2006 Project Report: Testing hypothesized links between climate change and the decline of the American pika

MFWP Scientific Collector's Permit: #1507

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Executive summary

Recent research implicates climate change in the extirpation of pika populations throughout the western US. Hypothesized links between climate change and pika mortality include reduced survival in microhabitats 1) where summer maximum temperatures are rising, 2) where winter minimum temperatures are falling due to reduced snow accumulation and subsequently reduced insulation of microhabitats, 3) where higher-nutrient forage is being replaced by lower-nutrient forage due to climate-related shifts in the plant community, and 4) where climate-related shifts in the animal community lead to increased predation or disease prevalence. This project is designed to evaluate the relative support for each of these hypotheses, by gathering data on pika demography from a variety of microhabitats in the Gallatin Range of Montana. The study area includes an array of pika habitats (taluses) representing all potential slope aspects. Each slope aspect experiences a different microclimate due to differential exposure to sun, wind, precipitation and accumulated snowfall, leading to distinct patterns of daily temperature variation and plant community structure. Since 1992, a large number of pikas have been tagged to track annual survival, recruitment and dispersal. Since 1995, available forage has been characterized within many pika territories. Since 2000, selected pika territories have been characterized in terms of daily temperature fluctuations. Pika foraging behavior has also been studied.

In 2006, 34 pikas were tagged (see Appendix for details). A study of pika-marmot interactions was initiated, including 1) a paired-sample tagging study to determine whether pikas near marmot dens experience lower mortality and 2) a play-back study to determine how pikas and marmots respond to predators and to each other's alarm calls. Automated cameras revealed that pikas use marmot dens. Temperature data-loggers were deployed within 33 pika territories. Each logger was placed under the central 'haypile' (food cache) of the territory owner, the primary center of owner activity. Available forage was characterized for seven pika territories. Preliminary results suggest that pika survival is reduced within this study area wherever haypile temperatures drop below -5˚ C, and wherever haypiles contain more flowering plants than grasses. Preliminary results do not suggest notable effects of higher temperatures on individual mortality within this area.

If these relationships prove to be representative, then we will have reason to investigate whether pika extinctions can be explained by some of the less intuitive effects of climate change, such as reduced snow accumulation or altered plant and animal communities.

Study overview and objectives

Recent research implicates climate change in several local extinctions of the American pika (*Ochotona princeps*) throughout the western US (Beever et al. 2003). Although patterns of pika extinction have been correlated with climatic variables, no mechanistic relationships have been established. This study focuses on ecological mechanisms that may explain how climate change affects individual mortality. Based on the ecology of *O. princeps*, we propose four distinct hypotheses linking climate change and individual mortality in this species. We expect individual pikas to experience higher mortality in microhabitats 1) where summer maximum temperatures are rising, 2) where winter minimum temperatures are falling due to reduced snow accumulation and subsequently reduced insulation of microhabitats, 3) where higher-nutrient forage is being replaced by lower-nutrient forage due to climate-related shifts in the plant community, and 4) where climate-related shifts in the animal community lead to increased predation or disease prevalence. Microhabitat may also affect individual fitness through effects on reproductive success, but this study is not designed to track reproductive success. The relative support for each hypothesis will be determined using data on individual survival and microhabitat characteristics gathered during a long-term study of pikas in the Gallatin Range of Montana.

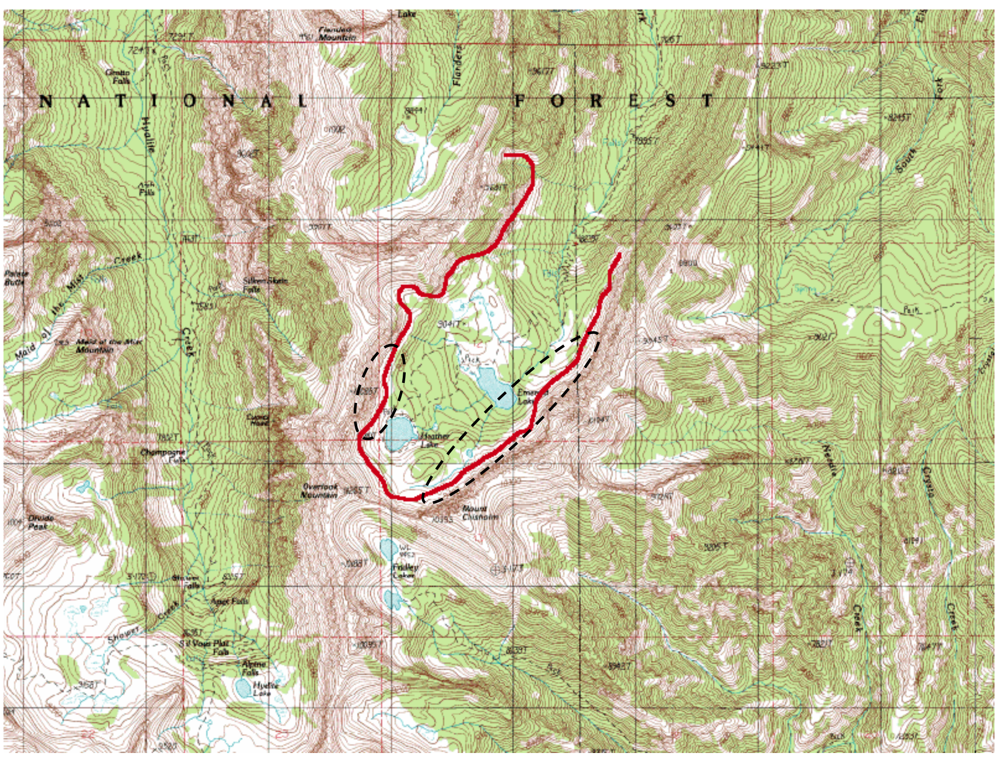

Figure 1. Topographic map of the main study area in Gallatin National Forest, Montana. Talus habitats lie along the red line at ~2800 m, below steep cliffs that ring the study canyon. Dotted outlines indicate 2006 trapping regions shown in Fig. 2.

The study area includes an array of pika habitats (taluses) representing all potential slope aspects (Fig. 1). Each aspect experiences a different microclimate due to differential exposure to sun, wind, precipitation and accumulated snowfall, leading to distinct patterns of daily temperature variation and plant community structure.

Beginning in 1989, the distribution and abundance of pikas at this site has been tracked by a variety of means. Since 1992, a large number of individuals have been tagged to track annual survival, recruitment and dispersal. Selected pika territories have been characterized in terms of available forage (since 1995), daily temperature fluctuations (since 2000) and distance from active marmot dens. Foraging behavior has also been studied, through experiments and by tracking haypile contents (since 1995) relative to available forage. Automated cameras have been employed to determine how pika haypiles are used by pikas and other associated species. Similar data will be gathered through at least August of 2008, under funding provided in part by WWF International.

Accumulated data will be used to relate survival and recruitment to, for example, temperatures experienced throughout the year, characteristics of available forage, and distance to nearest active marmot den. The relative support for various models relating individual survival to microhabitat characteristics, or relating population and climatic dynamics, will be determined using information theory (Burnham and Anderson 2002). Models with higher support will be used to suggest relatively important mechanisms linking climate change with pika demography, and can be used in conjunction with climate-change models to forecast shifts in the distribution of *O. princeps*.

Work accomplished in 2006

In 2006, 34 pikas were tagged (Fig. 2). Of these, 23 pikas occupied territories on slopes facing north-northeast, and 11 occupied territories on slopes facing east-southeast.

Temperature data-loggers were deployed within 33 pika territories, including 29 deployed within the main study area at ~2800 m, and four deployed at a 'low-elevation' site (Palisade Falls) ~10 km north of the main study area at ~2150 m. Of the 29 loggers within the main study area, 13 were deployed on slopes facing north-northeast, 16 on slopes facing east-southeast. All taluses at the lower-elevation site face south-southwest. Each logger was placed under the central 'haypile' (food cache) of the territory owner, which represents the center of owner activity throughout most of the year.

Available forage was characterized for only seven pikas in 2006. However, based on previous data from this site, available forage changes very little between years. Data are available from previous years on available forage within many of the territories belonging to pikas tagged in 2006.

Methods for studying pika-marmot interactions were developed and tested. Pikas responded to recorded calls made by marmots and a variety of potential predators. Although marmots were more common than usual within the study area this year, we were able to find areas with little evidence of marmot activity, allowing us to tag and observe pikas both near and far from active marmot dens. Automated cameras were placed at one active marmot den and at an adjacent pika haypile, to determine whether pikas use marmot dens and conversely.

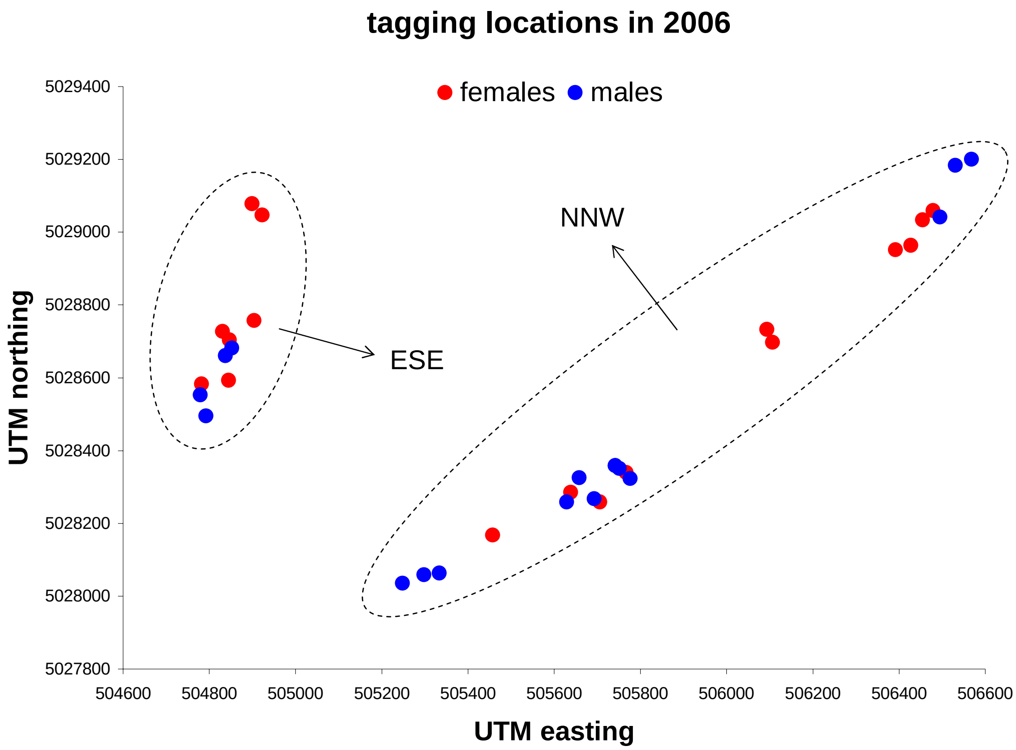

Figure 2. Locations of female (red) and male (blue) pikas tagged within the main study area in August of 2006. For reference, dotted regions are also shown in Fig. 1. Arrows indicate the average slope aspect of pika territories within each dotted region.

Notable observations in 2006

Early recruitment?

Every year, we attempt to complete a full census of the pika population in the main study area by searching all taluses near the red line in Figure 1. During this census, we attempt to find every active territory (revealed by active haypiles) and observe every territory owner. Normally, pikas can be classified as 'adult' (one or more years old) or 'juvenile' (less than one year old) simply by observing differences in pelage, proportion and vocal characteristics. By recording the proportion of territory owners each year that are juvenile, we obtain one estimate of annual recruitment. We complete the census at the same time every year (late August to early September), after most juveniles have obtained a territory and before most juveniles have matured to the point where they are difficult to distinguish from adults.

This year, for the first time, it was very difficult to differentiate between adults and juveniles. Juveniles often appeared to be at least as large as adults. This pattern was confirmed during trapping. Trapped animals can be examined carefully for evidence of molting (adults begin molting prior to August), sexual activity (juveniles do not reproduce) and scars (adults accumulate ear damage with age due to fighting, reproduction or tagging). Animals identified as juveniles during trapping were often as heavy as animals identified as adults. In fact, putative juveniles in 2006 weighed far more (mean = 128 g, sd = 23 g) than putative juveniles in any other year (mean = 83 g, sd = 26 g). This difference in juvenile weights was highly significant (one-tailed t-test: $P \ll 0.01$). In contrast, adults in 2006 (mean = 143 g, sd = 16 g) weighed about the same as adults in previous years (mean = 147 g, sd = 16 g). Reproduction must have occurred much earlier this year than in previous years.

Fewer predators?

Also of note was a conspicuous lack of mustelid predators in 2006. Prior to 2006, we observed roughly two mustelids per day of the census, including least weasels, short- and long-tailed weasels, pine martens and wolverines. This year, we formalized this count by recording the number of mustelids and all other mammals and birds observed within each pika territory during the census of each territory. However, this year only two mustelids were observed during the entire census period (8/16-8/30), despite more observers than usual. These mustelids, observed by field assistants, were weasels (species unconfirmed). The PI also observed wolverine and weasel tracks in the snow, each on only one occasion.

Wildfire

Finally, a wildfire (part of the Big Creek complex) moved into the main study canyon on 8/30/2006, putting an early end to our study this year. However, the PI returned to the study site in late September, and confirmed that the fire had not approached any of the talus habitats within this canyon.

Preliminary results

Based on a small dataset from 2005-2006, pika mortality appears to be related to the range of temperatures experienced at the haypile (Fig. 3).

Most importantly, the haypiles of pikas that died were twice as likely to experience temperatures below -5˚ C and over three times as likely to experience temperatures below -6˚ C (a). Overall, the pattern in Fig. 3 suggests two hypotheses: 1) pikas exposed to temperatures below -5˚ C are more likely to die, and 2) the haypiles of pikas that die experience larger temperature fluctuations, perhaps due to loss of hay or snow cover and the insulation that these provide. These hypotheses are not mutually exclusive, and there are at least two ways to interpret hypothesis 2: a) it could provide an explanation for pika mortality (loss of snow cover leads to colder pikas); or b) pika mortality may involve reduction of the haypile to the point where it no longer insulates the data logger from temperature fluctuations (loss of pikas leads to colder loggers). Next year, we will attempt to determine whether the haypile can insulate the data logger from temperature fluctuations, to address this possible explanation for these data. Regardless, these data suggest that pikas are more likely to die when over-winter temperatures at the haypile fluctuate outside of a relatively narrow window.

Given the literature on heat sensitivity in pikas (Smith 1974, Hafner 1994, Beever 2002, Beever et al. 2003, Grayson 2005), it may seem surprising that our preliminary results do not suggest notable effects of higher temperatures on pika mortality. However, this study area rarely experiences temperatures above 25˚ C. In contrast, we hypothesize that pika extinctions in the Great Basin occur mainly in areas experiencing summer maximum temperatures in excess of 35˚ C. Our Montana study area may be more suited for exploring effects of minimum temperature on pika mortality. We will continue to explore the range of thermal maxima faced by pikas in this region by extending our temperature measurements to pika habitats down-slope of our main study area. This year, we placed several temperature data-loggers within pika habitats ~700 m below the main study area. Data from these loggers will be available for the first time next year.

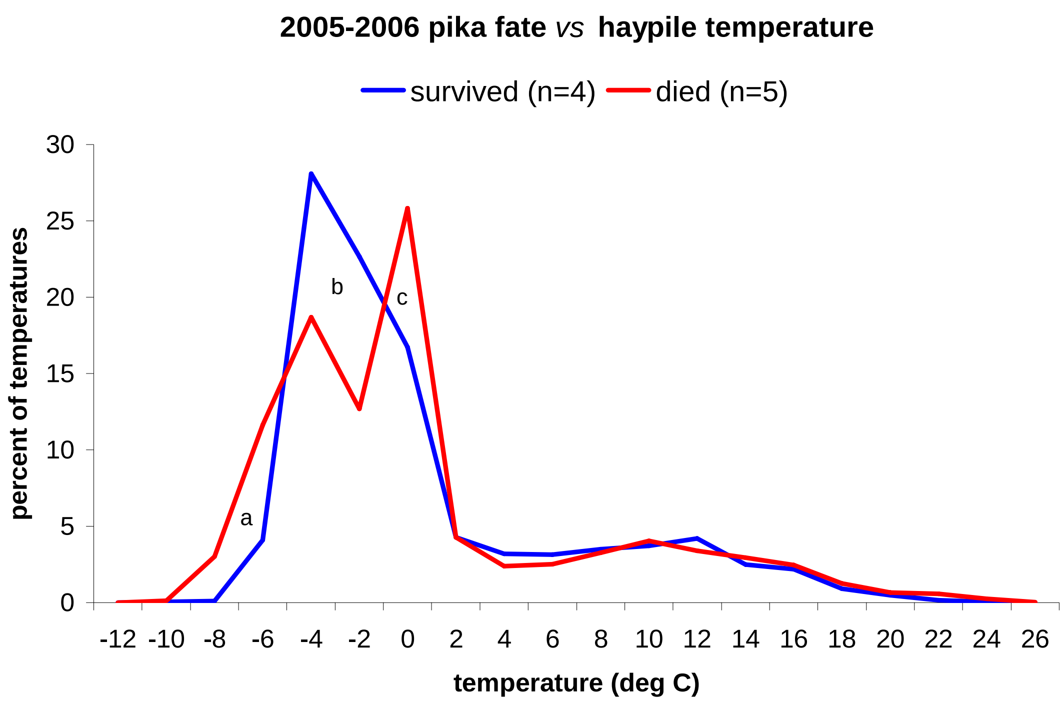

Figure 3. Annual temperature profiles recorded by data loggers placed under the haypiles of nine marked pikas. Haypile temperatures were recorded four times per day (at 2:00 a.m., 8:00 a.m., 2:00 p.m. and 8:00 p.m.) from 9/1/2005 to 8/16/2006. Of the nine pikas marked in August 2005, four were alive in August 2006. The other five were not found despite extensive searches, and their haypiles had been either vacated (n=1) or taken over by other pikas (n=4). Because pikas rarely disperse from established territories, these pikas are presumed dead. The haypiles of pikas that died were twice as likely to experience temperatures below -5˚ C and over three times as likely to experience temperatures below -6˚ C (see region “a”). The haypiles of pikas that survived were more likely to experience a narrower range of over-winter temperatures (see “b”). The peak at “c” suggests that dead pikas had also been more likely to experience haypile temperatures around 0˚ C. However, since 0˚ C lies near the mean and median haypile temperature experienced by all pikas, this peak is not likely to explain pika mortality.

Preliminary results also suggest that pika survival is weakly but significantly related to available forage. Data from 1995-2002 show that nine percent of the variance in pika survival was explained by haypile contents ($P<0.01$), and haypile contents were strongly correlated with available forage (Spearman's rank correlation coefficient = 0.73). Pikas with more graminoids (grasses) in their haypiles survived more often than those with more forbs (flowering plants). Therefore, at this study site, pikas are a bit more likely to survive where graminoids are more abundant. However, the relative abundance of graminoids may be related to slope aspect, which is related to the temperature profile of the microhabitat. Further research will determine whether this apparent effect of available forage on pika survival is more likely an effect of temperature.

Specific results are not yet available from 2006 studies of pika-marmot interactions, but the methods tested show some promise. Automated cameras gathered evidence that pikas use marmot dens. Pikas also continued to gather marmot scat for their haypiles. Evidence to date suggests a one-way interaction in which pikas make use of marmot dens, scat and alarm calls, while marmots do not appear to make use of pikas.

In summary, to date we have found preliminary evidence for effects of sub-zero temperatures and available forage on pika survival, and we have observed behaviors suggesting that pikas may benefit from marmot presence. If these relationships prove to be representative, then we will have reason to investigate whether pika extinctions can be explained by some of the less intuitive effects of climate change, such as reduced snow accumulation or altered plant and animal communities.

References

Beever, E.A. 2002. Persistence of pikas in two low-elevation national monuments in the western United States. Park Science 21(2):23-29.

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

Burnham, K.P., and D.R. Anderson. 2002. Model selection and inference: a practical information-theoretic approach. 2nd edition. Springer-Verlag, New York, NY.

Grayson, D.K. 2005. A brief history of Great Basin pikas. Journal of Biogeography 32:2103-2111.

Hafner, D.J. 1994. Pikas and permafrost: post-Wisconsin historical zoogeography of Ochotona in the southern Rocky Mountains, U.S.A. Arctic and Alpine Research 26:375-382.

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

Appendix: Locations of pikas tagged in August, 2006, under MFWP Permit #1507.

Pikas were trapped at the following coordinates using Tomahawk live traps (16”x6”x6”). Pikas were anesthetized with Isofluorane before handling. Both ears were tagged, using colored rabbit-ear tags from National Band and Tag Company, or a binary notching code. For example, “RW/GB” indicates a color pattern (red inside the right ear, white outside/behind the right ear; green inside the left ear, blue outside), while “1-0” indicates a notching pattern (notch in forward position along rim of outer ear, no notch in rear position; positions separated by a small hole). Pikas were weighed and sexed, and tissue samples were taken (M = stored dry for microsatellite analyses, G = stored in solution for genomic analyses). Contact Chris Ray (cray@colorado.edu, 303-489-8863) for details.

	UTM WGS 84 12 T		Eartag	Eartag Numbers		Weight		Tissue
Date	Easting	Northing	Colors	Right	Left	(grams)	Sex	Sample
8/16	0506107	5028697	BW/RW	344	428	159	F	M/G
8/16	0506093	5028733	GR/YG	467	429	131	F	M/G
8/16	0506392	5028951	RW/WG	422	412	127	F	M
8/17	0506479	5029059	BG/YR	468	426	148	F	M/G
8/18	0506427	5028964	YB/WR	401	497	132	F	M/G
8/19	0506495	5029041	WY/RR	452	478	140	M	M/G
8/20	0506531	5029184	GR/GG	441	463	147	M	M/G
8/20	0506568	5029200	RB/WG	420	445	~100	M	M/G
8/20	0506455	5029034	1-1/1-1			135	F	M/G
8/21	0505742	5028358	WB/YB	416	413	146	M	M/G
8/21	0505742	5028358	RB/BG	471	414	141	M	M/G
8/21	0505776	5028323	GG/1-1	450		150	M	M
8/22	0505693	5028267	YB/WB			148	M	M/G
8/22	0505706	5028259	WR/YY			152	F	M/G
8/22	0505767	5028340	YY/BB			148	F	M/G
8/22	0505248	5028035	0-1/0-1			160	M	M/G
8/23	0505457	5028167	WW/GG	40	55	127	F	M/G
8/23	0505658	5028325	YW/YW	4	95	156	M	M/G
8/23	0505638	5028285	WR/WG	43	98	135	F?	M/G
8/23	0505629	5028259	YB/GG	35	67	137	M	M/G
8/23	0505334	5028063	GB/1-0	89		106	M	M/G
8/23	0505298	5028059	WR/1-0	29		174	M	M/G
8/23	0505751	5028351	1-0/1-0			174	M	M/G
8/24	0504904	5028757	BR/YB	61	50	89	F	M/G
8/24	0504852	5028682	RB/GB	30	7	112	M	M/G
8/24	0504782	5028583	RB/YR	18	9	128	F	M
8/24	0504847	5028704	WW/RW	88	31	142	F	M
8/25	0504779	5028553	RR/GB	90	48	132	M?	M
8/25	0504831	5028727	YR/BG	91	94	111	F	M
8/25	0504792	5028495	BR/GW	60	1	147	M	M
8/25	0504845	5028593	GY/RG	74	15	113	F	M
8/25	0504837	5028661	YR/YR	75	51	151	M	M
8/29	0504899	5029078	RB/WB	14	53	118	F	M
8/29	0504923	5029047	WR/WB	96	10	138	F	M