THE KLUANE ECOLOGICAL MONITORING PROJECT
ANNUAL REPORT 2003

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The purpose of this annual report is to summarize for managers and interested members of the public some of the major, current findings of the monitoring program as well as other relevant research programs. The report begins with an overview of KEMP. Selected research findings outside of KEMP but relevant to the monitoring project are also summarized in this report. Regarding the KEMP protocols, patterns of general interest or findings with management implications are the main focus of this report. Further details can be obtained by referring to the references cited here. This annual report is intended to be a standing report that the KEMP team adds to, edits or changes in appropriate ways once each year.

Your comments on this report would be welcomed. 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

Since the close of the Kluane Boreal Forest Ecosystem Project in 1996 we have continued the ecological monitoring of the Kluane region and improved the monitoring methods being used. In particular we have now begun the analysis of these data with a focus on park and regional management. The Kluane Ecological Monitoring Project (KEMP) is a partnership between researchers at the Arctic Institute Research Station at Kluane Lake, Parks Canada, YTG Environment, CWS and Yukon College.

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 of Canada (Parks Canada, in press). By doing so, Parks Canada was partially fulfilling one of the major recommendations of the Panel on the Ecological Integrity of Canada's National Parks (2000). Furthermore, the draft Management Plan for Kluane National Park and Reserve of Canada (Parks Canada, in press) that has been submitted for ministerial approval offers clear support for EI monitoring within KNP&R.

YTG Environment's support for KEMP was contingent upon this program being recommended by the Alsek Renewable Resource Council. Once this recommendation was given, YTG Environment became an active participant and supporter of KEMP in 2000. They recognized the importance of having a long-term monitoring program in place in the Kluane region. Furthermore, the monitoring program offers one way to evaluate the forest management practices existing or planned in the region. To accomplish this latter goal, three transects were established, one in a forested area that had been harvested, one in an area planned to be harvested, and one in an adjacent area that would remain unharvested. A comparison among the three sites would document the regeneration of the forest after two different forest harvesting procedures.

Thus KEMP has several interrelated objectives. First, it provides long-term baseline information on undisturbed forest sites. This information is of value to many research programs as well as park and forest management in the Kluane region. Second, 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 the national park. Third, KEMP monitors the long-term processes that drive Kluane's boreal forest ecosystem. The Kluane Boreal Forest Ecosystem Project 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
Val Loewen of YTG Environment
Michelle Oakley of YTG Environment
Scott Gilbert of Yukon College
Joan Eamer of the Canadian Wildlife Service
Stan Boutin of the University of Alberta
Tom Jung of YTG Environment

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. However, we cannot monitor everything, and 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 1, and Figure 2 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) are being recorded several times each day at six monitoring transects. 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 are recorded. 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 are documented. Rationale: major food for red squirrels, passerine birds, and mice.
4. **Soapberry Production.** Measurements: soapberry production each year is recorded. Rationale: important food for grizzly bear, passerine birds, and rodents.
5. **Ground Berry Production.** Measurements: annual berry production is recorded for crowberry, bearberry, red bearberry, and cranberry. Rationale: major food source for small mammals and birds.
6. **Mushrooms**. Measurements: standing crop of mushrooms is recorded in early August each year 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 is documented from pellet plots annually. 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).

Support for KEMP also allows 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 monitor length of growing season and a coarse index of primary productivity recorded by

ecodistrict. Rationale: landscape patterns possibly affected by global climate change.

9. **Passerine and Landbirds**. Breeding bird surveys and point counts are completed annually. Rationale: trends in certain avian populations are monitored.
10. **Predator Abundance**. An annual index of relative abundance of coyotes, lynx and other predators is derived from a winter track transect in the Kluane Lake-Sulphur Lake corridor. 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. Rationale: major avian predator in the system.
12. **Snowshoe Hare Abundance.** Population density estimates calculated from live trapping hares twice per year at Sulphur, Silver and Jacquot Island monitoring grids. Rationale: the keystone species of the boreal forest with a ten-year population cycle.
13. **Red Squirrel and Ground Squirrel Abundance.** Population density estimates calculated from live trapping squirrels twice per year at two monitoring grids. 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 three monitoring grids. 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 is carried out on tagged willow and birch shrubs on four monitoring grids. 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 is documented. 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 the wardens of KNP&R have 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 and Salmon Surveys. Since 1977 the Warden Service of Kluane National Park and Reserve 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). Since 1976 the wardens have been counting Kokanee salmon observed on spawning beds between Kathleen Lake and Sockeye Lake. Recent results are 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.

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. We maintain on the web site http://www.zoology.ubc.ca/~krebs/kluane.html a detailed EXCEL file (*monitor.xls*) that summarizes monitoring data since 1973. As indicated in Table 1, many of the protocols have been developed only since 1997 and thus it is too soon to expect these protocols to have documented natural variation or clear ecological patterns from their results. These protocols must be carried out for several more years before patterns become clearly evident.

A preliminary analysis of the monitoring data from 2003 suggests the following patterns:

- Pine marten may be increasing in the Kluane region.
- Berry production on *Cornus canadensis* was extremely low this summer in the St. Elias Lake area correlating with the low thickness of snowcover during the early and mid parts of the previous winter.
- In areas surrounding the Jarvis River and southern parts of Kluane Lake, red squirrels are beginning to show a population decline.
- During 2003, white spruce cone production remained low on all of the monitoring transects.

- In the Shakwak Trench, snowshoe hares have remained at a low density longer than during the previous three cycles.

In addition, we would like to bring your attention to two interesting research publications produced by our colleagues from Kluane Lake (Reale et al. 2003, Danby 2003).

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 1.8m/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 $-96 \pm 35 km^3$/year, equivalent to a rise in sea level of 0.27 ± 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.

Climate Change and Spruce Bark Beetle Infestations

Climate records starting in 1945 show that the average annual temperature and amount of precipitation have been increasing in the SW Yukon. Winters show prolonged periods of severe cold less frequently, and early to mid December is significantly warmer. During the summer months there has been a decrease in average amount of precipitation in 7 out of the 10 years from 1989 to 1998. These climatic conditions have helped to promote a large infestation of spruce bark beetles in southwest Yukon and south Alaska.

Berg and Henry (2003) assembled weather records for Haines Junction and Burwash since the mid 1940s, estimated missing values and analysed for changes in the mean monthly temperature and total monthly precipitation present in these records. Their results for annual temperature as well as precipitation for the Burwash data are summarized in Figure 3. On an annual basis temperature has been increasing in the southwestern Yukon during the past 40 years and precipitation has been falling at Burwash. At Haines Junction the temperature trend is similar but the rainfall trend is opposite, rising rather than falling (Carrier 2003). The implications of climate change and the ways that various components of the Kluane ecosystems are responding to the changing climate is one of the clear focuses of the KEMP monitoring program.

The overall trend in Figure 3 is not smooth because of important year-to-year variations. For example, the annual temperatures for Haines Junction show a significant step upward in 1976-77 (Figure 4) that Mantua et al. (1997) describes as the shift of the Pacific Decadal Oscillation into its positive phase of warm North Pacific sea surface temperatures.

The run of warm summers during the 1990s appears to be one of the driving forces behind the spruce bark beetle outbreak that the Kluane region has experienced since 1994. The Kenai Peninsula in southern Alaska shows a similar pattern (Berg and Henry 2003). The southern Kenai experienced an unbroken run of warm summers in 1987-1997, and the Kluane region experienced a similar but shorter run in 1989-1995 (Figure 4). Both areas showed noticeable increases in red needle acreage due to spruce bark beetle three years after the onset of warm summers, with red needle acreages accelerating rapidly five years after the onset of warm summers (1992 for the Kenai, and 1994 for Kluane).

Within-season patterns of weather changes have also occurred. Paul Whitefield analyzed 5-day averages for temperature and precipitation over a twenty year period for the Kluane region (see Garbutt 2003). Wakefield made detailed comparisons for temperature and precipitation between two decades, comparing 1976-1985 to 1986-1995. The average winter temperature did not become significantly warmer over these two decades. However, he did find that in the latter decade there were successive winters without prolonged periods of severe cold, and that early to mid December was significantly warmer. He also found warmer temperatures during the early spring and throughout the growing season, especially in April where increases were statistically significant. Regarding precipitation, Whitefield examined trends on a weekly basis and found that over the two decades there was a significant change in snow during five weeks of the winter, three increases of snow from November through January and two decreases from February through April. While these changes were significant, they only involved small changes in snow depth. A large majority of precipitation occurred as rain in the summer months, and there was a net decrease in summer precipitation from 1986 to 1995 (see Garbutt 2003). Berg and Henry (2003) found that the drought index for the summer months in the Kluane region was above average for 7 out of 10 years from 1989 to 1998.

These weather patterns likely have intensified the spruce bark beetle infestation in the Kluane region in several important ways (Berg and Henry 2003). Warmer summers probably promoted greater beetle reproduction, both through enhanced survival of larvae and early pupation, converting beetles that usually take two years to complete their life cycle into one-year beetles. With more frequent warm summers, the beetle population can grow exponentially, and hence the critical importance of the duration of the run of warm summers. A second effect of warm summers is the increase in moisture stress experienced by the trees and a reduction in their ability to get rid of the beetles through a "pitching out" response. Furthermore, the warmer early to mid Decembers and the lack of severe cold periods probably has led to reduced beetle mortality in their over-wintering state (Berg and Henry 2003). There are at least four possible ways that changes in Kluane's climate has helped to support high densities of spruce bark beetle from 1994 to the present.

History of Spruce Bark Beetle Attacks in the Kluane Region

Spruce bark beetles have shown two large outbreaks in the Kluane region during the 20th century. Large beetle outbreaks in Kluane appear to be non-existent from approximately 1300 to the 1930s. The 20th century outbreaks appear to be correlated with warm winters and a series of warm, dry summers.

Berg and Henry (2003) sampled four Kluane forest stands during June 2001, and in recent times two major spruce bark beetle infestations were detected. Garbutt (2003) maps a widespread outbreak in the Kluane region (covering more than 250,000 ha of white spruce forest) that was first detected during 1994. In addition, the Papineau Road forest stand showed evidence of a beetle infestation that began in 1934 and continued to 1942. According to Downing (1957), this outbreak was part of an infestation that extended from approximately the BC-Alaska border to near the village of Champagne on the Alaska Highway.

Other than these two outbreaks, the four forest stands sampled show no major spruce bark beetle activity in the history of these stands. Rod Garbutt has cored and measured a small number of mature white spruce trees from five other sites in the Kluane region, and these trees offer no evidence of other widespread beetle outbreaks. By comparison, similar studies carried out on the Kenai Peninsula have documented five major beetle outbreaks, three during the 20th century and two during the 19th century (Berg and Henry 2003). These results suggest that there are significant differences in the dynamics of the spruce bark beetle in the Kluane forests as compared to the Kenai forests.

The two documented infestations in the Kluane region (beginning approximately 1934 and 1994) are probably linked to the series of drier, warmer summers and milder winters that became increasingly evident as the century progressed. However, if the future climate of the Kluane region continues to become warmer and drier, the white spruce trees of the region might experience two effects: (1) increased moisture stress, and (2) greater mortality from the increased production of spruce bark beetles. This combination may lead to increased attack and mortality of smaller size classes of trees, such as has been observed on the Kenai Peninsula in the 1990s.

This study suggests that widespread, intense spruce bark beetle attacks in the white spruce forests of the Kluane region are a 20th century phenomena, and that these large infestations were extremely rare in Kluane forests from approximately 1300 to the 1930s. The 20th century outbreaks appear to be strongly correlated with extended runs of warm summers, most recently in the 1989-1995 period.

Satellite Measurements of Primary Productivity

NDVI measurements taken from weather satellite images (NOAA-AVHRR) are a coarse measure of vegetation growth (primary productivity) made on large landscapes. An analysis of these data from 1993 through 2002 shows:

- **In 9 out of 11 national parks across northern Canada, there has been a significant increase in NDVI over this decade. However, the summer of 1995 showed exceptionally low NDVI values.**
- **The Kluane region shows this increase in NDVI over this decade. However, unlike much of the North, it only showed low values of NDVI during 1995 in areas dominated by snow and ice.**
- **Spring green-up in KNPR is significantly less variable than in other northern national parks, usually occurring between June 10th and 30th.**

The Advanced Very High Resolution Radiometer (AVHRR) onboard the National Oceanic and Atmospheric Administration (NOAA) series of polar-orbiting weather satellites collects images that is appropriate for monitoring many large-scale physical and biological phenomena. Each of these satellite images covers a large span of territory (each pixel in the image covers 1 km^2 on the ground). Thus the resolution of the images is relevant for monitoring at the broad landscape scale (Sparling et al. 2002).

The Normalized Difference Vegetation Index (NDVI) is one of several ratios developed to assess biomass and plant growth from satellite pictures. It is calculated from the amounts of red and near infra-red light that reflect off the ground surface (Parks Canada 1999). For AVHRR satellite images, NDVI is a ratio of Band 1 and Band 2. Thus NDVI measurements from AVHRR images are a coarse measurement of plant productivity at the landscape scale.

The Canada Centre for Remote Sensing and the Parks Canada Western Canada Service Centre have used AVHRR images and the GEOCOMP-N data set to provide us with cloud-free images of northern Canada every 10 days from April until October. Thus each image gives the maximum NDVI reading for each pixel over that 10 day composite period. They have analyzed 10 years of images (1993-2002) for patterns in plant productivity in 11 national parks in northern Canada (Aulavik, Auyuittuq, Ivvavik, Kluane, Nahanni, Quttinirpaaq, Sirmilik, Tuktut Nogait, Vuntut, Wapusk and Wood Buffalo).

Here are some of the findings they report for these northern national parks, and specifically for the Kluane region (Sparling et al. 2002):

- Across these 11 northern parks, there was a significant increase in NDVI over the ten-year period. Only Aulavik and Quttinirpaaq did not show this increase. This increase in plant productivity was more prevalent during the summer and autumn months as compared to spring, and the increase was present in many of the ecodistricts of the parks that were examined.
- Among these northern parks, 1998 exhibited exceptionally high NDVI values, and the decline of NDVI values present in 1999 to 2002 appears to be a return to values closer to the 10-year average. On the other hand, despite normal green-up times in most areas, the summer of 1995 showed exceptionally low NDVI values in all of these parks.
- NDVI values in northern national parks are most variable during the spring. The timing of green-up seems to be an important determinant of the cumulative NDVI value for that summer: early green-up is often found in years with high overall NDVI (1995 being an exception).
- In the Kluane region, we found a significant increase in NDVI over the ten-year period, and a closer examination showed that this increase was confined to the summer season. This increase was most prominent in two of the region's more productive ecodistricts (#887 "Burwash-Beaver Creek " and #888 "The Kluane Range"). The pattern of low NDVI values during 1995 was evident in Kluane's snow and ice ecodistricts, but it was barely detectable in two of the region's more productive ecodistricts (#892 "East side of Shakwhak Trench" and #915 "Yukon-B.C. border area").
- Green-up in KNPR shows less year-to-year variation than most of the northern parks examined. However, due to its diverse topography, spatial variation in Kluane's green-up was much greater than all of the other parks examined. In the Kluane region, green-up in 1995 was initiated during the end of the May 21 composite, which was significantly earlier than in the other years. Otherwise, green-up is pretty regular, occurring between the end of the June 1 composite and the end of the June 21 composite.

Mouse and Vole Abundance

Vole and mouse numbers in the Kluane Region declined from high levels in 2002 to low numbers in 2003, and these low numbers are expected to continue in 2004. Birds of prey like the hawk-owl and the boreal owl that specialize on voles and mice will probably be uncommon and not breed in 2004.

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*). 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.

What is interesting is that nearly all of these species reach high numbers in the same years, such as the 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. The 2002 rodent peak was widespread over much of the Yukon. By 2003 mouse and vole numbers had fallen back to low levels (Figure 5).

One of the first things that strikes us is that these three major peaks in mouse and vole numbers have occurred during the decline phase of the ten-year snowshoe hare cycle. Hares peaked in the Kluane region in 1971, 1980-81, 1989-90, and 1998. Basically mice and voles show a peak in their populations 2 or 3 years after the snowshoe hares have peaked. Since the hare cycle happens only about once every ten years, it takes a long time series of data to recognize this type of association. The 1989-90 hare peak was not followed by a particularly high mouse year in 1992 (Figure 5) so this pattern is sometimes broken. By what factors might snowshoe hares and mice numbers be correlated?

Two suggestions are that these species compete for food or have common predators. But neither of these ideas holds water. Snowshoe hares do not eat the same kinds of plants as mice and voles, so it is unlikely that there could be direct competition for food between these species. And the predators of hares like lynx and great-horned owls are not in general major predators of mice and voles. Coyotes certainly live off mice and voles when they are abundant, but in the Kluane region in the 'off' years there are simply not enough mice to support any predators. Weasels and marten can become temporarily common in years like 2002 when mice are everywhere, but they drop off to almost zero in between times when mice are uncommon. In general the average mouse abundance at Kluane is not high enough to support a suite of predators.

We think that mouse and vole numbers are driven by an indirect effect from the hare cycle on soil nutrients. We have suggested that hare browsing, grazing and defecation at high hare 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. To see if this idea is correct, we began in 1997 to measure the berry crop of our main berry-plants at Kluane, and when we have a few more years of data we will be able to tell you if this idea is correct or not. Berry production is probably related to climate as well as possibly being affected by the hare cycle, and this might account for the minor peaks in mouse numbers in this part of the Yukon.

The pattern shown in Figure 5 suggests that 2004 will be a year of low mouse and vole numbers.

Kokanee Salmon in the Kathleen River Watershed

Recent monitoring results suggest a possible serious decline in the Kokanee salmon population that inhabits Kathleen Lake and Sockeye Lake in Kluane National Park and Reserve.

Kokanee salmon are “land-locked salmon,” that is, sockeye salmon that no longer migrate to the sea because sometime during past centuries their migratory river route was blocked by a glacier, landslide or some other obstacle. The Dezadeash River watershed supports the only naturally occurring population of kokanee salmon in the southwestern Yukon with subpopulations occurring both inside and outside of the Kluane National Park and Reserve. However, at the present time it is unsure whether the Fredrick Lake population is still in existence. “Spawn-takes” from the Kathleen Lake watershed population have been used to initiate populations in other lakes in the Yukon.

The Warden Service of Kluane National Park and Reserve has been monitoring the number of kokanee salmon that occur on the river spawning beds between Kathleen Lake and Sockeye Lake in most years since 1976. This is the only native population of kokanee salmon that occurs in a national park in Canada. For operational reasons, the sampling methods have varied over the years, and these differences must be taken into account when interpreting these data. The results of this monitoring program are summarized in Figure 6. Taking varying sampling methods into account, these data still suggest an overall gradual decline in this population from 1976 to 2001. However, monitoring results from the last two years also suggests a possible steeper decline in the breeding population of these kokanee salmon, and these results have caused the Warden Service to consider what may be occurring in this salmon population and what should be done about it.

Research carried out during past years on this population and other fish populations in Kathleen-Sockeye lakes is relevant to this issue. Kokanee salmon on their spawning beds were sampled for parasites during “spawn-takes” during the mid-1990s, and the results suggested that this population is largely free of diseases and parasites. No major parasites outbreaks have been detected or reported in these fish populations since that time.

Aquatic experts are being consulted concerning the decline of this salmon population. Dr. Rollie Wickstrom of Environment Canada carried out extensive aquatic research on the lakes of Kluane National Park and Reserve during the 1970s (e.g., Wickstrom et al. 1977, 1981), and he has reviewed the recent monitoring results and is working with the Warden Service on this issue. He has brought Dr. Chris Foote of Malaspina College, an expert on kokanee salmon, into the discussions. Dr. Foote has observed that given the age-size classes represented in this kokanee population that it is unlikely that food resources are the limiting factor causing the possible population decline. Both biologists will continue to work with the wardens on this issue.

The Kluane Park Management Board and Kluane National Park staff are organizing a forum early in 2004 that will assist in the collection of local knowledge concerning the Kathleen-Sockeye aquatic ecosystems and these fish populations. Further consultations will be carried out over the next several months to help identify appropriate research projects and management actions for this kokanee population. Some of these initiatives will be considered for implementation.

Soapberry Crops and Bear Control Measures

If soapberries are a major grizzly food source, bear problems in Kluane Park might be correlated with soapberry crops. With 7 years of data to analyse, an inverse relationship between the abundance of soapberries and the frequency of bear sightings is beginning to emerge.

Diets of grizzly bears that do not have access to salmon or abundant ungulates are dominated by plant food (McLellan and Hovey 1995, Jacoby et al. 1999). Forbs typically dominate the early summer diet and berries dominate the late summer diet. Variation in forb and berry crops from year to year due to climatic variation could affect condition levels in bears and possibly impact on the frequency of human-bear interactions. We have not been able to find any studies that attempt to use measures of plant production in order to predict the frequency of human-bear interactions. However, Scott Nielsen, a graduate student at the University of Alberta, has recently begun a study correlating soapberry crops with grizzly bear management problems (Herrero, pers. comm.).

In 1997 we began monitoring the relative size of the soapberry crops in the Kluane Region. There is considerable variation in soapberry production, such that high production years have 5-6 times the biomass of berries of low production years. Figure 7 plots these soapberry counts against one measure of human-bear interactions in Kluane National Park. The number of grizzly observations for the Park is one approximate index of potential bear trouble in that year (Stewart 2003). There is a negative relationship between bear observations and soapberry crops for the 7 years we have data (Figure 7).

Two other measures of bear problems have been tallied – the number of days of trail closures for the Park is an approximate indication of bear trouble in that year, and the number of grizzlies that were killed in the region (excluding hunting kills) is another indication of difficult bear years for the area (Stewart 2003). Neither of these measures is closely related to soapberry production, based on the limited set of data we have available. This may be because a standard measure of bear-people problems has not been adequately developed for the Park or because other food sources are more important for bears. Forbs are important early summer food items, and perhaps some measure of forb production might add predictability to these relationships in a way that would be useful early warning indicators of management issues with grizzlies in the Park. Alternatively we might consider berry crops in the alpine zone of the Park as an alternative late summer food for which we should develop a monitoring protocol.

Dall Sheep Surveys

Dall sheep numbers on Sheep Mountain have fluctuated moderately over the past 25 years but on average have held steady over time. Consequently the population surveys suggest that there is no indication of any problems with this population that is so important for wildlife viewing in Kluane National Park and Reserve.

Since 1977 Kluane Park wardens have completed aerial surveys of the Dall sheep populations of several key ranges within the Park. These data have been analysed by Dehn (2001a, b) and we present here only one example of these data: total counts from Sheep Mountain. Figure 8 shows that this Dall sheep population has fluctuated within a narrow band and on average remained constant over the past 25 years.

Most of the Dall sheep populations in the Park that have been counted have maintained their numbers well during the last 25 years, with the possible exception of the Auriol Range population (Dehn 2001a). In addition, Hik and Carey (2001) found that Dall sheep have value as an integrated indicator of environmental conditions. They found that annual horn growth increments of sheep rams appear to be related to yearly variation in plant productivity and cyclic variation in precipitation and temperatures. Thus for several reasons – one being that they are highly valued by visitors to the Park – it is critical that monitoring continue on these sheep populations in order to watch for any serious population problems.

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 increasing evident in the Kluane region. Monitoring has provided early warning about possible changes in the kokanee salmon of Kathleen-Sockeye lakes. Data from the monitoring protocols are also verifying and testing further interrelationships active in the ecosystems of the Kluane region.

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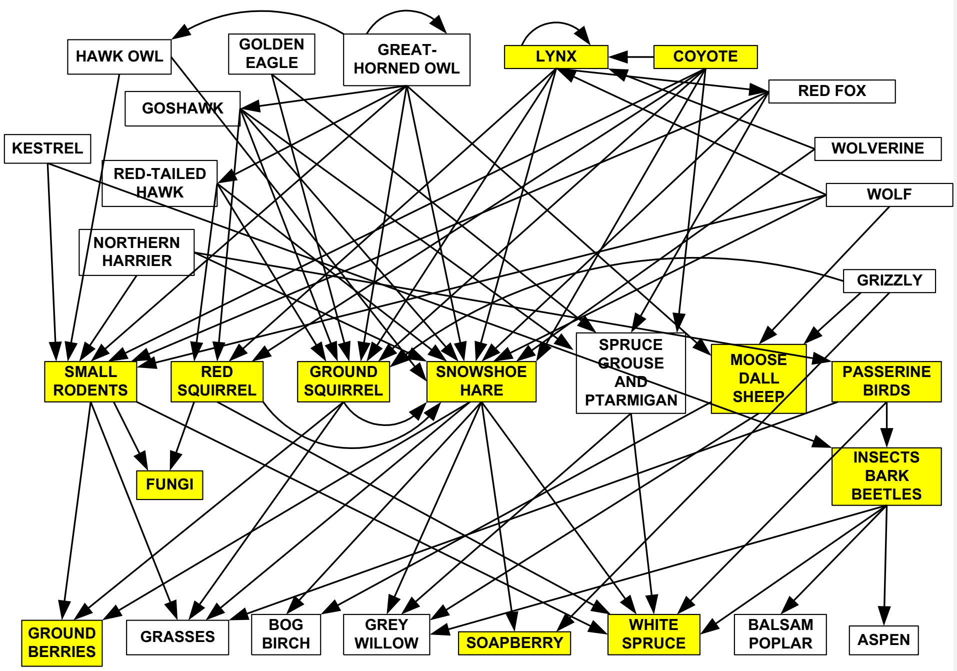

Figure 1. Food web for the boreal forests in the Kluane Region of the Yukon. The species being monitored in the Kluane monitoring project are shaded. University research personnel are monitoring the squirrels and rodents on only a few sites. Only the major feeding linkages are shown.

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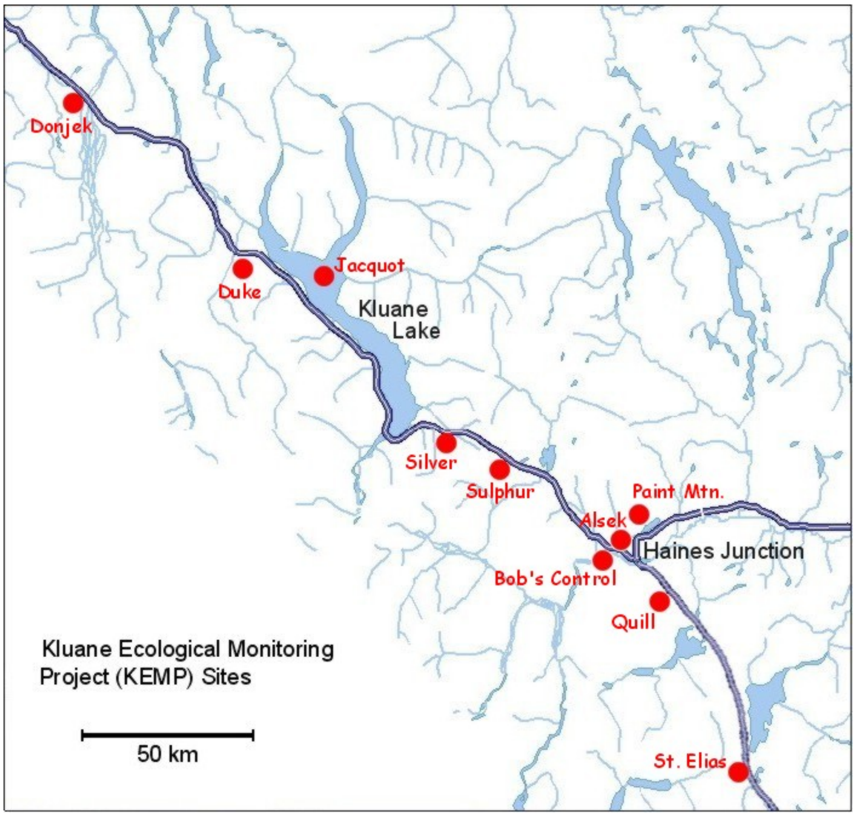


Figure 2. Map of the Kluane region showing the 10 monitoring sites. Each red dot represents a monitoring site.

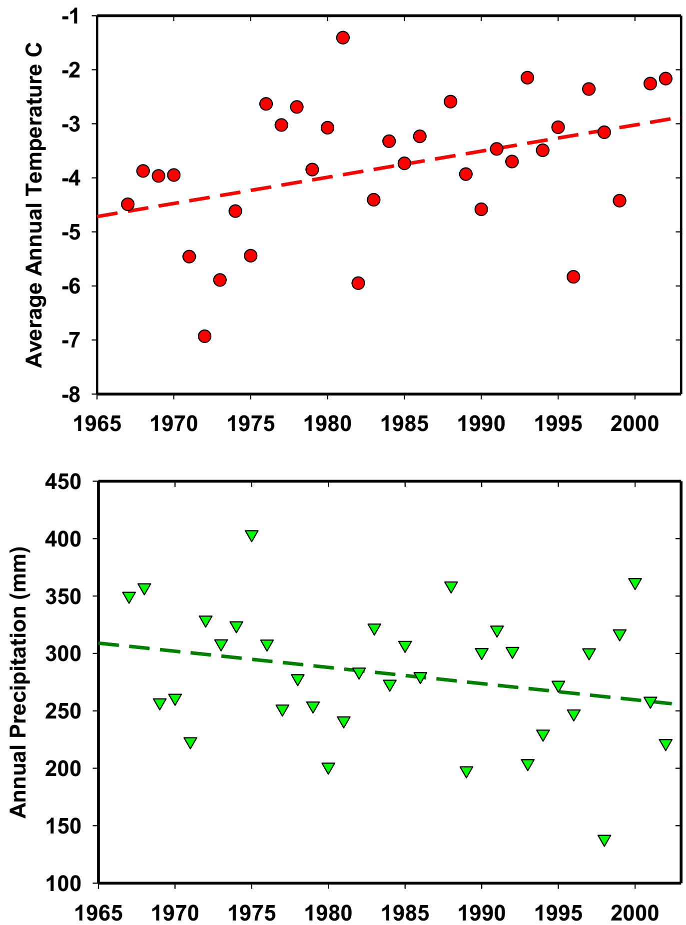


Figure 3. Trends in temperature (top graph) and precipitation (lower graph) in the Kluane region since 1967 from data collected at the Burwash Airport Meteorological Station. On average, annual temperature has been increasing 0.5 C every 10 years and annual precipitation has been falling by 14 mm every 10 years.

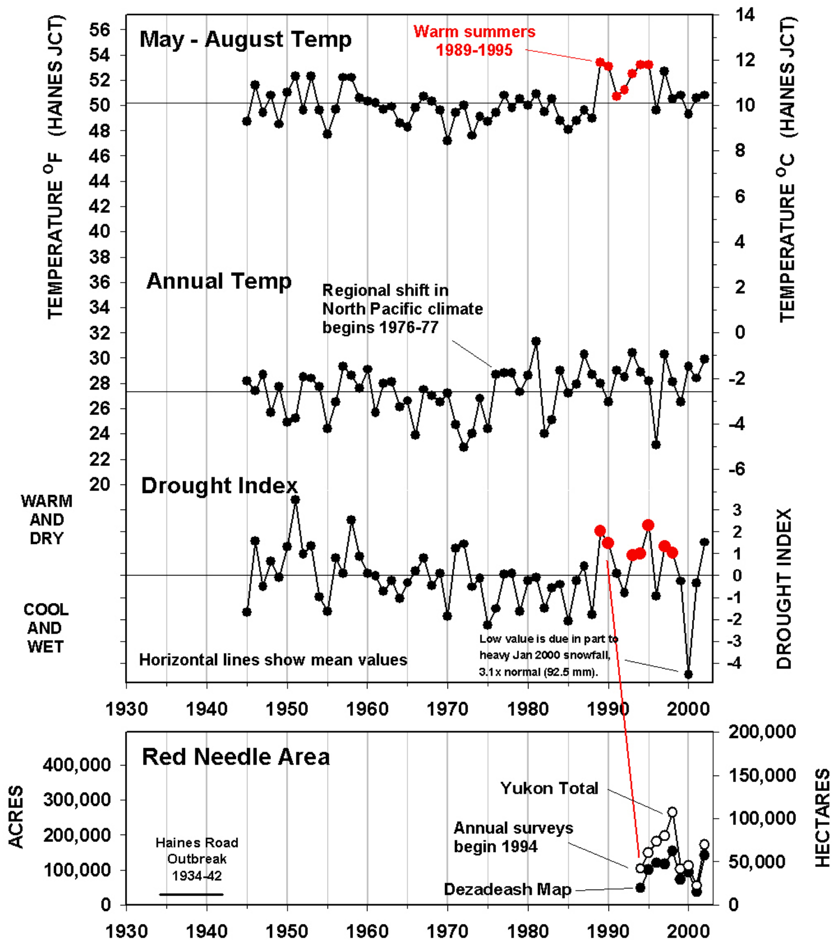


Figure 4. Detailed climatic data for Haines Junction from 1945-2002, with a measure of the intensity of drought stress and spruce dieback from bark beetle outbreaks.

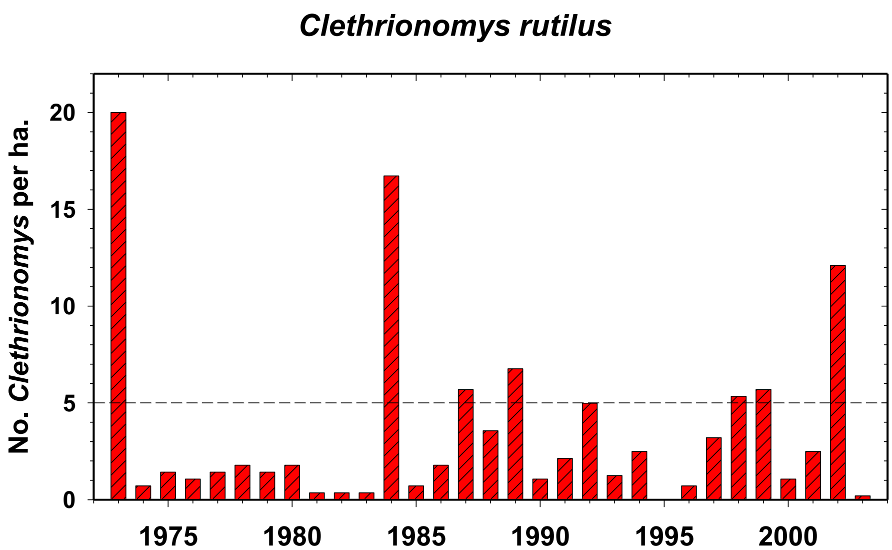
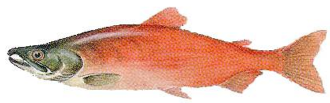


Figure 5. Spring red-backed vole abundance in the Kluane Region from 1973 to 2003. The large numbers of 2002 were followed by low numbers in 2003 and low numbers should continue in 2004.



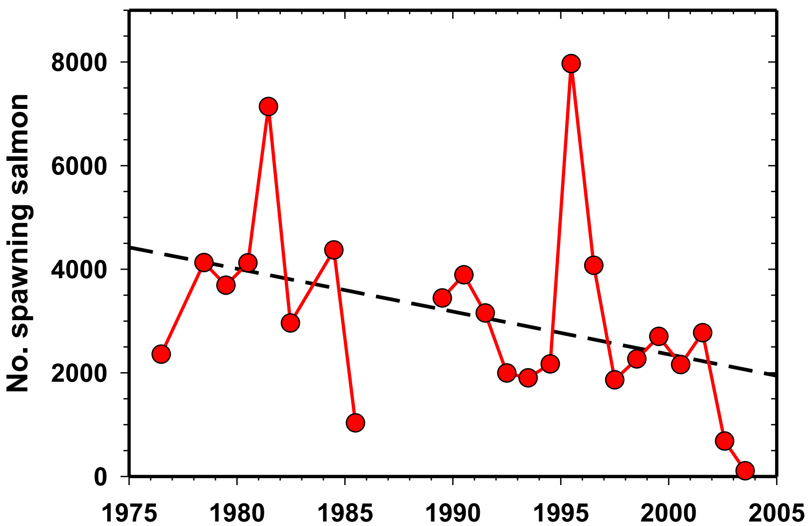


Figure 6. The number of kokanee salmon counted on the spawning beds in the river between Kathleen Lake and Sockeye Lake, Kluane National Park and Reserve, 1976 to 2003. Year-to-year variation is high but on average numbers have been declining by about 80 spawners per year since 1976.

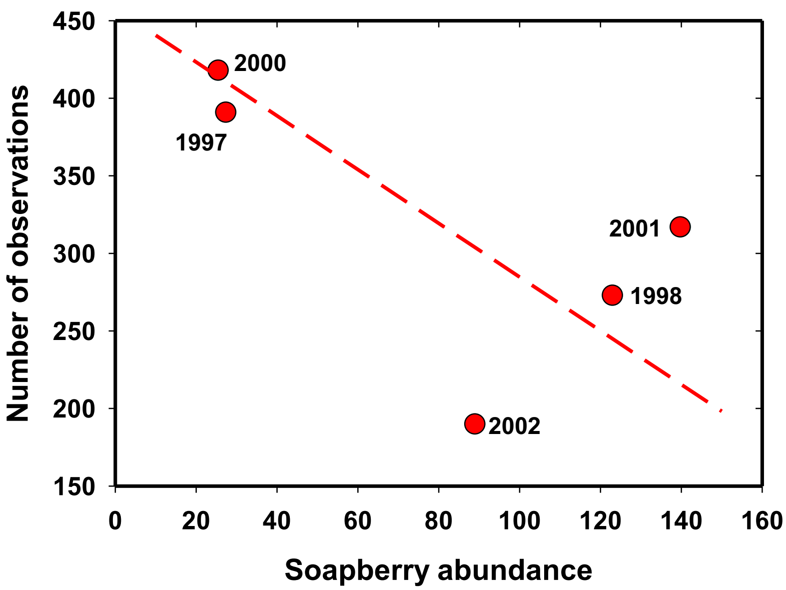


Figure 7. One index of grizzly bear problems in Kluane National Park in relation to average soapberry counts at 14 sites in the Kluane area from 1997 to 2002. There have been fewer bears observed in the Park in years of high soapberry counts. Soapberries are a major food for grizzlies in late summer and more bear problems may arise when bears are hungry.

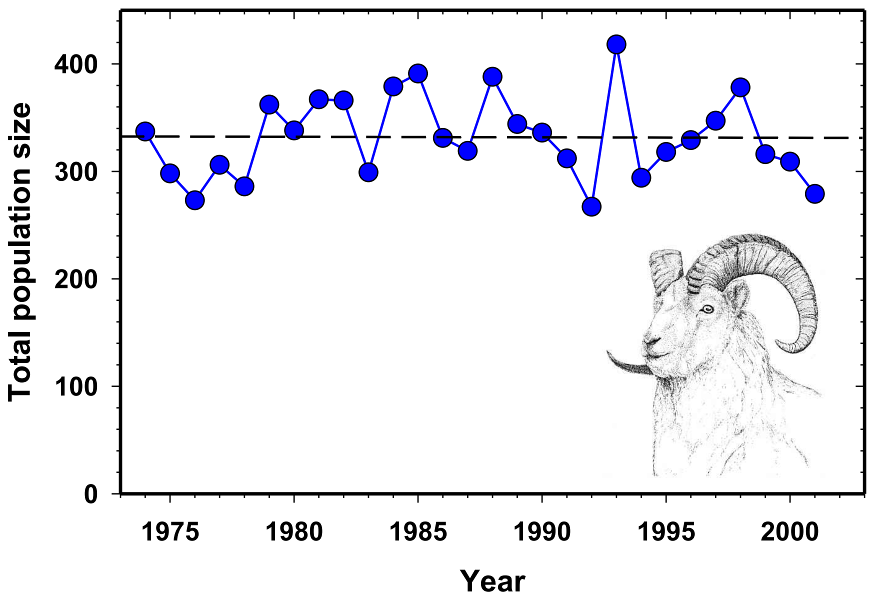


Figure 8. Dall sheep total population counts on Sheep Mountain carried out by Parks Canada wardens from 1974 to 2001. The dashed line indicates the average population of 332 sheep. (After Dehn 2001a and Parks Canada unpublished data).

Table 1. Fifteen monitoring variables and ranking score for their management implications for Kluane National Park and Reserve.

Variable	*Ranking Score*	*Comments*
Weather	1	6 automatic weather stations since 2001
Snow plots	2	4 transects measured since 1976
AVHRR satellite measurements	3	NDVI data since 1993
Snowshoe hare cycle	4	Quantitative data since 1976 at 3 sites
Kokanee salmon counts	5	1 area since 1976
Breeding bird surveys	6	4 areas since 1999 (CWS); 2 BBS routes since 1998
Ungulate populations	7	Dall sheep, moose, goats since 1977
Spruce bark beetle	8	12 areas, since 1997
Furbearer track counts	9	2 areas, since 1987
Spruce cone counts	10	3 areas since 1987; 14 areas since 1997
Soapberry crop	11	14 sites, starting in 1997
Red squirrel abundance	12	4 sites since 1985 (UA)
Mushroom counts	13	10 areas since 1997
Ground berry counts	14	10 areas since 1997
Glacier melting rates	15	1 area since 1967 (AINA)