

# THE KLUANE ECOLOGICAL MONITORING PROJECT ANNUAL REPORT 2004/2005

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The purpose of this report is to summarize some of the major current findings of the Kluane Ecological Monitoring Project (KEMP) for both managers and interested members of the public. It also summarizes relevant research conducted in the Kluane region outside of the KEMP project. Findings with management implications and patterns of general interest are the main focus; for more detailed information, please refer to the references cited.

The annual report is intended to be a standing report that the KEMP team adds to, edits or changes in appropriate ways once each year; this year's report covers the period from January 2004 – March 2005. 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 a detailed explanation of the objectives and structure of KEMP. As new patterns in the monitoring data become evident, the information in the *Results and Discussion* section may be changed and updated from one year to the next. In this year's report, this section includes summaries of surveys on ungulates, small mammals, and white spruce cone crops. Also included is an article about the effects of the spruce beetle infestation on red squirrel populations and a summary of a project looking at how to manage local forests in light of climate change. There is an update of the efforts being made to understand the apparent recent decline of spawning kokanee salmon in the Kathleen Lake watershed. Thanks to new funding from the Northern Ecosystem Initiative (NEI), the Kluane Ecological Monitoring Project is being extended to a new community altogether, and a review of the progress of the Community Ecological Monitoring Project (CEMP) in Mayo is part of this year's report. Finally, we have carried over a summary from 2003 about the rapid melting of glaciers in the Yukon and Alaska.

Your comments on this report are 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.

## 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 1999 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 in Kluane National Park in 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.

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). However, we still do not understand longer cycles and processes that drive boreal forest ecosystems. KEMP is helping to document some of those patterns and processes.

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  
Richard Greer of Parks Canada  
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  
Michelle Oakley and Lorne LaRocque of Yukon Department of Environment  
Scott Gilbert of Yukon College

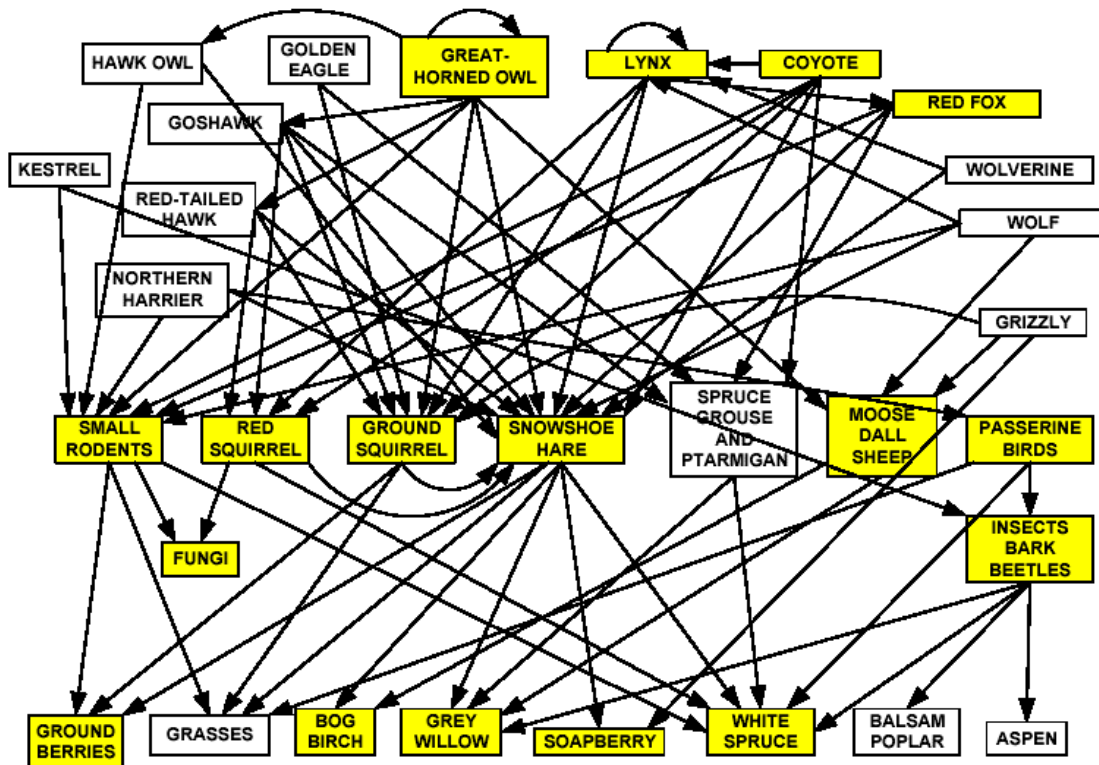
Joan Eamer, Manager, Polar Programme UNEP/GRID - Arendal  
 Stan Boutin and Jalene LaMontagne of the University of Alberta  
 Tom Jung of Yukon Department of Environment  
 Roy Turkington of the University of British Columbia

Contributors to this year's report include:

Lorne LaRocque of Yukon Department of Environment  
 Charley Krebs of the University of British Columbia  
 Jalene LaMontagne of the University of Alberta  
 Mark O'Donoghue of Yukon Department of Environment  
 Aynslie Ogden of the University of British Columbia

**Protocols Monitored and Cooperating Research Programs**

Figure 1 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



**Figure 1.** 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.

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 1, and Figure 2 (on page 7) shows the location of the monitoring sites.

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 2). 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 Handbook 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 1988. 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 (2003). Environment Yukon also performs ungulate surveys in the region; recent survey results for moose, bison, Dall's Sheep and caribou are discussed below.

**Salmon Surveys:** Since 1976 KNP&R staff has been counting Kokanee salmon observed on spawning beds between Kathleen Lake and Sockeye Lake. An update on the apparent recent decline of Kokanee in the Kathleen Lake watershed is discussed below.

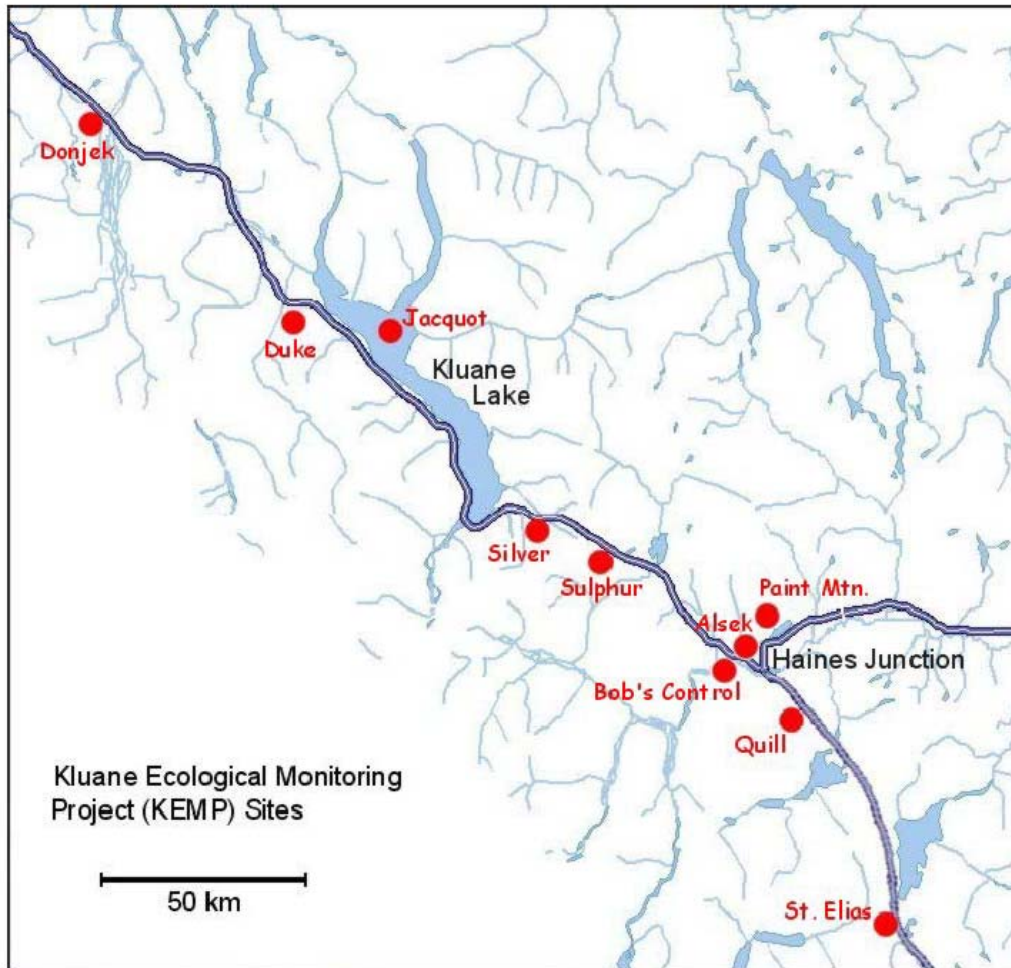
**Red Squirrel Ecology and Population Dynamics:** Since 1986 Stan Boutin of the University of Alberta has supervised research on the ecology and population dynamics of red squirrels in white spruce forests of the Kluane region, and these extensive studies continue to add depth to our understanding of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

**Mayo Community Ecological Monitoring Project (CEMP):** New funding from NEI allowed the geographical expansion of KEMP in 2004. This gave rise to the Community Ecological Monitoring Project (CEMP), with Mayo as the first new community taking part. CEMP will gather technical ecological monitoring data using methods similar to those used by KEMP. Additionally, CEMP will act as a pilot project for gathering local/traditional knowledge about ongoing and historical ecosystem indicators, which will eventually provide a framework for collecting similar data in the Kluane area.



**Figure 2.** Map of the Kluane region showing the 10 monitoring sites. Each red dot represents a monitoring site.

## Results and Discussion

For the purpose of this annual report, we wish to focus on findings from research projects and monitoring protocols that document dynamics in Kluane's boreal forest or that have management implications. 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.

While some of our ecological data dates back to the 1970's, it is important to point out that many of the protocols presently in use have only been implemented since 1997. Therefore, it is too soon to expect to have documented natural variation or clear ecological patterns. These protocols must be carried out for several more years for patterns to become evident.

In addition to the summaries below, we would like to bring your attention to a number of interesting publications related to the Kluane boreal forest that have

recently appeared. The 2004 Yukon Report published by the Canadian Forestry Service (Garbutt 2005) provides an overview of the advance of the spruce beetle infestation in southwestern Yukon. Dehn and Henry (2004) offer a detailed power analysis of the snowshoe hare population data, relating it to park management decision-making. Anthropologist Julie Cruikshank's new book, *Do Glaciers Listen? Local Knowledge, Colonial Encounters, and Social Imagination*, explores, in part, how climate-influenced geological events in the Kluane region may be reflected in the traditional oral histories of local aboriginal peoples. Finally, our colleagues have produced a number of noteworthy research articles related to the Kluane ecosystem, and these are listed in the attached Appendix.

## **Ungulate Monitoring in Kluane Region**

**Monitoring of moose, bison, Dall's sheep and caribou by Kluane Regional Management, Yukon Department of Environment generally showed improved survival of calves and lambs compared to recent years. Early spring green up and warm dry weather at birthing are believed to have favoured survival.**

### **Moose**

In advance of the new Aishihik Wildlife Management Planning Process, we did a moose census in a 3800km<sup>2</sup> area around Haines Junction in 2004. Initial analysis of the results shows an estimated abundance of 577 moose or a density of 150 moose/1000km<sup>2</sup> (a density that is about average for the Yukon), and a calf to cow ratio of 32/100. While this calf to cow ratio should promote some population growth, this census is showing a decline in moose abundance since our last census in 2000. Yearly composition surveys looking at calf recruitment and distribution from 2000-2004 indicated a declining population. (Note that testing in 2000 and 2001 showed weather and not wolf predation to be the limiting factor in calf survival.)

### **Bison**

We estimate that the Aishihik Wood Bison Herd near Aishihik Lake presently numbers 500-600 individuals. In addition to monitoring the herd using radio collars and monthly telemetry relocations, we also try to do a census of the herd each year in July. This is when most of the bison aggregate into a subalpine habitat just west of Long Lake. In 2004, this census was not possible due to forest fire activity. Instead, we did a composition count in mid-November, during which we counted 400 bison, including 74 calves. Calf survival and recruitment rates have been very good since 1998, having consistently remained at 18-20%. The management plan for the bison is to keep the herd size to about 500 adults before calving, primarily through a limited entry permit hunt in place since 1998.

### **Dall's Sheep**

Sheep were counted in the Ruby Range in late July 2004 on the east side of Talbot Arm, in an area we have surveyed periodically since 1984. This year's survey was delayed and limited by forest fires, but 633 sheep were counted, including 104 lambs or 29 lambs per 100 nursery sheep. Generally 25-30 lambs/100 nursery sheep indicates a stable population. Nursery sheep include

ewes, yearling and some two year old rams. 82 full curl rams were seen for a total of 152 rams.

Note that KNP&R Wardens also survey the sheep, moose and goat populations inside the park. Close cooperation between Environment Yukon and KNP&R will allow testing to see if the patterns described above are present in the ungulate populations of the larger region.

### **Aishihik and Kluane Caribou Herds**

We do composition surveys of the Aishihik and Kluane herds during the rut in early October when caribou are most aggregated and antlers can be used for age determination. If recruitment rates are over 25 calves/100 cows, this suggests a stable or slowly increasing herd.

We counted 673 of an estimated 1700 Aishihik caribou during the 2004 rut survey. The calf to cow ratio was 28 calves/100 cows, compared to a four year average of 30.6 calves/100 cows. For the Kluane Herd, we counted 102 of an estimated 300 animals. The calf to cow ratio was 21 calves/100 cows; the four year average is 23.5 calves/100 cows. These numbers suggest the herd has stabilized somewhat since its decline in the 1990's.

### **Chisana Caribou Herd**

With the experimental Chisana caribou recovery project entering its third year, researchers are observing a significant improvement in calf survival rates. The project involves holding pregnant cows in a holding pen until they have calved and their calves are at least 2 weeks old, in order to protect the offspring from neonatal predation. Prior to the recovery project the Chisana had suffered at least 15 years of very poor calf survival, resulting in a herd of predominantly old cows and few bulls or younger age animals. From an estimated herd size of over 2000 in the early 1980s, the herd had declined to about 700 animals in 2003. The objective of the Chisana recovery project is to improve the sex and age structure of the herd.

In 2004 the contribution of captive reared calves to the herd accounted for about one-quarter of overall calf survival. Of the 29 calves released with their radio-collared mothers in June of 2004, 22 were still alive by October – a 76% rate of survival. Eight calves born to radio collared cows outside of the pen were also monitored. By mid-October only two of these were still alive. The higher survival rate for captive reared calves may be attributed to higher body weights – on average, by the end of October, they weighed an additional 15.4lb (almost 7.0kg) as compared to wild born calves. This is likely an effect of the supplemental feeding their mothers received during captivity.

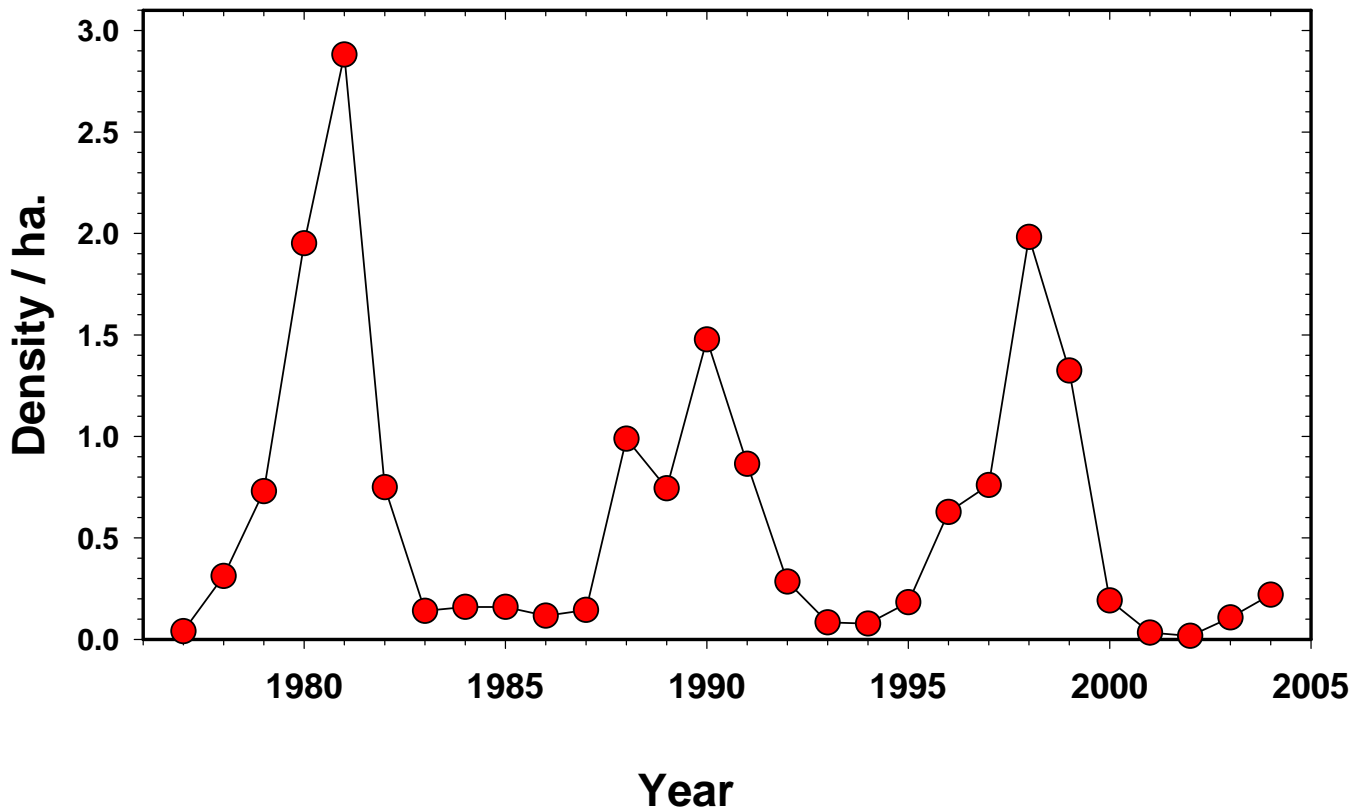
This truly international project provides valuable research for recovering small threatened woodland caribou populations throughout North America, and its success hinges on considerable effort from both Canadian and American partners. Active partners include the Yukon Department of Environment, US Geological Survey, Canadian Wildlife Service, Wrangell-St Elias National Park and Preserve, Alaska State Fish and Wildlife Service, White River and Kluane First Nations, Yukon Fish and Wildlife Management Board, and University of Alaska Fairbanks.

For more information about ungulate monitoring, contact acting Regional Biologist Lorne LaRocque at 867-634-2110 or [lorne.larocque@gov.yk.ca](mailto:lorne.larocque@gov.yk.ca)

## Snowshoe Hare Populations

**Snowshoe hares were in the increase phase of their population cycle in the Kluane region in 2004, and numbers are currently expected to peak in 2007.**

The snowshoe hare is the dominant herbivore in the Kluane boreal forests, and its fluctuations affect many members of the food web shown in Figure 1. For the past 27 years we have been monitoring hares by live trapping so that we have estimates of absolute abundance for this period. Figure 3 shows the changes in the hare population over 1976 to 2002. In this part of the Yukon hares peaked in 1998 and began declining to their cyclic low in 1999, reaching rock bottom in 2002. They began the next phase of increase in summer 2003 and should peak again in 2007. Hares in spring 2004 were at the same density as they were in spring 1995. The last two cycles have been 9 and 8 years between peaks, at the lower range of most historic cycles, which average 9.6 years between peaks.



**Figure 3.** Spring density of snowshoe hares on unmanipulated forest sites near Kluane Lake, 1977 to 2004. Estimates are given for spring (April 1) each year. Hares peaked in the Kluane area in 1980-81 and 1977-98, and were in the phase of increase in 2004.

Hares in the Kluane region have been slightly out of phase with those in the northern part of the Yukon. Hares in northern Yukon peaked during the winter of 1999-2000, in phase with hares in central Alaska. Casual observations suggest that the populations in all three areas (Kluane, northern Yukon and central Alaska) were in phase during the 1989-1990 peak and the 1980 peak, and we do not know how often these larger regions have shown hare cycles that are out of phase. At present hares in the Mayo region appear to be at about the same density as hares at Kluane and we might anticipate that all the Yukon will be in phase during the coming cyclic peak in 2007.

### Arctic Ground Squirrels

**Arctic ground squirrel numbers in the Kluane Region continued to be low in 2004, although there is a trend towards a slow recovery.**

Arctic ground squirrels are one of the most common small mammals in the Kluane Region but they have become relatively scarce since 2000. Their numbers rise and fall with the 10-year cycle of snowshoe hares in the boreal forest because of shared predators. After the last hare peak in 1998, ground squirrels fell to the lowest level we have seen in 20 years (about one animal per 8 ha), and have been slow to make a comeback (see Figure 4).

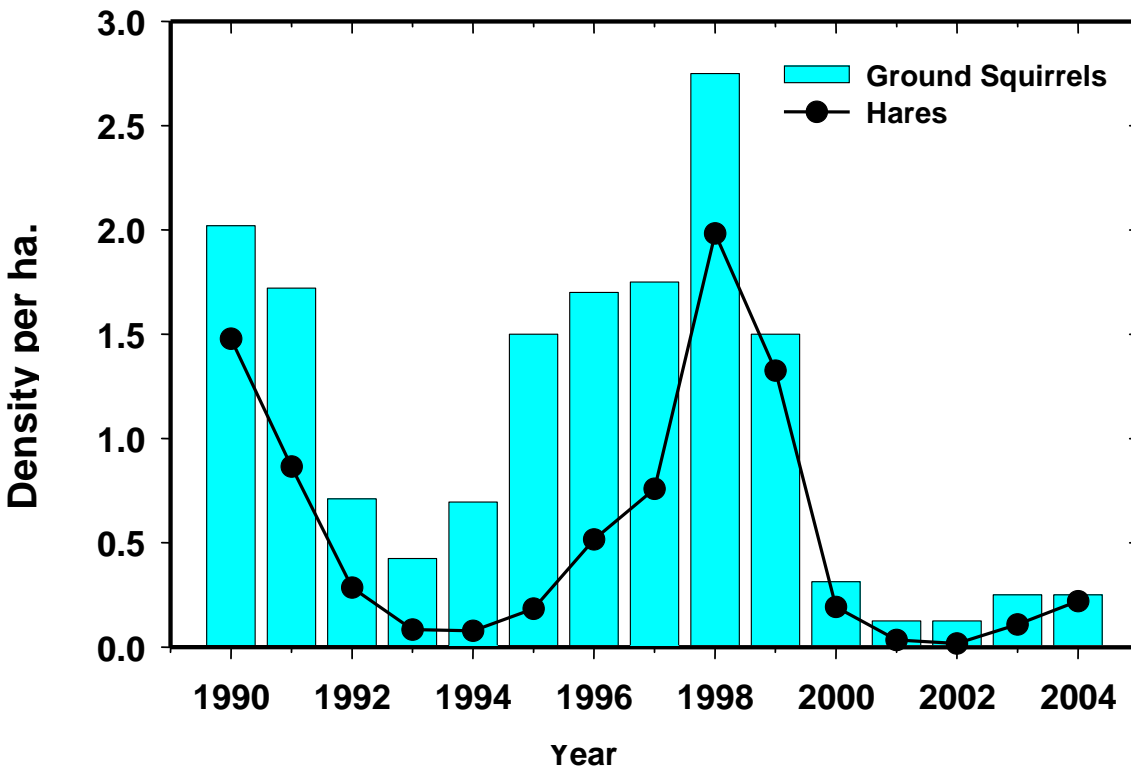


Figure 4. Arctic ground squirrel densities from 1990-2004. Hare numbers are also indicated to show relationship between hare and ground squirrel cycles.

The low density reached by ground squirrels in 2001-2002 was only one-third the level of the previous low in 1993. We do not know why 2001 densities were so low, but since predation is the major limiting factor on ground squirrels, we would suspect that severe predation drove them to low numbers. A possible alternative explanation is that poor overwinter survival contributed to low numbers in 2001.

Because of the severity of this latest population crash, it will take longer to see a recovery. As of 2004, ground squirrel numbers had reached about one per 3-4 ha, and we anticipate that they will continue to increase in 2005 and will regain their former abundance during the next 3 years.

It is interesting to compare the ground squirrels numbers being observed in the boreal forest with ground squirrel numbers at higher elevations. In alpine areas in the Ruby Ranges ground squirrel numbers reached their lowest level in 1999 and then rose slowly over the next 3 years (Gillis et al. 2005). By 2003, alpine ground squirrels had reached relatively high numbers, while ground squirrel numbers in the boreal forests of the valley remained very low.

## Mouse and Vole Abundance

**Mouse and vole numbers continued to be low in 2004, as expected. Monitoring efforts to investigate a possible correlation between the snowshoe hare cycle and rodent numbers are ongoing.**

We have been following mouse and vole numbers in the Kluane regions since 1973. There are at least 8 species of mice and voles in our area. The two most common ones are the deer mouse or white-footed mouse (*Peromyscus maniculatus*) and the northern red-backed vole (*Clethrionomys rutilus*), and of these the deer mouse is the worst pest in houses. In addition there are 6 vole species (mostly field voles *Microtus* in grassy habitats) including the singing vole (*Microtus miurus*) whose colonial 'songs' you can hear in the woods or at higher elevations. This part of the Yukon is blessed with a high diversity of rodents. Recent work has uncovered possibly a second species of *Peromyscus* (*P. keeni*) in the Haines Junction area (M. O'Donoghue, pers. comm.).

What is interesting is that nearly all of these species reach high numbers in the same years, such as the recent peak in small mammals during 2002. While there may be minor outbreaks in between, there have been major mouse years here in 1973, 1984, and in 2002. Since this outbreak, rodent numbers have been low in the Kluane region during both 2003 and 2004 (see Figure 5).

It is also interesting that each of these three major peaks in mouse and vole numbers have occurred during the decline phase of the ten-year snowshoe hare cycle. By what factors might snowshoe hares and mice numbers be correlated? It may be that the rodent numbers are driven by an indirect effect from the hare cycle on soil nutrients. Our thinking is that hare browsing, grazing and defecation at high numbers releases nutrients that are then taken up by the berry producing plants in the forest understory. This nutrient release stimulates a good berry crop 2-3 years after the hare peak and mice thrive on the enhanced

plant production. Once we have a few more years of data about annual berry crops, we will be able to tell you if this idea is correct or not.

### Red-backed voles (*Clethrionomys rutilus*) at Kluane

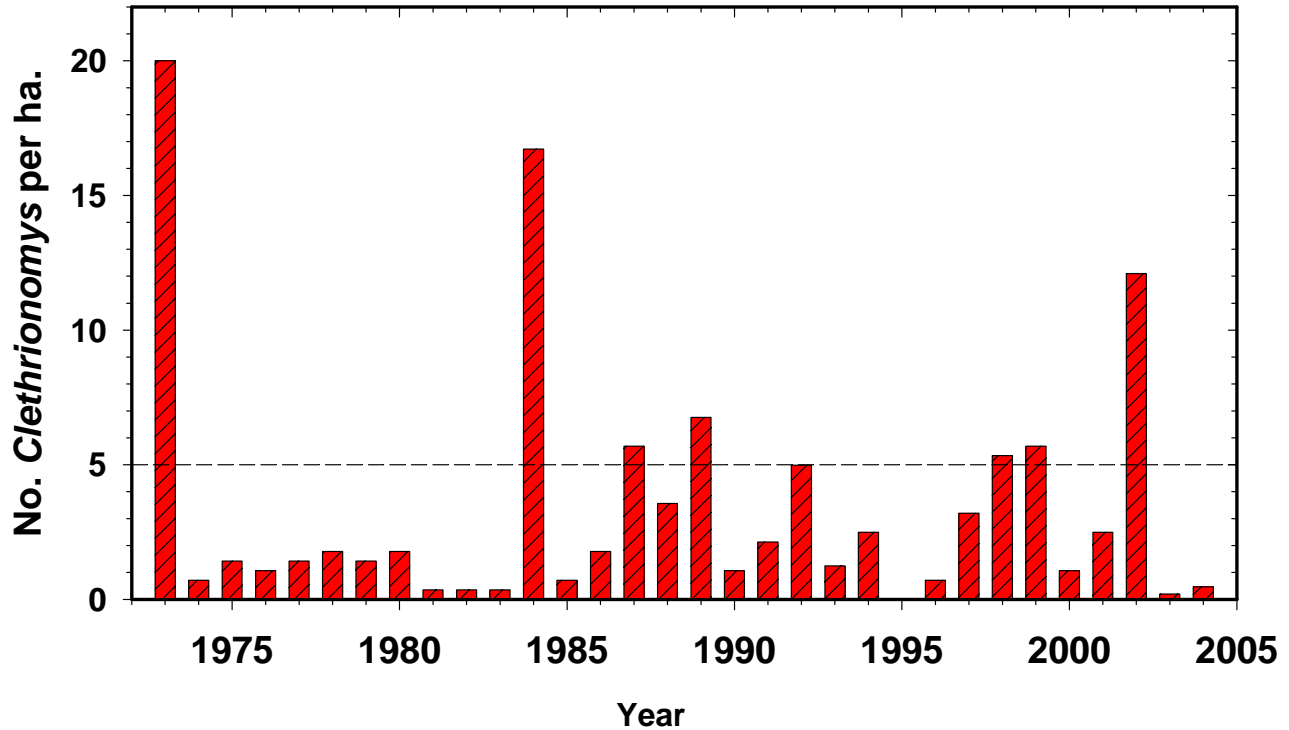


Figure 5. Red-back vole (*Clethrionomys rutilus*) densities from 1973-2004 in the Kluane region.

### Effects of Spruce Bark Beetle Infestation on Red Squirrel Population Density

As of 2004, spruce bark beetles have killed 13% of the spruce trees (>5cm dbh) in 2 sites, with ~10% more attacked. This, in conjunction with 6 years of low cones, has led to the lowest red squirrel densities recorded in 18 years of monitoring.

Stan Boutin (University of Alberta) and students have been studying red squirrels since the late 1980's and tracking the changes in red squirrel density over time on two primary study grids (Figure 6). Prior to the spring of 1999, average squirrel densities (mean  $\pm$  se; per ha) were  $3.3 \pm 0.2$  (Kloo) and  $2.5 \pm 0.1$  (Sulphur). After the peak in red squirrel density seen in the spring of 1999, squirrel densities in both study areas have been in constant decline. In the spring census of 2004 they were down to 2.0 and 1.1 red squirrels per ha on Kloo and Sulphur, respectively, the lowest densities recorded for these populations since censuses began.

White spruce seeds are the year-round staple food source for red squirrels in the Kluane area, and the decrease in the availability of this food source is

believed to be causing the declines in red squirrel density. Spruce seed availability is down for two main reasons. First, the mean cone production by individual trees has been low since the white spruce cone mast in the late summer of 1998 (Figure 7). Second, the incidence of spruce beetle killed trees in the study areas has increased greatly over the past 3 years.

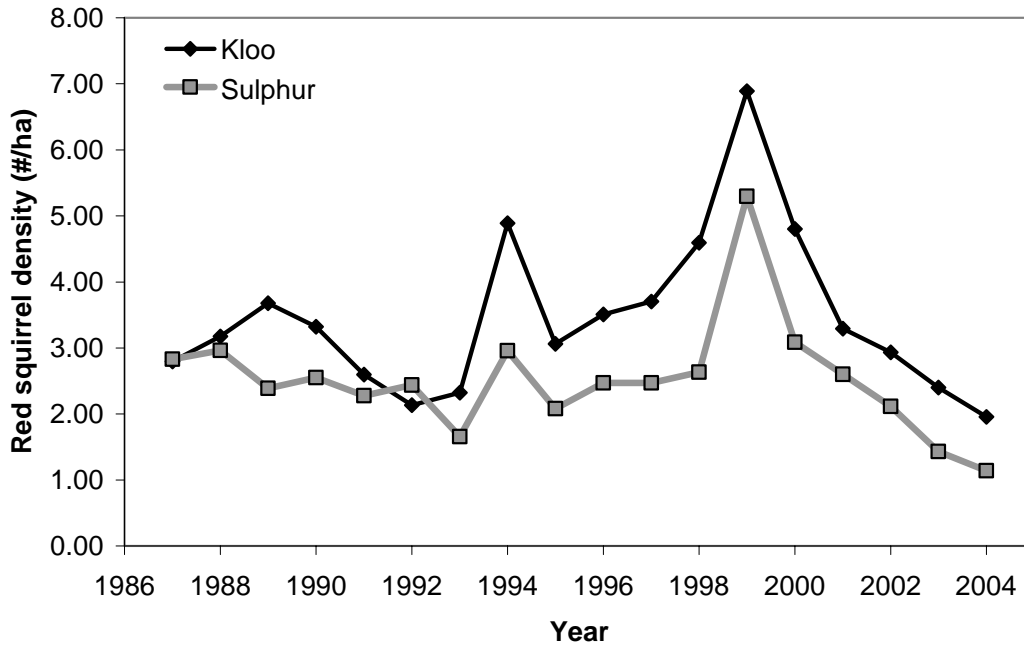


Figure 6. Spring red squirrel population densities on 2 study grids, from 1987 to 2004.

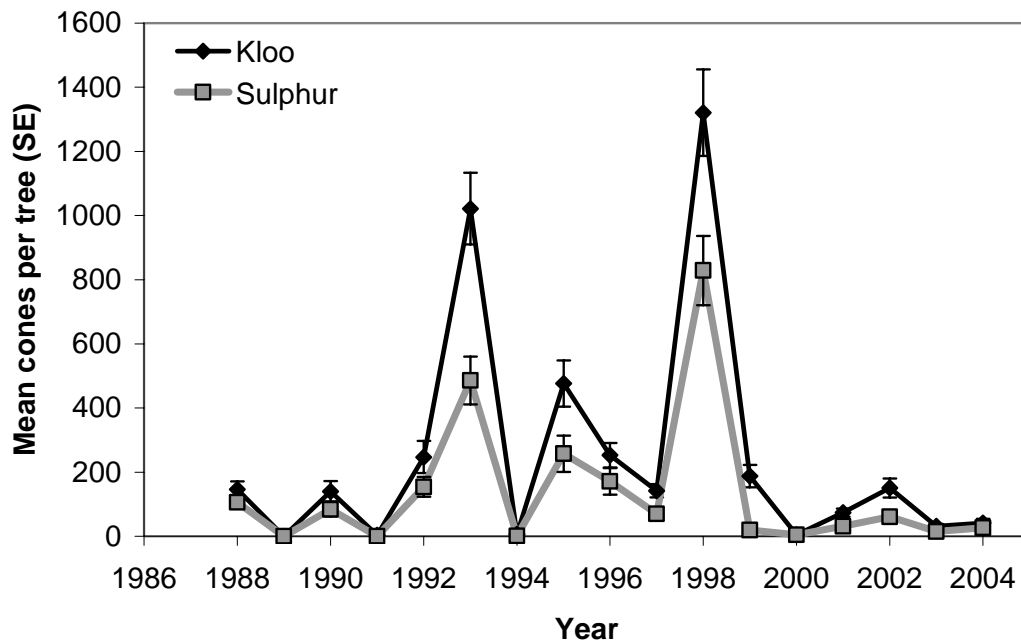


Figure 7. Mean cone production by individual white spruce trees, late July 1988-2004.

In the early stages of the 1994 spruce beetle outbreak in the Kluane region, spruce beetles killed the largest trees in each of the study grids, but little beetle activity was detected in the area again until 2002. In the summers of 2002 and 2004, the two study grids were sampled to determine the impact of beetles on the density of cone producing trees (trees > 5cm diameter at breast height; LaMontagne and Boutin, unpublished data). Transects were run throughout each of the grids, with the diameter at breast height (dbh) and attack status of all white spruce trees in transects recorded. From 2002 to 2004 the number of dead white spruce trees of cone-producing size doubled (Table 1). As of 2004, the spruce bark beetle had killed approximately 12.6% of the white spruce trees on Kloo, and 15% of the trees on Sulphur.

		Kloo	Sulphur
Study grid area		23 ha	31 ha
Total area sampled		23100 m <sup>2</sup>	33600 m <sup>2</sup>
Mean white spruce density (trees per ha)		714	1276
Percent dead trees (of all white spruce)	2002	6.4%	6.5%
	2004	12.6%	15.0%
Percent attacked trees (of live white spruce only)	2004	7.8%	10.8%
Percent attacked + dead trees (of all white spruce)	2004	19.3%	24.2%

**Table 1. Incidence of spruce beetle attack on white spruce trees in 2002 and 2004.**

Therefore, in addition to the low cone production by individual trees, 1 in 8 trees that would have been of cone producing size on Kloo and 1 in 7 trees on Sulphur, were no longer alive to contribute cones. When the 2004 spruce bark beetle attacked trees are considered, the number of white spruce trees that might soon be lost increases to 1 in 5, and 1 in 4 on Kloo and Sulphur, respectively (although some spruce trees can recover from a light to moderate infestation of beetles). Furthermore, because spruce beetles typically attack larger trees, the average dbh of white spruce has declined in the study grids. Since tree basal area is suggested to be a factor in the cone production ability of white spruce trees (Greene and Johnson 1994), the decline in average tree dbh may also be a contributing factor, to some extent, for the low mean cone production.

The ongoing loss of cone producing trees due to the beetle kill means that overall food availability is much lower than that suggested simply by the decline in average cones per tree. The result is low red squirrel densities, with larger average territory sizes than observed in the past (LaMontagne, unpublished data), perhaps to compensate for cone availability. Additionally, red squirrels

have been observed feeding on spruce beetle larvae when available within their territory (Pretzlaw et al., unpublished manuscript).

Therefore, low average cone production by white spruce may be a strong contributor to the recent decline in red squirrel densities. Furthermore, the removal of the cone producing trees by spruce bark beetle may in the long term also have a negative influence on the recovery of the red squirrel populations to their historic densities.

## White Spruce Cone Crops

**As the previous summary explains, there is evidence the spruce bark beetle infestation is reducing the abundance of white spruce cones on at least two study grids near Kloo and Sulphur Lake. This next summary looks at the results of counting spruce cones across a larger area, giving us a “landscape scale” overview of spruce cone crops.**

White spruce is the only conifer in the Kluane Lake area, and it produces seeds only sporadically with most years having few cones and a few years having large numbers of cones. These ‘mast years’ are important for red squirrels, rodents, and seed-eating birds like chickadees that rely on spruce seeds for a significant fraction of their diet.

KEMP researchers and KEMP partners together have been counting cones on white spruce since 1987 in collaboration with Dr. Stan Boutin of the University of Alberta, who has been studying red squirrel populations. We count cones on one side of marked trees with binoculars, and have counted between 300 and 1200 trees each summer since 1987. Because these are not total cone counts, we treat them as an index of cone production. Since 1987 average cone counts have varied from 0 to over 350 cones per tree, with the last mast year having occurred in 1998 (see Figure 8). 2004 was typical of a low year for spruce cones, with 50.2% of the 1164 trees counted having zero cones and at the other extreme one tree with 967 cones (counted off a photograph). Because there has not been a large cone crop for 7 years, red squirrel middens are now depleted and we would expect their numbers to fall significantly.

The spruce bark beetle epidemic has complicated cone counts because trees that are stressed by bark beetle attack may respond by putting out a large cone crop before they are killed by the beetles. In 2004 ‘green-attacked’ spruce trees produced more than twice as many cones as ‘unattacked’ trees (47 cones per tree compared with 22 cones on average). Since 2000, ‘green-attacked’ spruce trees have produced on average 48% larger cone crops than ‘unattacked’ trees. Since many trees attacked by the bark beetles die, we expect to find that on a landscape basis, white spruce seed production has been reduced drastically during the past 10 years. We have been measuring seed fall per square meter on two areas in recent years but at present do not have enough data to determine if there has indeed been a landscape level reduction in seed fall since the 1990s.

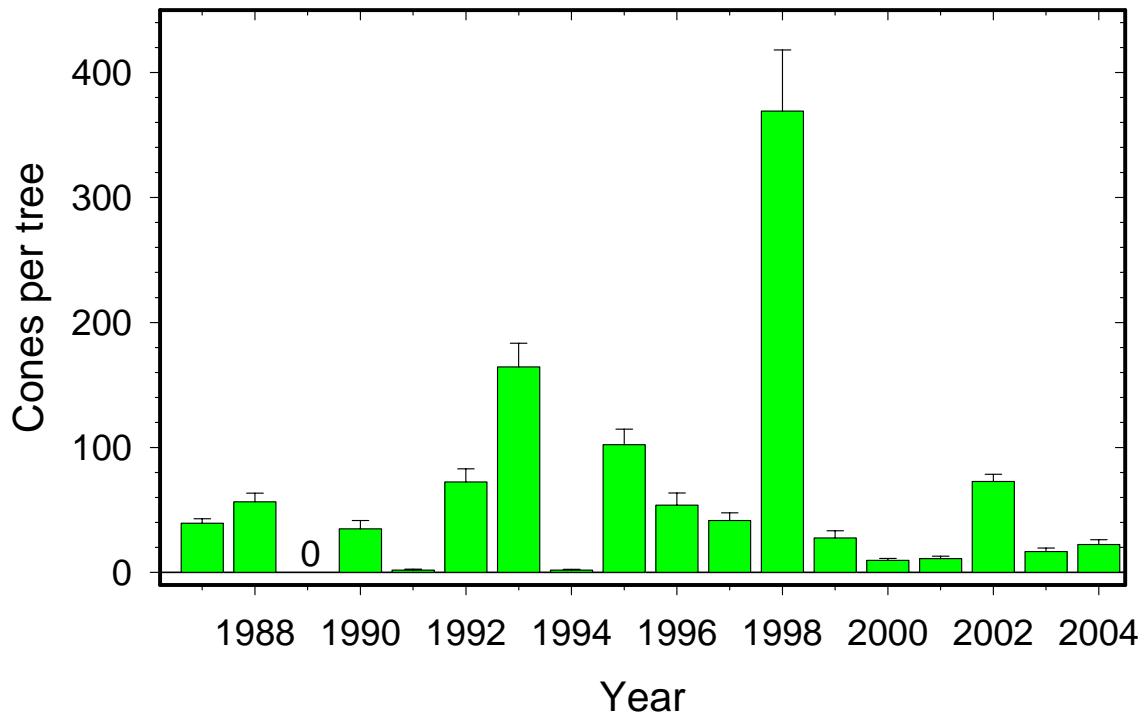


Figure 8. Index of average number of cones counted on individual white spruce trees from 1987-2004. (Note that these data was collected from a larger region as compared to the data found in Figure 7, and they show conclusively that the big cone crops of 1993 and 1998 were region-wide.)

## Kokanee Salmon in the Kathleen Lake Watershed

Last year's KEMP report discussed the steep recent decline in the numbers of adult kokanee salmon returning to spawning beds on Sockeye Creek. The annual count of spawning salmon carried out during August 2004 suggested that this decline in the number of spawning kokanee is ongoing, and the closure of the kokanee fishery is being extended into 2005.

Kluane National Park and Reserve Wardens have been monitoring the number of kokanee salmon that occur on the Sockeye Creek spawning beds between upper Kathleen Lake and Sockeye Lake in most years since 1976. These data suggest an overall gradual decline in this population from 1976 to 2001. However, since 2002, the lowest numbers of kokanee in over 30 years of monitoring have been observed, suggesting the possible onset of a significant decline in kokanee numbers.

Before 2002, the average number of kokanee observed on the spawning beds ranged from just over 2000 salmon to just under 4500 salmon each year. In contrast, fewer than 1000 were observed during the 2002 spawning season

(Henry et al. 2003), 160 were observed in 2003, and most recently in 2004 as few as 53 spawning adults were observed (de Graff 2005).

A technical working group was formed in 2003 to investigate why so few kokanee are showing up on the Sockeye Creek spawning beds.\* Several hypotheses about the decline have been put forward and are being assessed, although there are as yet no conclusive results.

One hypothesis is that changes in water temperatures and flow rates may have caused the fish to abandon spawning beds at Sockeye Creek for spawning sites elsewhere in the Kathleen Lake system. Investigation of past weather records and some, but not all, of the data being produced by new monitoring efforts do lend some weight to this hypothesis.

For example, preliminary investigation of past weather records has shown that there may be a correlation between lower August rainfall and lower numbers of spawning salmon returning to Sockeye Creek. This correlation suggests that if lower rainfall contributes to lower water levels, and that lower water levels leads to warmer water temperatures, the net result could be that kokanee abandon the Sockeye Creek spawning site. Additionally, data collected from weather gauges installed at the spawning beds in 2004 has revealed that the average water temperatures recorded at the spawning beds that year were near the upper limit of temperature tolerance of kokanee eggs (de Graff 2005). Both of these findings suggest support for the hypothesis that changes in water temperature (specifically, warmer temperatures) may be causing kokanee to abandon the Sockeye Creek spawning beds.

However, while the average water temperatures for 2004 were near the upper limit of temperature tolerance for eggs, they were within acceptable ranges for actual spawning kokanee from other regions. Furthermore, stream gauges installed at the spawning beds have yielded data showing that the water flow rate at the site is also within the acceptable range for kokanee elsewhere. These data would seem to indicate that at least some of the requirements of spawning kokanee are still being met at Sockeye Creek.

Regardless of these seeming contradictions, no other spawning beds have yet been found in the lake system. In order to further test the hypothesis about a possible abandonment of the Sockeye Creek spawning beds, more data collection and analysis will be required.

Other lines of investigation about the apparent decline have so far been inconclusive. While stomachs of lake trout collected from the local ice fishery have shown no evidence of serious predation, the number and types of samples available are not sufficient to rule out predation by larger fish (L. Freese, pers. comm.). Tests of the physical water conditions in the Kathleen Lake system have shown only that water quality has remained consistent over a 30-year sampling interval (de Graff 2005). Attempts to access local knowledge through meetings with local fishers and First Nations, as well as a creel census of anglers, have not provided any obvious indications about what is happening to the kokanee.

There are several other hypotheses about the apparent kokanee decline. For example, warmer water temperatures may be causing kokanee eggs to hatch before enough plankton are available as a food source, leading to starvation of newly-hatched kokanee. Phytoplankton and zooplankton populations may have changed such that there is not as much food available to kokanee in the lake as in the past. It is possible that a combination of factors and changes taking place concurrently are combining to affect a decline in kokanee numbers. These and other hypotheses continue to be assessed and investigated by resource managers in the Park.

*\*The technical working group includes Lloyd Freese, Terry Skjonsberg and David Henry (of KNP&R), Rolly Wickstrom (Canadian Wildlife Service), Chris Foote (Malaspina University-College), Aaron Foos (Environment Yukon Fish & Wildlife), Mike Jim (Champagne & Aishihik First Nations), Nick de Graff (fisheries biologist), and Jody McKenzie-Grieves (University of Calgary).*

## **Mayo Community Ecological Monitoring Project Summary of 2004 Activities**

**KEMP has been expanded into a Community Ecological Monitoring Project (CEMP), starting in the Mayo region. CEMP will gather both technical ecological monitoring data as well as local knowledge about ongoing and historical ecosystem indicators.**

Additional funding from the Northern Ecosystem Initiative (NEI) allowed the KEMP partners to expand the geographical range and research scope of the Kluane Project last year. At a meeting in August, the partners decided to focus expansion to the Mayo area first. The wider project is now called the Community Ecological System Monitoring Project (CEMP). In addition to technical monitoring and data collection, the project will also include collection of local knowledge and aboriginal traditional knowledge, thus providing direct community involvement and training opportunities.

The project in the Mayo area will have three components. First, gathering of technical data on a number of ecosystem indicators will be carried out each year, beginning in winter 2004. In preparation for carrying out this component of the project, a crew from Kluane came up to Mayo in September and worked with a local crew and Yukon College students to establish 5 monitoring grids. We'll use these grids to collect data on snow depths, spruce cone crops, berry crops, and abundance of small mammals (voles and mice), red squirrels, and snowshoe hares. We will continue to count tracks of carnivores along two 25-km transects that we established as a part of the Northern Tutchone Regional Program 4 years ago. Additionally, we will conduct a Breeding Bird Survey along a standard 40-km BBS transect through the area, and conduct annual surveys of owls.

Second, we have set up an annual survey of local knowledge on ecosystem indicators, using interviews of knowledgeable local residents. We developed a questionnaire that asks about conditions and changes observed during the past year in weather conditions (temperatures, rain, snow, ice, and

water levels), mushrooms, plants, fish, amphibians, birds, mammals, and subsistence activities. In 2005, two interviewers will talk with 20 people in the local area who have been most active on the land. This will give us a permanent record of environmental conditions as observed by the local community.

Finally, we are holding a workshop in February 2005 with long-term (more than 50 years) Mayo-area residents about the changes in climatic conditions that they have observed during their lifetimes, and how these changes have affected them. This will give us an historical base for our monitoring program.

The Mayo CEMP has many partners. Field work is being coordinated by Mark O'Donoghue, the Yukon Government's regional biologist for the Northern Tutchone Region. The First Nation of Nacho Nyak Dun and the Mayo District Renewable Resources Council have both collaborated in developing and are active participants in the local program. Liz Hofer from the Kluane Project is providing training for local technicians and setting up the field sampling. Yukon College students also took part in setting up and sampling field sites as a part of their Renewable Resources program. Finally, the Arctic Borderlands Ecological Knowledge Coop has contributed its database design, allowed use of its local knowledge questionnaire as a model, and provided training to local interviewers.

Funding for the Mayo CEMP involved arranging two agreements, one from the NEI to the University of British Columbia (UBC), and then a second from UBC to the Yukon Government. These funding agreements were finalized in January 2005.

## **Forest Management in a Changing Climate: Building the Environmental Information Base in the Southwest Yukon**

**Understanding the effects of climate change on forests in Southwest Yukon is critical for making sound regional forest management decisions. A project to collect and assess available information on climate change in the Southwest is underway, and findings will be made available in Fall 2005.**

Healthy forests are the foundation of the Strategic Forest Management Plan for the Champagne and Aishihik Traditional Territory (CATT). It is therefore important to determine how forests in the region might be affected by global warming. Climate-associated impacts such as drought, wildfire, and outbreaks of insects and diseases – already concerns in Southwestern Yukon – are projected to become more frequent and severe, affecting forest productivity, ecosystem functioning, and habitat values in the CATT. The development of a sound, knowledge-based decision-making capacity for the region is critical. The Northern Climate Exchange, funded by Environment Canada's Northern Ecosystem Initiative, is currently coordinating a project to synthesize available information on climate change for the southwest Yukon. The project will also explore the pros and cons of various forest management actions that could reduce the vulnerability of area forest ecosystems to global warming. Intended as the first step in a longer-term process of evaluating climate impacts, assessing risks to ecosystem and community values, and developing scenarios for

adaptation, the project aims to support informed forest management decision-making for the CATT in light of climate change.

*For more information about this project, please contact project coordinator Aynslie Ogden at [aogden@yknet.yk.ca](mailto:aogden@yknet.yk.ca)*

## **Rapid Wastage of Glaciers in the Yukon and Alaska**

**Glaciers straddling the Alaska-Yukon border and in southern Alaska have been melting at an average rate of 0.5 m of thickness per year since the mid-1950s. However, they have recently increased to a melting rate of 1.8 m/year.**

Arendt et al. (2002) surveyed 67 glaciers in Alaska, southwestern Yukon and northeastern B. C. Eleven of these glaciers span the border between Alaska and Canada and one glacier (Kaskawulsh) was entirely within the Yukon. They used laser altimetry to estimate volume changes of these 67 glaciers from the mid-1950s to the mid-1990s. The average rate of thickness change of these glaciers was  $-0.52$  m/year. Repeated measurements of 28 glaciers (including the Kaskawulsh Glacier) from the mid-1990s to 2000-2001 suggest an increased average rate of thinning of 1.8 m/year. Extrapolation to all glaciers in Alaska yields an estimated total annual volume change during this past decade of  $-96 \pm 35$  km<sup>3</sup>/year, equivalent to a rise in sea level of  $0.27 \pm 0.10$  mm/year. These recent losses are nearly double the estimated annual loss from the entire Greenland Ice Sheet during the same time period and are much higher than previously published loss estimates for Alaska glaciers. They form the largest glaciological contribution to rising sea level yet measured.

## **Conclusion**

This report has summarized some important research findings as well as some patterns emerging from monitoring data for the Kluane region. Several effects of the warming climate are becoming increasingly evident in the Kluane region. For example, warming temperatures may be prolonging the spruce beetle infestation, and the subsequent reduction in the availability of spruce cones may be contributing to a decline of red squirrels. Data from the monitoring protocols are verifying and testing further interrelationships active in the ecosystems of the Kluane region, and continued monitoring will be required for us to draw more substantial conclusions. Data gathered from the new CEMP initiative in Mayo will also provide further basis for comparisons in coming years and will enable us to start a Yukon-wide monitoring network to determine how general are the changes caused by global warming.

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