THE KLUANE ECOLOGICAL MONITORING PROJECT
ANNUAL REPORT 2006/2007

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The purpose of this report is to draw attention to some of the major current findings of the Kluane Ecological Monitoring Project (KEMP), with a particular emphasis on those findings that have potential management implications. Because the report is directed at both managers and members of the public, we discuss patterns that are of more general interest or that have management importance. Additionally, we summarize relevant research conducted outside the KEMP project, both in the immediate region and, where appropriate, in the larger Yukon Territory. For more detailed information on any of these topics, we refer you to the references cited.

Those readers already familiar with previous annual reports are reminded that information about new findings can be found primarily in the *Results and Discussion* section that begins on page 7. Most of the information in the front section of the report remains the same from one year to the next in order to provide new readers with a detailed explanation of the objectives and structure of KEMP.

We begin this year's report with an overview of the Yukon Community Ecological Projects (CEMPs). Whitehorse has been collecting data using some of the KEMP protocols since 2005 and this year we are highlighting the growth of this community project. This is followed by a brief summary of last year's results and trends from Mayo, Southeast Yukon and Kluane. We also report on two subalpine projects on opposite sides of the Shakwak Valley. Ryan Danby has documented the recent climate induced advance of treeline in the Kluane Ranges, while a long-term study across the valley in the Ruby Ranges has been investigating population changes of pika over the past twelve years. Snowshoe hare are considered to be a keystone species in the boreal forests, with strong links to both predators and herbaceous vegetation. In this report we suggest other, more indirect associations, by linking them to two more herbivores in the Yukon food web: Dall's sheep and red-backed voles. We then provide a guide to 20 years of red squirrel research that has been based out of Squirrel Camp. Also included is a report on a recent conference about climate change held in Haines Junction. We have chosen a random selection of presentations and observations from this forum to give readers a taste of the many subjects and views that were discussed. Finally, we give a brief report on unusual sightings of plants and animals that have been observed over the past two years in the Kluane region.

For ease of reference, the page that each article begins on is provided here:

Overview of the Monitoring Program

The Kluane Ecological Monitoring Project is a partnership between researchers at the Arctic Institute Research Station at Kluane Lake, Parks Canada, Yukon Department of Environment, the Canadian Wildlife Service (CWS) and Yukon College. The program in its present form has been running since the close of the Kluane Boreal Forest Ecosystem Project in 1996. Since 1996, we have continued our ecological monitoring in the Kluane region and improved the monitoring methods being used. In particular we have begun the analysis of these data with a focus on park and regional management.

Parks Canada became an active participant in the program in 1998 as part of an effort to monitor the ecological integrity of Kluane National Park and Reserve (KNP&R). This program complements the long-term monitoring program initiated by KNP&R Wardens during the 1970s. The maintenance of ecological integrity in KNP&R and the greater regional ecosystem is a priority in the newly approved Kluane National Park and Reserve Management Plan (2004) and ecological monitoring is one of the strategic goals for the park. The long-term databases provided by both the park's Warden service and KEMP have been analyzed for management thresholds, and these results will appear in the forthcoming KNP&R State of the Park Report.

Yukon Department of Environment (Environment Yukon) became an active participant in KEMP in 2000, once support for the program was recommended by the Alsek Renewable Resource Council. Like other partners in the project, Environment Yukon recognizes the importance of long-term monitoring for the Kluane region. Furthermore, the monitoring program assists in evaluating existing and planned forest management practices. (For example, three forestry transects have been established in the region to document regeneration of trees after the application of different forest harvesting procedures.)

KEMP has several interrelated objectives. First, it constitutes an early warning system of significant changes taking place in the greater Kluane ecosystem. The early detection of these changes should guide medium to long-term planning, management and research in the Kluane region and in Kluane National Park and Reserve. Second, KEMP provides long-term baseline information on undisturbed forest sites, information that is of value to many research programs as well as park and forest management in the region. Third, KEMP monitors the long-term processes that drive Kluane's boreal forest ecosystem. The Kluane Boreal Forest Ecosystem Project which preceded KEMP documented important interactions and ecological processes during the ten years of its existence, 1986 to 1996 (see Krebs et al. 1995, 2001). KEMP is continuing the work started in the '80s and '90s by documenting the longer cycles and processes that drive boreal forest ecosystems.

Protocols Monitored and Cooperating Research Programs

Figure A shows the food web of the boreal forest region around Kluane. If we wish to monitor ecological integrity, we need to measure key components in each of the levels of this food web. As we cannot monitor everything, we have concentrated our efforts on sixteen significant indicators described below. We believe that these indicators constitute the best balance for obtaining early warning of ecosystem change, evaluating forest management practices and advancing our understanding of the dynamics of boreal ecosystems. Species being monitored are indicated by shading in Figure A, and Figure B (on page 4) shows the location of the monitoring sites.

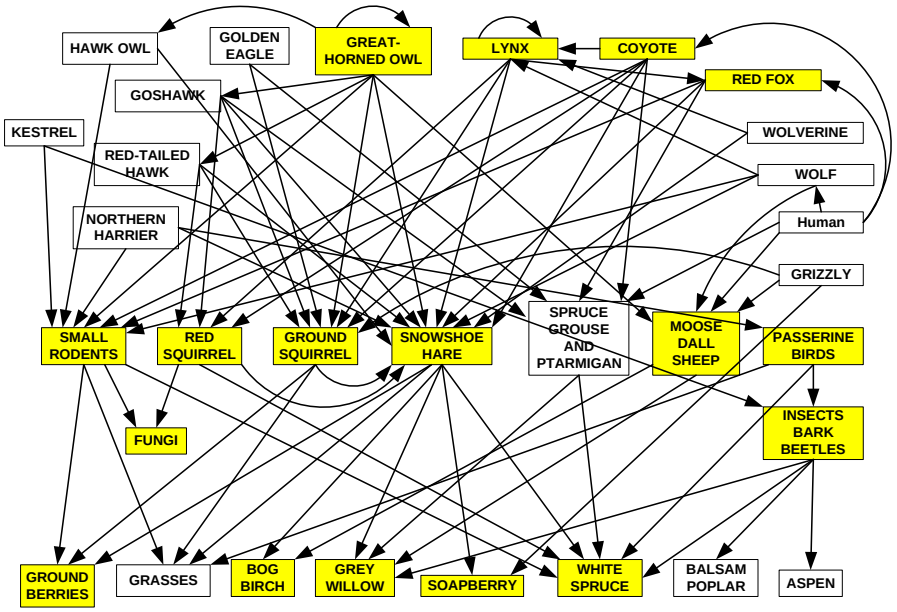

FIGURE A. Food web for the boreal forests in the Kluane region of the Yukon. The species being monitored in the Kluane monitoring project are shaded. University research personnel are monitoring the squirrels and rodents on only a few sites. Only the major feeding linkages are shown.

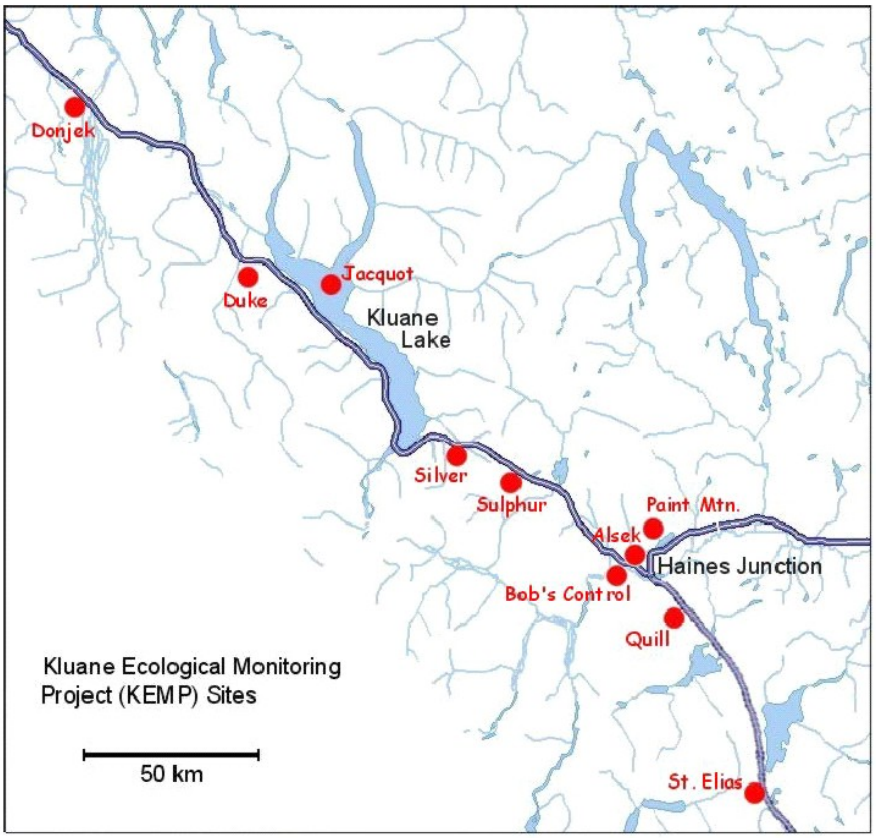

FIGURE B. Map of the Kluane region showing the 10 monitoring sites. Each red dot represents a monitoring site.

Active participants in the program include:

Charles Krebs of the University of British Columbia
David Henry of Parks Canada
Liz Hofer of the AINA Research Station at Kluane Lake
Alice Kenney of the University of British Columbia
Ray Breneman of Parks Canada
David Hik of the University of Alberta
Rudy Boonstra of the University of Toronto
Mike Gill of the Canadian Wildlife Service
Mark O'Donoghue of Yukon Department of Environment
Val Loewen of Yukon Department of Environment
Scott Gilbert of Yukon College
Michelle Oakley, Lorne LaRocque and Linaya Workman of Yukon Department of Environment
Richard Greer
Todd Heakes
Joan Eamer, Manager, Polar Programme UNEP/GRID - Arendal
Stan Boutin of the University of Alberta
Roy Turkington of the University of British Columbia
Tom Jung of Yukon Department of Environment
Todd Powell of Yukon Department of Environment
Jan Adamczewski of Yukon Department of Environment

A brief description of what we measure in each protocol and why we measure it is given below:

1. **Weather.** Measurements: temperature, precipitation, days with 25 cm or more of snow cover (hiemal threshold) have been recorded hourly each day since 2001 at six permanent monitoring transects that span the Kluane region from the Donjek to the St. Elias monitoring sites (see Figure B). An additional weather monitoring station was installed in 2004 near Sockeye Lake to enhance weather monitoring in the immediate vicinity of kokanee spawning beds. Regional weather data (Haines Junction and Burwash) are also available. Rationale: weather is a key driver of the ecosystem.
2. **White Spruce**. Measurements: tree health with respect to spruce bark beetle attack and the growth rates of trees have been recorded since 1997. Survival of spruce seedlings and saplings is monitored in harvested and unharvested areas. Rationale: major tree species in the region.
3. **White Spruce Cone Production.** Measurements: annual rates of cone production have been documented since 1987. Rationale: major food for red squirrels, passerine birds, and mice.
4. **Soapberry Production.** Measurements: soapberry production has been recorded each year since 1997. Rationale: important food for grizzly bear, passerine birds, and rodents.
5. **Ground Berry Production.** Measurements: berry production has been recorded annually for crowberry, bearberry, red bearberry, and cranberry since 1997. Rationale: major food source for small mammals and birds.
6. **Mushrooms**. Measurements: standing crop of mushrooms has been recorded in early August each year since 1997 as an index of mushroom fruiting. Rationale:

important food for red squirrels and other mammals, highly variable in production from year to year.

7. **Snowshoe Hare Abundance.** Measurements: relative density of hares has been estimated from pellet plots annually since 1976. Rationale: the keystone species of the boreal forest with a ten-year population cycle.

We have prepared a separate handbook of the details of the monitoring protocols for each of the species groups listed above (Kluane Monitoring Protocols for 2004 (September 2003), available on the web at http://www.zoology.ubc.ca/~krebs/kluane.html).

KEMP also assists the following additional monitoring initiatives to be carried out in the Kluane region. Parks Canada conducts satellite monitoring; Parks Canada and CWS cooperate on avian monitoring, and Elizabeth Hofer and Charles Krebs carry out the other projects. A brief description of each follows:

8. **AVHRR Monitoring.** Ten-day composite satellite images monitoring length of growing season and a coarse index of primary productivity has been recorded by ecodistrict using NDVI data available since 1993. Rationale: landscape patterns possibly affected by global climate change.
9. **Passerine and Landbirds**. Breeding bird surveys and point counts have been completed annually since 1998. Rationale: trends in certain avian populations are monitored.
10. **Predator Abundance**. Annual index of relative abundance of coyotes, lynx and other predators has been derived from a winter track transect in the Kluane Lake-Kloo Lake corridor since 1986. Rationale: an index of major terrestrial predators in the system.
11. **Great Horned Owl Census.** Annual population density estimate is based on breeding pairs between Kluane Lake and Hungry Lake; owls have been monitored since 1987. Rationale: major avian predator in the system.
12. **Snowshoe Hare Abundance.** Population density estimates have been calculated from live trapping hares twice per year at Sulphur, Silver and Jacquot Island monitoring grids since 1976. Rationale: the keystone species of the boreal forest with a ten-year population cycle.
13. **Red Squirrel and Arctic Ground Squirrel Abundance.** Population density estimates from live trapping both species twice per year at two monitoring grids; red squirrels have been monitored since 1987, ground squirrels since 1990. Rationale: important herbivores and alternate prey species in this boreal ecosystem.
14. **Small Mammal Abundance.** Population density estimates calculated from live trapping mice and voles twice per year at four monitoring grids since 1973. Rationale: small mammals are major prey for many predators; these species create a 4-5 year population cycle as well as major irruptions in the area.
15. **Shrub Growth.** An annual production index has been carried out on tagged willow and birch shrubs on four monitoring grids since 1988. Rationale: shrub growth varies with climate and browsing pressure.

16. **Shrub Browse.** Rate of loss of tagged twigs of willow and birch due to browsing has been documented since 1988. Rationale: willow is a major winter food source for moose and both shrubs for snowshoe hare.

In addition to these sixteen protocols, a number of research and management projects are being conducted in the Kluane region. Through cooperation and partnerships, these projects contribute important additional information that is valuable for long-term monitoring in the Kluane region.

Snow Plots: Since 1976 KNP&R staff has measured the thickness of snow pack at four established snow stations from February to May each year, and Inland Waters of DIAND analyses these data. This information helps to monitor hydrological and weather changes in the region.

Ungulate Surveys: Since 1977 KNP&R staff has conducted aerial surveys of moose, sheep and goat populations in or adjacent to KNP&R. These surveys document trends and dynamics in these ungulate populations and have recently been reviewed and analysed by Dehn (2001a,b). Environment Yukon also performs ungulate surveys in the region; recent survey results for moose are discussed on page 25.

Salmon Surveys: Since 1976 KNP&R staff has been counting Kokanee salmon observed on spawning beds between Kathleen Lake and Sockeye Lake.

Red Squirrel Ecology and Population Dynamics: Since 1986 Stan Boutin of the University of Alberta has supervised research on the ecology and population dynamics of red squirrels in white spruce forests of the Kluane region, and these extensive studies continue to add depth to our understanding of this key small herbivore in Kluane.

Snowshoe Hare and Small Mammal Ecophysiology: Since 1991 Rudy Boonstra of the University of Toronto has conducted detailed studies on the physiology of stress in snowshoe hares and small mammals, investigating the relationships between endocrine systems and populations dynamics.

Pika and Marmot Abundance and Population Dynamics: Since 1996 David Hik of the University of Alberta has supervised research on the ecology and population dynamics of pika and hoary marmot populations in the alpine tundra of the Ruby Range to the east of Kluane Lake. These studies will permit important comparisons of the alpine and the forested ecosystems in the Kluane region.

Vegetation Dynamics: Since 1989 Roy Turkington of the University of British Columbia has supervised research on the dynamics of herbaceous vegetation in the Kluane area, with emphasis on the importance of competition and soil nutrients to vegetation succession.

Community Ecological Monitoring Project (CEMP): New funding from NEI allowed for the geographical expansion of KEMP in 2004, giving rise to the Community Ecological Monitoring Project (CEMP). Mayo was the first community to take part, and in 2005 technical monitoring grids were also set up near Watson Lake and at Wolf Creek in Whitehorse. A local biologist in each of these areas has determined which of the KEMP protocols (described above) are relevant to CEMP-Mayo, CEMP-Watson Lake and CEMP-Whitehorse, and those protocols are now being carried out. CEMP-Mayo is also a pilot project for gathering local/traditional knowledge about ongoing and historical ecosystem indicators, and will eventually provide a framework for collecting similar information in the Kluane area.

Your comments on this report are always welcome. Please send them to David Henry, Parks Canada, PO Box 5495, Haines Junction, YT, Canada, Y0B 1L0 or e-mail them to David.Henry@pc.gc.ca. He will distribute them to other members of the KEMP team.

Results and Discussion

As stated at the outset of this report, the articles that follow focus on findings that have management implications or that document dynamics in Kluane's boreal forest. To give access to a sample of the actual data, we maintain a detailed EXCEL file (*monitor.xls*) on the web site http://www.zoology.ubc.ca/~krebs/kluane.html that summarizes monitoring data since 1973. Additionally, our colleagues have produced a number of noteworthy research articles related to the Kluane ecosystem, and these are listed in the Appendix on page 26.

While we are certainly succeeding in documenting various trends and patterns in the Kluane boreal forest, we need to keep two things in mind. First, as we learn more about this particular ecosystem, our new knowledge is giving rise to yet more questions. Second, while some of our ecological data dates back to the 1970s, many of the protocols presently in use have only been implemented since 1997. As such, certain protocols must be carried out for several more years before clear ecological patterns will begin to become evident.

CEMP Expands Across the Yukon

The Kluane Ecosystem Monitoring Project expanded its geographical range and research scope during the last few years with additional funding from the Northern Ecosystem Initiative (NEI). The wider project is called the Community Ecosystem Monitoring Project (CEMP), and now includes technical data collection from Kluane, Mayo, Watson Lake, Faro and Whitehorse. Local knowledge and aboriginal traditional knowledge are also compiled from the Mayo region. We introduced the Mayo CEMP in our 2004-2005 report and this year we are featuring an overview of the Whitehorse community project. Regional coordinators then give a brief summary of the trends and new developments from their respective projects.

Whitehorse: Our monitoring efforts carry on a project started in the 1990s by Joan Eamer, who was working for Environment Canada in Whitehorse at the time. She spearheaded a local effort to establish two Smithsonian/Man and the Biosphere Forest Biodiversity Plots (SI/MAB Forest Biodiversity plots) at Wolf Creek. In 2005, with support from the Northern Ecosystem Initiative, we were able to expand the monitoring work as part of the Yukon Boreal Forest Monitoring Project. This effort eventually was renamed the Community Ecological Monitoring Project and made us the Whitehorse link in an expanding monitoring network. A group of Whitehorse biologists and Yukon College students have started, what we hope, will be long-term monitoring work.

Johnstone and Eamer (1998) laid out some of the objectives for monitoring changes in biodiversity and ecosystems. The Whitehorse CEMP project follows some of their good advice such as designing the monitoring program so it can be maintained for the long term and embedding educational opportunities for students. They also mention the practical reality of changing a design due to trade-offs required by labour or funding

constraints. The constraint in our case is that we have a single study area in each of two habitats and lack any replicates for these study plots.

In 2005 we set up a 10 ha monitoring grid at Wolf Creek in old growth white spruce habitat. During that first year we were able to implement several monitoring protocols using the standard KEMP methods, for example, estimating mushroom biomass, spruce cone numbers, berry production and spruce bark beetle attacks. We also laid out snowshoe hare pellet transects so they could be counted in following years. In the fall of 2005 we established a 10x10 grid network to live trap small mammals using Longworth live traps. We were able to set up the grid, prebait traps and carry out a two-day trapping session in mid-September.

In the fall of 2006 we set up a 10 ha monitoring grid in pine habitat in the Gunnar Nilsson and Mickey Lammers Research Forest on the Takhini Hotsprings Road. This study area is more representative of habitats in the Whitehorse area and provides a link between the CEMP group and the other research groups working in the research forest. So far we have only set up plots to measure berry production and snowshoe hare pellet transects on this new study area.

Our results gathered so far are preliminary but offer some insights. We find it interesting that the Wolf Creek study area had no discernable spruce bark beetle activity in August of 2005. If the spruce bark beetle outbreak in Kluane were to spread to Whitehorse we will have established a baseline prior to any spread. Our small mammal census in the fall of 2005 provided interesting results with three species represented: red-backed voles, deer mice and long-tailed voles. We caught 90 red-backed voles in just two days of trapping with 100 live-traps and this seems extremely high by comparison with Kluane trapping patterns. By the spring of 2006 our live-trapping efforts yielded a catch of 11 red-backed voles and the two-day catch later that year in September was 41.

Summer students hired by Environment Yukon as part of the Student Training and Employment Program (STEP) and students from Yukon College's Renewable Resources Management Program usually assist with the monitoring fieldwork. A few students were hired as technicians to help set up some of the study plots during the past two years. In September, 2006 a class of ecology students carried out the protocols to count snowshoe hare pellets and mushrooms. The data collected for the combined CEMP and KEMP have also been used by Yukon College students in their statistics course.

One of the challenges in working in an urban/rural area such as Whitehorse is establishing land tenure. The Wolf Creek study area was chosen because of the multi-disciplinary work going on there called the Wolf Creek Research Basin study. It forms part of the Canadian Global Energy and Water Cycle Experiment (GEWEX) Program as well as being identified as an Ecological Monitoring and Assessment Network (EMAN) site in 1997. We do worry that we lack any formal land tenure and the adjacent rural residential neighbourhood means there is always the potential for accidental or malicious disturbance. Our tenure arrangement at the Takhini Research Forest seems more secure but it is also adjacent to a rural residential neighbourhood.

Mayo: The project in the Mayo area has three components. First, gathering of technical data on a number of ecosystem indicators is being carried out each year. We have established 5 monitoring grids in the area where we gather data on snow depths, spruce cone crops, berry crops, and abundance of small mammals (voles and mice) and snowshoe hares. Results from the sampling in summer 2006 show a very poor year for spruce cones compared to the mast crop in 2005, mixed crops of berries (lots of blueberries but fewer than in 2005, low numbers of cranberries, high numbers of bunchberries, and slightly lower abundance of all other berries compared to 2005), and increasing numbers of small mammals (mostly red-backed voles) and snowshoe hares. We continued counting tracks of carnivores along a 25-km transect that we established as a part of the Northern Tutchone Regional Program 5 years ago, and this showed slowly increasing, but still fairly low, numbers of marten and lynx. Finally, we conducted the third annual Breeding Bird Survey along a standard 40-km BBS transect through the area in June. In order of abundance, Swainson's thrushes, dark-eyed juncos, orange-crowned warblers, ruby-crowned kinglets, yellow-rumped warblers, American robins, and alder flycatchers have consistently been the most frequently heard bird species along the route. In 2006, the highlight was observation of 3 singing yellow-bellied flycatchers, which are quite uncommon in the Yukon.

Photo by Todd Heakes

Figure 1. Mayo resident Bruno Faugeron trapping small mammals.

The second main part of the Mayo CEMP monitoring is an annual survey of local knowledge on ecosystem indicators, using interviews of knowledgeable Mayo-area residents. We use a questionnaire that asks about conditions and changes observed during the past year in weather (temperatures, rain, snow, ice, and water levels), mushrooms, plants, fish, amphibians, birds, mammals, and subsistence activities. Two interviewers have talked with 20 people in the local area who have been most active on the land in each of the past 2 years. Mayo-area residents noted a fairly warm year in 2005 with little snow, early melt in the spring and late freeze-up in the fall. More open water on the river and creeks made it hard for some trappers to travel around and fur seemed to become prime later in the winter than usual. In general, ducks seem to be staying later in the fall than in previous years as well. Interviewees noted a good year for mushrooms, blueberries, swans, moose calves, and lynx, but fewer grouse and red squirrels and lots of mosquitoes and hornets. These interviews give us a permanent record of environmental conditions as observed and felt by the local community; we are conducting our interviews about 2006 conditions in February 2007.

The third part of the Mayo CEMP is the recording of traditional knowledge about the changes in climatic conditions that elders and long-term residents have observed during their lifetimes. We held a workshop in February 2005 with local elders and from it

produced a report on their views of the changes they've seen and how they've been affected by them. This gives us an historical base for our monitoring program.

Southeast Yukon: Southeast Yukon expanded participation in the Community Ecological Monitoring Program in 2006 by adding a CEMP grid in Faro. This new grid is located on Mitchell Road (on the way into the Town of Faro) and helps fill a gap in this part of the territory. Two additional hare pellet transects were located on the east side of Faro as well. Snowshoe hare monitoring sites were expanded in the Watson Lake area to 80 plots per site in an attempt to improve hare estimates from the region. Hare numbers are generally low in Southeast Yukon compared to the rest of the territory, but with the current limited information available, it seems that numbers are increasing.

The original three CEMP grids installed at Garden Creek, Joe Lake and Cosh Creek were assessed fully for the first time in 2006. Like many places, not a single new white spruce cone was counted. A noticeable trend upwards by snowshoe hare was reflected in all three sites, but berries were unremarkable this year. In this corner of Yukon a slightly different small mammal population assessment protocol is used. This is the fourth assessment year of small mammals at Garden Creek and the second year at Cosh Creek. Each site showed an increase in small mammals (notably red-backed voles), but no site has yet reached the peak numbers seen in 2003. General talk from around this part of the territory suggests that small mammal numbers are increasing over the last two years.

Kluane: Sampling of several ecosystem indicators continues in the Kluane region extending from Donjek River in the north to St. Elias Lake in the south with the most intensely monitored core area located in the study area of the former Kluane Boreal Forest Ecosystem Dynamics Project, from Kluane Lake to Kloo Lake. Here we report trends in some of this year's results:

- White spruce cone production dropped very low as expected in the year following the heavy mast year of 2005.
- Mice and voles have generally higher densities than the previous few years.
- Ground squirrel populations continue very low although there is some evidence that recruitment is beginning.
- Snowshoe hares clearly are beginning to increase toward a peak with the Jacquot Island population perhaps already at peak densities. This island pattern typically has been ahead of the mainland cycle by 1-2 years.
- Track transect counts indicate that most predators are in an increase phase, especially lynx and coyotes, with some reproduction occurring after a few years of no young lynx showing up in the counts.
- The number of nesting pairs of great horned owls is slowly increasing.

There are a few cautionary management implications from these trends. At this stage in the cycle of lynx numbers, it would serve trappers best interests to trap as few females as possible. In the general region it may become increasingly important to identify and protect the ideal nesting trees for Great Horned Owls. The nests are used from year to year and the spruce beetle infestation has destroyed some of the traditional trees in the intensive study area.

Collectively, the Yukon CEMPs have expanded the geographical extent of the Kluane Project's technical monitoring, added new information from local and traditional

knowledge, and provided direct community involvement and training opportunities. In comparison to the long time series from Kluane, the community databases are just beginning, but we anticipate that the NEI funding has given us a valuable start at building long-term monitoring in other areas of the Yukon.

Recent Population Dynamics of White Spruce at Alpine Treeline

Treeline advance in the Kluane region was examined in relation to climate change. Many trees at treeline established during the 20th century, providing evidence of an upslope advance during periods of climate warming from 1920 to 1950, and 1980 to present.

The boundary between forest and tundra ecosystems, commonly known as 'treeline', is expected to advance as climate continues to warm. Treeline advance is expected to have significant effects on the global climate system through feedback processes, and more locally, on wildlife habitat and human land use. But exactly how rapidly treeline will advance and how widespread this advance will be remains unclear. To answer these questions, I examined the last 300 years of treeline change in the northwestern portion of the Kluane Ranges using dendroecology and supplemented this long-term record with recent aerial photography. This research was not part of KEMP, but its results are clearly very relevant.

Six locations were selected for reconstructing treeline stand dynamics. These were located on north and south-facing slopes in the Duke River, Burwash Creek, and Quill Creek drainages. Using tree ring analysis I was able to precisely date establishment and death of spruce trees and reconstruct vegetation change at each location. The results provide evidence of a rapid change in response to climate warming during the early-mid 20th century. Treeline advanced considerably (65-85 m in elevation) on warm, south-facing slopes and tree density increased significantly (40-65%) on cooler, north-facing slopes (Figure 2). The mechanism of change appears to be occasional years of extraordinarily high seed production (mast events, which are induced by hot, dry summers) followed by successive years of conditions favourable for seedling growth and survival. Experimental work east of Kluane Lake indicates that in addition to temperature, snow-related variables – including depth and timing of melt – are among the most important of these conditions (Danby and Hik 2007).

These results are supported by repeat aerial photography. By standardizing image geometries and scale, I was able to rigorously compare photographs taken in 1947 with images taken in 1989. Significant changes were observed over the 42 years, but the degree of change varied throughout the study area. The most common change was an increase in canopy size of individual trees, and an increase in stand density resulting from the establishment of new individuals. Several instances of treeline advance were also observed. As with the dendroecological data, an absence of major natural disturbances or widespread land use change indicates that these changes are attributable to climate.

Collectively, these results challenge the conventional notion that treelines will respond gradually to future climate warming and provide evidence that the pattern of advance could be highly variable in the Kluane region, depending not only on air

temperature, but also on variables such as snowfall, slope, aspect, soil temperature, and existing vegetation types.

Photo by Ryan Danby

Figure 2. The forest-tundra transition (treeline ecotone) on a steep, south-facing slope along Quill Creek, northwest of Burwash Landing. Labels represent the shrubland (A), woodland (B), and forest (C) zones. Most trees in the woodland zone established during the 20th century, providing evidence of an upslope advance that coincides with periods of climate warming from 1920 to 1950, and 1980 to present.

For more information about this project, please contact Ryan Danby at rdanby@ualberta.ca

Relationship Between Snowshoe Hares and Dall's Sheep Lambs

On Tachäl Dhäl (Sheep Mountain), a low lamb crop appears one or two years after the snowshoe hare population has peaked. We suspect that shared predators switching from hares to lambs are one of the main factors driving this relationship.

The ten-year cycle in snowshoe hares is an important driver of interactions in the boreal forest (Krebs et al. 2001). From the lagged cycling of lynx and coyote to the effects of hare browsing intensity on the phenol concentration of adventitious shoots in boreal forest trees (Bryant 1981; Henry 2002), the ebb and flow of the hare population influence many species in the boreal forest community.

Dall's sheep have not been previously considered as a species interacting with snowshoe hares. Since 1974 park wardens have collected monitoring data on the Dall's sheep population on Tachäl Dhäl (Sheep Mountain) that is adjacent to the Kluane Boreal

Forest study area (Krebs et al. 2001). Since 1976 Charles Krebs and researchers have monitored the snowshoe hare population in this area. These databases suggest that low lamb counts on the nursery range (where ewes, lambs and non-breeding yearlings aggregate after lambing season) consistently followed peak densities of snowshoe hares (Figure 3). We use time-series analysis to test the consistency of this hypothesized relationship (Wilmshurst et al. 2006).

Specifically, we tested the hypothesis that the number of surviving lambs counted in mid-summer from the Dall's sheep on Tachäl Dhäl is correlated to the density of snowshoe hares in the surrounding boreal forest. We examined correlations between the number of lambs and the number of snowshoe hares at different phases in the 10-year snowshoe hare cycle. There were significant cross correlations between the ratio of lambs-to-nursery-sheep versus hare densities with one and two-year time lags. Lamb numbers also showed clockwise rotation with respect to hare densities when points were joined chronologically. Simple population models suggest several relationships: When hare densities are close to their maximum, lamb population growth rates are inversely related to hare densities. During the low phase of the hare population cycle, lamb population growth rates show density independent fluctuations. In the absence of compelling evidence for direct interactions between Dall's sheep and hares, we hypothesize that at least in part the inverse relationship between lamb population growth and hare density is mediated indirectly via shared predators such as lynx, coyotes and golden eagles.

This study illustrates the biological value of long-term datasets. The forthcoming Kluane State of the Park Report will illustrate their management value.

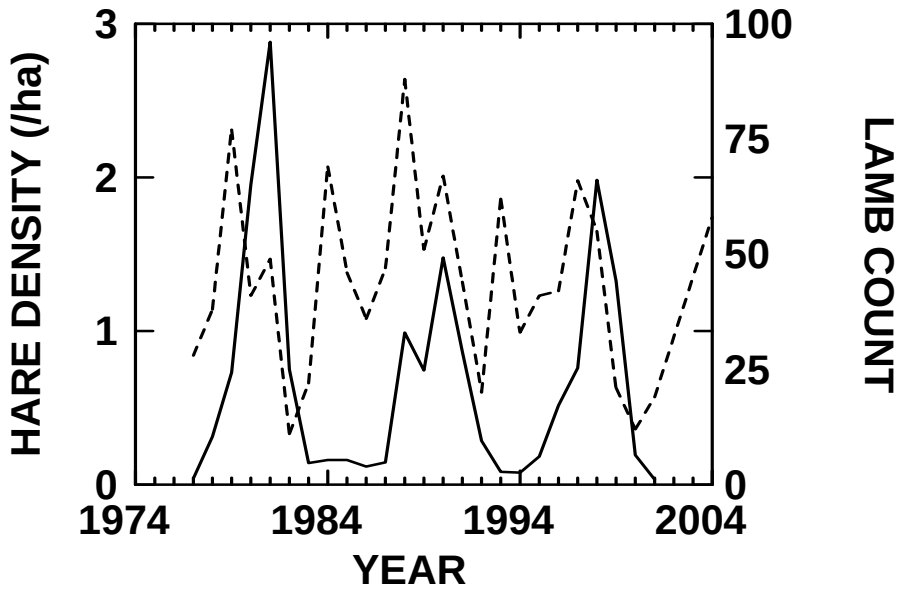

Figure 3. Snowshoe hare densities from the Kluane Boreal Forest Project study area (solid line) and Dall's sheep lamb counts from the KNP&R annual Sheep Mountain aerial surveys (dashed line).

For more information about this project, please contact John Wilmshurst, Richard Greer or David Henry. Address your questions to David.Henry@pc.gc.ca

Population Limitation of the Northern Red-backed Vole

Northern red-backed vole populations show a regular 3-5 year cycle in parts of the Eurasian boreal forest but not in North America. Overwinter survival of voles mediated by ground berries produced the previous summer is thought to be one of the important factors determining these trends.

Across the vast boreal forests of North America, no population cycles in *Clethrionomys* species occur. In Eurasia, by contrast, some *Clethrionomys* populations of the same species undergo regular 3–5-year cycles. We examined the effects of nutrients, food, competitors, predators and climate on population limitation in the northern red-backed vole (*Clethrionomys rutilus*) in the southwestern Yukon to determine why this difference occurs.

From 1986 to 1996 we added food, reduced large mammal predators and excluded snowshoe hares from large plots and found that none of these manipulations affected red-backed vole abundance. Adding nutrients such as nitrogen, phosphorus and potassium (NPK) fertilizer had a slight negative effect, probably acting through a reduction in dwarf shrub productivity caused by competition from grasses.

We monitored weasel populations directly through trapping and indirectly through snow tracking. Predation by these vole specialists was irrelevant as a limiting factor most of the time because voles in this area do not reach the densities needed to sustain weasel populations. Other boreal forest mammal and bird predators did not focus on red-backed voles. However, when red-backed vole populations increased in the forest and *Microtus* voles also increased in the meadows, weasel populations increased and may have temporarily depressed red-backed voles in winter.

Photo by Alice Kenney

Figure 4. A red-backed vole surrounded by two common berry producing species: kinninnick and red bearberry.

We monitored one major potential food, white spruce seeds, but seed fall was not related to population changes in red-backed voles, even after mast years. We assessed the impact of weather variables, and the average depth of the snow pack during winter (October–March) was correlated directly with vole demography, having both direct effects in that year and delayed effects in the following year. Our long-term trapping data (1973–96) indicate that *Clethrionomys* populations fluctuated, with peaks following hare peaks by 2–3 years.

We propose that the key variable limiting these vole populations is overwinter survival, and this is a function of overwinter food from berries produced during the

previous summer by dwarf shrubs. These shrubs may be stimulated by abundant moisture from winter snows or by periodic fertilization from large quantities of pellets produced at snowshoe hare peaks.

In 2005 Kevan Cowcill designed and implemented an experiment to test whether berry production affects the population fluctuations of small mammals in the Kluane region. His work is finished but this project will continue for a few more years to see if any distinct patterns emerge.

For information on this project, please contact Rudy Boonstra or Charles Krebs. Address your questions to boonstra@utsc.utoronto.ca

An Overview of Red Squirrel Research 1987-2007

Twenty years of red squirrel research has yielded findings about the relationship between squirrel food sources and population dynamics, squirrel evolution in the face of climate change, and the energetics of this northern homeotherm. These and other findings are fostering opportunities for more in-depth squirrel research.

Squirrel Camp is located on the Alaska Highway, 35 km northwest of Haines Junction. The Kluane Red Squirrel Project is an interdisciplinary, large-scale field experiment designed to test the importance of food abundance to the ecology and evolution of red squirrels. Since 1987, Stan Boutin (University of Alberta) has completely enumerated populations to quantify survival, reproductive success, population dynamics, and natural selection. Since 2005, high food conditions have been experimentally mimicked on three replicate grids by supplementing each individual with peanut butter.

Ecological Research
Cone crops vary by three orders of magnitude among years (Figure 5). The ability to quantify resources available to individuals as well as reproductive success has allowed us to determine how changes in resource availability affect life history traits and population dynamics (Figure 6).

Main results:

- Squirrels anticipate spruce masts and increase reproductive output, thereby increasing population size in synchrony with the resource pulse and eliminating population lag (Boutin et al. 2006).
- Squirrels feeding on larval spruce bark beetles represent a short-term solution to a climate-mediated beetle outbreak that reduces spruce seed production and habitat suitability (Pretzlaw et al. 2006).
- Two reproductive tactics co-occur in female red squirrels: a tactic based on early sexual maturity at the cost of a lower survival versus a tactic based on delayed sexual maturity and longer lifespan (Descamps et al. 2006).
- Breeding dispersal and bequeathal of territories to offspring by adult females serves as a form of parental investment (Berteaux and Boutin 2000).

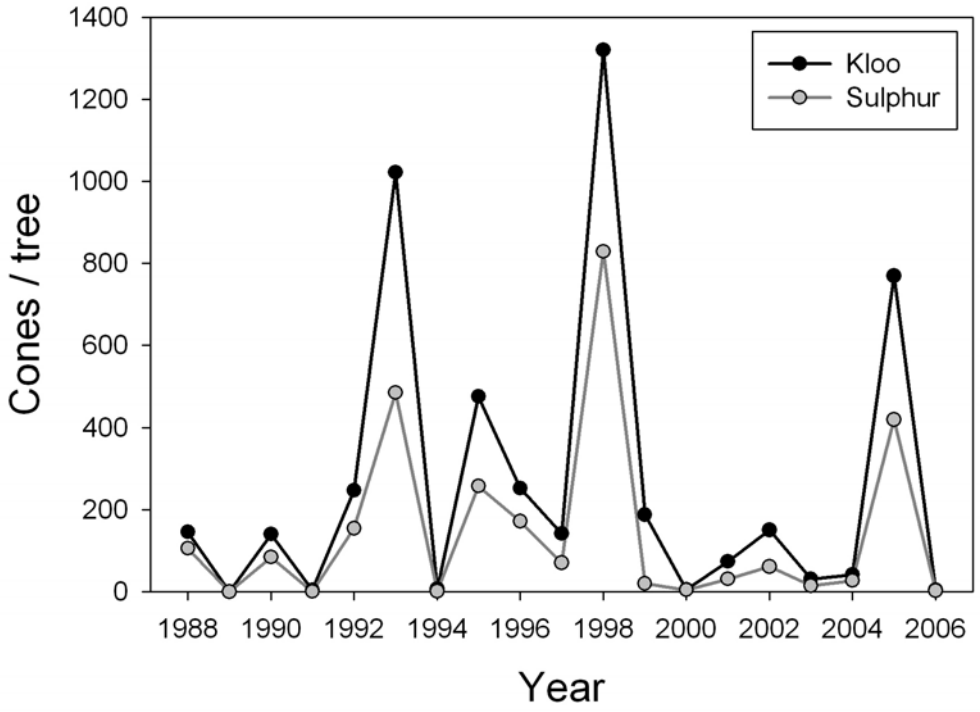

Figure 5. Mean cone production (# cones/tree) by individual white spruce trees on two study grids 1988-2006.

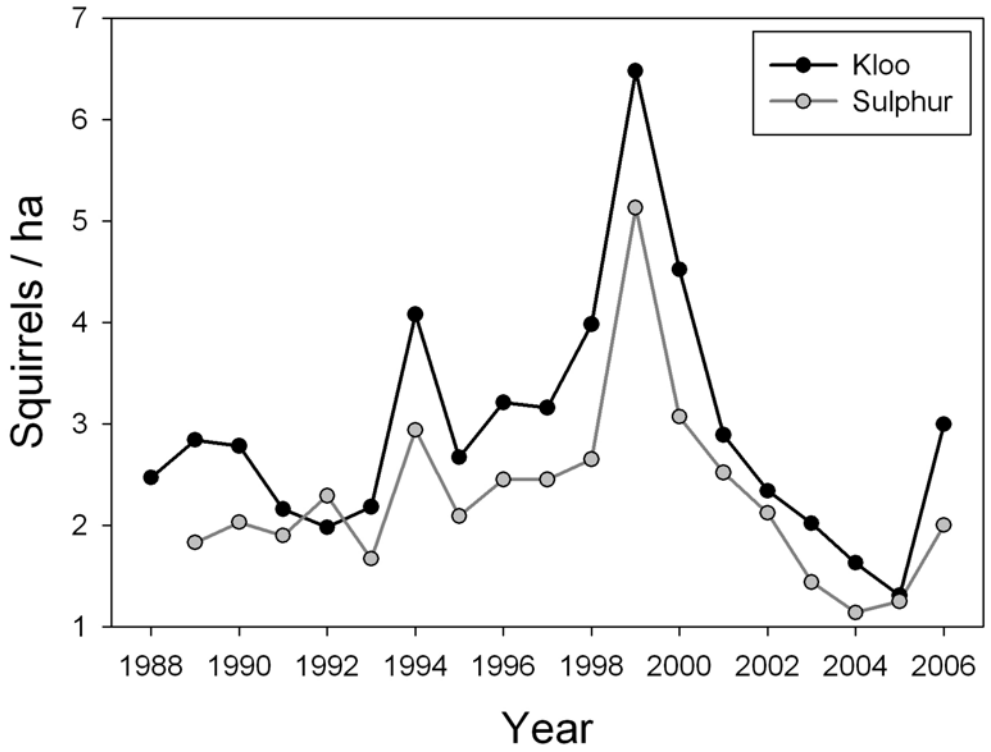

Figure 6. Spring population density (# individuals/ha) of red squirrels on two study grids 1988-2006.

Current research topics:

- How variation in resource levels affects territory size, reproduction, and population growth.
- Proximate and ultimate causes of natal dispersal.
- Determinants of male reproductive success.
- The role of vocalizations in kin recognition.

Evolutionary Research

The application of molecular markers, quantitative genetics, and genomics to a natural population offers the opportunity to study evolution in action. Andrew McAdam (Michigan State University) uses a combination of field manipulations and multigenerational pedigree data to examine maternal effects, heritability, and natural selection.

Main results:

- An 18-day advancement in the timing of spring breeding coincides with patterns of global climate change (increasing spring temperature and food availability), which have served as selective forces in the evolution of earlier breeding (Réale et al. 2003).
- Juvenile growth rate is heritable but also experiences large maternal effects (McAdam et al. 2002).
- Selection upon juvenile growth rates varies in strength and direction among cohorts as a result of the combined effect of multiple environmental conditions including spring temperatures and the abundance of spruce cones (McAdam and Boutin 2003).

Current research topics:

- Quantifying heritability, genetic correlations, and selection gradients, changes in phenotypes, and breeding values across generations.

Energetics Research

Murray Humphries (McGill University) has developed protocols to measure resting and field metabolic rates of red squirrels during key periods including cone caching, winter, and peak lactation. In addition, focal behavior sampling during September and October allows estimation of the number of cones cached by individual squirrels. Knowing the food available on territories, how much is stored, and energy expenditure, allows inferences about associated life history traits and fitness of individual squirrels.

Main results:

- Squirrel energy expenditure levels in this population are extremely low for homeotherms and decrease as it gets colder (Humphries et al. 2005).
- Food availability and energetic ceilings do not limit litter size, but a trade-off exists between offspring number and offspring survival (Humphries and Boutin 2000).
- Energy storage during early lactation is used to reduce demands during late lactation (Humphries and Boutin 1996).

Current research topics:

- How individuals acquire energy from their environment and allocate it to reproduction

Website
For a detailed description of the project, the people involved, and a list of peer-reviewed publications, please refer to the project website. (http://www.redsquirrel.msu.edu/).
For more information on these projects, please contact:
Ecology - Stan Boutin - stan.boutin@ualberta.ca
Evolution - Andrew McAdam - mcadama@msu.edu
Energetics - Murray Humphries - murray.humphries@mcgill.ca
For information about this article, contact Mark Andruskiw - mca2@ualberta.ca

Collared Pika Population Changes in the Ruby Range

Pika populations are sensitive indicators of climate influences. Monitoring collared pikas at one site in the Ruby Range is documenting the importance of slope aspect and spring snowmelt on pika population growth.

The collared pika (*Ochotona collaris*) is one of two pika species within North America, the other being the American pika (*O. princeps*). The collared pika's range includes the mountainous areas of Yukon, northern British Columbia, western Northwest Territories, and Alaska (Broadbooks 1965) while the American pika's range includes the mountain areas from mid-British Columbia south to Nevada (Smith et al. 1990).

Pikas live within talus (boulderfield) patches, and intensively forage within a 6m band of vegetation at the talus-meadow interface. Through their foraging activities, pikas are known to affect nutrient cycling (Aho et al. 1998), and alter plant species diversity, above ground biomass, and plant morphology (Huntly 1987, McIntire and Hik 2002, 2005). In addition, pikas are sensitive indicators of climate influences because of their intolerance of warm daytime temperatures (Smith 1974) and inability to withstand freeze-thaw events during winter (Smith et al. 2004). Several studies have suggested that pikas are in danger of extinction in many regions of western North America because of global climate change (McDonald and Brown 1992, Beever et al. 2003, Grayson 2005, Parmesan 2006).

In a long-term study of alpine ecology and herbivore population dynamics, a collared pika population was censused annually from 1995 to 2006 in a 4-km^2 alpine valley within the Ruby Range, east of Kluane Lake. The valley had three main aspects that faced east, west, and south. The east- and west-facing aspects were monitored from 1995-2006 and the south-facing aspect was monitored from 1998-2006. All pikas were marked with uniquely coloured ear-tags and retrapped each summer from mid-June to mid-August using Tomahawk live-traps baited with fresh vegetation. The entire study site was monitored 4-5 times weekly to detect unmarked individuals that were then targeted for trapping. Annual population abundance was based on a complete enumeration of the study site.

Population density (using all ages and both sexes) in August of each year declined on the east- and west-facing aspects between 1995 and 2006 (Figure 7). Pika density (number of pikas per hectare of talus habitat) on the east-facing aspect declined from approximately 2.5 pikas/ha in 1995 to a low of 0.13 pikas/ha in 2003 before slowly recovering to 1.3 pikas/ha in 2006. Pikas on the west-facing aspect followed a similar pattern. Population density was consistently higher on the south-facing aspect, had

consistently higher population densities and greater inter-year variation relative to the east- or west-facing aspects.

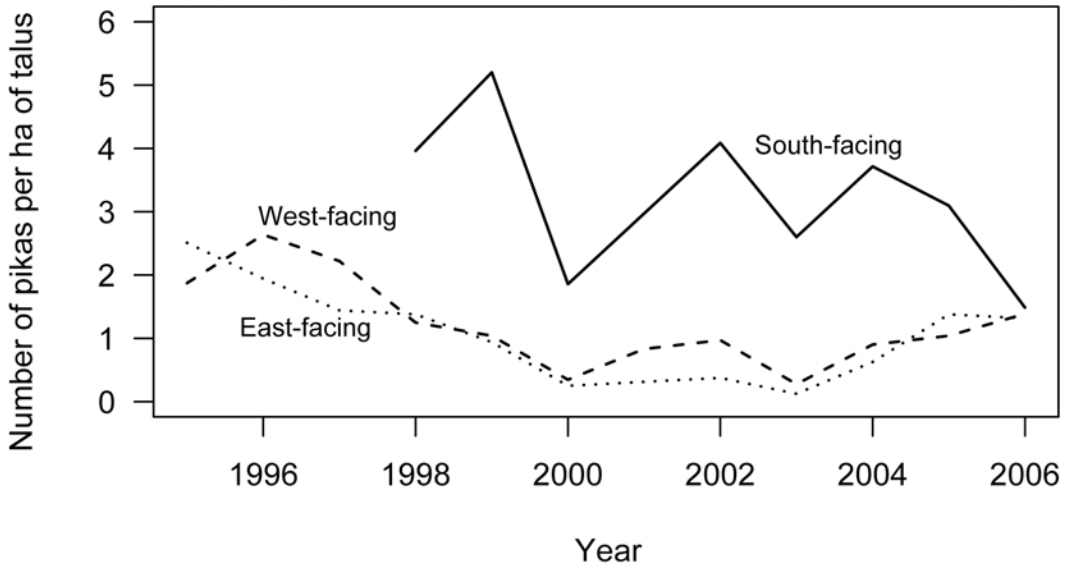

Figure 7. Collared pika population density trends for three regions of an alpine valley defined by aspect in the Ruby Range, east of Kluane Lake, from 1995 to 2006. Population density was derived from a complete enumeration of live-trapped individuals with uniquely coloured ear-tags.

Changes in population growth rates were explored using life table response experiments (Caswell 2001). The variation in population growth rates at our site was due largely to variation in adult female survival and adult female fertility; juveniles contributed little (<20%) to population change. Fertility was not correlated to either population density or climate. Pika survival, however, was strongly related to the winter Pacific Decadal Oscillation, apparently through its affect on the timing of spring snowmelt in the previous winter (Morrison 2007). Late spring snowmelt reduced over-winter survival and impeded population growth, whereas earlier snowmelt improved adult survival in the subsequent winter.

For more information on this project, please contact Shawn Morrison at shawn.morrison@ualberta.ca

Conference Focuses on Local Effects of Climate Change

The Conference entitled "Climate Change in Our Backyard" was held in Haines Junction during the spring of 2006. It was a forum that blended worldwide patterns with local observations to examine how Kluane's traditional lifestyles, human activities as well as its plant and animal populations are being affected by the changing climate.

In the early spring of 2006 the Champagne and Aishihik First Nations and The Alsek Renewable Resource Council hosted the "Climate Change in Our Backyard" conference. More than 130 local residents, resource managers, and visiting researchers gathered in Haines Junction to share local knowledge, observations and experiences with climate change in the southwest Yukon.

The conference was held at the Haines Junction Convention Centre and brought together presentations given by a mixture of people and round table discussions. Here are a few of the interesting points that the presenters made:

- Linaya Workman and Bob Hayes observed that Dall's sheep on Decoeli Mountain appear to be impacted by increasing winter rain. Biologists counted half as many sheep there in 2000 as were there in 1985. Too much snowfall and too much rain at the wrong time of year may have strong implications for sheep.
- Jill Johnstone presented evidence that the southwest Yukon is very dry, showing warmer and drier conditions and declining growth in trees. The trees most vulnerable to drought are the seedlings trying to grow after a fire or logging, not the older trees with good root systems.
- Moose Jackson, an Elder from Champagne and Aishihik First Nations, observed that the summers are getting hotter and conditions are drier. Many of the little lakes and ponds in the bush are drying up, and he can no longer read moose tracks near the ponds, because they are not there.
- Jody Walker of the Northern Contaminants Program presented data supporting the conclusion that in the Yukon, with very few exceptions, traditional foods are safe to eat.

Round table discussions collected valuable local observations from many conference participants. Here are a few of the interesting points that were shared during these discussions:

- Weather is showing many changes. The most common ones mentioned were less snow, more variable weather and temperatures, more rain in winter, warmer winters, more wind, more weather "events," and overall drier conditions.
- Fish populations and habitat are showing important changes. Among them: trout in Kathleen Lake are bigger; there are red worms more frequently in burbot (ling cod); northern pike are smaller and easier to catch; sucker populations are increasing and replacing other fish; there are fewer whitefish, and grayling spawning beds are being damaged by erosion and debris.
- Many mentioned a decrease in gophers (arctic ground squirrels), and that they are smaller and less tasty. Snowshoe hare numbers are down and do not appear to be recovering as quickly as usual. Some people observed that muskrat habitat is drying up.

Given the many observed effects of climate change, it was generally agreed that we should take a slow and careful approach to managing the forests of the southwest Yukon. Fire will have a strong impact on both the landscape and the plants and animals that live there. Conference participants felt that traditional uses of plants, berry picking and firewood harvesting would all be strongly affected by fire, as well as wildlife, tourism and recreation. Education, prevention, lessening fuel loads and prescribed burning were considered the key constituents in a community plan for managing fire.

For more information on this conference, readers are encouraged to obtain a copy of "Climate Change in Our Backyard", available from the Champagne and Aishihik First Nations or the Alsek Renewable Resource Council.

Animals and Plants Appearing in New Places

Recent years have seen new nesting records for birds (surfbird and long-eared owl), range expansion for ungulates (elk, white-tailed deer and wood bison), as well as a mammalian predator (cougar) moving into the Kluane region. A rare sedge has been found growing in a new location inside KNP&R. Unusual sightings of plants and animals are always of interest, especially if they are documented. Here are some recent ones from the Kluane region.

Each year people in the Kluane region see animals, birds, and plants (or field signs of some species) appearing in new places. Some of these observations indicate a species expanding beyond their usual or known ranges, while others may represent an individual or small group dispersing in search of new range or simply on an exploratory foray. We record here some of the adequately documented observations of unusual events seen by observers during the last two years and we suggest that monitoring these sightings would be of value to managers and the general community.

While working on a ptarmigan ecology project based at Pika Camp in the Ruby Ranges, Sabine Nouvet and Scott Wilson discovered a small population of nesting surfbirds. In the summer of 2005 they found one nest, on a west-facing slope that was covered in only grass, lichen, heather, and rock at about 1800m. The following year a dependant chick was found in a similar habitat, and based on observations of displaying birds, these researchers believe there are at least two pairs nesting in this valley above Printer's Pass. Previously, the surfbird had only been found nesting in central and northern Yukon (Sinclair et al., 2003), and this may be the most southerly nesting population in the world. People working or venturing in the Ruby, Dezadeash and Kluane Ranges during the summer months should look for these birds in similar habitats.

Even more surprising was the discovery of a long-eared owl nest in July, 2005. The nest was located on one of the Squirrel Camp research grids and successfully fledged one young. Nearest known nesting sites for this species are at Fort Simpson, Northwest Territories (Doug Tate, Nahanni National Park, personal communication) and Dawson Creek, B.C. (Phinney, 1998). The only other record of this owl in the Yukon is of a specimen collected along the Dempster Highway in 1977 (Frisch, 1987).

Concern for a nationally threatened species of sedge prompted Parks Canada to develop an agreement with NatureServe Yukon to initiate a survey of the distribution and abundance of the Baikal sedge (*Carex sabulosa*) in Kluane National Park and Reserve (KNP&R) in 2006 (Figure 8). The surveyors searched

Photo by Jennifer Line

Figure 8. Baikal sedge growing on the sand dunes of Kluane National Park and Preserve.

appropriate habitat for possible new locations, as well as resurveying a dune system at the confluence of the Kaskawulsh and Dezadeash rivers, the only known location in KNP&R. Previously, this species had only been found at six different sand dune systems in the Yukon and a single location in Alaska. The 2006 survey found the Baikal sedge growing at a second location in KNP&R, about halfway between the Kaskawulsh-Dezadeash confluence and the toe of the Lowell Glacier. COSEWIC (2005) lists natural changes to the dune systems as the major threat to this species. Natural succession, damming of the Alsek River by the Lowell Glacier, and a change in wind patterns as a result of climate change are three events that could each alter the rare habitat required by *Carex sabulosa*. The Species at Risk Act requires that a recovery action plan be implemented for all listed species and one for this sedge on the edge will be drawn up in the near future.

Elk in the Yukon have not previously been known to wander west of Champagne. Sightings of elk in our area this past summer included two bulls that ranged between Dezadeash Lake and Million Dollar Falls, a report of four cows near Motherall Creek, and an eight point bull elk seen on Gopher Mountain, just southeast of Dezadeash Lake. A hunting guide working near the Haines summit, who is also an experienced deer hunter, saw a male white-tail deer at Stanley Flats on the Haines Road.

Not only are ungulates moving into new habitat, some evidence suggests that one of their main predators may be "following". Several sightings of the elusive cougar or puma or mountain lion were reported near the south end of Kluane Lake over the summer season 2006. One interesting observation involves the story related to the KNP&R wardens by an American traveler who stopped at the base of Tachäl Dhäl (Sheep Mountain) in September. The report on file indicates that Jim Bowerman set up his spotting scope and noted some unusual activity with moose and cougars in close proximity to each other. When he moved to the Slim's River bridge to reposition his scope for better viewing, he saw that two cougars appeared to be feeding on two moose and that there was at least one additional predator on one of the carcasses, perhaps a coyote. He is an experienced hunter and has hunted cougars in Washington State. That and the fact that he spent a total of nine hours behind a spotting scope increase the value of his report. This sighting could possibly be a mother with cub, implying not only the presence of this species but also some potential successful reproduction in the Yukon. Cougars tend to travel and hunt alone except for mothers with cubs, which can remain together for up to two years.

Also at that end of Kluane Lake in late fall of 2006, a wood bison bull moved into the area around the Silver City aerodrome. No resident could recall seeing bison here during past years. This bull was displaying unusual rut or post-rut behaviour for a brief time, but grazed alone over the course of several days and presumably then returned to Cultus Bay where four bulls had been seen over the summer.

The pattern of slow and steady expansion of the "new" ungulate species like elk (introduced), deer (naturally moving into the area), and wood bison (reintroduced) should be of interest to managers both in KNP&R and outside the protected areas. Observations of those species as well as the others that we cite here should be monitored and reported regularly. We propose this annual report become a forum for the regional notes. YTG and Kluane park wardens could provide seasonal summaries and this information could also be made available to the ECHO and the two local First Nations newsletters.

For more information on this article, please contact Liz Hofer at elizabeth.hofer@lincsat.com *or Todd Heakes at* heakest@unbc.ca

Conclusion

This report reflects our increasing understanding of what ecological integrity means for the park as well as the Kluane region. For example, the alert thresholds that were introduced in last year's report as well as a re-analysis of long-term ungulate survey data are providing important management thresholds that will be presented in the forthcoming KNP&R State of the Park Report. We are gaining new insights into what kind of land use activities the regional ecosystem may or may not be able to sustain. Long-term studies such as the pika project in the Ruby Ranges, red squirrel research in the Shakwak Valley and KEMP are laying the groundwork for tracking the effects of global warming on the boreal forest food web. Local forums like the recent climate change workshop in Haines Junction are helping local residents to provide input into management decisions. The monitoring techniques developed in the Kluane area have been adopted by the Community Ecological Monitoring Projects in Mayo, Watson Lake and Whitehorse, providing further basis for comparisons in coming years. There is yet much work to be done towards gaining a broader picture of ecosystem integrity for the park and the Kluane area. But as we continue to verify and test the interrelationships active in the region's ecosystems, we move closer to understanding the longer cycles and processes driving the system and closer to establishing a long-term baseline of ecosystem change for the region.

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