# THE COMMUNITY ECOLOGICAL MONITORING PROGRAM ANNUAL REPORT 2009

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## Executive Summary

The Community Ecological Monitoring Program (CEMP) arose in 2005 as a regional extension of the Kluane monitoring project to begin a regional assessment of the health of the Yukon boreal forest ecosystem.  This is the second annual report to coordinate the data on white spruce cone crops, ground berry production, small mammals, snowshoe hares, and arctic ground squirrels at Kluane Lake, Mayo, Faro, Watson Lake, and Whitehorse.  White spruce cone counts were very low in 2009, following the last high cone years of 2005 and 2007. Ground berries in the forest were relatively poor in 2009, although bearberries were abundant at Mayo. Red-backed voles were particularly abundant in 2009 at Kluane and generally abundant at other sites as well in 2009. Snowshoe hares continued to decline on all areas in 2009 towards the bottom of their 10-year cycle. Mushroom production was very low at all sites in 2009 with the exception of Watson Lake. Soapberries were relatively scarce at Kluane Lake in 2009. Snow track counts in winter for mammalian predators are being done at Kluane and Mayo, and we started them at all CEMP sites in 2009-2010. At Kluane all mammalian predators except weasels decreased in the winter of 2008-09. Local knowledge interviews were completed at Mayo by Mark O'Donoghue and summarized, an important step in bringing local knowledge of trends together with our CEMP data. As additional data are added in the years to come, the regional patterns of ecosystem changes will become more evident.

## Introduction

Since we began work in the Kluane boreal forest in 1973 we have been monitoring the ecological integrity of the Kluane region, and have over the years improved the monitoring methods being used.  In 2005 we were able to expand some of the monitoring protocols to Mayo, Watson Lake, and Whitehorse, and in 2007 we began collecting data at Faro. This will permit us to focus on regional trends in measures of ecosystem health.  The Community Ecological Monitoring Program (CEMP) is a partnership between researchers at the Arctic Institute Research Station at Kluane Lake, YTG Environment, the Canadian Wildlife Service and Yukon College. Additional monitoring in the Yukon is being done by Parks Canada and other research groups but we have not tried to summarize all of this monitoring here. We concentrate here on the CEMP monitoring being carried out in the central and southern Yukon.

This monitoring program has several interrelated objectives. First, it provides long-term monitoring data that provide important baseline information on undisturbed forest sites, and 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 central and southern Yukon boreal forest ecosystem. The early detection of these changes should guide medium to long-term planning and biodiversity management and research. Third, CEMP monitors the long-term processes that drive the 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 (Krebs, Boutin and Boonstra 2001). However, we still do not understand the longer cycles and processes that drive boreal forest ecosystems on a landscape scale and help to protect its biodiversity. CEMP is helping to document some of those patterns and processes.

An important part of CEMP is the community involvement by way of traditional and local knowledge. Interviews are carried out each year at Mayo, and community involvement in Dall sheep and arctic ground squirrel censuses at Kluane are part of this work. We will report on this work briefly in this report.

## Why Monitoring is Needed

What are the goals of this monitoring program? It is important to keep in mind where we are headed in any monitoring design. The key question we need to be able to answer is *how will the Yukon's ecosystems respond to climate change*? The answer to this simple question is not simple. Some parts of our Yukon ecosystems are directly dependent on climatic variables like temperature and rainfall. Others, for example like snowshoe hares, depend immediately on the abundance and hunting success of predators like lynx, so that the question then becomes will climate change affect lynx hunting success and if so how?

There are only three approaches ecologists are using to answer this broad question. First, sit and count, wait and see. This is the simplest approach to describe the system as it changes. As such it does not permit any management actions to thwart changes, since, by the time you see changes, it is too late to do very much about them. Nevertheless, this approach is important because we carefully document what is happening here and now. Second, we can build mathematical models of the ecosystem, similar to the ones now being used to project how climate might change as $CO_2$ goes up. The problem is that ecosystems are much more complex than the physical climate, and we do not know very much about how all the ecosystem component species interact. We are learning slowly but so far models for ecosystem change are not very useful. Third, we can work on components of the ecosystem that appear to be directly affected by climate, and build models of these components. This is our approach. We have picked ecosystem variables like ground berry production and spruce cone production that are commonly thought to be under the control of weather, and we are building predictive models that we can test to predict for example the abundance of ground berries from temperature and rainfall data in particular months of the previous year. We can then test these models from year to year to see if they are accurate and to change them as we need to. By itself this approach will not solve the broad problem of ecosystem change, but it is a start and

in combination with the first approach we will gradually improve our understanding of where we are headed with climate change.

The key to these approaches is to have a comprehensive monitoring program in place that gathers data year after year. We cannot start and stop monitoring programs for a few years any more than we can stop and start reporting on the stock market for a few years. The need is thus for a commitment in funding and in people to carry these goals forward. This is what we have begun in the CEMP program and we summarize here what we have so far achieved.

## Protocols Monitored and Cooperating Research Programs

Figure 1 shows the food web of the southern and central Yukon boreal forest region.  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



**Figure 1**.  Food web for the boreal forest in the southern and central Yukon.  The species being monitored in at least two of the CEMP sites are shaded. We will add further species to the monitoring program next year. Only the major feeding linkages are shown.
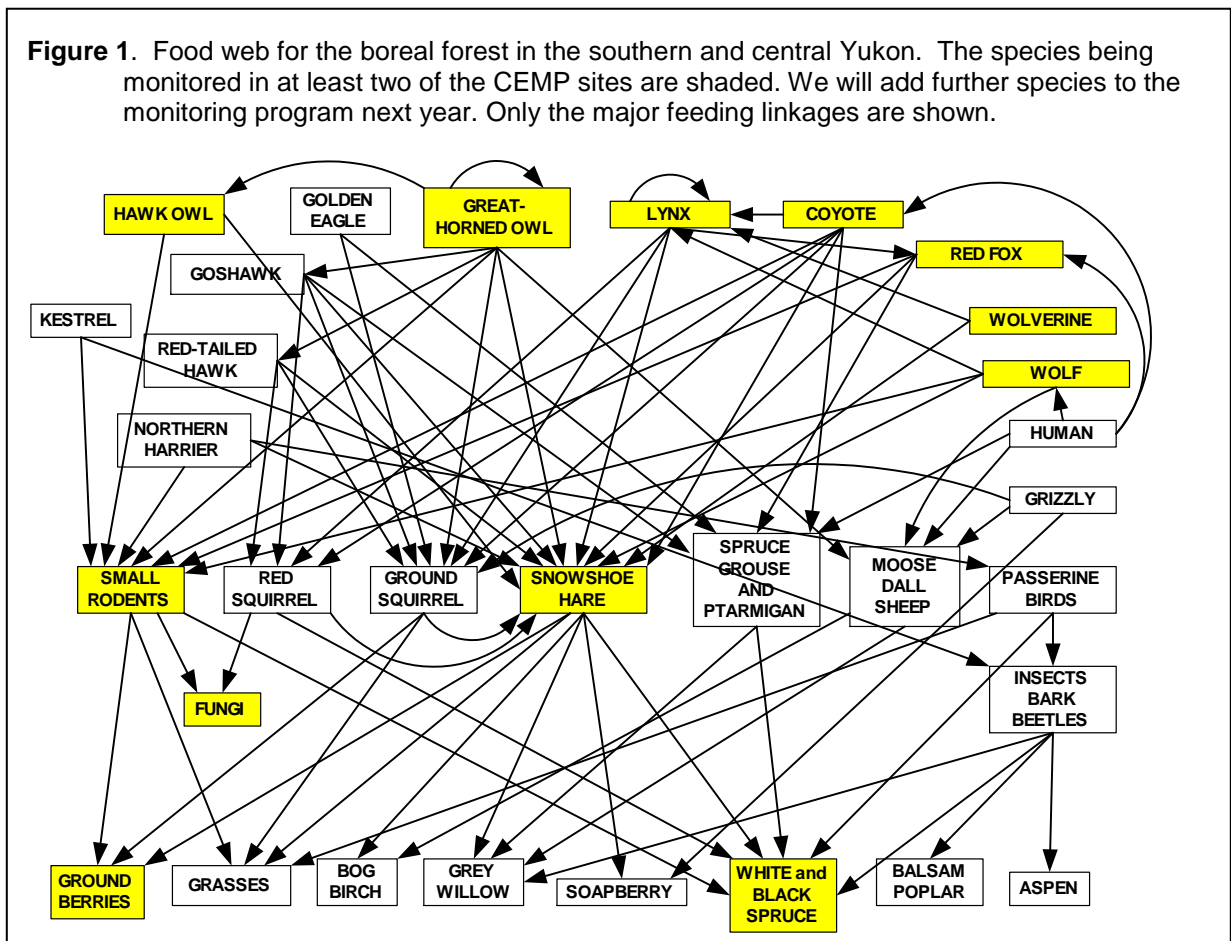
everything, and we have concentrated our efforts on 7 significant indicators.  We believe that these indicators constitute a start for obtaining early warning of ecosystem change, evaluating forest management practices and advancing our understanding of the dynamics of boreal ecosystems.  The 7 indicators that are being monitored are listed below, and suggestions for additional indicators are given at the

end of this report. The species that are being monitored are indicated by shading in Figure 1.

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

1. **White Spruce Cone Production.**  Measurements: annual rates of cone production are documented.  Rationale: major food for red squirrels, passerine birds, and mice.

2. **Ground Berry Production.**  Measurements: berry production is recorded each year for the major berry producers in the Yukon boreal forests – crowberry, bearberry, red bearberry, toadflax, and cranberry.  Rationale: major food supplies for small mammals and birds.

3. **Mushroom Production:** 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.

4. **Small Mammal Abundance.**  Measurements: population density estimates calculated from live trapping mice and voles twice per year at Kluane and Whitehorse, and once per summer at other CEMP sites.  Rationale: major prey for many predators; these small mammals create a 3-4 year population cycle as well as major irruptions in the area.

5. **Snowshoe Hare Abundance.**  Measurements: population density estimates calculated from live trapping hares twice per year at Kluane and by counting fecal pellets once per year at all CEMP sites.  Rationale:  the keystone species of the boreal forest with a ten-year population cycle.

6. **Predator Abundance**.  Measurements:  index of relative abundance of coyotes, lynx and other predators from winter track transect is being carried out annually in the Kluane Lake area and at Mayo, Watson Lake, Faro, and Whitehorse.  Rationale: an index of major terrestrial predators in the system.

7. **Great Horned Owl Census.**  Measurements: annual population density estimate is based on breeding pairs in the Kluane Lake region and will be coordinated with the BC Owl Census for other areas. Rationale: major avian predator in the system.

We have prepared a separate handbook of the details of the monitoring protocols for each of the species groups listed above (CEMP Monitoring, 2009, available on the web at http://www.zoology.ubc.ca/~krebs/).

In addition to these 7 protocols, a number of research and management projects are being conducted in the Yukon (e.g. the Breeding Bird Survey, Christmas Bird Counts). Through cooperation and partnerships, these projects contribute important additional information that is valuable for long-term monitoring in the Yukon.

Two general questions underlie this monitoring program. First, is there synchrony among sites in these indicators? Regional synchrony can be achieved by ecological indicators responding to weather variation that has a widespread regional

signature, or by large-scale dispersal of animals like lynx and coyotes. Second, are there regional patterns of variation in the density or productivity of indicators? For example, snowshoe hares may be on average more abundant in some areas than they are in others. In turn, all these regional similarities or differences need to be explained ecologically.

## Results and Discussion

For the purpose of this Annual Report, we would like to discuss some of the findings from 5 of the protocols.  We maintain on the web site http://www.zoology.ubc.ca/~krebs/ a detailed EXCEL file (*monitor.xls*) that has all the summarized data from our monitoring efforts at Kluane since 1973.  As indicated in Table 1, many of the protocols have been developed for CEMP only since 2004 and thus regional comparisons within CEMP are limited to the years 2005 to 2009.

### *(a) White Spruce Cone Production*

White spruce produce a variable number of cones each year, and at irregular intervals very large crops are produced in 'mast years'.  We have been counting cones on spruce in the Kluane area since 1986, and Figure 2 shows the variation in



**Figure 2**.  White spruce cone counts on CEMP sites for 2004 to 2009.  Green cones are counted from the top 3 m of a tagged set of trees each August.  Only the cones visible from one side of the tree are counted, so this is an index of cone production, not an absolute measure.  There was a complete cone failure in 2004 at Kluane and in 2006 at all sites. The 2009 count was a nearly complete cone failure as well.
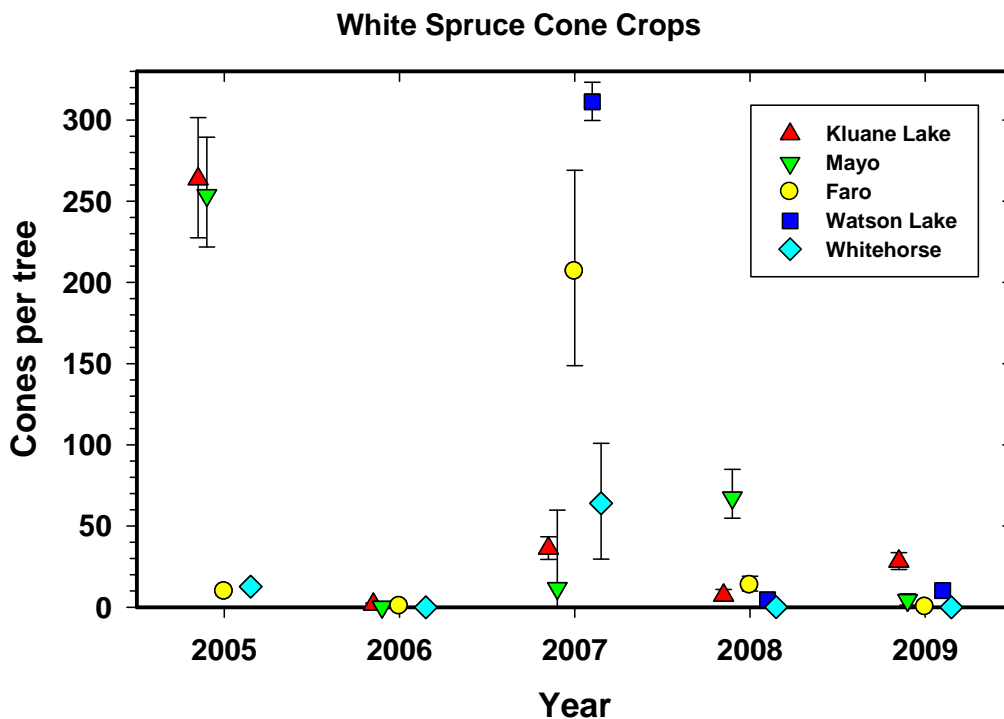
cone counts over the CEMP sampling sites since 2005. The 2005 cone crop was moderate, but the 2006 cone crop was nearly a complete failure at Kluane, Mayo, Watson Lake, and Whitehorse.  If years of high cone production are driven by weather variables, we should soon be able to correlate our weather data with these cone production events.  There is a suggestion of a 5-year cycle in cone crops in the Kluane area, but this cyclic interval is so variable it does not allow for prediction of when the next large cone crop should be expected. We have data on cone crops at Kluane Lake since 1987 but attempts to predict cone crops statistically from summer temperature and rainfall of the previous 2 years have not been very successful. There is some suggestion of a correlation with rainfall in the summer two years before the crop, but the correlation is not strong.

What is surprising about Figure 2 is that all the 4 regional counts show the same pattern of high and low years, and there was a very low crop in summer 2009 at all sites. Further data are required to quantify this regional synchrony in cone crops. Cone counts are highly variable, as Figure 2 shows and different sites within a region can be quite variable. Some of this variability will be reduced when we can achieve larger sample sizes. We recommend counting cones on about 100 trees at each site, but some sites have fewer samples in some years. Because of this variability in cone production, it will take a series of poor years for us to conclude that cone production is failing.  Red squirrels and seed-eating birds might provide a more responsive index of detrimental cone crop changes.
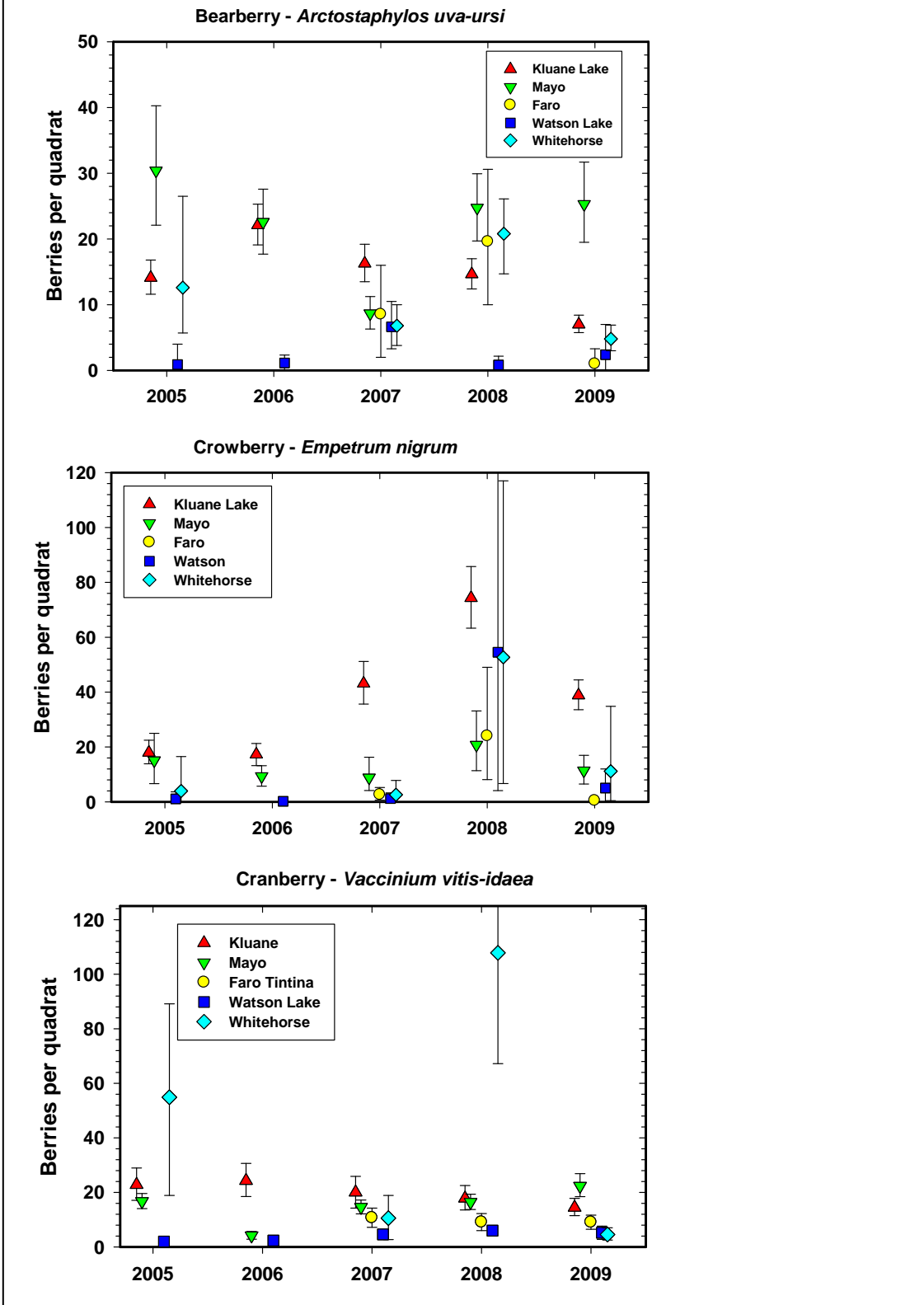
### (b) Ground Berry Production

Five species of ground berries are counted in permanent quadrats each year. The major berry producing plants are bearberry (*Arctostaphylos uva-ursi*), red bearberry (*A. rubra*), crowberry (*Empetrum nigrum*), toadflax (*Geocaulon lividum*), and cranberry (*Vaccinium vitis-idaea*). For each of these species green berries are counted in late July or early August before the berries are harvested by bears, mice, and chipmunks.  Figure 3 shows the data we have accumulated on three of the species of ground berries since 2005.

Bearberry counts are highly variable among the four monitoring areas. In particular Watson Lake sites have very few bearberries for all these years, approximately one-tenth the numbers of Kluane, Mayo, Faro, and Whitehorse. There is some general agreement of year to year variation among the four sites with abundant bearberries but the variation is large enough to require more data to see a clear pattern.

Crowberry counts show a clearer pattern of agreement among all the sites with a high production year only in 2008 and very low counts in the other 4 years. The average production of crowberries at Kluane is 2-3 times that of each of the other 4 sites for these five years of data.

Cranberry counts show yet a different pattern with very low production at Watson Lake sites, low but relatively constant production at Kluane, Mayo and Faro,

**Figure 3**.  Average berry counts for 3 species of ground berries at CEMP sites from 2005 to 2009.

and high counts only at the Whitehorse sites in 2005 and 2008. Whitehorse is the most productive site for cranberries of all our monitoring sites.

We have recently analyzed the climatic controls of ground berry production in the Kluane region from data gathered over 1994 to 2008 (Krebs et al. 2009). Each species of ground berry in the Kluane area responded to different climatic signals of temperature and rainfall, and there was no general climate pattern to which all the species of ground berries responded. Future data will permit us to evaluate whether these predictive climatic equations that seem to operate well in the Kluane area also apply to the other CEMP sites. Our working hypothesis is that ground berries respond to regional weather patterns but that individual berry species require a different suite of weather variables (monthly temperatures, monthly rainfall) from the current and previous years in order to produce a large berry crop.

### (c) Small Rodent Numbers

The most common rodent on all of the CEMP sites is the red-backed vole (*Myodes* = *Clethrionomys rutilus*), and we have estimated the abundance of this species by live trapping, marking, and releasing individuals. Live trapping at Kluane and Whitehorse is done in spring and late summer, and at Mayo only in late summer. Data are not yet available for Watson Lake or Faro. Figure 4 shows the changes in red-backed vole numbers for the period 2005 to 2009.



**Figure 4**. Population estimates for red-backed voles in three CEMP areas, 2005-2009. Trapping grids have an effective trapping area of about 2.81 ha. Summer months are shaded.
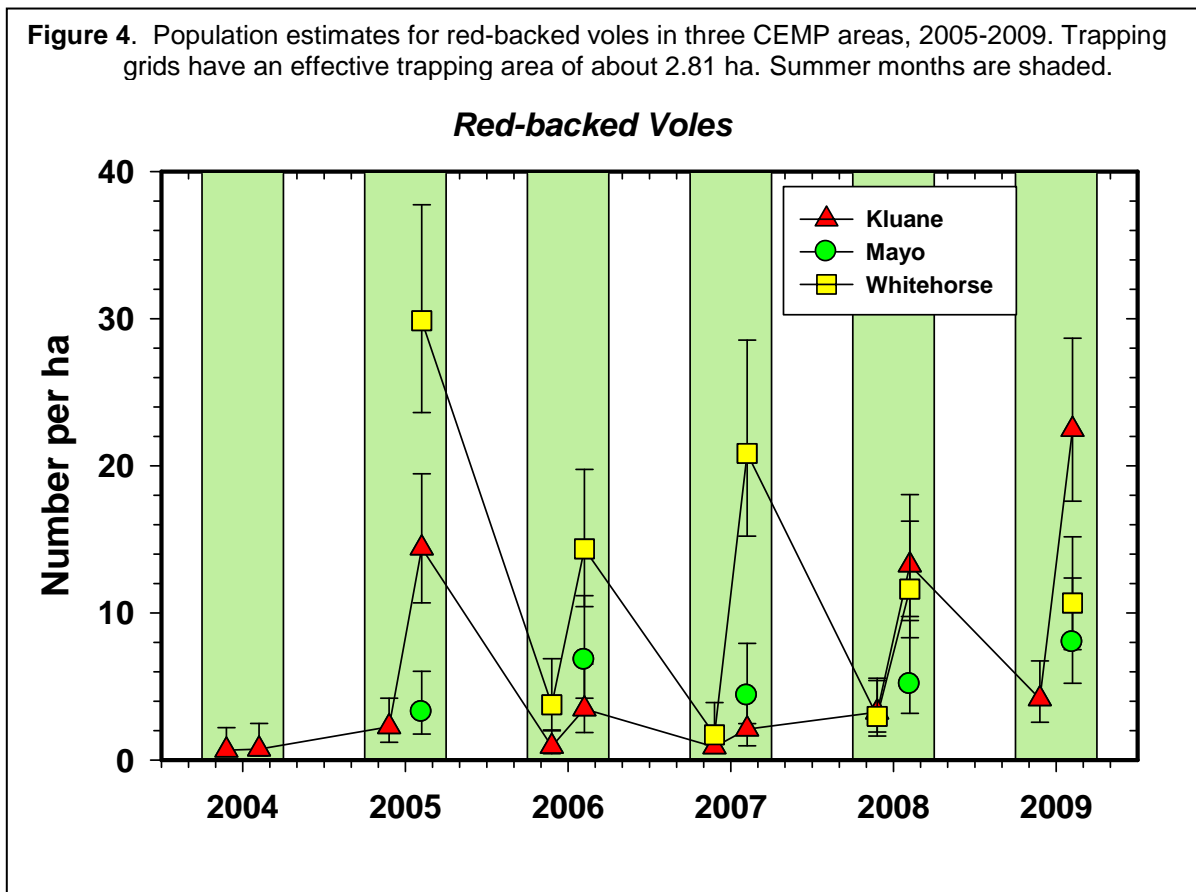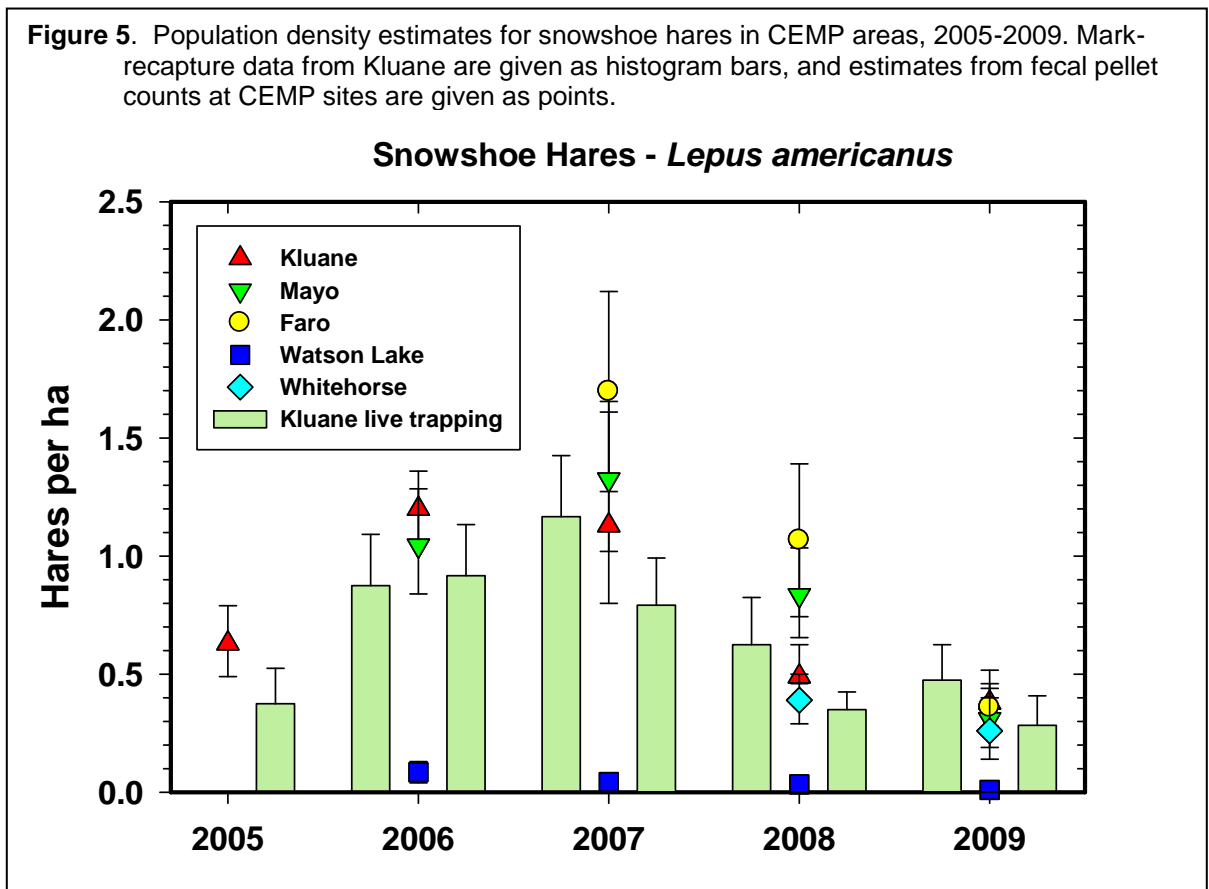
Red-backed voles at Kluane have fluctuated in 3-4 year cycles for the past 25 years and this pattern is shown in Figure 4 with peak years of 2005 and 2008-09. But Mayo populations have been nearly stable from 2005 to 2009, and Whitehorse populations were extremely high in the late summer of 2005 and again in late summer 2007 and less abundant in 2008 and 2009. We do not yet have data from Watson Lake or Faro.

Further data are needed to determine if there a similar pattern of population change in red-backed voles at the different CEMP sites in subsequent years.

The only other small mammal that is common to many of the CEMP sites is the deer mouse, *Peromyscus maniculatus*. At present the number of captures of this rodent species is too low on most of the sites to discuss any common patterns of population change.

### (d) Snowshoe Hare Numbers

The snowshoe hare is a keystone species in much of the boreal forest because it is the prey of so many predators (see Figure 1). Snowshoe hares fluctuate in 9-10 year cycles throughout the boreal zone. At Kluane we have estimated the abundance of snowshoe hares by live trapping, marking, and releasing individuals. We developed a simple census method for hares by the use of fecal pellet counts carried out once a year in early summer (Krebs et al. 2001) and this technique has been used at all the CEMP sites for comparative data. Figure 5 shows the changes in hare numbers since 2004 at the CEMP sites.



**Figure 5**.  Population density estimates for snowshoe hares in CEMP areas, 2005-2009. Mark-recapture data from Kluane are given as histogram bars, and estimates from fecal pellet counts at CEMP sites are given as points.

Two points stand out in Figure 5. First, Watson Lake sites had almost no snowshoe hares in any of the four years. Second, all other CEMP sites are following the Kluane hare cycle closely, with peak populations in 2007 and declining populations in 2008 and 2009. Regional synchrony is well established in snowshoe hares, but not all areas in western Canada and Alaska are in phase. For example, in 2008 Old Crow Flats had high hare populations while CEMP areas were already in decline, and there are reports of high hare populations in the Copper River area of Alaska from 2008 (E. Hofer, pers. comm.). Areas to the south in British Columbia near Smithers are very low in 2009 after reaching a peak in 2002-2003 (Frank Doyle, pers.comm.).

### (e) Arctic Ground Squirrel Abundance

We have been following arctic ground squirrel numbers in the Kluane region since 1973 but have detailed data only since 1990. The most striking recent trend has been a very low population level for ground squirrels. This 'low' has been widespread over much of the southern Yukon, and in the Whitehorse area residents have commented on the low numbers of ground squirrels that have been seen in past summers. We monitor ground squirrels only at Kluane and consequently they do not qualify as a CEMP indicator at the present time, but clearly the patterns shown at Kluane have been more general in parts of the southern Yukon.

In the past ground squirrel numbers have followed the hare cycle with perhaps a slight delay, and the cause of this cycle has been attributed largely to predation. Snowshoe hare predators starve as hare numbers fall and they eat more alternate prey such as ground squirrels, driving down their numbers as well. Spruce grouse are another species that suffer in the decline phase of the hare cycle. So the general pattern of a 9-10 year cycle in arctic ground squirrels in the Kluane area has now been interrupted by a prolonged low phase.

Ground squirrels went locally extinct on the Duke Meadows near Kluane Lake in 2006 and in 2008 Scott Donker began a re-introduction project by moving 29 squirrels into the Duke Meadows in collaboration with the Kluane First Nations. Only one squirrel of those relocated was found there in 2009, and 12 additional ground squirrels were added in late summer 2009 to hopefully bolster the population. The objective of this program is to establish a viable population of arctic ground squirrels in the Duke Meadows in order to support the traditional activities of the Kluane First Nation. Success will be evaluated in 2010 for this re-introduction program.

### (f) Brief Notes on Other Monitoring Measurements and Future Needs

We are in the process of coordinating the monitoring at each of the five CEMP sites. Mushroom production is being estimated at Kluane and Whitehorse and we have expanded coverage to all CEMP sites in 2009. Mushroom production was very low at all sites in 2009 with the exception of Watson Lake.

Soapberries are a favorite food of grizzly bears, and are being counted at Kluane and we have evaluated the feasibility of expanding these counts to the other four CEMP areas in 2009. There are few soapberries on some of our sites. Red squirrel numbers

have been studied extensively at Kluane for years by Stan Boutin's group, and we are evaluating the possibility of using call counts as indices on the other CEMP sites in 2010. Snow track counts in winter for mammalian predators are being done at Kluane and Mayo, and we started them at all CEMP sites in 2009-2010. Bird surveys in the Yukon are being done by other groups, but we would like to coordinate owl survey counts with the BC Owl Survey in future years to get coverage at all CEMP sites.

Our goal in this monitoring program is to develop statistical methods of estimating the abundance and productivity of our seven indicators of ecosystem health for the Yukon boreal forest. We expect all of these to change as the climate alters, and we need to be able to predict how climatic variables do or do not affect our indicators. There are only three ways to determine the impact of climate change – to observe what happens (the passive approach), to monitor changes and try to explain them ecologically, and to develop and use models which include climatic variables to predict what will happen (our active approach). Long-term data sets are essential to this endeavour and we learn as we go along from year to year.

## Local Knowledge Interviews

An important part of our overall CEMP proposal has been to link these specialized ecological measurements with local knowledge interviews in each of the communities. These two approaches provide an important broad way of determining ecological integrity of the Yukon environment. We have planned to conduct these interviews in all the monitoring sites but a shortage of funds has limited the amount we could do with local interviews. Mark O'Donoghue has recently summarized local knowledge interviews in Mayo (O'Donoghue 2010). The strength of the local knowledge interviews is that they give insight into many environmental changes that we best monitor by local knowledge. Many examples are illustrated in the Mayo report – changes in the abundance of wolves, wolverine, moose and deer, as well as changes in the availability of fish and berries for the local population. Changes in winter ice conditions in relation to climate change can be evaluated, as well as general human impacts on wildlife. One summary taken from the Mayo document about the effect of human activities on local wildlife illustrates the additional information that can be obtained by local knowledge interviews:

"The economic downturn caused a number of changes in human activities in the Mayo area in 2008-09.  People interviewed noted less mining exploration, highway tourism, back-country tourism, and aircraft traffic than in the previous two years.  Use of ATVs, aircraft traffic, and mining exploration caused the biggest concerns about their effects on wildlife and subsistence activities of all the activities considered.  Most people interviewed thought that there were cumulative effects of all human activities on wildlife in the Mayo area."

Reports on the larger carnivores can also provide trends, as this quotation shows:

"Relatively few coyotes are seen in most years in the Mayo area, but more people interviewed noted seeing some or lots of coyotes in the last two years [2008-09] than in the three years [2005-07] before that."

It is important that we attempt to continue to utilize local knowledge to help provide the larger picture of changes in Yukon's ecosystems as the climate continues to warm.

Since 2007 a program has been developed by Liz Hofer, Lorne LaRocque, Sam White and Geraldine Pope to monitor Dall sheep on sheep winter range in the Kluane area in response to community-driven interests. This has been another local success with the collaboration of YTG, Parks Canada, Kluane First Nation, and the CEMP program, with assistance from Manfred Hoefs. The objective is to count sheep, observe predators, and evaluate winter range in the Kluane Lake area by ground based surveys that include people from all of the participating groups. As this program develops it will form part of a community based monitoring program for Dall sheep, which are vitally important to the people of the Kluane region, an important component of these mountain ecosystems and an important tourist attraction in the Kluane area.

## Conclusion

In this report we have presented a few of the time series of monitoring results that we have obtained from the CEMP program since it was begun in 2005. With only 5 years of data, our conclusions to date must be tentative, but we have a firm foundation for coordinating these regional data sets. We need to proceed to answer two questions:

(1) How much correlation is there between the Kluane Lake sites and other sites at Mayo, Faro, Watson Lake, and Whitehorse?

(2) How much correlation is there between climatic measurements and biological measurements? For example, can we develop a predictive equation for cone crops from temperature and precipitation data that will apply across all CEMP sites?

The database management system for CEMP is well set up, and we have developed a good group of workers with skills to make the needed measurements. With the data we have gathered and will continue to gather, we can begin to address the important management issues for the southern and central Yukon and to provide a detailed assessment of how climate change is affecting biodiversity in the boreal forest ecosystem in this part of the Yukon. In connection with local knowledge interviews a broad picture of how the environment is changing will emerge from these efforts.

## Acknowledgements

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