COSEWIC
Assessment and Status Report

on the

Collared Pika
Ochotona collaris

in Canada

SPECIAL CONCERN
2011

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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COSEWIC
Assessment Summary

Assessment Summary – November 2011

Common name
Collared Pika

Scientific name
Ochotona collaris

Status
Special Concern

Reason for designation
This small rabbit-relative is a Beringian relict that is restricted to talus slopes in alpine areas in northern west British Columbia, Yukon, and Northwest Territories. This region comprises over half the global range of this species, and is witnessing climate-driven shifts in habitat, temperature, and precipitation at faster rates than elsewhere in Canada. A demonstrated sensitivity to climate variability, coupled with poor dispersal ability and the naturally fragmented nature of its populations, heightens the vulnerability of this small mammal to climate change. The species is well-studied in a very limited portion of its range, but baseline information on population trends at the range level, and a clear understanding of the extent and severity of climate impacts to this species and its habitat in the coming decades is limited. However, the best available information suggests that this species may be particularly sensitive to a changing climate, including concomitant increases in precipitation variability, leading to reductions in habitat availability. The potential of negative impacts of climate change to the persistence of this species over the long term is substantial.

Occurrence
British Columbia, Yukon, Northwest Territories

Status history
Designated Special Concern in November 2011.

COSEWIC
Executive Summary

Collared Pika
Ochotona collaris

Wildlife species description and significance

The Collared Pika (*Ochotona collaris*) is a small (~160 g), asocial, alpine-dwelling lagomorph. It is one of two pika species in North America, along with American Pika (*O. princeps*). Collared Pikas are dull grey with pale grey patches on their napes and shoulders, which form a partial collar around the neck. They display no obvious sexual dimorphism. Pikas have been deemed ‘harbingers of climate change’ because of their demonstrated sensitivity to climate patterns .

Distribution

In Canada, the Collared Pika occurs primarily in the mountainous regions of Yukon Territory, extending into northern British Columbia and into Northwest Territories west of the Mackenzie River. Outside Canada, Collared Pikas occur in southern and central Alaska. There is one designatable unit for Collared Pika in Canada.

Habitat

Collared Pikas inhabit primarily alpine boulder fields (talus) that are interspersed with meadow. This talus-meadow combination offers access to forage (meadow) and shelter from predators and weather (talus). Collared Pikas are behaviorally restricted to talus patches and typically remain within 10 metres of the talus edge when foraging in meadows. Population densities are generally higher on south-facing slopes presumably because of their higher primary productivity.

Biology

Collared Pikas are generalist herbivores that collect two diets during summer. The first is consumed immediately, while the second is stored in ‘haypiles’ within the talus matrix for consumption during winter. Pikas defend individual territories (about 15-25 m radius) and have a promiscuous mating system. Pikas become sexually mature after their first winter and, after a 30-day gestation, produce a litter of 3-4 offspring in a nest located within the talus. Most litters are produced in mid-June. Juveniles emerge to the surface 30 days later and disperse within days. Juveniles grow to near-adult size during their first summer and must establish a territory and a haypile before winter. Adults exhibit high site fidelity once a territory is established.

Annual survival has been linked to both winter climate and the timing of spring haypile initiation. The primary predator of Collared Pikas is the Short-tailed Weasel, and occasionally Red Foxes and raptors. Pikas generally do not live longer than 4 years and generation time is just over 2 years.

Population sizes and trends

A study of Collared Pika populations in a single location in the Ruby Ranges Ecoregion of southwestern Yukon showed that the population size fluctuated considerably over time. Although there are no other empirical data available on population sizes and trends elsewhere and almost no directed surveys, Collared Pikas are believed to be otherwise widespread and may be locally abundant within the species’ range.

Threats and limiting factors

Due to the remote nature of its range in Canada, direct disturbance to Collared Pika habitat and populations has been minimal and is expected to remain so in the coming decades. The greatest threat to Collared Pika populations is most likely to be from climate warming, the effects of which are already known to be occurring in this northern region that is characterized by a dry, subarctic climate. Local extirpations and upslope range retraction of American Pika has been documented in the interior Great Basin of the U.S., but the extent to which this condition is applicable to Collared Pika is unknown, given some differences in habitat and other uncertainties. The most likely risks to Collared Pika persistence are related to the direct effects of temperature, moisture or weather conditions and habitat changes. Pikas survive best under cool, dry conditions, and changes in either direction (i.e., higher temperatures, or cold wet conditions) leave them susceptible to death through exposure. Loss of suitable alpine habitat may occur through a) changes in the species composition of alpine vegetation communities, b) a direct loss of habitat due to treeline advance, or c) climate becoming physiologically intolerable. A loss of alpine habitat would increase distances between suitable patches, possibly reducing gene flow, rescue effects, and regional persistence.

Protection, status, and ranks

Currently, the Collared Pika is not listed under the Canadian *Species at Risk Act*, the United States *Endangered Species Act* or under the *Convention on International Trade in Endangered Species of Wild Fauna and Flora*. The International Union for the Conservation of Nature lists the Collared Pika as “Lower Risk/Least Concern.” The NatureServe conservation status ranks are Globally Secure, Nationally Secure in both Canada and the United States, and Secure in Alaska. Under the national General Status program, they are listed as Sensitive in Northwest Territories. The draft conservation status ranks for both Yukon and British Columbia were uplisted from Secure to Sensitive between the 2005 and 2010 assessments, and they are listed nationally as Sensitive.

TECHNICAL SUMMARY

Ochotona collaris
Collared Pika — Pica à collier
Range of occurrence in Canada (province/territory/ocean): Yukon, British Columbia, Northwest Territories

Demographic Information

Generation time	Mean age of breeding adults: 2.0 ± 0.2 years
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown over range
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations]. *Number of adults in one well-studied site (Ruby Range, YT) has fluctuated over 10 years, but no directional trend detected*.	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown over range
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown over range
Are the causes of the decline clearly reversible and understood and ceased? *Population fluctuations likely driven by winter and early spring weather conditions.*	Not applicable given no evidence for decline
Are there extreme fluctuations in number of mature individuals? *At the Ruby Range site, the # adults declined sharply after 1998, but has since recovered. Population growth rates (λ) at that site ranged from 0.33 to 1.96.*	Unknown

Extent and Occupancy Information

Estimated extent of occurrence	Global: 1,141,360 km^2 Canada: 644,003 km^2
Index of area of occupancy (IAO)	Unknown, but likely exceeds 2000 km^2.
Is the total population severely fragmented?	No, naturally fragmented metapopulation structure does not meet the definition of severely fragmented.
Number of locations∗	Unknown, but likely exceeds 10, even in the case of threat defined by climate change.
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	Unknown, but unlikely over next 10 years.

∗ See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy? *Such a decline has, however, been documented in the closely related American Pika in the U.S.*	No, not in the next 10 years.
Is there an [observed, inferred, or projected] continuing decline in number of populations? *Such a decline has, however, been documented in the closely related American Pika in the U.S.*	Unknown, but unlikely over next 10 years.
Is there an [observed, inferred, or projected] continuing decline in number of locations? *Such a decline has, however, been documented in the closely related American Pika in the U.S.*	Unknown, but unlikely over next 10 years.
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat? *On a decade to century scale, there is a predicted decline in habitat area and quality via global warming and loss of alpine habitat.*	No loss of habitat expected within 10 years.
Are there extreme fluctuations in number of populations?	Unknown, but possibly mediated by the metapopulation structure seen in pikas.
Are there extreme fluctuations in number of locations∗?	Unlikely
Are there extreme fluctuations in extent of occurrence?	Unlikely
Are there extreme fluctuations in index of area of occupancy?	Unlikely

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
Pika Camp Population, Ruby Ranges, Yukon (4 km^2)	2009: 49 adults
Vulcan Mountain, Front Range of Kluane National Park and Reserve (1 km^2)	2006: 13 total 2007: 4 adults, 0 juveniles
All other locations	Unknown.
Total	Unknown, but likely > 10,000

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	The mean PVA results for an analysis conducted in one 4-km^2 intensively studied area yielded 4 scenarios ranged between 6-11% probability of extinction over next 20 years. This cannot be extrapolated to the entire Canadian population.

Threats (actual or imminent, to populations or habitats)

Continued climate warming will likely increase variability in temperature, moisture, or weather conditions with potential direct effects on dispersal, thermoregulation, or loss of access to meadow forage due to icing. Climate change is also projected to reduce the amount of suitable alpine habitat and increase distances among patches of habitat. The magnitude of these impacts to Collared Pika is potentially high over the long-term but is fundamentally unknown due to lack of information on both baseline abundance and distribution, and population-level responses to projected changes.

∗ See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? Alaska (U.S.): Not listed in Alaska or U.S.	
Is immigration known or possible?	Immigration is possible from Alaska.
Would immigrants be adapted to survive in Canada?	Yes. Climate and habitat are similar.
Is there sufficient habitat for immigrants in Canada?	Yes.
Is rescue from outside populations likely? *Given that the main threat is climate change, which will probably result in habitat changes both in Canada and in adjacent Alaska, effective rescue is unlikely.*	Yes, theoretically possible from Alaska.

Current Status

Special Concern (November 2011)

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code:** Not applicable
Reasons for designation: This small rabbit-relative is a Beringian relict that is restricted to talus slopes in alpine areas in northern west British Columbia, Yukon, and Northwest Territories. This region comprises over half the global range of this species, and is witnessing climate-driven shifts in habitat, temperature, and precipitation at faster rates than elsewhere in Canada. A demonstrated sensitivity to climate variability, coupled with poor dispersal ability and the naturally fragmented nature of its populations, heightens the vulnerability of this small mammal to climate change. The species is well-studied in a very limited portion of its range, but baseline information on population trends at the range level, and a clear understanding of the extent and severity of climate impacts to this species and its habitat in the coming decades is limited. However, the best available information suggests that this species may be particularly sensitive to a changing climate, including concomitant increases in precipitation variability, leading to reductions in habitat availability. The potential of negative impacts of climate change to the persistence of this species over the long term is substantial.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. There is no evidence of any decline in mature individuals.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. EO and IAO exceed thresholds under this criterion.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. The population is likely > 10,000 mature individuals and there is no evidence of any decline in mature individuals.
Criterion D (Very Small or Restricted Total Population): Not applicable. The total number of individuals and the distribution exceed thresholds under this criterion.
Criterion E (Quantitative Analysis): Not applicable. PVAs have been conducted for one small study area and cannot be extrapolated to the Canadian population.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2011)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune

Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

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Collared Pika
Ochotona collaris

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2011

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and classification

Scientific name: *Ochotona collaris*

English name: Collared Pika

French name: Pica à collier

Classification:
- Class – Mammalia
- Order – Lagomorpha
- Family – Ochotonidae
- Genus – *Ochotona*
- Species – *Ochotona collaris*

The Collared Pika is in one of two extant families in the Lagomorph order (the other being Leporidae [rabbits and hares]). Worldwide, there are 30 species in the genus *Ochotona* (Hoffmann and Smith 2005). The Collared Pika (*Ochotona collaris,* Trouessart 1897) was first described by Nelson (1893) and is one of two Ochotonidae in North America. The other North America species is the American Pika, *O. princeps* (Lissovsky *et al.* 2007; Lanier and Olson 2009), which shares a common ancestor that migrated from Asia across the Bering Land Bridge (Lanier and Olson 2009). The two North American pika species diverged from their closest relatives (a group of Asian pika species) sometime prior to the Pleistocene between 4.7 and 15.7 million years ago (Lanier and Olson 2009).

Broadbooks (1965) noted that the physical, ecological, and behavioural differences between *O. collaris* and *O. princeps* are so slight that the two could be considered the same species. Indeed, Youngman (1975) considered *O. collaris* to be the same species as *O. princeps*, as did Banfield (1977). Corbet (1978) lumped both North American northern Asian (*O. hyperborea* and *O. alpina*) pika species*.*

Ochotona alpina, O. hyperborea, *O. princeps* and *O. collaris* are today treated as separate species (Smith *et al*. 1990; Hoffmann and Smith 2005) in part on the basis of chromosome number. *O. hyperborea* has a diploid chromosome number of 40, *O. alpina* has 42, whereas both *O. collaris* and *O. princeps* have 68 (Adams 1971; Vorontsov and Ivanitskaya 1973). Weston (1982) demonstrated that *O. collaris* and *O. princeps* are morphologically distinct from one other. Recent phylogenetic analyses also indicate that *O*. *collaris* and *O. princeps* are genetically distinct from one other and represent a monophyletic lineage that is separate from the Old World *Ochotona* (Niu *et al.* 2004; Lissovsky *et al.* 2007; Lanier and Olson 2009).

Collared Pikas are known locally in some Yukon communities as “rock rabbits” or “coonies”. They are well known to, and easily recognized by, many Aboriginal People that spend time hunting and travelling in alpine habitats within the species’ range. They are valued by Aboriginal People, in part, because they are traditionally hunted for food during extended excursions above treeline, where few other sources of meat are available.

Morphological description

Collared Pikas are small grey lagomorphs (Figure 1). Their common name is derived from the pale grey patches on their napes and shoulders, which form a partial collar around the neck. Unlike rabbits and hares, Pika hind limbs are only slightly larger than their front limbs, their tails are inconspicuous, and their ears are relatively small and round (MacDonald and Jones 1987).

Figure 1. Photograph of an adult Collared Pika in talus habitat located in southwestern Yukon, Canada (Photo (c) Kieran O'Donovan).

Sixteen Collared Pika specimens from Alaska weighed an average of 129 g (range 117-145 g; MacDonald and Jones 1987) and Nagorsen (2005) reported a mean mass of seven specimens from British Columbia of 146.7 g (range 123-173 g). Mean mass for southwestern Yukon specimens was 157.3 g for males (range: 130-185 g, n = 97) and 157.4 g for adult females (range: 130-200 g, n = 126) (Franken and Hik 2004b). Males and females are distinguishable via eversion of the pseudocloaca.

Similar species

The only North American species similar to the Collared Pika is the allopatric American Pika. Although very similar in cranial morphology, the Collared Pika may be distinguished from the American Pika by its lighter dorsal pelage, white underbelly, and distinctive collar of light grey fur on its neck (Nagorsen 2005).

Population spatial structure and variability

Collared Pikas live in spatially fragmented alpine habitats and demonstrate dynamics characteristic of a classical metapopulation (Franken 2002; Franken and Hik 2004a) in which an assemblage of local populations is connected through dispersal or migration (Hanski and Gaggiotti 2004). More specifically, Collared Pika populations meet all Hanski and Kuussaari's (1995) criteria for a metapopulation. First, they are behaviourally and physiologically restricted to patches of talus that are interspersed by a matrix of inhospitable meadow (Morrison *et al.* 2004). Second, all patches are at risk of extinction (i.e., there is no mainland population). Third, dispersal is limited by distance (Franken 2002). Finally, the dynamics of local populations are not synchronous (Morrison and Hik 2008).

Research on Collared Pika patch extinction and recolonization patterns indicated the probability of patch extinction is best predicted by habitat quality (e.g., the amount of vegetation near talus) and proximity to neighbouring patches (i.e., connectivity), with poor-quality and poorly connected patches having a higher probability of extinction (Franken and Hik 2004a). Recolonization of extinct patches also was correlated to measures of habitat quality such as aspect and vegetation (Franken and Hik 2004a). Aspect had the largest effect on patch recolonization, with southwest-facing patches having the highest probability of being recolonized (Franken and Hik 2004a). Additional research in Tombstone Territorial Park also indicated the importance of elevation, patch area, patch perimeter, and rock size in determining talus patch occupancy patterns (Andresen *et al.* 2010). Thus, habitat quality, as well as connectivity, must be considered when evaluating Collared Pika metapopulations and their likelihoods of persistence.

Genetic diversity

Most studies of pika metapopulation dynamics have been undertaken at relatively small scales such that the rates of interchange among more distant (e.g., > 4 km apart) patches remain unknown. Generally, alpine-dwelling pikas, such as the Collared Pika, typically disperse very short distances (Franken 2002; Franken and Hik 2004a) and their populations tend to be small and isolated (Smith *et al*. 1990). These factors can lead to the development of low levels of genetic diversity within populations and high levels of genetic differentiation among populations. For instance, populations of American Pikas from separate mountain ranges display very high levels of genetic differentiation (Hafner and Sullivan 1995).

Collared Pikas, however, do not display the degree of population genetic differentiation seen in its close relatives. Lanier and Olsen (2009) examined the evolutionary history of Nearctic pikas using *cyt*b and ND4 sequences and included several American, Northern (*O. hyperborea*), and Collared Pika populations in their analyses. They found only a very small level of genetic divergence among Collared Pika populations in Alaska and Yukon suggesting a very recent population expansion had occurred.

In spite of the low mean dispersal distance of juveniles, evidence from microsatellites indicated that they are not prone to frequent inbreeding. Zgurski and Hik (unpublished data) genotyped 366 Collared Pikas from a site located in the southwestern Yukon using the primers described by Zgurski *et al*. (2009). The data were then used to examine the mating system of the population. Close inbreeding was very rare, and the population maintained its genetic diversity even after having undergone a significant decrease in density (Zgurski and Hik unpublished data).

Designatable units

Unlike *O. princeps* (Hafner and Smith 2010), *O. collaris* is monotypic and contains no subspecies (MacDonald and Jones 1987). This classification may, however, be due to the small number of studies conducted on *O. collaris* in comparison to *O. princeps.* The presence and discovery of cryptic lineages in rock-dwelling pikas is common due to their fragmented ranges and often isolated populations (Li and Ma 1986; Formozov *et al*. 2006; Lissovsky *et al*. 2007). It is therefore possible that future studies will reveal distinct subspecies within *O. collaris*, there is no evidence of genetic differentiation among *O. collaris* populations throughout the species' range (Lanier and Olsen 2009).

Trefry and Hik (2010) reported that Collared Pika vocalizations are distinct among populations and that the call differences likely reflect genetic differences. However, none of these populations are known to possess any other morphological or behavioural traits that distinguish them from other populations; nor are any of them disjunct from the rest of the species' range. Future work may result in the designation of more distinct and/or evolutionarily significant units within this species, given the naturally fragmented nature of the range and certain presence of impassable barriers between good quality habitat. This report is, however, based on a single designatable unit of *Ochotona collaris*.

Special significance

As a group, alpine-dwelling pikas, such as Collared Pikas, are sensitive to variations in climate patterns, and may serve as an 'early-warning' (indicator) species for changes occurring in alpine ecosystems (McDonald and Brown 1992; Smith *et al*. 2004a). Therefore, monitoring pika populations may assist in the management and assessment of multiple alpine species. Collared Pika are hunted in Alaska, and by First Nations in Yukon. They are an important food item to some First Nations people when they are in alpine areas and other more commonly used food species are not available.

DISTRIBUTION

Global range

Collared Pikas inhabit the mountains of northwestern North America. Beyond their Canadian range (see **Canadian range** below), they also occur in the mountains of east-central and south-central Alaska (MacDonald and Cook 2009), including the Chugach, Ogilvie, Wrangell, and St. Elias Mountains, the Talkeetna and Wrangell Ranges, the Yukon-Tanana Uplands and the Alaska Range. No occurrences have been documented on the Kenai Peninsula (Cook and MacDonald 2004). They may occur in the eastern Brooks Range (MacDonald and Jones 1987), but reports of them there have not been documented with photographs or specimens (MacDonald and Cook 2009). MacDonald and Cook (2009) describe Collared Pikas as being 'locally common' in Alaska.

Nagorsen (2005; Figure 2) noted a separation distance of 800 km; however, recent reports have narrowed this gap to <650 km (Figure 3). Because the gap includes potential habitat (i.e., continuous mountainous terrain), it is conceivable that their ranges may be somewhat closer together than currently known.

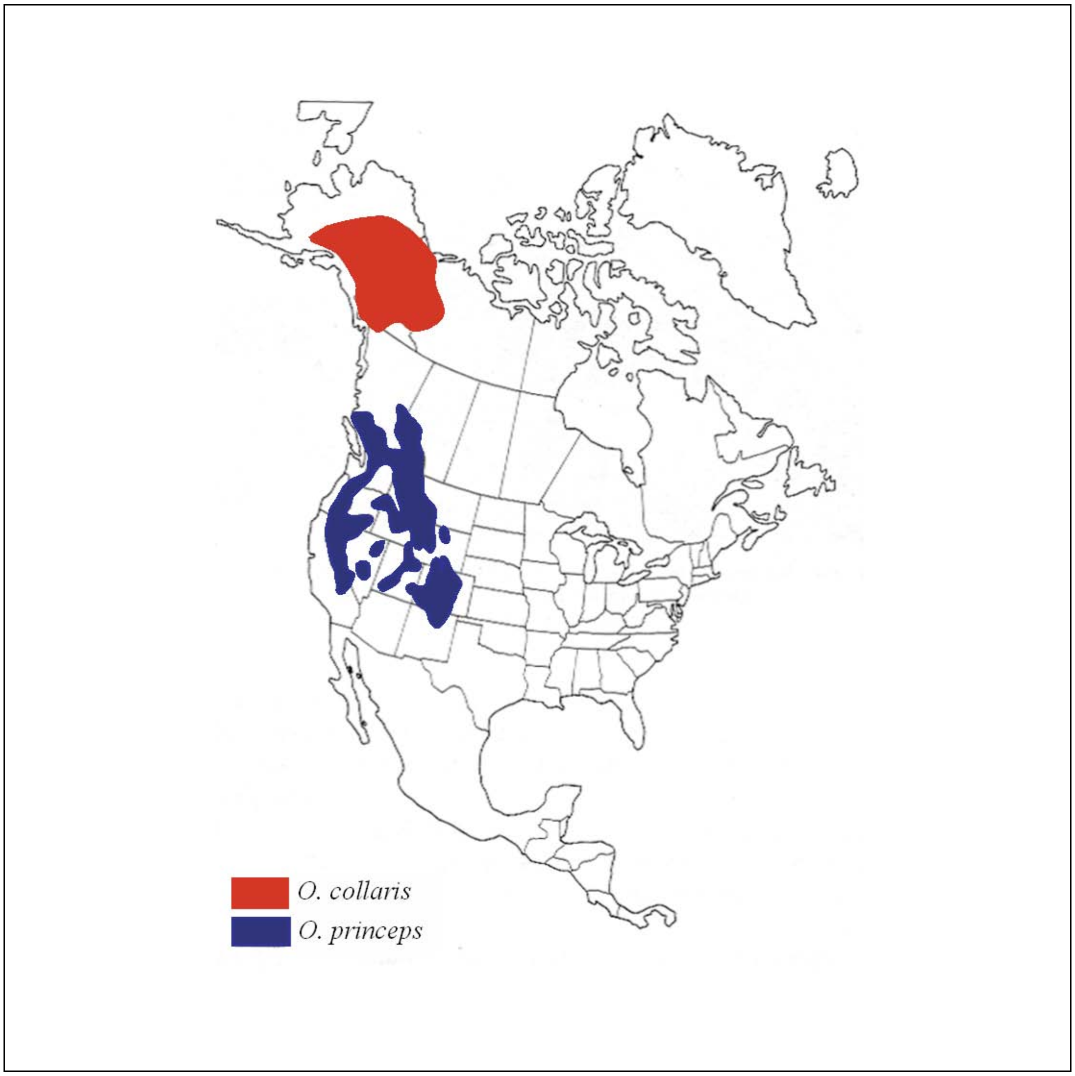

Figure 2. Current global distribution of Collared Pika (*O. collaris*) and American Pika (*O. princeps*). The image was modified from Smith *et al*. (1990). Note: the range of *O. collaris* has been modified for this Status Report (Figure 3).

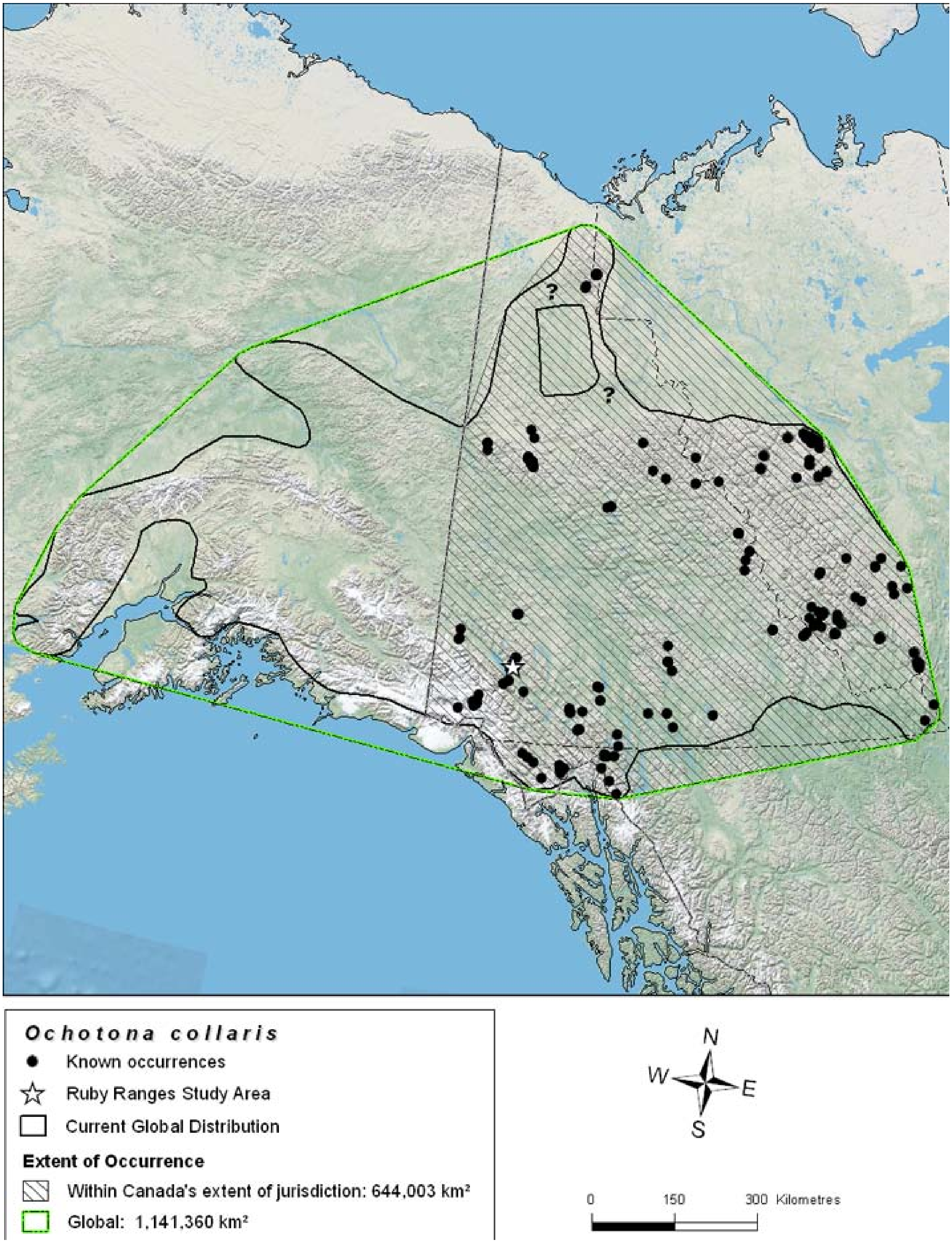

Figure 3. The global range of Collared Pikas (i.e., estimated extent of occurrence) and locations of specimen collections and field observations from Canada.

The most recent estimates of Collared Pika global and Canadian ranges were provided by Smith *et al*. (1990), supplemented by scientific publications, reports, museum specimens, field observations and local knowledge (Figure 3). This map was modified by input from jurisdictional biologists, and digitized using GIS to produce estimates of extent of occurrence (EO) (Table 1). The global range of the Collared Pika is approximately 1,141,360 km^2, of which 60% occurs in Canada, and 40% in Alaska.

Table 1. Global and Canadian extent of occurrence for Collared Pikas. Estimates are based on the summary of Smith *et al.* (1990) and recent field observations (Figure 3).

Jurisdiction	Total area of jurisdiction (km^2)	Extent of occurrence (EO)			
		Area (km^2)	% of jurisdiction	% of national range	% of global range
Canada					
Yukon	482,500	444,745	92.2	69.8	39.2
NWT	1,346,000	160,944	12.0	25.0	14.1
BC	945,000	38,314	4.1	6.0	3.4
Canada EO Total	2,773,500	644,003	–	–	56.4
USA					
Alaska	1,718,000	430,596	25.1	100	38
Global Totals	4,491,500	1,141,360[1]	–	–	–

[1] Extent of occurrence (EO) is measured by a minimum convex polygon drawn to encompass all the known, inferred, or projected sites of present occurrence, excluding cases of vagrancy. The sum of Canada's EO and Alaska's EO is therefore, not equivalent to the total global EO.

Canadian range

The Canadian range of the Collared Pika is located in the mountainous regions of Yukon Territory, the northern Coast Mountains of British Columbia (Nagorsen 2005), and the Mackenzie Mountains of the Northwest Territories (MacDonald and Jones 1987) (Figure 3). Most Collared Pika habitat is located within the Taiga Cordillera, Boreal Cordillera, and Taiga Plains EcoRegions, with a small amount in the Taiga Plain and Pacific Maritime EcoZones (Smith *et al*. 2004b). The Liard River valley possibly serves as an ecological barrier determining the southern limit of the Collared Pika (Tate, D. 2011, pers. comm.).

Search effort

Apart from two small study areas in Yukon, there have been almost no systematic surveys for Collared Pikas within their range in Canada (see **POPULATION SIZES AND TRENDS**). Pikas are not well-sampled in routine small mammal surveys, most likely because traps are not generally placed in or immediately adjacent to talus patches, but also because they are likely not effectively sampled in most small mammal traps (T. Jung, 2011, pers. comm.). Although they are readily observed or heard when present in the direct vicinity, the remote nature of their habitat means that relatively few observers access these areas. Pika observations are, moreover, undoubtedly underreported because they are either not recognized or recorded (e.g., Nahanni

National Park Reserve; Tate, D. 2011 pers. comm.). Incidental observations and museum collection records (Tables 1 and 2) provide the basis for the distribution map (Figure 3). In the Mackenzie Mountains opportunistic observations come from big game hunting outfitters (N. Larter 2011 pers. comm.), but there are large sections of Collared Pika range in the NWT that remain unsurveyed (S. Carrière. 2011 pers. comm.).

While Collared Pikas are specialized to talus slopes within mountainous ranges (see **HABITAT**) and potential habitat within ecoregions or ecozones can be mapped and calculated (Table 3; see **EcoRegion method to calculate AO**), occupation of that habitat by pikas is not always predictable. Additionally, talus habitat is patchy, both on and between mountains and not every mountain in the distributional range has talus patches that can serve as potential pika habitat (T. Jung, in litt.). D. Tate (2011 pers. comm.) noted that in 2009, alpine areas of the Ram Plateau (62.5 N-123.9 W) did not have Collared Pikas despite abundant talus slope habitat, although this survey was not systematic. This species is easily detectable by its distinct vocalizations, so its presence is unlikely to be missed by naturalists visiting appropriate alpine habitat. Work done for the NWT Ecological Classification in the Mackenzie Mountains and Richardson Mountains has provided an overview of the extensive possible pika habitats in the NWT (ECG 2010), although actual systematic surveys are needed to confirm presence of pikas in these habitats.

With respect to the gap between the ranges of Collared and American Pikas (Figure 2), Nagorsen (2005) indicated that while more surveys may extend the known ranges of these two species, sufficient fieldwork has been done to conclude that pikas are absent from a large area in northern B.C., including mountain ranges with potential habitat.

Canadian extent of occurrence, EO

Based on Smith *et al*.'s (1990) species' range map, supplemented by recent locality data, the extent of occurrence in Canada is approximately 644,003 km^2, of which 69% is in Yukon, 25% in the Northwest Territories, and 6% in northern British Columbia (Table 1, Figure 3).

Canadian index of area of occupancy, IAO

The observational and specimen data required to determine the index of area of occupancy (IAO) for Collared Pikas within Canada are unavailable. No systematic surveys have been conducted that would allow an accurate estimate of IAO (Table 2).

Table 2. Number of museum specimens and field observations of Collared Pikas per decade across its global range. Location data from these specimens and field observations were used to create Figure 3.

Decade	Alaska	British Columbia	Northwest Territories	Yukon Territory	Canada total	Grand total
1850-1899	0	2	0	0	2	2
1900-1909	0	5	0	15	20	20
1920-1929	12	0	0	0	0	12
1930-1939	3	0	0	0	0	3
1940-1949	0	12	1	19	32	32
1950-1959	50	11	1	4	16	66
1960-1969	32	0	4	52	56	88
1970-1979	2	0	3	16	19	21
1980-1989	17	1	3	6	10	27
1990-1999	19	0	1	8	9	28
2000-2009	137	1	50	45	96	233
Unknown	0	8	2	3	13	13
Grand total	272	40	65	172	277	549

Table 3. Area (km^2) of potential Collared Pika habitat within the EcoRegions and EcoZones of Yukon Territory 'known or suspected' to contain pikas (sensu Smith *et al*. 2004b). These 23 EcoRegions contain 455,858 km^2 (94.5 %) of the total Yukon area of 482,443 km^2. Potential habitat was defined as the area of alpine or rocky habitat.

EcoRegion #	EcoRegion	EcoZone	Total Area in Yukon (km^2)	Area of Potential Pika Habitat (km^2)
51	Peel River Plateau	Taiga Plain	14,810	1,481
53	Ft. McPherson Plain	Taiga Plain	2,840	28
66	Muskawa Plateau	Taiga Plain	730	7
165	British-Richardson Mtns	Taiga Cordillera	22,900	18,320
168	North Olgilvie Mtns	Taiga Cordillera	39,260	17,667
169	Eagle Plains	Taiga Cordillera	20,400	1,020
170	MacKenzie Mtns	Taiga Cordillera	42,900	21,450
171	Selwyn Mtns	Taiga Cordillera	35,578	12,452
172	Klondike Plateau	Boreal Cordillera	38,471	7,694
173	St. Elias Mtns	Boreal Cordillera	19,245	7,698
174	Ruby Ranges	Boreal Cordillera	22,737	13,642
175	Yukon Plateau-Central	Boreal Cordillera	26,803	8,041
176	Yukon Plateau-North	Boreal Cordillera	57,091	11,418
177	Yukon Southern Lakes	Boreal Cordillera	29,892	8,968
178	Pelly Mtns	Boreal Cordillera	34,258	15,416
179	Yukon-Stikine Highlands	Boreal Cordillera	7,028	3,514
180	Boreal Mtns and Plateaus	Boreal Cordillera	948	379
181	Liard Basin	Boreal Cordillera	21,113	10,557
182	Hyland Highland	Boreal Cordillera	14,661	7,331
184	Mt. Logan: Icefields	Pacific Maritime	4,193	629
Totals			455,858	167,712

Given this lack of data, methodology such as the 2 km x 2 km grid technique to determine IAO would provide considerable underestimates of IAO. The EcoRegion method described below provide estimates of the amount of alpine habitat potentially available to Collared Pikas, which was used to estimate the species' area of occupancy (AO). However, not all alpine areas provide suitable habitat for Collared Pikas, and not all suitable habitat is occupied (see **Search effort**).

EcoRegion method to calculate AO

Data regarding the amount of alpine and rocky habitat within each Yukon EcoRegion are available (Smith *et al*. 2004b) and provide an estimate of potential habitat within the Yukon portion of the AO. Based on Yukon EcoRegion data, 167,712 km^2 was alpine or rocky habitat (Table 3). This value represents 37% of the land area within the 20 EcoRegions known or suspected to contain pikas, and approximately 35% of the entire Yukon Territory.

Collared Pika range is generally limited to the Taiga Cordillera EcoZone in NWT, and to the Boreal Cordillera EcoZone in British Columbia. Based on EcoRegion data from Yukon (Table 3), approximately 34.8% of the Boreal Cordillera EcoZone and 44.0% of the Taiga Cordillera EcoZone is either alpine or rocky habitat. When these percentages are applied to the EO in BC and NWT, there are 92,155 km^2 of potential habitat for Collared Pika in NWT, and 5,453 km^2 in BC. Overall, the potential alpine and rocky habitat for Collared Pikas in Canada is approximately 265,320 km^2. However, in the absence of survey data, the amount of this area actually occupied by Collared Pikas remains unknown.

HABITAT

Habitat requirements

Collared Pikas are mountain animals that primarily inhabit boulder fields (talus) located above treeline that are adjacent to alpine meadows (Figure 4). Pikas are generally found between 700 and 1800 m above sea level (Youngman 1975). They are rarely found >10 m from talus, although Rausch (1961) reported having seen Collared Pikas in a forested valley living near scattered rocks and Youngman (1975) reported one living in a burrow by Kluane Lake in Yukon (confirmed by K. Hodges several decades later; pers. comm.). Since talus is distributed patchily, Collared Pikas have a naturally fragmented distribution.

Figure 4. Typical Collared Pika habitat in the Ruby Ranges of southwestern Yukon that combines talus slopes for shelter and alpine meadows for forage. (Photo (c) Shawn F. Morrison.)

Because Collared Pikas need access to vegetation for forage, they are usually found at higher densities in talus patches with large perimeters that provide access to adjacent meadow vegetation (Franken and Hik 2004a). Broadbooks (1965) notes that they are typically found near the edge of talus patches, presumably because of the advantage of both shelter and proximity to forage. Collared Pika densities are generally higher on south-facing slopes (Morrison and Hik 2007), likely due to these slopes having higher primary productivity and lower annual snow cover. Recent patch occupancy surveys in Tombstone Territorial Park indicated the presence of pikas was influenced by elevation, talus patch area, rock size, and talus patch perimeter (Andresen *et al*. 2010). The majority of sites (96%) occupied by pikas were at elevations between 1200-1600 m, with the remainder occurring in elevations between 1600-1800 m (Andresen *et al*. 2010). Pikas were also more likely to occur at sites with medium (30-50 cm wide) or large (50-100 cm wide) rocks (Andresen *et al*. 2010). A large patch area of predominantly talus habitat, a large patch perimeter and the presence of *Dryas* spp. and *Carex* spp. were also good predictors of pika occupancy (Andresen *et al*. 2010).

Habitat trends

With most Collared Pika habitat in Canada located in remote high-elevation areas, the range of this species has been subjected to minimal direct anthropogenic disturbance. Global climate warming, on the other hand, has the potential to affect the suitability of alpine habitat for Collared Pikas by a) direct loss of alpine area due to encroachment by advancing tree- and shrub-lines, b) modification of alpine forage species composition, and c) changes to thermal and moisture environments. Although a growing body of literature suggests that changes such as these are already underway in the region, data are lacking to quantitatively assess Collared Pika habitat trends or determine whether the EO or IAO of this species has changed over time.

One prediction consistently offered in climate change literature and supported by an accumulating body of evidence is that the impacts of climate warming will be most pronounced in arctic and subarctic regions (ACIA 2004; Hinzman *et al*. 2005; Intergovernmental Panel on Climate Change 2007; Post *et al*. 2009; Zhang *et al*. 2011). The principal effects relevant to Collared Pika habitat include increased vegetation growth, including the spread of tall shrubs into tundra communities, and thawing of permafrost. Although less is known of these processes in subarctic alpine regions, expectations for such changes are similar in nature to low latitude-high altitude areas, albeit less predictable due to climatic diversity inherent in areas that are characterized by pronounced topographic variability (Danby and Hik 2007).

Dendrological data from southwestern Yukon indicates alpine treeline advanced upslope to encroach on alpine tundra habitat during the early to mid-20th century (Danby and Hik 2007). During this time, White Spruce (*Picea glauca*) advanced most rapidly on south-facing slopes (65-85 m gain in elevation) relative to north-facing slopes, probably due to differences in permafrost. In addition to elevational advances, tree stands also increased 40-65% in stem density. Tree and shrub encroachment into alpine ecosystems was not simply a gradual response to warming, but was pulsed and may have followed a threshold response model due to increased summer temperatures (Danby and Hik 2007). The patterns and timing of treeline advance were not uniform, but were varied according to slope, aspect, spatial scale, and individual species characteristics (Danby and Hik 2007).

A similar increase in shrub (*Salix* spp.) densities in alpine sites has been observed in southwestern Yukon (Myers-Smith 2011). Repeat photography and remote sensing data from northern Alaska and Yukon (at non-alpine tundra sites) revealed a rapid and substantial replacement of tundra habitat by shrub species between 1950 and 2000 (Sturm *et al*. 2001; Tape *et al*. 2006; Myers-Smith 2011). Although studies within Collared Pika range are restricted to southwestern Yukon, a pan-Arctic expansion of shrubs into formerly shrub-free tundra habitat appears to be occurring, the cause of which has been hypothesized to be warming growing season temperatures (Tape *et al.* 2006). Strong summer warming (>1.5° C) is occurring over parts of Collared Pika range for which weather data exist (Zhang *et al.* 2011).

Limited data are available to determine whether alpine meadows within Collared Pika range have progressed upslope at their higher elevational limits. A recent Ph.D. study has documented the expansion of willow shrubs to higher elevation in the Kluane Region, the first demographic study to illustrate advance of woody shrub species in alpine tundra over a large geographic region (Myers-Smith 2011). Regional studies similarly confirm the high variability in the rate and magnitude of altitudinal treeline advance due to recent climate change (Harsch *et al*. 2009). By contrast, the extent and configuration of talus patches that characterize Collared Pika habitat have not likely changed since historical times, and are not likely to be affected by a changing climate.

Simulation studies of Yukon alpine habitat suggest that the EO and IAO of Collared Pikas will decline due to treeline advance (Danby 2007). For example, the 3.4°C increase in mean annual temperature predicted for southwestern Yukon by 2080 (Flato *et al.* 2000) could cause a 525 m rise in altitudinal treeline and a reduction in the amount of alpine habitat in the Kluane Lake region from 8110 km^2 to 1755 km^2 (a 78.4% loss), assuming no new alpine habitat is created at higher elevations. If only a 100 m rise is assumed, the amount of alpine habitat would decline to 5758 km^2, a 29% loss of alpine habitat (Danby 2007). It should be noted that this study did not account for variation in slope, aspect, time lags, or a number of other potentially important factors. It is, moreover, impossible to predict either the timeframe in which this is likely to occur or the manner in which Collared Pika populations are most likely to respond. Nevertheless, the conclusion is clear: extrapolating these coarse results over the entire IAO indicates a substantial loss of alpine habitat can be expected under even moderate climate warming scenarios within the next 60 years. The expected consequence of this change for Collared Pikas could be a direct loss of habitat in addition to its increasing fragmentation, which would likely alter metapopulation structure and ultimately regional persistence. A loss of alpine habitat could also increase distances among suitable patches, possibly reducing gene flow, rescue effects, and regional persistence. The magnitude of such changes that could reasonably be expected in the next decade or two is, however, unknown, and further challenged by lack of information on range-wide Collared Pika abundances and distribution.

Further potential exists for changes to the species composition of alpine vegetation communities (Tait 2002; Beniston 2005). The responses of alpine plant species to increasing temperature are specific to individual species. Repeated measurement of alpine vegetation communities in Yukon over the past 42 years has revealed increased plant species diversity (Shannon–Weiner index) and richness (Danby *et al*. 2011). The increased species richness and diversity in that study were due to the establishment of new species, particularly graminoids such as *Poa arctica* and *Hierochloe alpina*, although the most abundant graminoid, *Carex consimilis*, declined in relative importance between 1968 and 2010. The authors concluded the changes to vegetation communities were consistent with the observed 2°C increase in the mean annual temperature that took place between 1968 and 2010 (Danby *et al*. 2011). A shorter-term (6-year) experimental manipulation of ambient temperature and soil nitrogen levels resulted in similar changes to alpine vegetation communities (Koh and Hik, unpublished data). Such site- and species-specific responses to increasing annual temperatures are commonly observed in northern vegetation communities (Chapin and Shaver 1985). Given the diet breadth of Collared Pika (see **BIOLOGY**) and lack of information on nutritional consequences of anticipated changes to vegetation communities, the population-level consequences of changes on Collared Pikas are unknown, but are unlikely to be major in the next decade or two.

Under warming scenarios, mountain permafrost probabilities in the region are predicted to decline progressively, with zonal boundaries rising in elevation (Bonnaventure and Lewkowicz 2011). Modelling results from three study areas within Collared Pika range yielded almost complete disappearance of permafrost (< 10% remaining) if mean annual air temperature increases by 5^0C K and about 20% with a 1^0C increase (Bonnaventure and Lewkowicz 2011). Permafrost loss would be expected to affect Collared Pikas indirectly through its effects on vegetation communities (i.e., changes in vegetation composition discussed above), the nutritional consequences of which for pikas are unknown.

Increasing temperatures may also have important direct consequences for Collared Pikas due to their physiological temperature and/or moisture tolerance limits (see **THREATS**). Thus, Pika distribution or abundance may respond prior to measurable changes in the alpine vegetation communities discussed here.

BIOLOGY

Life cycle and reproduction

Social structure and breeding system

North American pikas are solitary and territorial (Smith *et al.* 1990). They defend their territories by chasing and fighting intruders (Broadbooks 1965; Svendsen 1979), scent marking via cheek rubbing (Barash 1973) and calling (Broadbooks 1965; Barash 1973; Conner 1984). However, despite their aggression toward strangers, neighbouring males and females often tolerate one another's presence (Brandt 1989). At the Ruby Ranges study site in southwestern Yukon, individuals defended summer territories that were a mean of 0.16 ha (females) or 0.2 ha (males) (Franken 2002). Neighbouring males and females have a greater proportion of overlap between their territories than do neighbouring individuals of the same sex. Specifically, females were more likely to have a larger portion of their territory overlap with males. In some instances a male may have more than one female territory either partially or completely within his territory (K. O'Donovan unpublished data). The extent of overlap among neighbours varies seasonally as female movement is less restricted in the fall, leading to wider forays into surrounding territories (K. O'Donovan, unpublished data).

Collared Pikas have a largely promiscuous mating system as both males and females may have multiple mates (Zgurski and Hik, unpublished data). In southwestern Yukon, pairs of Collared Pikas that produced offspring (n = 141 pairs) were situated an average of 668 m (SD = 527 m) from each other, indicating that they were not restricted to mating with their nearest neighbours and would go on temporary excursions to find mates (Zgurski and Hik, unpublished data).

Reproduction

Collared Pikas breed during the first spring after their birth and there is little variation in the age at first reproduction in the species (Franken 2002). Conception for Collared Pikas in the southwestern Yukon typically occurs during late May and parturition occurs 30 days later (Franken and Hik 2004b). There is annual variation in the average date that young are born, both across and within sites. The average annual parturition dates among females in the southwestern Yukon varies from June 3 to July 3 (Franken and Hik 2004b). The earliest recorded births of Collared Pikas are in early April, although such early births are rare (Franken and Hik 2004b). Later parturition dates are associated with high snow accumulation and late spring snow melt, although parturition date does not appear to affect juvenile survival rates (Franken and Hik 2004b).

Rausch (1961) suggested that female Collared Pikas in Alaska have two litters per year, based on finding a pregnant female that was also lactating. However, Franken and Hik (2004b) found no evidence that females in the southwestern Yukon weaned more than one litter per year. Mean litter size ranges from 2.2 to 3.0 offspring (Smith *et al*. 1990), although MacDonald and Jones (1987) reported up to six offspring in a litter. Franken and Hik (2004b) reported that, on average, females successfully wean only one young per litter per year based on observations at the time of emergence from natal dens. Generation time (as calculated by mean age of breeding adults in the Ruby Ranges study site is 2.0 ± 0.2 years (see **POPULATION SIZES AND TRENDS**).

Collared Pikas are born blind and nearly hairless in nests within the talus. They reach adult size by 40-50 days post-parturition (MacDonald and Jones 1987). Their growth rates are among the fastest known for lagomorphs and are faster than those of *O. princeps*, likely because juvenile Collared Pikas must disperse, find a territory and build a cache of food for winter before mid-September (Franken and Hik 2004b).

Diet and foraging behaviour

Collared Pikas are generalist herbivores and their foraging activities include a) immediate consumption of vegetation and b) caching vegetation for consumption during winter (also known as 'haying'). They rarely venture more than 6-10 m from talus while they are foraging or haying (Morrison *et al*. 2004; McIntire and Hik 2005) because a) pikas typically escape from predators by fleeing into crevices within the talus (Holmes 1991), b) talus provides relief from the heat (MacArthur and Wang 1973) and c) increased vigilance when farther from talus makes foraging less profitable (Roach *et al*. 2001).

Collared Pikas forage on meadow vegetation located adjacent to the talus margins and appear to use whatever species are locally available (Rausch 1961) although they avoid forage species with low nutritional value. For example, Morrison *et al*. (2004) found that Collared Pikas avoid caching Arctic White Heather (*Cassiope tetragona*), which has low nitrogen content, low water content and low digestibility. Hudson *et al.* (2008) found that the caches ("haypiles") of Collared Pikas contained, in descending prevalence, graminoids, deciduous shrubs, semi-evergreen shrubs and forbs; lichens and bryophytes made up less than 5% of the biomass of the haypiles examined. Collared Pikas have also been reported to cache lycopods (*Lycopodium* spp.) and ferns (Rausch 1961).

Because Collared Pikas do not hibernate, they spend much of their time during the summer gathering vegetation to cache in their haypiles. Haypiles are generally located within the talus matrix where they are usually protected from the weather (Figure 5). Haypile locations often are reused from year to year, even if the resident pika is replaced.

Figure 5. An active Collared Pika haypile from southwestern Yukon. (Photo (c) Jessie Zgurski.)

The date that individual Collared Pikas begin haying is variable and ranges from mid-June to mid-September (Morrison *et al*. 2009). Haying typically begin at low elevations and increases in rate (i.e., number of trips per hour) as summer progresses, presumably to match the growth of vegetation (Morrison *et al.* 2009). Daily haying rates peaked from 0500-0900 hours and again from 2100-2400 hours, although Collared Pikas may make haying trips at any time of day (Morrison *et al.* 2009). Manual excavations of 27 haypiles indicated that their mean mass was 3.1 $\pm$ 0.82 kg (95% CI) by mid-September, while simulations of haypile mass (based on known haying rates and the mean mass of vegetation deposited per haying trip) indicated that haypiles could contain an average of 7.4 kg of vegetation (Morrison *et al*. 2009). These estimates vary because it is difficult to completely excavate haypiles, as much of the vegetation can be placed deep within the talus matrix.

Based on haying rates and load size per haying trip, approximately 75% of haypiles contained sufficient food for 90 days and 50% contained sufficient food for 177 days (Morrison *et al.* 2009). Overwinter survival in pikas is partially related to the timing of initiation of haying behaviour in some, but not all, years (Morrison *et al*. 2009). While there are few studies of pika wintering ecology, there is evidence to suggest that haypiles do not serve as the sole source of winter food and that Collared Pikas do forage outside of their haypiles beyond the plant growth season. In Yukon, individuals have been observed foraging in meadows in September and October (K. O'Donovan, personal observation), and stable isotope analysis of diet composition has established use of some plants typically found in the subnivean space during winter and spring, such as Moss Campion (*Silene acaulis*) (D.S. Hik *et al*., unpublished data). Dearing (1997) confirmed the primary function of haypiles to be as the major source of sustenance for American Pikas during winter, but discussed evidence for autumn and winter foraging on lichens, tree bark, evergreen trees and shrubs.

As the quality of the meadow vegetation declines in autumn, the trade-off between nutritional constraints and predation risk change such that it is no longer an optimal strategy to continue foraging in the riskier meadows surrounding the talus. As such, pikas rely heavily on lichen growing among the comparatively safe boulders within the talus (K. O'Donovan, personal observation). It may be that lichens form a previously unidentified, yet critical, forage resource at that time of year.

Physiology and adaptability

Data on Collared Pika physiology are limited to measurements of the animal's body temperature (Irving and Krog 1954). However, data for the closely related American Pika are available and may be applicable to Collared Pikas.

North American Pikas have several physiological characteristics that make them well-adapted to cold environments but limit their ability to cope with excess heat. For example, American Pikas have a higher basal metabolic rate than predicted by allometric models, and they have a lower thermal conductance than predicted based on their body size (MacArthur and Wang 1973). Their low thermal conductance allows them to maintain their normal body temperature during cold months with a minimal expenditure of energy (Smith and Weston 1990).

Their ability to tolerate excess heat, on the other hand, is limited. Their upper lethal body temperature is 43°C (MacArthur 1973) and death can occur after two hours of exposure to an ambient temperature of 28°C (MacArthur and Wang 1973). Smith (1974b) found that pikas caged without access to shade can die at temperatures as low as 25.5°C. However, American Pikas behaviourally thermoregulate by remaining below the talus surface during hot periods (MacArthur and Wang 1974; Smith 1974b), although activity is limited. For example, American Pikas limited the amount of time they spent above ground during the summer at low altitude sites (2550 m) in the Sierra Nevadas (Smith 1974b). At higher elevation sites (3400 m) where the average maximum daily temperature was 8.3°C lower, American Pikas remained active throughout the daytime (Smith 1974b). Similar to American Pika (Millar and Westfall 2010), talus habitats that are used by Collared Pikas for den sites, food sources, and nesting provide microclimate conditions that can ameliorate weather extremes, by creating cool and moist refugia in summer months and insulation in winter.

Dispersal and migration

Dispersal of juveniles is a key component of Collared Pika metapopulation dynamics and has a large effect on regional population persistence and gene flow (see **Population spatial structure and variability**). Collared Pikas disperse shortly after weaning (Franken 2002). A juvenile is considered to be post-dispersal when it settles on a vacant territory and begins haying. Juveniles in the southwestern Yukon usually begin haying by July 26, indicating that dispersal for most juveniles is complete by late July; adults begin haying about two weeks earlier than juveniles in some, but not all, years (Morrison *et al*. 2009).

Dispersal distances in Collared Pikas are limited as they rarely travel far from boulder fields, which are patchily distributed across the landscape. Long-distance dispersal often requires that Collared Pikas cross lowland habitat that they generally avoid. Based on a limited number of direct observations, Franken (2002) found that, on average, male and female Collared Pikas dispersed 375 m and 351 m from their natal dens, respectively. Genetic maternity analysis (n=198) indicated that the mean dispersal distance of juveniles was approximately 630 m and that some animals dispersed up to 2 km (Zgurski and Hik unpublished data). However, this study would not have detected longer dispersal distances, as any animals that dispersed over 2 km would have left the study area. A serendipitous encounter in 2007 on the Hubbard Glacier, Yukon, suggests Collared Pikas are capable of longer-distance dispersal movements (K. O’Donovan, personal observation). This pika was live-trapped on the glacier while it was presumably dispersing across the ice and, at the time of capture, was >1 km from the nearest non-glaciated terrain. There is no sex-biased dispersal in Collared Pikas and males and females disperse approximately the same average distance (Franken and Hik 2004a).

Interspecific interactions

Competition for forage resources

Collared Pikas commonly co-exist on talus patches with Hoary Marmots (*Marmota caligata*) and Arctic Ground Squirrels (*Spermophilus parryii*). All three species use talus patches for shelter and forage in adjacent alpine meadows, although ground squirrels and marmots also commonly den within meadows. Pikas forage in a narrow (<10 m) band of vegetation adjacent to talus patches, and most foraging activity occurs within 6 m of the talus edge (McIntire 1999; Morrison *et al*. 2004; McIntire and Hik 2005). Marmots also focus their foraging activity near talus edges, with most activity being within 25 m of talus. This overlap of pika and marmot foraging area creates the possibility for competition. Additionally, voles, including Northern Red-backed Voles (*Myodes rutilus*), Tundra Voles (*Microtus oeconomus*) and Singing Voles (*M. miurus*), along with lemmings (such as the Brown Lemming, *Lemmus trimucronatus* and Collared Lemming, *Dicrostonyx groenlandicus*) may also occur on or near talus inhabited by Collared Pikas. The effects of interspecific competition on pika population dynamics are unknown. However, in a study of habitat use, Franken (2002) speculated that pikas may adjust their selection of territories based on the presence of marmots.

Disease and parasites

Collared Pikas are affected by a number of internal and external parasites. Internal parasites include nematodes: *Cephaluris collaris*, *C. alaskensis*, *Labiostomum rauschi*, *L. talkeetnaeurus* (Rausch 1960; Hoberg *et al*. 2009), a cestode: *Schizorchis caballeroi* (Rausch 1960), and numerous coccidia: *Eimeria barretti, E. banffensis, E. calentinei, E. cryptobarretti, E. circumborealis, E. klondikensis*, *E. princepsis, Isospora marquardi,* and *I. yukonensis* (Hobbs and Samuel 1974; Lynch *et al*. 2007). External parasites include at least three flea species: *Monopsyllus tolli*, *Ctenophyllus armatus*, and *Amphalius runatus* (Holland 1958), along with mites and botflies (Smith 1978). The effects of disease and parasites on Collared Pika survival, reproduction, and population dynamics are unknown.

Predation

No comprehensive studies of specific sources of mortality of Collared Pikas have been published. At the Ruby Ranges study site, no successful predation events have been observed despite thousands of hours of observation of marked individuals. Rausch (1961) reported a Short-tailed Weasel (*Mustela erminea*) carrying a dead Collared Pika and noted they are likely major predators of Collared Pikas in south-central Alaska. Other potential predators of Collared Pikas are likely Red Foxes (*Vulpes vulpes*) and raptors. For example, Everatt *et al.* (pers. comm.) saw a Northern Harrier (*Circus cyaneus*) attempt to prey on a pika, although the pika managed to flee under talus before being captured. Carbyn and Patriquin (1976) reported Northern Goshawks (*Accipiter gentilis*) and Golden Eagles (*Aquila chrysaetos*) ‘hunting alpine mammals’ in Nahanni National Park Reserve. The Snowshoe Hare (*Lepus americanus*) cycle is known to stimulate production of a large surplus of young predators, many of which might be pika predators as well. Flushes in the population sizes of Red Foxes and Ermines following snowshoe hare peaks and declines within Collared Pika range could put additional predation pressure on pikas in alpine areas (D. Reid, pers. comm).

POPULATION SIZES AND TRENDS

Sampling effort and methods

The primary source of data on Collared Pika abundances and demographics is from a 15-year study in the Ruby Ranges. Although there have been published articles about Collared Pika ecology from other locations, there are no others that provide demographic data. Patch occupancy data have been collected in Tombstone Territorial Park (Andresen *et al*. 2010).

Southwestern Yukon, Ruby Ranges EcoRegion

A mark-recapture study of Collared Pikas was conducted in the Ruby Ranges in southwestern Yukon, east of Kluane Lake (61°13′ N, 138° 16′ W; 1600-2200m elevation) (Franken 2002; McIntire and Hik 2002; Morrison and Hik 2007). Census data on marked individuals were collected in the 4 km^2 alpine valley from 1995 to 2010. Population abundance was calculated as the sum of all marked individuals of all ages and sexes enumerated by late summer of each year. Survival rates were estimated as described in Morrison *et al*. (2007).

St. Elias Icefields and Vulcan Mountain

Surveys of remote pika populations were conducted on several occasions between 1991 and 2007 in the St. Elias Icefields and Front Ranges of Kluane National Park and Reserve (D. Hik, K. O'Donovan, unpublished data). Collared Pikas are found on isolated nunataks (isolated peaks of rock projecting above a surface of inland ice or snow) throughout the St. Elias Icefields but rarely with more than 2-3 individuals at each site. For example, in an area of approximately 100 km^2 in the upper regions of the Kaskawalsh and Hubbard glaciers in the St. Elias Mountains 10 nunatak sites were visited. These 10 sites represent all the accessible sites in this area that showed potential for pika occupancy (i.e., presence of vegetation and slope angle). At each site, a thorough search for signs of current or previous pika activity was conducted. However, surveys did not involve live-capture or marking and were often limited by terrain. Pika counts at nunataks represent the minimum number known alive, and are best represented as presence/absence data.

A high alpine valley on Vulcan Mountain totalling approximately 1 km^2, in the Front Ranges of Kluane National Park and Reserve, was surveyed in 1998/1999 and again in 2006/2007. Pikas were live-trapped and earmarked at this site, and there was higher search intensity than at nunatak locations. Data for all years were considered to be a complete census of that valley's pika population.

Tombstone Territorial Park

Andresen *et a*l. (2010) took an occupancy modelling approach to assess patch use by collared pikas in Tombstone Territorial Park, central Yukon. They surveyed 59 discrete talus patches in 4 mountains within the park for collared pika presence. The modelled detection probability was high (91%), based on either seeing or hearing a Collared Pika. Each talus patch was independently surveyed at least twice. Patch occupancy in this study was 56.4%, indicating that not all talus patches with the distributional range had pikas, even if nearby talus patches were used.

Abundance

Southwestern Yukon, Ruby Ranges EcoRegion

The 2009 census at the long-term study site in southwestern Yukon indicated a minimum of 68 pikas (49 adults and 19 juveniles) in the 4 km^2 study area in mid-August. If ≥95% of the resident population is trapped by late-summer, as reported by Morrison and Hik (2007), there may have been 68-71 pikas present at this site.

The mean age of reproductively mature pikas was 2.0 $\pm$ 0.2 years (median = 1, range 1-4, n = 49 adult pikas) in 2009. The age structure of adults in 2009 was weighted toward younger age classes such that 53.1% were 1 year old, 14.3% were 2 years, 16.3% were 3 years, and 16.3% were 4 years old. No pikas were five years or older in the 2009 population.

Vulcan Mountain

The number of animals in this small population varies between years. In 1998, eleven individuals were present and trapped in the 1 km^2 study area, but declined to seven individuals in 1999. Thirteen pikas were captured at the Vulcan Mountain site in 2006. In 2007, four pikas were captured; however, these were all unmarked animals and none of the pikas captured in 2006 was observed or retrapped.

Canadian population estimate

Collared Pika population estimates within its global and Canadian range are unknown (Andresen *et al*. 2010). Extrapolation of population-level data from the study area in southwestern Yukon (above) would not produce meaningful estimates due to uncertainty regarding both the amount of alpine habitat inhabited by pikas, and the extent to which the southwestern Yukon site is representative of other parts of the Canadian range. Given its widespread occurrence throughout its range, the population of Collared Pikas in Canada likely exceeds 10,000 mature individuals.

Fluctuations and trends

Quantitative Collared Pika population trend information is available only for the Ruby Ranges study area in southwestern Yukon. Total pika abundance began declining after 1998, and declined from 72 pikas in 1998 to only 24 pikas in 2000 (Table 4), despite an increase in the area censused. Therefore, when data were standardized for area, the decline was even more pronounced in the original study area. Since 2000, the population grew to a maximum of 86 pikas in 2007, with most growth occurring after 2003. Population growth rates (λ, lambda) at this site ranged from 0.51 to 1.96 (Table 4) and adult abundance largely followed the trends for the entire population. The number of adults did not decline from 1995 to 2009 (slope = 1.33 ± 0.96), and was stable or increasing from 1998 to 2009 (consistent study area size; slope = 2.97 ± 1.34). Transforming count data into densities provided similar conclusions. Density estimates (0.62 and 2.27 pikas/ha of talus; Table 4) in the Ruby Range were lower than estimates reported from Alaska (6.4 and 7.2 pikas/ha; Broadbooks 1965) suggesting there may be wide temporal and spatial variability in population density for Collared Pikas.

Table 4. Number of adult and juvenile pikas in late summer, and population growth rate, from 1995 to 2009 in the Ruby Ranges, southwestern Yukon. Population sizes include males and females, and the population growth rate ($\lambda_t = N_{t+1}/N_t$) is the finite annual rate of increase in the number of pikas (N) between year *t* and year *t+1*. Data were summarized across all years of data (1995-2009), as well as 1998-2009 to standardize across changes in the size of the study area.

Census year	# Adults	# Juveniles	# Unknown age	Total population	Growth rate (λ)	Density (total # pikas per ha)
1995	38	23	6	67	1.03	2.21
1996	39	28	2	69	0.80	2.27
1997	36	13	6	55	1.31	1.81
1998	45	25	2	72	1.00	1.87
1999	34	37	1	72	0.33	1.87
2000	14	10	0	24	1.71	0.62
2001	10	31	0	41	1.29	1.07
2002	27	25	1	53	0.51	1.38
2003	17	10	0	27	1.96	0.73
2004	15	37	1	53	1.17	1.38
2005	33	29	0	62	1.31	1.61
2006	55	26	0	81	1.06	2.11
2007	59	27	0	86	0.83	2.24
2008	62	8	1	71	0.96	1.85
2009	49	19	0	68	–	1.77
All Years						
Mean	35.5	23.2	1.3	60.1	1.09	1.7
SE	4.3	2.4	0.5	4.7	0.11	0.1
1998-2009						
Mean	35.0	23.7	0.5	59.2	1.10	1.52
SE	5.4	2.9	0.2	5.8	0.14	0.16

Available Aboriginal traditional knowledge related to the Collared Pika population trends elsewhere in its range is limited. A few First Nations members in the Yukon, however, have indicated that some sites traditionally known to harbour Collared Pika now appear to be devoid of this animal (T. Jung, pers. comm. 2011). For instance, park wardens in Tombstone Territorial Park in central Yukon have observed that some talus slopes in the Ogilvie Mountains that housed Collared Pikas as recently as 2005 no longer appear to have any sign of its presence (L. Hughes, pers. comm. 2011). Similarly, recent local extirpations have been reported in southern Yukon, within the Coast Mountains (P. James, pers. comm. 2011) and the Pelly Mountains (S. Smarch, pers. comm. 2011). Similar observations by Yukon First Nations at other local sites are possible, but unreported.

Survival

The mean overwinter survival rates for adult females in the southwestern Yukon was 0.368 ± 0.045, although survival has varied from 0.13 to 0.61 (Table 5). Juvenile survival rates were generally lower than for adult females (mean = 0.273 ± 0.033; Table 5). Survival patterns from 1995 to present followed the same pattern as population size with rates falling after 1998 before rising again after 2002.

Table 5. Annual survival rates of adult females, adult males, and juvenile Collared Pikas, southwestern Yukon, 1995-2009. Survival rates were calculated from a marked population of pikas live-trapped annually.

Year	Adult Females	Adult Males	Juveniles
1995	0.476	0.385	0.217
1996	0.429	0.571	0.464
1997	0.611	0.286	0.308
1998	0.222	0.444	0.280
1999	0.133	0.333	0.108
2000	0.143	0.143	0.333
2001	0.333	0.750	0.258
2002	0.167	0.400	0.120
2003	0.571	0.500	0.400
2004	0.333	0.200	0.189
2005	0.500	0.643	0.517
2006	0.545	0.500	0.192
2007	0.484	0.609	0.185
2008	0.206	0.526	0.250
Mean	0.368	0.449	0.273
SE	0.045	0.046	0.033

Adult annual survival rates at this site were positively correlated with mean winter Pacific Decadal Oscillation (PDO) values with a lag of one year (Morrison and Hik 2007). The PDO (Mantua and Hare 2002) is a repeating, 20-30 year cycle of climate anomalies in the sea surface temperature of the northern Pacific Ocean, and higher PDO values are correlated with early snow melts (Morrison and Hik 2007). Collared Pikas may benefit from an early spring snowmelt due to earlier plant growth that results in improved foraging and caching opportunities (Morrison and Hik 2007).

Population viability analysis

A series of four density-independent count-based population viability analyses (PVA) were conducted on census data from the southwestern Yukon study site (see **Sampling effort and methods**), which is located within the drier portions of the global range of this species. The probability of extinction was calculated according to a diffusion approximation model (also known as a stochastic exponential growth model) in which the annual growth rate stochastically fluctuated around the mean (Morris and Doak 2002). This type of PVA is structurally simple, but robustly approximates complex population-level detail (Holmes 2004; Sabo *et al*. 2004; Holmes *et al*. 2007; Kendall 2009). Each PVA estimated the probability that the population would be reduced to a single individual (i.e., the quasi-extinction threshold was set at 1) between 2009 and 2059 (i.e., 50 years into the future). Bootstrap confidence intervals were based on 5000 iterations of the model. The PVA was implemented using the '*popbio*' library of the software package *R* (Stubben and Milligan 2007; R Development Core Team 2010).

Four PVAs were considered: 1) adult pikas from 1995-2009, 2) adult pikas from 1998-2009, 3) total number of pikas from 1995-2009, and 4) total number of pikas from 1998-2009. The starting population size for each PVA was based on the number of pikas in the study area in mid-August, 2009. The number of pikas included individuals that may have immigrated to the area as juveniles. The four combinations were selected to control for changes in the area of the study site that occurred in 1998, and to examine the probability of quasi-extinction for the breeding and total populations. All four PVAs produced similar results. Overall, the probability of quasi-extinction was 6-11% within 20 years, and 19-29% within 50 years (i.e., by 2059), although the 95% confidence limits were quite large (Figure 6). Note these PVA analyses did not consider the predicted reduction in the amount of alpine habitat and increased patch isolation as a consequence of impending climate warming (see **Habitat trends** and **THREATS AND LIMITING FACTORS**), and cannot be extrapolated to the full range of the species in Canada.

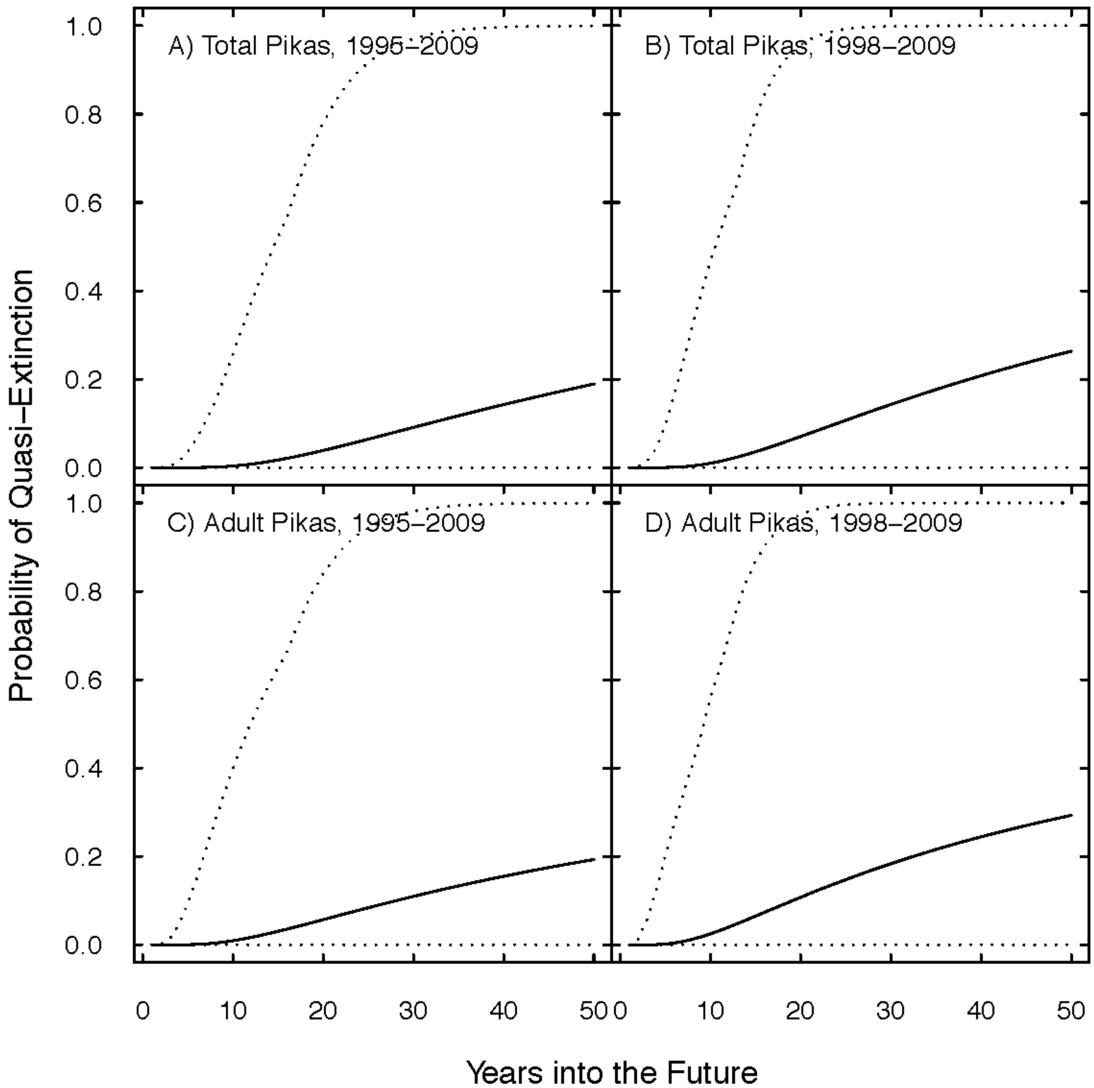

Figure 6. Probability of quasi-extinction of a Collared Pika population in southwestern Yukon based on a count-based population viability analysis. The solid line indicates the mean probability based on 2500 runs of the PVA model, and the dotted lines provide boot-strapped 95% confidence intervals.

Rescue effect

Movement or dispersal of individuals from Alaska could theoretically rescue the Canadian population of Collared Pikas. Although Collared Pikas have not been formally assessed in Alaska, they are believed to be widespread and 'locally common' (MacDonald and Cook 2009). Collared Pika populations are naturally fragmented and form a metapopulation in which the movement of juveniles commonly rescues areas that have experienced local extirpations (see **Population spatial structure and variability**). Immigrants from Alaska would be adapted to survive in Canada as environmental and habitat features are similar. However, climate factors resulting in a decline in the Canadian population would likely also affect the Alaskan population, reducing the likelihood or speed of a rescue effect.

The typically low average dispersal distances of Collared Pikas also reduce the likelihood of a rescue effect. North American pikas are largely philopatric and usually disperse only 300-600 m from their natal dens (Smith 1974a; Peacock 1997; Franken 2002), although individuals occasionally disperse 2-3 km (Peacock 1997; Zgurski and Hik, unpublished data). Additionally, Collared Pika populations isolated from others by more than 20 km of non-alpine habitat can be considered unlikely to be recolonized should they become extirpated (see **HABITAT)**.

THREATS AND LIMITING FACTORS

Due to the remote nature of its range in Canada, direct disturbance to Collared Pika habitat and populations has been and is expected to remain relatively minimal in the coming decades. The principal threat that has the potential to impact the persistence of this species is climate change. The overall assigned threat impact to Collared Pika in Canada as calculated through IUCN threat classification (Master *et al*. 2009) employing a 10-year time horizon is low (Appendix 1).

Climate change

Collared Pika range occurs in high-elevation, high-latitude areas that are already witnessing climate-driven shifts in habitat and temperature at faster rates than elsewhere in Canada (see **Habitat trends**). Like American Pikas (Galbreath *et al*. 2010), there is evidence to suggest that changing climatic conditions influenced Collared Pika distribution from prehistoric times to the present. This is reflected in the historical shifts in its geographic range that took place in tandem with glacial-interglacial cycles whereby the species had a more extensive range during the last glacial maximum than at present (Guthrie 1973; Mead 1987; Hafner 1993; Grayson 2005). While changes to subarctic alpine regions are projected to be significant due to climate warming, and have already been documented, the timing and extent of the most probable changes are unknown, particularly over the short term (see **Habitat trends**). Moreover, several factors preclude understanding of the extent to which climate change has or will affect Collared Pika populations within the coming decades. These include very limited weather and climate monitoring over much of the range (Zhang *et al.* 2011), lack of knowledge of Collared Pika baseline abundance and distribution, and inability to predict how local conditions and behavioural adaptations of individuals could serve to mitigate negative effects. Nevertheless, the most likely risks to this species' persistence with a changing climate are related to the direct effects of moisture, temperature or weather conditions affecting dispersal, thermoregulation, or loss of access to meadow forage due to icing, and effects on habitat discussed in **Habitat trends**.

The naturally fragmented nature of pika habitat, poor dispersal ability, and high energetic requirements of these species are characteristics that heighten the vulnerability of this species to a changing climate. Insight from research on American Pikas, a closely related species that is similar in habitat requirements, behaviour, ecology, and physiology (Broadbrooks 1965) and has been subject to a relatively large body of climate change-related inquiry (see references in Beever *et al*. 2011), may be instructive. American Pikas appear to be undergoing some range retraction in response to recent warming at fragmented and low-elevation sites within their range. Beever *et al*. (2003) reported 7 of 25 (28%) pika populations surveyed in the interior Great Basin (southern Oregon and western Nevada) have been extirpated at some point between the early 1900s and the 1990s. Additional surveys during 2005-2007 revealed additional extirpations and upslope range shifts (Rodhouse *et al*. 2010). With the low-elevation range boundary now moving at an average rate of 145m/decade, the rate of local extinction and upslope range retraction is occurring at a much higher rate than in the 20th century (Beever *et al*. 2011). The extirpated populations were located primarily in areas that lacked thermal refuges, were low in elevation and were generally hot and dry in comparison to sites with extant populations of pikas (Beever *et al.* 2003; Beever *et al*. 2010; 2011). Additionally, in Yosemite National Park in California, the lower elevational range of the species has contracted and moved upslope by 153 m and at least one historic population has become extirpated (Moritz 2007).

Although ecological niche models further predict that the American Pika will undergo a significant range retraction in response to climate change (Galbreath *et al*. 2009), it has been unclear how generalizable the results from the Great Basin are to the rest of the range of this species. Indeed, documentation of American Pika populations outside their typical bioclimatic envelope suggests ecological niche models may overestimate future extinction risks (Beever *et al*. 2008; Simpson 2009). In an analysis of American Pika distribution changes throughout the Southern (U.S.) Rocky Mountains, where habitat is more continuous than in the Great Basin, Erb *et al*. (2011) found only 4 of 69 historically occupied sites to have been extirpated over the past few decades. In a "rapid assessment" survey of American Pikas in 11 mountain ranges in the Sierra Nevada, Great Basin, and central Oregon, Millar and Westfall (2010) suggested that populations in the Sierra Nevada and southwestern Great Basin were "thriving". In a recent decision not to protect American Pika under the U.S. *Endangered Species Act*, Crist (2010:11) concluded that "the species range has not contracted upslope on a range-wide basis in the recent past and changes in the elevation range of the species appear to be site-specific." Nevertheless, these studies underscored the importance of water (in the form of precipitation and sub-surface moisture) as a key driver of pika persistence. Local extirpations were only documented by Erb *et al*. (2001) at sites that were consistently dry over the past century, and not in sites where the climate had changed, and Millar and Westfall (2010) also found a strong relationship between pika sign and high precipitation as well as sub-talus ice and water reserves.

American Pika persistence in the Great Basin was strongly influenced by both chronic heat stress (as measured by mean summer temperature) and acute cold stress (as measured by the number of days temperatures under talus dropped below –5°C or –10°C) (Beever *et al.* 2010). The 1998 collapse of the Ruby Range Collared Pika population (See **Fluctuations and trends**) was attributed to the warm winter that resulted in low snow accumulation, with subsequent increases in winter mortality, as pikas were poorly insulated against extreme weather conditions such as freezing rain (Morrison and Hik 2007; 2008). Although there is no direct evidence for increases in mortality as a result of decreased snowpack, extirpation sites documented by Erb *et al.* (2011) lend support to this hypothesis for American Pika, given the association between persistently low precipitation and low snow cover. Acute heat stress (as measured by days above 28°C) was a weak predictor of American Pika persistence (Beever *et al*. 2010), perhaps due to the ability of individuals to behaviourally thermoregulate by hiding within talus, allowing them to persist in regions beyond their typical bioclimatic envelope (Rodhouse *et al.* 2010).

Collared Pika range is characterized by a semi-arid, subarctic climate with long, cold winters and short warm summers. Concomitant with rises in annual temperature, precipitation has been increasing in the region, along with more extreme weather events. Much of the Collared Pika range in the Yukon receives an average of less than 300 mm of precipitation a year (Scudder 1997). Arctic Climate Impact Assessment (ACIA 2005) predicted broadly for the areas north of 60 degrees latitude to see a 7.5-18.1% increase in precipitation by 2071-2090, using five different models. At the same time, however, warmer spring temperatures over western and northern Canada have resulted in widespread decreases (39% of stations; Zhang *et al*. 2011) in spring snow cover, as part of a hemispheric-wide trend of earlier melt of snow and ice (Lemke *et al*. 2007). Despite increasing precipitation, temperature-driven increases in potential evapotranspiration are predicted to increase, leading to an overall drying effect across the landscape due to warmer temperatures and a longer growing season (SNAP 2011).

An already-changing climate in Collared Pika range has yielded a shorter snow cover season, less winter snow accumulation, earlier melt of snow and ice in the spring, an earlier and longer plant growth season with fewer frost days, with an overall decreasing potential for water availability (Zhang *et al.* 2011). Spring and winter weather conditions that have a demonstrated influence on the timing of spring snowmelt and subsequent plant growth have a known relationship with decreases in Collared Pika overwinter survival (Morrison and Hik 2007). More years with late spring snowmelt over larger regions could translate into negative range-level impacts with time. On the other hand, more years with earlier snowmelt could result in earlier growth of high-quality vegetation and improve pika survival (Morrison and Hik 2007).

Winter mortality would also be expected to rise as a consequence of increasing frequency of winter precipitation falling as rain rather than snow (see Knowles *et al*. 2006). This increased mortality would occur either with subsequent icing-over of food plant resources or through exposure (Smith *et al*. 2004). The main effect of winter rain and icing on Collared Pikas would be to remove any positive benefit of the subnivean environment that provides thermal insulation from air temperature extremes. One effect would be a temporary loss of access to food resources (including haypiles that are not protected from rain), while another would be increased exposure to extreme temperatures with the loss of the subnivean blanket. The former is episodic, while the latter could become a chronic condition over the course of the winter (e.g., ice layers in snow) and across years. Winter freezing and thawing events in alpine and high latitude ecosystems are expected to increase in frequency due to climate change (IPCC 2001; ACIA 2005; Zhang *et al.* 2011), and increasing winter rainfall is already occurring in western North America (Knowles *et al.* 2006; Zhang *et al*. 2011).

In summary, continued climate warming within Collared Pika range will increase variability in temperature, moisture, or weather conditions with potential effects on moisture availability. This could directly affect survival through impacts on dispersal, thermoregulation, and/or loss of access to forage. Climate change is also projected to reduce the amount of suitable alpine habitat and increase distances among patches of habitat (see **Habitat trends**). In contrast to American Pikas in the southern part of their range, search effort for Collared Pikas has been too limited to detect any changes in occupancy even if they have occurred anywhere, and the locales where long-term studies of this species are being undertaken in Canada constitute prime habitat. Because pikas appear capable of substantial behavioural thermoregulation, the extent to which these changes would affect population dynamics is an open question. Nevertheless, the best available information suggests that the narrow niche of this species may render populations particularly vulnerable to negative effects of a changing climate that include increasing temperatures and precipitation variability, suggesting a strong potential of negative impacts of climate change to the persistence of this species over the long term.

Habitat alteration and disturbance

The primary human agents of disturbance within Collared Pika range are oil and gas exploration and drilling, mineral exploration and development, and associated roads and utility corridors. Because Collared Pika habitat does not tend to intersect with areas of interest for such natural resources, anthropogenic alteration and disturbance to their habitat is unlikely to be a threat to Collared Pikas at regional scales. Most Pika habitat is in remote high-elevation areas that receive little human activity or disturbance. Localized disturbances such as road construction, mineral exploration, or tourism activities may affect populations where they occur if modifications to the talus affect access to haypiles, reduce crevices used for shelter, increase predator abundance, or alter the vegetation along the talus edge. Given the metapopulation structure exhibited by this species, these activities could also negatively affect recolonization and maintenance of populations. Avalanches do not normally occur in coarse talus, but when they do occur, landslides can both destroy and create Pika habitat.

Hunting and trapping

Collared Pikas are not commercially hunted or trapped in Canada. Yukon First Nations have a tradition of harvesting a small number (approximately 10-100) Collared Pikas annually (T. Jung, pers. comm.). Harvest of collared pikas by non-First Nations is not allowed in Yukon or British Columbia and is not known to occur in NWT.

PROTECTION, STATUS, AND RANKS

Legal protection and status

The Collared Pika is not listed under the Canadian *Species at Risk Act*, the United States *Endangered Species Act* or under the Convention on International Trade in Endangered Species of Wild Fauna and Flora.

Non-legal status and ranks

The International Union for the Conservation of Nature (IUCN) lists the Collared Pika as “lower risk/least concern” (Smith and Johnston 2008). NatureServe (2011) lists the Collared Pika’s conservation status as G5 (globally secure) and N5 (nationally secure) in both Canada and the United States. In Alaska, the Collared Pika has been assessed as S5 (secure; ANHP 2011); in British Columbia as S3S4 (B.C. Conservation Data Centre 2011); and in Yukon as S4 (Randi Mulder, pers. comm.). It has not been assigned a NatureServe rank in Northwest Territories (NatureServe 2011). Note that the NatureServe global and national status rankings were last reviewed in 1996 and 2000, respectively. In the National General Status program (Wild Species 2010), the Collared Pika has been assigned a rank of Sensitive for all jurisdictions within its range (Canada, Yukon, British Columbia, and Northwest Territories; CESCC 2011).

Habitat protection and ownership

In Yukon Territory, Collared Pika habitat occurs within Kluane National Park and Reserve, Tombstone Territorial Park, Kusawa Territorial Park, Agay Mene Territorial Park, Asi Keyi Territorial Park, and Ni'iinlii Njik (Fishing Branch) Territorial Park. In the Northwest Territories, it occurs within the Nahanni National Park Reserve; in British Columbia, pika habitat is preserved within Tatshenshini-Alsek Provincial Park, and potentially Tatlatui Provincial Park (unconfirmed sighting). In Alaska, the Wrangell-St. Elias National Park and Preserve, the Denali National Park and Preserve, the Yukon-Charley Rivers National Preserve, and Lake Clark National Park all contain Collared Pika habitat. Overall, in Canada, approximately 78,000 km^2 of the Collared Pika's extent of occurrence is contained in protected areas.

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

David S. Hik, PhD, University of Alberta, has been studying Collared Pikas since 1991, and since 1995 has led a research program in the southwestern Yukon looking at the various effects of climate variability and climate change on the population, community and landscape ecology of mountain environments, with a special emphasis on Collared Pikas. Students have undertaken studies of pika-plant interactions, changes in treeline and shrub-line dynamics, and the behaviour and demography of multiple alpine species. Since 1993, Dr. Hik has been a member of the IUCN Lagomorph SSG.

Jessie Zgurski, MSc, is an Edmonton-based biologist completing her PhD at the University of Alberta on the population genetics and behaviour of Collared Pikas. Previous to this, she has also conducted research on leaf development in the model vascular plant *Arabidopsis thaliana* and on the phylogeny of vascular plants, cycads and lilies.

Kieran O'Donovan is a Yukon-based ecologist, currently undertaking his MSc at the University of Alberta, studying habitat selection and spatial use of alpine mammals in southwestern Yukon. He has worked extensively in northern wildlife ecology since 2001 in arctic, alpine and boreal ecosystems. His research has addressed questions on the impacts of human disturbance on wildlife, population monitoring, behavioural observations and habitat use.

Shawn F. Morrison, PhD, is an Edmonton-based ecologist with Dryas Research Ltd. His PhD dissertation at the University of Alberta focused on Collared Pika population dynamics and foraging ecology in southwestern Yukon. Prior to that research, he conducted research on the population ecology, behavioural ecology, habitat management, and predator-prey interactions of a variety of wildlife species including ungulates, predators, birds, and small mammals.

COLLECTIONS EXAMINED

Museum of Southwest Biology (MSB), Department of Biology, University of New Mexico

Smithsonian Museum of Natural History (SMNH), Washington, DC

University of Alaska Museum of the North (UAM), Fairbanks, Alaska

Canadian Museum of Nature (CMN), Ottawa, Ontario

National Museum of Natural History; Smithsonian Institution; Washington, DC (USNM)

Royal BC Museum (RBCM), Victoria, BC

University of British Columbia

Kansas Museum of Natural History (KU), University of Kansas, Lawrence, KS

Royal Ontario Museum (ROM), Toronto, Ontario

David Hik Lab Collection, Department of Biological Sciences, University of Alberta

University of Alberta Zoology Museum, Department of Biological Sciences, University of Alberta

Royal Alberta Museum, Edmonton, Alberta

Appendix 1. THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Common Name	Collared Pika
Species or Ecosystem Scientific Name	*Ochotona collaris*

	Level 1 Threat Impact Counts	
	high range	**low range**
Very High	0	0
High	0	0
Medium	0	0
Low	1	1
Calculated Overall Threat Impact:	Low	Low

Threat		Impact (calculated)	Scope	Severity	Timing	Site(s) or Population(s)	Stress	Comments
1	Residential & commercial development	__						
1.3	Tourism & recreation areas	---						Example - Tombstone and Kusawa Parks in Yukon
3	Energy production & mining							
3.1	Oil & gas drilling	---				Throughout range	Reduction in available habitat	Population size is unknown; unlikely that 1% of total population will be affected; patches are not found where oil/gas are present
3.2	Mining & quarrying	---				Throughout range	Reduction in available habitat	Mineral exploration may affect total population but less than 1%
3.3	Renewable energy	---						Renewable energy is negligible; infancy only (ex. windmill)
4	Transportation & service corridors							
4.1	Roads & railroads	---				Throughout range	Reduction in available habitat	Related to mining and oil & gas exploration and development
4.2	Utility & service lines	---				Throughout range	Reduction in available habitat	Related to mining and oil & gas exploration and development
6	Human intrusions & disturbance							
6.1	Recreational activities	---				Throughout range, likely more of an issue in parks & accessible hiking areas	Some harassment by humans and dogs; however, talus slopes are generally avoided by hikers	Scope of threat is less than 1%: Only a small percentage of species habitat is accessible to public
10	Geological events							
10.3	Avalanches/landslides	---		Extreme	High			Avalanches do not normally occur in coarse talus. Landslides can both destroy and create pika habitat.
11	Climate change & severe weather	Low	Small	Moderate - Slight	High			

Threat		Impact (calculated)	Scope	Severity	Timing	Site(s) or Population(s)	Stress	Comments
11.1	Habitat shifting & alteration	Low	Small	Moderate - Slight	High	All	Reduced habitat (loss of forage plants, loss of alpine habitat, and increased distances among patches of habitat.	The magnitude of this threat is unknown, but could be potentially substantial. See **Habitat trends** and **THREATS** sections of Status Report.
11.3	Temperature extremes	Low	Small	Moderate - Slight	High	All	Increased rain events in winter lead to increased exposure, lack of access to food resources	Demonstrated vulnerability to climate variability. See discussion in **THREATS** sections of Status Report.