

THE COMMUNITY ECOLOGICAL MONITORING PROGRAM ANNUAL REPORT 2010

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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 third 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 extremely high in 2010, following the last high cone years of 2005 and 2007. Ground berries in the forest were moderate in 2010, and in general higher than they were in 2009. Red-backed voles declined to low numbers in 2010 at Kluane and were generally low at other sites except for Faro. Snowshoe hares continued to decline on all areas in 2010 and are at the bottom of their 10-year cycle. Mushroom production was very low at all sites in 2010 with the exception of Mayo. Soapberries were relatively abundant at Kluane Lake in 2010 but have not been counted elsewhere. 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 remained low except marten and weasels which increased in the winter of 2009-10. 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 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?

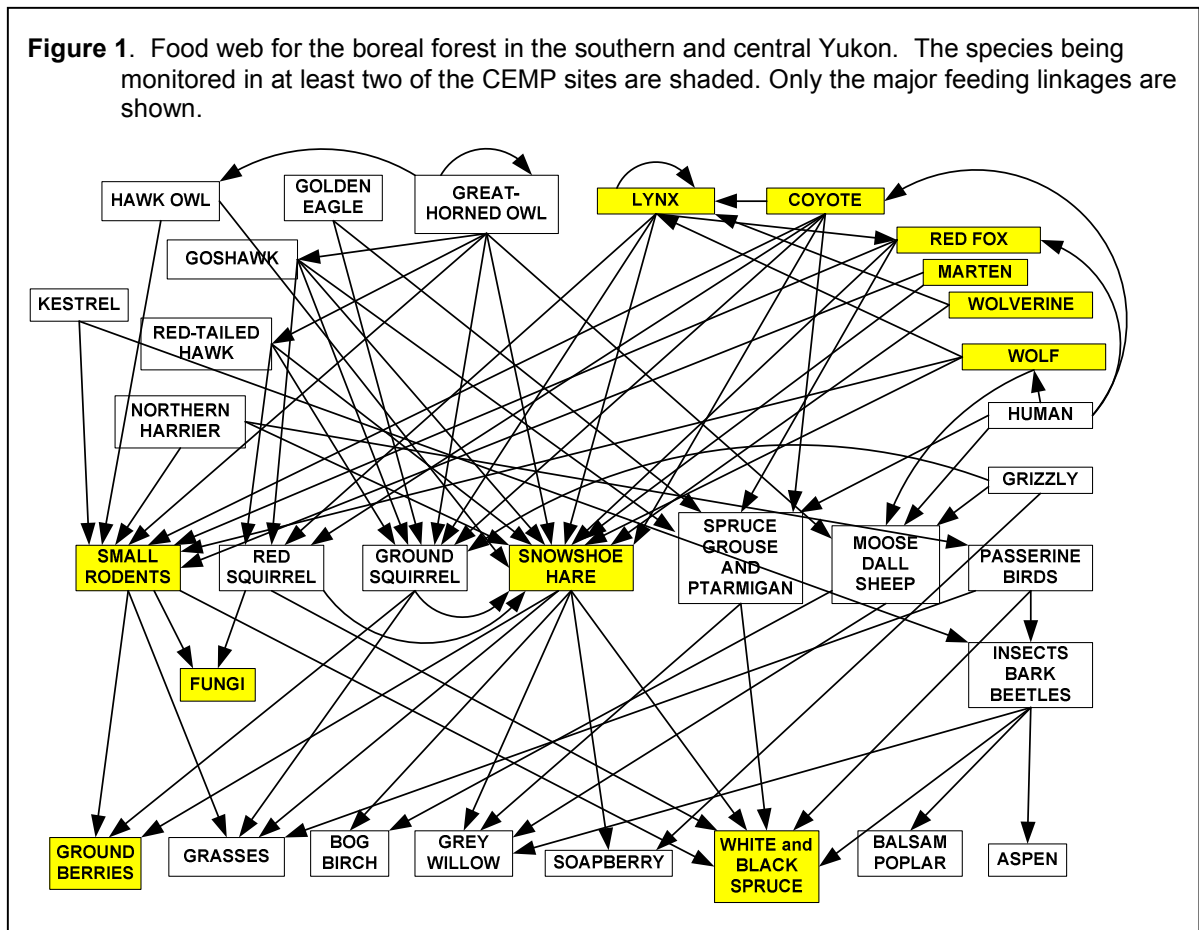
There are only three approaches ecologists are using to answer this broad question. First, sit and count, wait and see. This is the simplest approach to describe the system as it changes. As such it does not permit any management actions to thwart changes, since, by the time you see changes, it is too 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 CO₂ 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 identify key components of the ecosystem that appear to be responding rapidly to climate change and target them for experimental attack or more in-depth studies to try to understand the underlying complexity. This requires intense multi-year research, best carried out by graduate students. 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 needed. 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



everything, and we have concentrated our efforts on 6 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 6 indicators that are being

monitored are listed below, and a suggestion to add soapberry monitoring is 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, bears 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.

We have prepared a separate handbook of the details of the monitoring protocols for each of the species groups listed above (CEMP Monitoring, 2010, available on the web at <http://www.zoology.ubc.ca/~krebs/kluane.html>).

In addition to these 6 protocols, a number of research and management projects are being conducted in the Yukon (e.g. the Breeding Bird Survey, Christmas Bird Counts, Owl Surveys). 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.

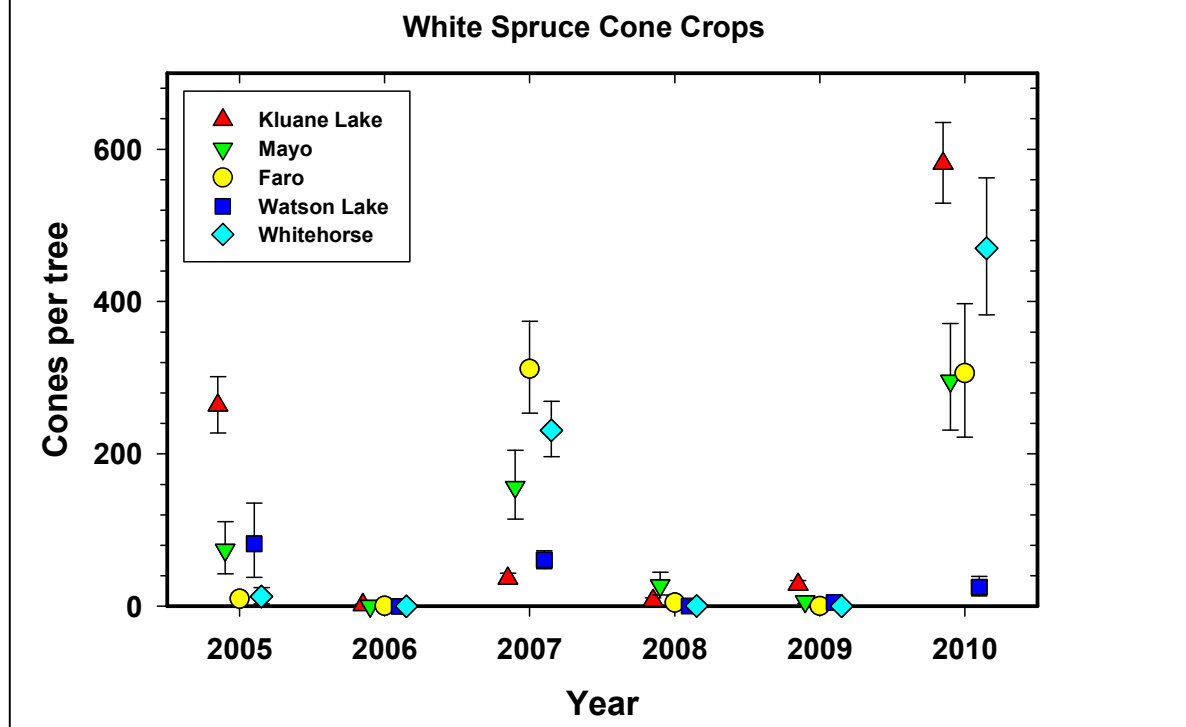
Results and Discussion

For the purpose of this Annual Report, we would like to discuss some of the findings from 5 of the protocols. The Predator Abundance data are not presented in detail because we have too few data from all the sites for comparison. We maintain on the web site <http://www.zoology.ubc.ca/~krebs/kluane.html> a detailed EXCEL file (*monitor.xls*) that has all the summarized data from all 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. In the figures that follow we report means and 95 % confidence limits unless indicated otherwise.

(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 2005 to 2010. 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 2006, 2008, and 2009 at all sites. The 2010 count was the largest we have seen during the last 25 years.



cone counts over the CEMP sampling sites since 2005. The 2005 and 2007 cone crops were moderate, but the 2006, 2008 and 2009 cone crops were 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 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 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 were very high crops in summer 2010 at all sites except Watson Lake. Many of the spruce trees in 2010 had so many cones the cones had to be counted on photographs on a computer. Figure 3 shows a typical white spruce tree. Further data are required to quantify the regional synchrony in

Figure 3. A white spruce heavily laden with cones, August 2010. Counts were counted on 873 individually marked trees in 2010. This tree had 2118 cones visible.



Photo: Alice Kenney

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. Because of this variability in cone production, it will take a series of several poor years (> 7) in a row 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 4 shows the data we have accumulated on three of the species of ground berries since 2005.

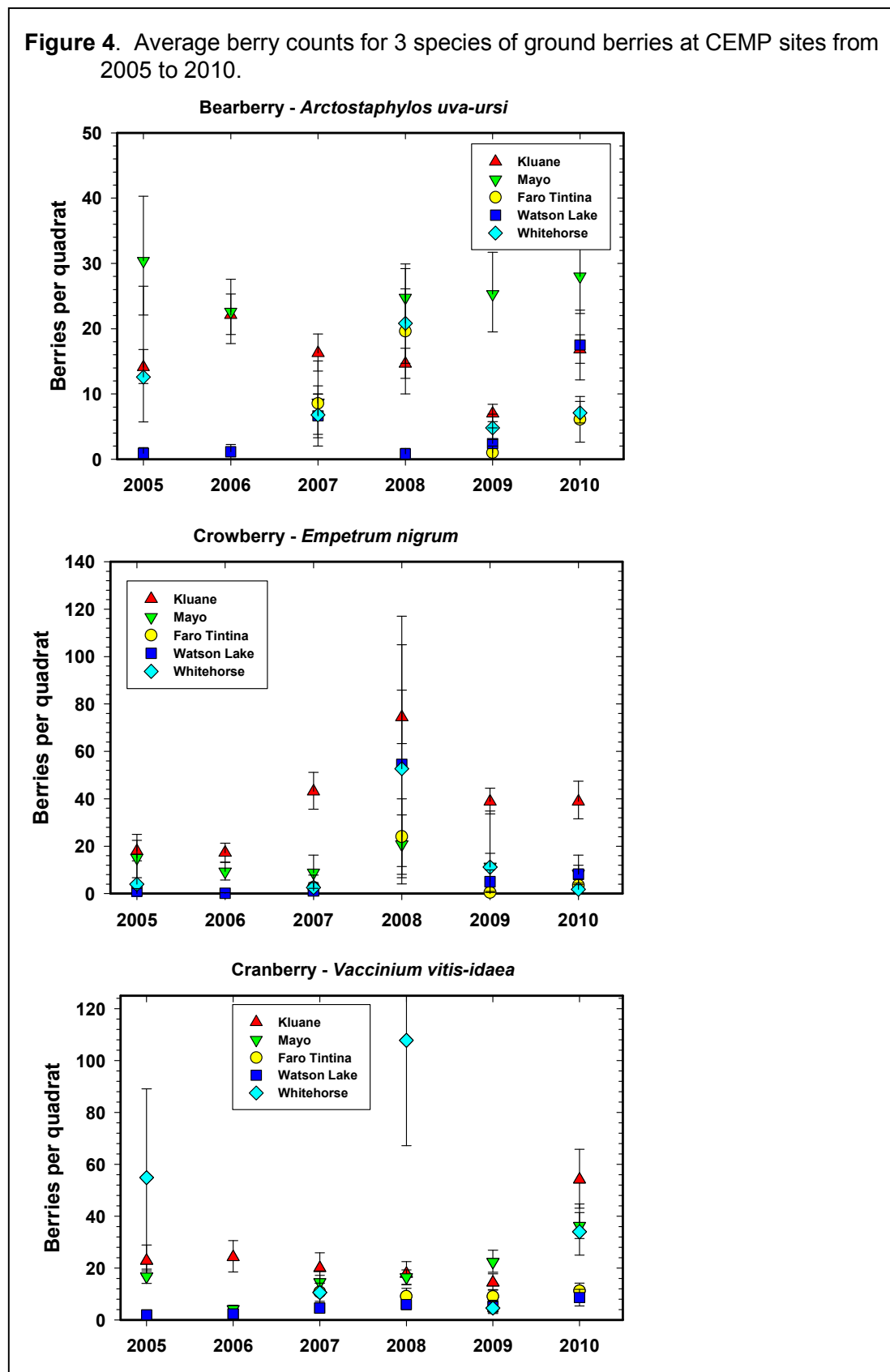
Bearberry counts are highly variable among the five monitoring areas. In particular Watson Lake sites had very few bearberries for all these years until 2010. Mayo has the most consistently high counts of bearberries. There were slightly more bearberries on all the sites in 2010 than in 2009. The pattern of change is similar among sites between years but the variation is large enough to require more data to see if there is a clear pattern or if local processes (e.g. at Mayo) determine berry production in this species.

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 six years of data, and all sites except Kluane were relatively low in 2010.

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, and a general trend to increased counts in 2010 in all areas with a higher than average count at Kluane. Whitehorse had the highest counts so far recorded in 2008 but in other years Whitehorse has been similar in production to the other sites.

We have recently analyzed the climatic controls of ground berry production in the Kluane region from data gathered over 1994 to 2008 resulting in climatic equations relating berry production to climate (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.

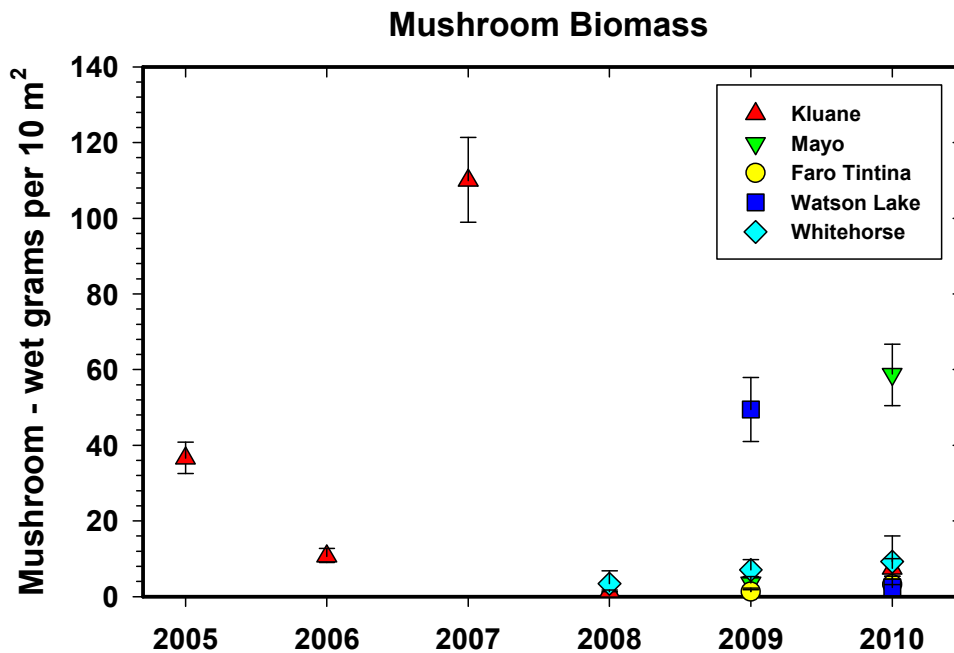
Figure 4. Average berry counts for 3 species of ground berries at CEMP sites from 2005 to 2010.



(c) Mushroom Production

Since 2008 we have begun monitoring aboveground mushroom production on several of the CEMP sites. Data on mushroom production from Kluane Lake has been collected since 1995 and we have published a climate model to predict mushroom crops (Krebs et al. 2008). Figure 5 shows the aboveground biomass of mushrooms for the CEMP sites. Mushrooms were extremely abundant at Kluane in 2007 and have since been very scarce. Moderate to high mushroom abundance was evident at Watson Lake in 2009 and at Mayo in 2010, while all other sites had low production. As we accumulate more data from all the CEMP sites in the next few years we will be able to test the climate model developed for Kluane to determine its generality.

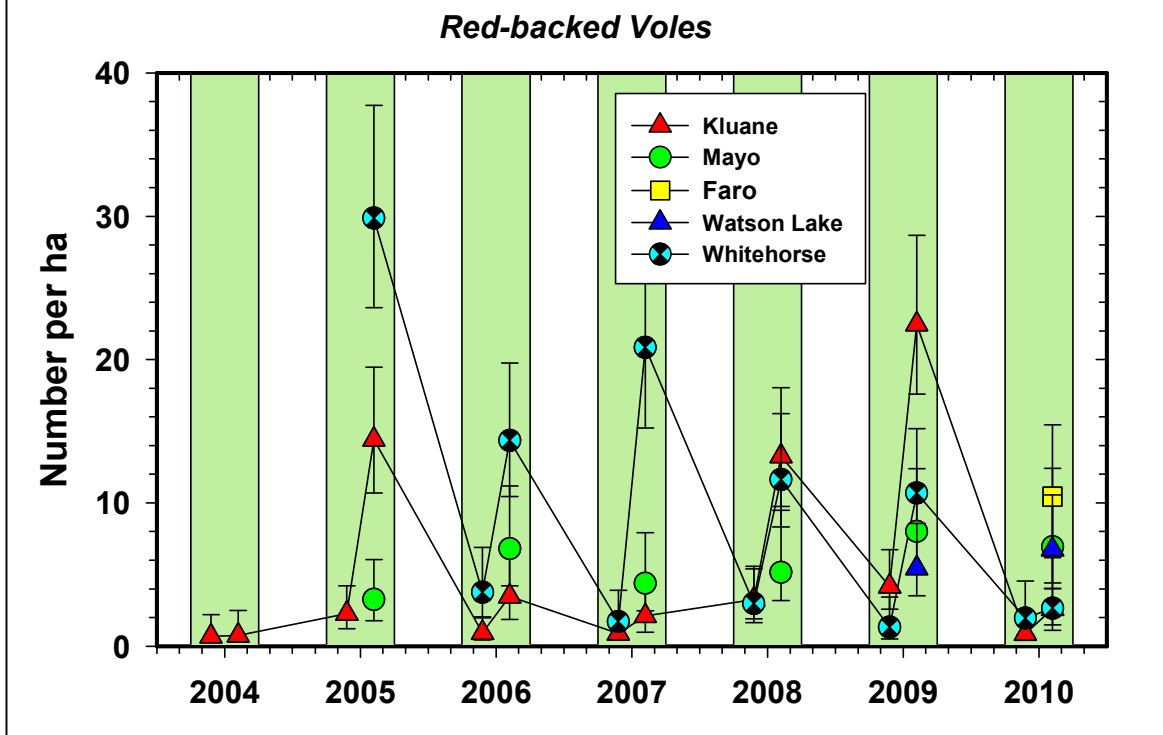
Figure 5. Aboveground mushroom biomass in early August (g wet weight per 10 m²). Kluane sites have been measured since 1993. Other sites were added in 2008 and 2009.



(d) 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, Faro, and Watson Lake only in late summer. Figure 6 shows the changes in red-backed vole numbers for the period 2004 to 2010.

Figure 6. Population estimates for red-backed voles in three CEMP areas, 2004-2010. Trapping grids have an effective trapping area of about 3 ha. Summer months are shaded.



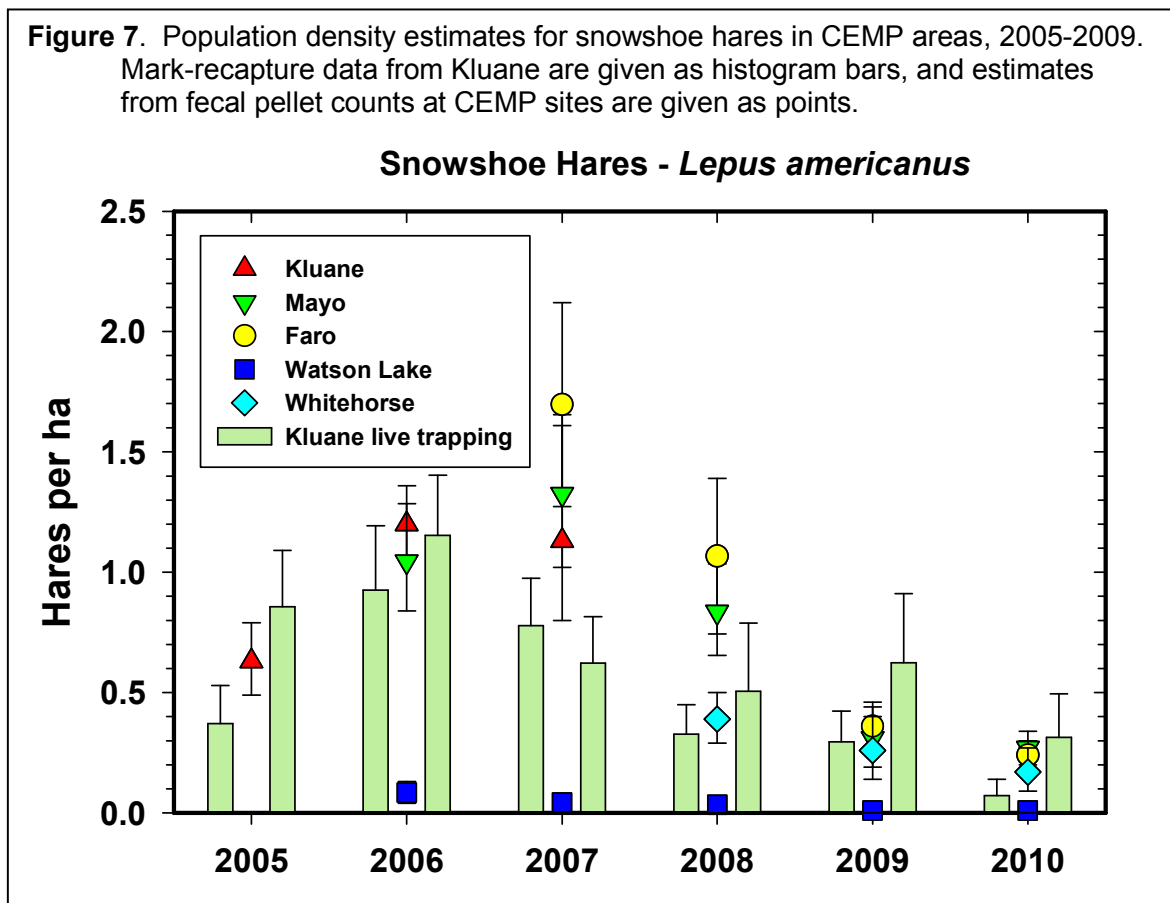
Red-backed voles at Kluane have fluctuated in 3-4 year cycles for the past 25 years and this pattern is shown in Figure 5 with peak years of 2005 and 2009. But Mayo populations have been nearly stable from 2005 to 2010, and Whitehorse populations were extremely high in the late summer of 2005 and again in late summer 2007, less abundant in 2008 and 2009, and at low ebb in 2010. The pattern to date does not suggest any synchrony in fluctuations of red-backed vole numbers in the southern and central Yukon. Further data are needed to determine if this asynchrony continues in red-backed vole populations 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. Deer mice remained between 1-3 per ha on all sites from 2005 to 2010.

(e) 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 7 shows the changes in hare numbers since 2005 at the CEMP sites.



Two points stand out in Figure 7. First, Watson Lake sites had almost no snowshoe hares in any of the five years. Second, all other CEMP sites are following the Kluane hare cycle closely, with peak populations in 2006-7 and declining populations in 2008, 2009, and 2010. The hare population at Kluane showed a strong increase over the summer of 2009, but this increase was trimmed back to low numbers by the spring of 2010. 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 (as did the Denali region in Alaska) while CEMP areas were already in decline. There were reports of high hare populations in the Copper River area of Alaska from 2008 (E. Hofer, pers. comm.), but a suggestion of a decline in the last year. Areas to the south in British Columbia near Smithers are very low in 2009-2010 after reaching a peak in 2002-2003 (Frank Doyle, pers. comm.).

(f) Arctic Ground Squirrel Abundance

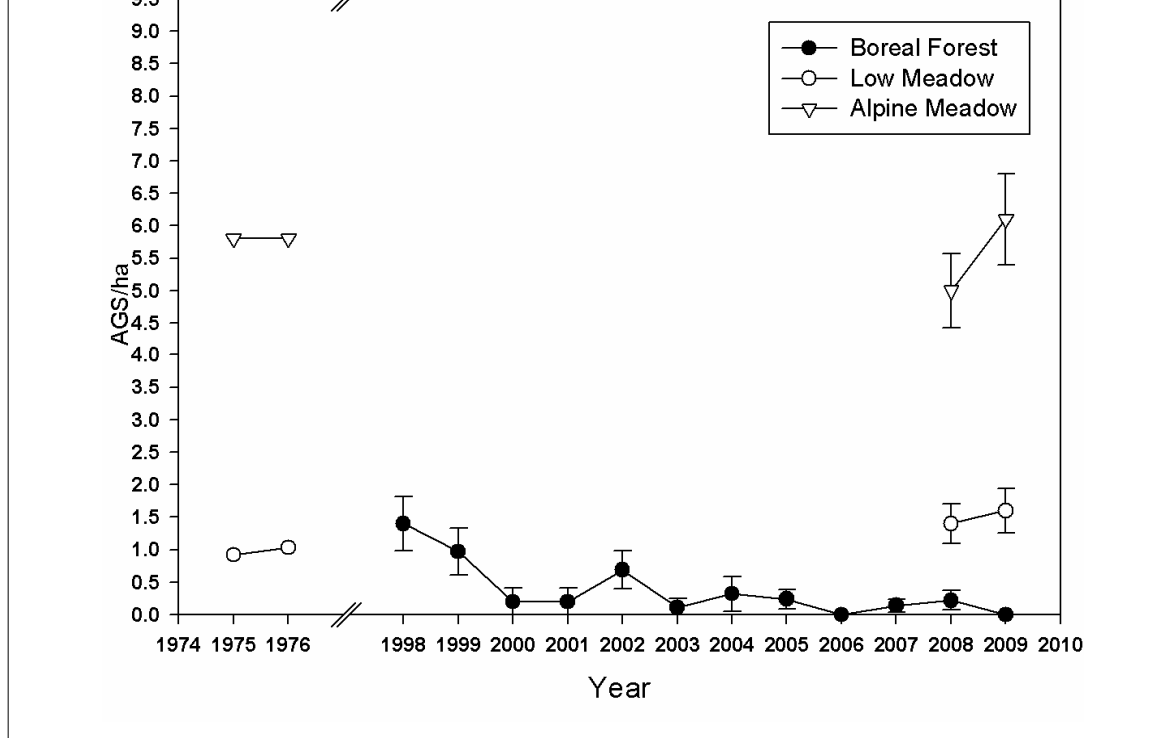
We have been following arctic ground squirrel numbers in the Kluane region since 1973 but have detailed data only since 1990. The most striking recent trend has been a very low population level for ground squirrels. This 'low' has been widespread over much of the southern Yukon, and in the Whitehorse 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 Nation. Only one squirrel of those relocated was found there in 2009, and 12 additional ground squirrels were added in late summer 2009 to 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.

Donker (2010) investigated ground squirrel populations at the landscape scale in 2008-2010. He found high populations in all the alpine tundra sites he surveyed and very low populations in all the boreal forest sites (Figure 8). Low elevation meadows had some ground squirrels but not in high abundance. Notably the alpine populations Donker studied were at the same high density recorded by Jeff Green in the 1970s (Green 1977). Scott Donker concluded that the boreal forest may be functioning as a sink habitat with high mortality and that low elevation and alpine meadows are population sources with lower mortality. The implication is that over the next several years ground squirrels will re-colonize the boreal forest from healthy alpine populations.

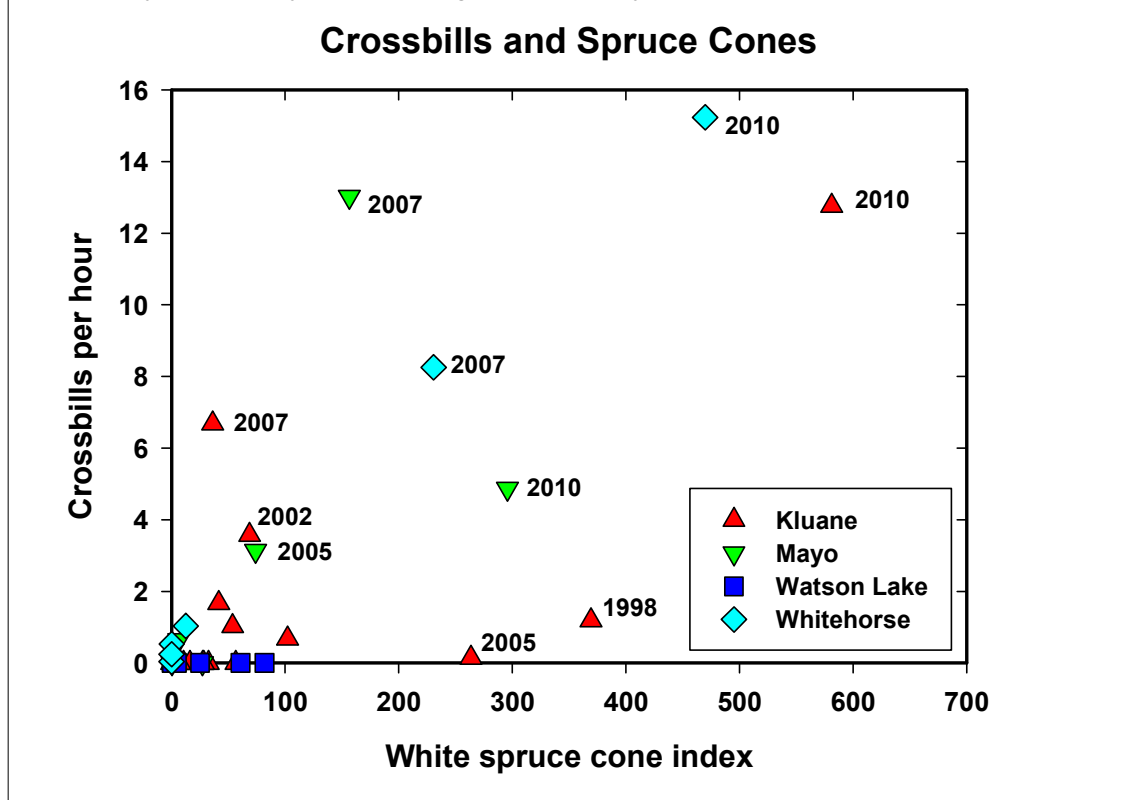
Figure 8. Density estimates (no. per ha) of arctic ground squirrels in three different habitat types in the Kluane region, Yukon. Bars represent 1 SE. (1975-1976 data from Green (1977), Boreal data from Krebs et al. 2009, unpubl.) (Source: Donker 2010.)



(g) Crossbill Numbers

White-winged crossbills and red crossbills feed on white spruce seeds and are highly migratory so that they appear in large numbers in winters of major seed falls. We have correlated the Christmas Bird Counts at Mayo, Haines Junction, Watson Lake and Whitehorse with our observed white spruce cone crop index to see if crossbill counts follow our cone crops. Figure 8 shows the correlation based on the data we have. While Whitehorse and Mayo show the expected high correlation, Kluane is rather more scattered. In some years like 2005 Kluane cone crops were substantial but only a few crossbills were tallied. We presume this is a reflection of the failure of migrating crossbills to locate all areas of good cone crops. Since 2010 was such a high year for spruce cone production, we expected large numbers of crossbills to show up in the Christmas 2010 counts and this was the case except for Watson Lake. We will continue in future years to see if crossbills respond to cone crops at our monitoring sites.

Figure 9. Christmas Bird Counts of white-winged and red crossbills in relation to white spruce cone counts in the southern and central Yukon. Cone counts began at Mayo, Watson Lake, and Whitehorse in 2005 and in 1987 at Kluane. The cone crop in summer of year t is correlated with the bird count of Xmas of year t . The years on the graph are the year of Christmas.



(h) 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. Changes in personnel have complicated keeping the protocols for data collection in the field completely standardized. Fortunately 2010 was a time of improvement in coordination of the monitoring program, and we are now trying to adjust to the differences among the sites and the data needs of each site.

Soapberries are a favourite 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 2010. Soapberry counts began at Mayo in 2010. We place a high priority on counting soapberries in all sites by 2011. There are few soapberries on some of our sites which makes this a challenge. Red squirrel numbers have been studied extensively at Kluane for years by Stan Boutin's group, and we are evaluating the possibility of using midden counts or call counts as indices on the other CEMP sites. Snow track counts in winter for mammalian predators are critical for

understanding predator changes and have been done at Kluane and Mayo; we started them at most CEMP sites in 2009-2010, and will begin in Whitehorse in 2010-11. 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 six 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 2011). The strength of the local knowledge interviews is that they give insight into many environmental changes that we best monitor by local knowledge and on the impacts of these changes on rural people. They also place the results we find from our technical monitoring in the larger context of the whole regional landscape. 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:

People interviewed in the Mayo area noted that 2009 was warm and dry from spring to fall compared to the past, and this was followed by a warm winter with little snow. Spring break-up of ice was early and quick and the fall freeze-up was late. The dry weather led to few mushrooms and generally poor berry crops, especially blueberries, and there were few cones on spruce trees. The salmon run was fairly good, but hunters had a harder time finding moose in the fall. Low snow levels in the winter also led to moose staying up high in the mountains through most of the winter. People interviewed noted fewer mosquitoes and hornets than usual, and lower numbers of grouse, red squirrels, marten, and deer. Snowshoe hares are at a cyclical low and numbers of their predators, especially lynx, also declined. Species that had been increasing in recent years—swans and porcupines—remained abundant, but the interviews suggested the increases may have levelled off. Mining exploration and use

of off-road vehicles increased in the Mayo area, leading to some concerns about their impacts on wildlife and the environment.

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 6 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? We have seen that, for example, mushroom abundance can vary greatly between sites, yet snowshoe hare numbers are highly correlated among sites.
- (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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plentiful and we are grateful for the support we have received. We thank all the people who toiled under the summer sun and rain to produce the data tallied here, with special mention this year to Libby Anderson, Peter Upton, Marina Milligan, Todd Heakes, and members of the Y2C2 Green Team. We thank everyone who has counted birds in the Christmas Bird Counts for the crossbill data used in Figure 9. For comments, additions or corrections on this report please contact krebs@zoology.ubc.ca.

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