic plant species may also alter the composition of plant species in the pika's meadow foraging habitat (Beever et al. 2003), potentially changing the species composition to one that is less favorable for the pika. Although alpine and subalpine habitats tend to have fewer invasive plant species than lower elevation habitats, exotic plant invasions have been increasing in alpine and subalpine areas (McDougall et al. 2005, Parks et al. 2005). These invasions have been facilitated by changing climate conditions due to global warming, intentional introductions in ski developments to stabilize soils, intentional introductions to provide forage food for livestock grazing, hitch-hiking on livestock, and colonizing after fragile meadow habitats have been degraded by livestock (McDougall et al. 2005, Parks et al. 2005, New Mexico Department of Game and Fish 2006). In some montane areas, fire suppression has been cited as a factor contributing to the encroachment of trees into alpine and subalpine meadows (Dyer and Moffett 1999, Table 2; Fagre et al. 2003, Krajick 2004), which would limit the foraging area available to pikas.

B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

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

C. Disease or Predation

Predation

Potential predators of the American pika include coyotes (*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). 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 where larger animals cannot go (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). 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). 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).

Changing climate conditions may also affect the pika's 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.

D. Existing Regulatory Mechanisms are Inadequate to Protect the American Pika

Existing regulatory mechanisms have been inadequate to prevent the decline of the American pika in the Great Basin and are inadequate to ensure this animal's survival in the wild. The reduction of greenhouse gas pollution is essential to slow global warming and ultimately stabilize the climate system while there is still suitable pika habitat remaining.

1. Regulatory Mechanisms Addressing Greenhouse Gas Pollution and Global Warming are Inadequate

Greenhouse gas emissions and global warming are the greatest threats to the American pika and yet also the least well regulated. The primary international regulatory mechanisms addressing greenhouse gas emissions global warming are the United Nations Framework Convention on Climate Change and the Kyoto Protocol. While the entering into force of the Kyoto Protocol on February 16, 2005 marks a significant partial step towards the regulation of greenhouse gases, it does not and cannot alone adequately address the impacts of global warming that threaten the American pika with extinction. There are currently no legal mechanisms regulating greenhouse gases on a national level in the United States. Existing state measures on their own are also not sufficient. As detailed below, all existing regulatory mechanisms are clearly inadequate to protect the American pika from further declines and extinctions.

a. The United Nations Framework Convention on Climate Change

The United Nations Framework Convention on Climate Change ("UNFCCC") was adopted in May 1992 at the first Earth Summit held in Rio de Janeiro, Brazil, and entered into force in March 1994 (EIA 2004). The stated objective of the UNFCCC is the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (EIA 2004). Due to the complexity of climate issues and the widely divergent political positions of the world's nation states, the UNFCCC itself was unable to set emissions targets or limitations, but instead created a framework that set the stage for a range of subsequent actions (UNFCCC 2004). The UNFCCC covers greenhouse gases not otherwise controlled by the Montreal Protocol on ozone-depleting substances (UNFCCC 2004).

The UNFCCC assigns differing responsibilities to its 189 parties, based on their differing levels of economic development (UNFCCC 2004). Annex I parties include 41 mostly developed countries. Annex I countries set a goal (but not a requirement) of returning their emissions by 2000 to 1990 levels (UNFCCC 2004). They are required to make regular reports on implementation, including reporting on levels of greenhouse gas emissions and policies and measures to reduce them (UNFCCC 2004). Annex II is a subset of Annex I countries which includes the 23 highly developed countries which are required to financially and otherwise support the efforts of the developing countries (UNFCCC 2004). Countries with economies in transition ("EITs") include 14 countries in Eastern and Central Europe and the former Soviet Union which are listed in Annex I but do not have the additional responsibilities of the other Annex I countries. Non-Annex I parties include all parties not included in one of the former categories and are mostly developing countries (UNFCCC 2004). Non-Annex I parties have general commitments to respond to climate change but have fewer obligations and are expected to rely upon external support.

The UNFCCC has not yet effectively controlled greenhouse gas emissions. The year 2000 has come and gone without the UNFCCC's goal of reducing greenhouse gas emissions from Annex I countries to 1990 levels being met. More than ten years after the UNFCCC came into force, "dangerous anthropogenic interference with the climate system" remains undefined (International Climate Change Taskforce 2005). There is a growing body of evidence, however, that anthropogenic greenhouse gas emissions have already caused "dangerous" climate change.

b. The Kyoto Protocol

In 1997 the Kyoto Protocol became the first additional agreement added to the UNFCCC to set emissions targets. The Kyoto Protocol set goals for developed countries only to reduce their emissions to at least 5% below their 1990 levels between 2008-2012, the "first commitment period" (UNFCCC 2004). The Kyoto Protocol required ratification by a minimum of 55 countries, encompassing at least 55% of the carbon dioxide emissions of Annex I countries before it would enter into force. Over seven years passed before this occurred. The Kyoto Protocol entered into force on February 16, 2005, 90 days after it was ratified by Russia (UNFCCC 2005).

Despite its long-awaited ratification, the Kyoto Protocol is inadequate to prevent significant climate change, and consequently the decline to extinction of the American pika. First, the Protocol's overall emissions reduction targets for the first commitment period are highly unlikely to be met, due in large part to the refusal of the United States to ratify the agreement. Second, even if the Kyoto targets were met, they are far too modest to impact greenhouse gas concentrations and global warming sufficiently to ensure the survival of the American pika. Third, negotiations have not even begun in earnest for emissions reductions beyond 2012. Each of these issues is addressed in turn below.

The refusal of the United States to ratify the Kyoto Protocol, announced by the Bush Administration in 2001, is a major reason why Kyoto targets are unlikely to be met. Because the United States is responsible for over 20% of worldwide carbon dioxide emissions (EIA 2004), it is highly unlikely that overall targets can be met without US participation. The Kyoto target for the US was a 7% reduction in greenhouse gas emissions levels from 1990 levels by 2012 (EIA 2004). Between 1990 and 2001, United States emissions have in fact increased by 13%. Total United States emissions are projected to grow a staggering additional 43.5% through the period 2025 (GAO 2003a).

In addition to the outright intransigence of the United States, the overall and many country-specific Kyoto targets are unlikely to be met based on current progress and data. While some Annex I countries have achieved their Kyoto targets or at least some reductions, many other Annex I countries have seen their emissions increase substantially (Figure 4). Emissions also increased in many of the developing nations between 1990 and 2000 (UNFCCC 2004). In addition, although emissions of the EIT countries decreased significantly from 1990-2000 as a result of economic contraction in these countries, they increased from 2000 to 2001 and are projected to continue to do so (EIA 2004). Overall, the EIA estimates that worldwide carbon emissions in 2025 will exceed 1990 levels by 72% (EIA 2004).[3]

There are other problems with implementation of the Kyoto Protocol as well. For example, accurate, consistent, and internationally comparable information that is essential for sound policymaking is still lacking in many areas (UNFCCC 2004). Many countries have yet to build a sound institutional framework and a number have yet to even report on their institutional arrangements or have pointed out that their systems are weak (UNFCCC 2004). The Protocol will only succeed at meeting its modest goals if the parties fulfill their commitments, yet mechanisms for enforcement have not yet been tested and are likely ineffective. There are no financial penalties or automatic consequences for failing to meet Kyoto targets (UNFCCC 2004).

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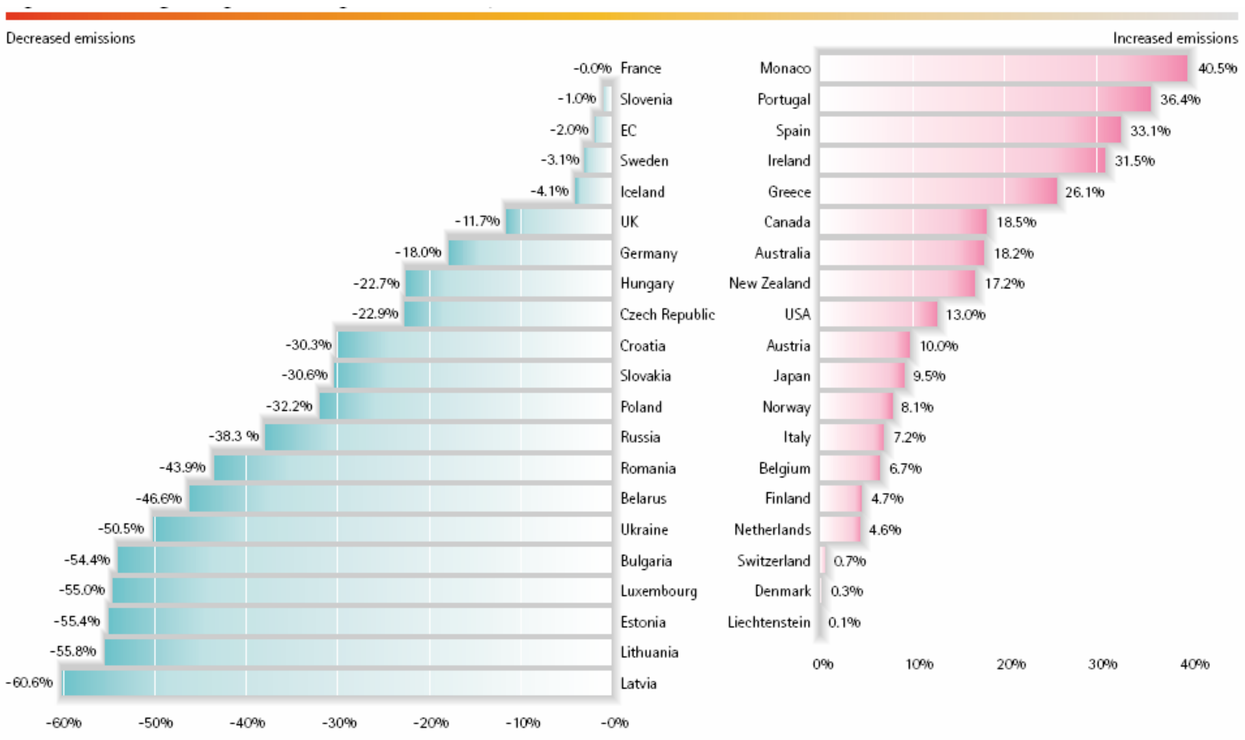
[3] EIA (2004) projections do not reflect the potential impacts of the Kyoto treaty, because it had not yet come into force when the projections were prepared (EIA 2004). Compliance with Kyoto or other measures to reduce greenhouse gases could cause actual emissions to differ from the projections (EIA 2004), however, as discussed above, compliance with overall Kyoto targets is unlikely.

Figure 4. Changes in Greenhouse Gas Emissions by Annex I Countries, 1990-2001
Source: UNFCC (2004:25).



Even in the unlikely event that overall Kyoto targets were fully met by the year 2012, the reductions are far too small to substantially reduce global warming and improve the plight of the American pika. Implementation of the Kyoto Protocol would only slightly reduce the rate of growth of emissions – it would not stabilize or reduce atmospheric greenhouse gas concentrations (Williams 2002). Carbon dioxide levels currently stand at over 380 ppm, from pre-industrial levels of 280 ppm, and are increasing at more than 2 ppm per year (International Climate Change Taskforce 2005). Stabilizing carbon dioxide concentrations at 440 ppm (23% above current levels, and a level likely to lead to a greater than 2° C average global temperature rise) would require global emissions to drop below 1990 levels within a few decades, with emissions eventually declining to a very small fraction of current levels, despite growing populations and an expanding world economy. These cuts will not be achieved simply by compliance with Kyoto (Williams 2002). The IPCC SRES scenarios predict carbon dioxide concentrations of between 490 and 1260 ppm by 2100 (Albritton et 2001), and these scenarios all assume significant reductions in the rate of greenhouse gas emissions (Nakićenović et al. 2000).

Additionally, Kyoto only sets targets for action through 2012. There is no current regulatory mechanism governing greenhouse gas emissions in the years beyond 2012. Discussions for targets for the second compliance period from 2012-2016 have not yet begun (EIA 2004). While the European Union delegation attempted to begin discussions at the Conference of the Parties in Milan, Italy in 2003, in Buenos Aires in 2004, in Montreal in 2005, and in Nairobi in 2006, progress was blocked by the United States. No binding or even voluntary agreement yet exists to deal with the cuts needed beyond the Kyoto Protocol.

Because the climate responds to changes in greenhouse gas concentrations with a time lag, past emissions have already committed the planet to a certain degree of warming and climate change (Williams 2002, ACIA 2004, Meehl et al. 2007). We are, in fact, already committed to an approximately doubling of the warming we have already experienced (Meehl et al. 2007).

The goal of the UNFCCC is to stabilize greenhouse gas concentrations in the atmosphere at a level that prevents dangerous anthropogenic interference with the climate system (EIA 2004). Yet scientists have already stated "it is difficult to avoid the conclusion that potentially dangerous anthropogenic interference in the climate system is already underway" (Stott et al. 2004) (discussing the contribution of past greenhouse gas emissions to the deadly European heatwave of 2003), and that there simply is no "safe" level of elevated carbon dioxide concentrations (Stainforth et al. 2005).

c. United States Climate Initiatives are Ineffective

Because the United States is responsible for over 20% of global greenhouse gas emissions, regulation of United States emissions is essential to saving the American pika from extinction. Unfortunately, despite the nature and magnitude of the risks, and a variety of actions by Congress and the Executive Branch, there is still no regulation of greenhouse gas emissions on the national level in the United States.

Beginning in 1978, Congress established a "national climate program" to improve understanding of global climate change through research, data collection, assessments, information dissemination, and international cooperation. National Climate Program Act of 1978, 15 U.S.C. §§ 2901 *et seq.* Two years later, in the Energy Security Act, Congress directed the Office of Science and Technology Policy to engage the National Academy of Sciences in a study of the "projected impact, on the level of carbon dioxide in the atmosphere, of fossil fuel combustion, coal-conversion and related synthetic fuels activities" authorized by the Energy Security Act. Pub. L. No. 96-294, tit. VII, § 711, 94 Stat. 611, 774-75 (1980). In 1990, Congress enacted the Global Change Research Act, 15 U.S.C. §§ 2931-2938, which established a 10-year research program for global climate issues, directed the President to establish a research program to improve understanding of global change, and provided for scientific assessments every four years that analyze current trends in global change. *Id.* at §§ 2932, 2933, 2936(3). Congress also established a program to research agricultural issues related to global climate change. Pub. L. No. 101-24, tit. XXIV, § 2402, 104 Stat. 4058, 4058-59 (1990). Finally, two years later, in the Energy Policy Act of 1992, Congress directed the Secretary of Energy to conduct several assessments related to greenhouse gases and report to Congress. Pub. L. No. 102-486, § 1604, 106 Stat. 2776, 3002.

The Global Climate Protection Act of 1987 directed the Secretary of State to coordinate U.S. negotiations concerning global climate change. 15 U.S.C. § 2901 note; § 2952(a). Following those negotiations, President George H.W. Bush signed, and the Senate approved, the UNFCCC, which, as discussed above, has yet to effectively control greenhouse gas emissions.

Greenhouse gas emissions have also not yet been effectively regulated under the United States Clean Air Act ("CAA"). Section 103(g) directs the Environmental Protection Agency

(“EPA”) to establish a “basic engineering research and technology program to develop, evaluate, and demonstrate nonregulatory strategies and technologies for air pollution prevention” that would address substances including carbon dioxide. 42 U.S.C. § 7403(g). The CAA also states that nothing in Section 103(g) “shall be construed to authorize the imposition on any person of air pollution control requirements.” *Id.*

In 2003, the EPA rejected a petition urging it to regulate greenhouse gas emissions from automobiles under CAA Section 202, stating as follows:

> After careful consideration of petitioners' arguments and the public comments, EPA concludes that it cannot and should not regulate [greenhouse gas] emissions from U.S. motor vehicles under the CAA. Based on a thorough review of the CAA, its legislative history, other congressional action and Supreme Court precedent, EPA believes that the CAA does not authorize regulation to address global climate change. Moreover, even if [carbon dioxide] were an air pollutant generally subject to regulation under the CAA, Congress has not authorized the Agency to regulate [carbon dioxide] emissions from motor vehicles to the extent such standards would effectively regulate car and light truck fuel economy, which is governed by a comprehensive statute administered by DOT.
>
> In any event, EPA believes that setting [greenhouse gas] emission standards for motor vehicles is not appropriate at this time. President Bush has established a comprehensive global climate change policy designed to (1) answer questions about the causes, extent, timing and effects of global climate change that are critical to the formulation of an effective, efficient long-term policy, (2) encourage the development of advanced technologies that will enable dramatic reductions in [greenhouse gas] emissions, if needed, in the future, and (3) take sensible steps in the interim to reduce the risk of global climate change. The international nature of global climate change also has implications for foreign policy, which the President directs. In view of EPA's lack of CAA regulatory authority to address global climate change, DOT's authority to regulate fuel economy, the President's policy, and the potential foreign policy implications, EPA declines the petitioners' request to regulate [greenhouse gas] emissions from motor vehicles. 68 Fed. Reg. 52922, 52925 (footnote omitted).

In 2007, the Supreme Court overturned the EPA’s refusal to regulate these emissions, and remanded the matter to the agency for further consideration. *Massachusetts v. U.S. EPA*, 127 S. Ct. 1438 (2007). The EPA has yet to act following the remand. Moreover, the EPA has yet to act upon California’s request for a waiver to implement its Clean Vehicle Law, passed in 2002 (AB 1493, Pavley) which requires greenhouse gas reductions from automobiles sold in California, and is thus activiely preventing this law from going into effect.

The George W. Bush Administration’s climate initiative, referenced by the EPA as a primary reason for declining to regulate greenhouse gas emissions from motor vehicles and revealed after the Administration renounced the Kyoto Protocol, plainly fails to effectively address global warming. This initiative is based entirely on voluntary measures which are incapable of effectively controlling greenhouse gas emissions. This climate plan, termed the Global Climate Change Initiative, also focuses only on reducing the amount of greenhouse gas emissions per unit of energy produced ("emissions intensity"), not the overall level of emissions (GAO 2003a). In the absence of new climate initiatives, United States emissions intensity is expected to decrease by 14% by 2012, while total emissions continue to increase (GAO 2003a). The Bush plan, if fully implemented and successful, would decrease emissions intensity by a mere additional 4%, for an overall reduction of 18%, but total emissions would still continue to increase. Even according to the Bush Administration's own arithmetic, full implementation and success of the plan will result in US greenhouse gas emissions in 2012 that are 30% higher than 1990 emissions, as opposed to the 7% reduction called for by the Kyoto Protocol (Holdren 2003). Cumulative emissions between 2002-2012 will continue to grow and would be a mere 2% less with the plan than without it (GAO 2003a).

Moreover, the US Government Accounting Office ("GAO") found that the Bush plan does not explain how even the modest 4% claimed reduction in energy intensity will be met. The Bush plan fails to provide any emissions savings estimates at all for 19 of the 30 plan elements (GAO 2003b). Of those 19, at least two seem unlikely to yield any emissions savings at all by 2012 (GAO 2003b). Of 11 initiatives for which savings estimates were provided, at least eight were not clearly attributable to the Bush plan, and there were problems with others as well (GAO 2003b). Overall, the GAO could confirm that emissions savings would be realized from only three of the Bush plan elements (GAO 2003b), an extremely inauspicious finding for the ultimate success of the already modest proposal.

In the absence of federal leadership, state and local governments have taken the lead in measures to reduce greenhouse gas emissions. While certainly a step in the right direction, unfortunately, these measures on their own are insufficient to prevent the extinction of the American pika. For example, the strongest law enacted to date is the California Global Warming Solutions Act of 2006. Signed into law in September, 2006, it 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. *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. While the

California Global Warming Solutions Act is a promising first step, like the Kyoto Protocol, it is insufficient on its own to slow global warming sufficiently to ensure the survival of the American pika.

While there is still time to save the American pika, bolder action from the U.S., and from the rest of the world, is needed 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).[4]

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 stronger greenhouse gas limitations be enacted immediately.

For all the reasons discussed above, existing regulatory mechanisms relating to global warming are inadequate to ensure the continued survival of the American pika. Regulatory measures relating to other threats to the pika are also inadequate to ensure its survival in the face of advancing climate change. Ensuring the American pika's survival requires immediate and dramatic action, particularly in the United States, to reduce greenhouse gas emissions.

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[4] 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).

Protecting the American pika under the Endangered Species Act will bring attention to its plight and encourage both voluntary and regulatory action.

E. Other Natural and Anthropogenic Factors

Pika populations appear to be sensitive to human disturbance either because human disturbance negatively impacts pika activities or adversely affects sensitive pika habitat. 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 detected 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, 3 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 sites had greater habitat availability, making it difficult to distinguish between the importance of being located in wilderness or having a greater talus area.

Beever et al. (2003) also found “abundant evidence of direct human influence” at three of the six extirpated sites where the pikas’ talus habitat had been degraded by human activities or where human activities may have altered pika behaviors (i.e. recreational shooting):

> 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 1930s, and we found numerous gun shells on taluses there (Beever et al. 2003:45).

Of great concern for the pika, the alpine and subalpine foraging habitats they rely on are sensitive to disturbance and are difficult to restore once they have been degraded by human activities or grazing. Beever et al. (2003) highlighted the characteristics of alpine and subalpine ecosystems that compound the effects of human disturbance and make restoration extremely difficult: short growing season, variable precipitation, relatively low primary productivity, temperature fluctuations, high wind speeds, and shallow, weakly developed soils. The threats posed to alpine and subalpine meadows from human disturbance, including road construction and recreational use, were identified in the State Wildlife Action Plans of New Mexico and Nevada. Construction of roadways and recreational use in and near alpine meadows was identified as a threat to the health of alpine meadows in New Mexico (New Mexico Department of Game and Fish 2006):

> …poor placement and construction of roadways remain land-use factors with the potential to drain the wetlands of Rocky Mountain Alpine-Wet Meadow habitats…. The presence of roads and trails in and near alpine-montane wet meadows may result in reduced water quality, increased erosion, and eventual drainage of the wetlands (p. 183).

Recreation and climate change were identified as the primary problems facing alpine communities in Nevada, and the long-term effects of off-road vehicles on sensitive alpine vegetation were highlighted (Nevada Department of Wildlife 2005):

> Warmer temperatures resulting from climate change may have long-term impacts on alpine habitats and their species through the fragmentation and loss of habitat. Many high elevation habitats in Nevada are within established Wilderness Areas or other undeveloped areas where non-motorized recreation is the most common use. OHV use is typically concentrated at the lower elevations but incursion of OHVs and snowmobiles into alpine areas can disturb wildlife or damage alpine vegetation, which is slow to recover (p.159).

Research and Management Recommendations

The scientists studying the American pika have made important recommendations regarding studies for detecting and monitoring population trends and understanding the impacts of climate change, habitat loss, human disturbance, and other threats to pika populations. We include these points here because future research will be essential to protecting the pika from future population extinctions. The FWS should consider these points in its recovery plan process and in its research funding decisions.

Surveys to document the status of American pika subspecies throughout the range are needed and should be implemented immediately. The protocols in Beever et al. (2003) and the Grinnell Resurvey Project serve as models for such studies. Specifically, site-specific resurveys of pika populations at discrete time intervals across the American pika's elevational and latitudinal range would permit researchers to evaluate the current status of pika populations and detect range-wide population trends over time. Resurveys in regions with historic records of pika presence and absence will be especially useful in determining long-term population trends. Populations at lower elevations and lower latitudes are expected to be particularly vulnerable to extirpations from changing climate conditions and should be prioritized. Following Beever et al. (2003), measuring a range of potential explanatory variables will allow researchers to better understand the factors underlying detected population changes. In particular, measuring microclimate conditions in the pika's talus and meadow foraging habitats will provide a better mechanistic understanding of how climate conditions affect the pika. Given the short life span of pikas, demographic studies to measure survival and reproductive rates, including the timing of mortality, may also be feasible in shorter-term 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 from anthropogenic influence. Moritz et al. (2007) gave detailed suggestions for further monitoring and research in California's Sierra Nevada and more generally:

> 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 implemented 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 Network; 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. 2007:37-38).

Critical Habitat

The ESA mandates that, when the USFWS lists a species as endangered or threatened, the agency generally must also concurrently designate critical habitat for that species. Section 4(a)(3)(A)(i) of the ESA states that, "to the maximum extent prudent and determinable," the USFWS:

> shall, concurrently with making a determination . . . that a species is an endangered species or threatened species, designate any habitat of such species which is then considered to be critical habitat . . . .

16 U.S.C. § 1533(a)(3)(A)(i); *see also id.* at § 1533(b)(6)(C). The ESA defines the term "critical habitat" to mean:

> i. the specific areas within the geographical area occupied by the species, at the time it is listed . . . , on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and
>
> ii. specific areas outside the geographical area occupied by the species at the time it is listed . . . , upon a determination by the Secretary that such areas are essential for the conservation of the species.

Id. at § 1532(5)(A).

Petitioner expects that USFWS will comply with this unambiguous mandate and designate critical habitat concurrently with the listing of the American pika. We believe that all current and historic nesting islands and waters utilized by the species for foraging meet the criteria for designation as critical habitat and must therefore be designated as such.

Conclusion

For all the reasons discussed above, Petitioner Center for Biological Diversity requests that the U.S. Fish and Wildlife Service list the American pika as a threatened or endangered species because it is in danger of extinction or likely to become so in the foreseeable future in all or a significant portion of its range. We believe that the entire species currently qualifies for listing as threatened. However, because the American pika is comprised of thirty-six recognized subspecies, and several of these subspecies are more immediately imperiled than others, we also formally request that USFWS conduct a status review on each subspecies to determine if separately listing any subspecies as threatened or endangered is warranted. Specifically, we request that the five American pika subspecies that inhabit the Great Basin be listed as endangered due to their small population size, declining population trend, declining range extent, and the substantial long-term threat that global warming poses to their persistence: the Ruby Mountains pika (*O. p. nevadensis*), *O. p. tutelata*, the White Mountains pika (*O. p. sheltoni*), the Gray-headed pika (*O. p. schisticeps*), and the Taylor pika (*O. p. taylori*). In addition, we request that Lava-bed pika (*O. p. goldmani*) and Bighorn Mountain pika (*O. p. obscura*) be listed as endangered due to their small population size, isolation from mainland pika population sources, and substantial ongoing threats to their persistence. Finally, we request that the remaining subspecies be listed as threatened. This petition has demonstrated that the American pika and its constituent subspecies clearly warrant listing under the Endangered Species Act based on the five listing factors specified in the statute.

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

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