THE COMMUNITY ECOLOGICAL MONITORING PROGRAM ANNUAL DATA REPORT 2019

Charles J. Krebs, Tom Jung, Mark O'Donoghue, Piia Kukka, Scott Gilbert, Shawn Taylor, Alexandra Francis, Rudy Boonstra, Stan Boutin, and Alice J. Kenney

Key Ecosystem Changes in 2019

- White spruce cone crop high only at Kluane and Whitehorse
- Ground berry crops and soapberries low in almost all areas
- Mushrooms scarce at most areas but abundant at Kluane
- Snowshoe hares declining with poor reproductive success
- Red squirrels at Kluane at record low numbers with little reproduction
- Small rodents at very low numbers
- Lynx declining but still common but coyotes have declined to low numbers
- Marten very low at Kluane and scarce at Mayo

Executive Summary

To determine how the boreal forest ecosystem will respond to climate change we have been monitoring white spruce cone crops, ground berry production, mushroom abundance, small mammals, snowshoe hares, and carnivore abundance at Kluane Lake, Mayo, Faro, Watson Lake, and Whitehorse. This is the 20th annual report to summarize these data. 2019 was an extraordinary year. White spruce cone counts were very high at Kluane and Whitehorse in 2019 but very low at other sites. Ground berries in the forest were moderate to low in 2019 with some variability in berry counts from site to site. Soapberries were few in 2019 at Whitehorse, and low also at Mayo and Kluane. Red-backed voles declined to low numbers at Kluane in 2019 and remained at low densities at all other CEMP areas for 2019. Snowshoe hares declined 65% from Fall 2018 to Fall 2019 in all areas except Whitehorse and Watson Lake, which have perennial very low hare abundance on the CEMP sites. The hare decline in the southern Yukon should be accelerating in winter 2019-20 with lynx still common. Red squirrels were at low numbers in 2019 and failed to produce any successful litters until a few young were produced late in the summer. Snow track counts in winter 2018-19 for mammalian predators were completed at Kluane and Mayo, but poor snow conditions prevented predator snow tracking at Faro and Watson Lake. Marten numbers dropped off dramatically in 2019 at Kluane and Mayo, and weasel numbers collapsed at both sites. We continue to investigate whether remote cameras can substitute for snow tracking to census mobile predators and possibly moose and bears in the Kluane region on KFN and CAFN territory. In 2019, 59,874 photos of animals from 80 cameras were classified. The climate models we have developed can make predictions of how the

monitored mushroom and plant populations will perform in 2020, and a table of predictions for 2020 is provided, along with the predicted and observed results for 2019. As we accumulate more data, these models should become more and more precise in their predictions.

Introduction

Since detailed ecological studies of the Kluane boreal forest began in 1973 we have been monitoring the ecological integrity of the Kluane region on the traditional territories of KFN and CAFN, 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 has permitted us to focus on regional trends in measures of ecosystem health and change. The Community Ecological Monitoring Program (CEMP) is a partnership between biologists at Environment Yukon, Yukon College, and the Outpost Research Station at Kluane Lake. Additional monitoring in the Yukon is being done by Parks Canada and other research groups but we have not tried to summarize all this monitoring here. We concentrate here on the CEMP monitoring being carried out in the central and southern Yukon.

Why Monitoring is Needed and our Goals

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 like spruce cone crops 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 the question then becomes will climate change affect predator hunting success and if so how?

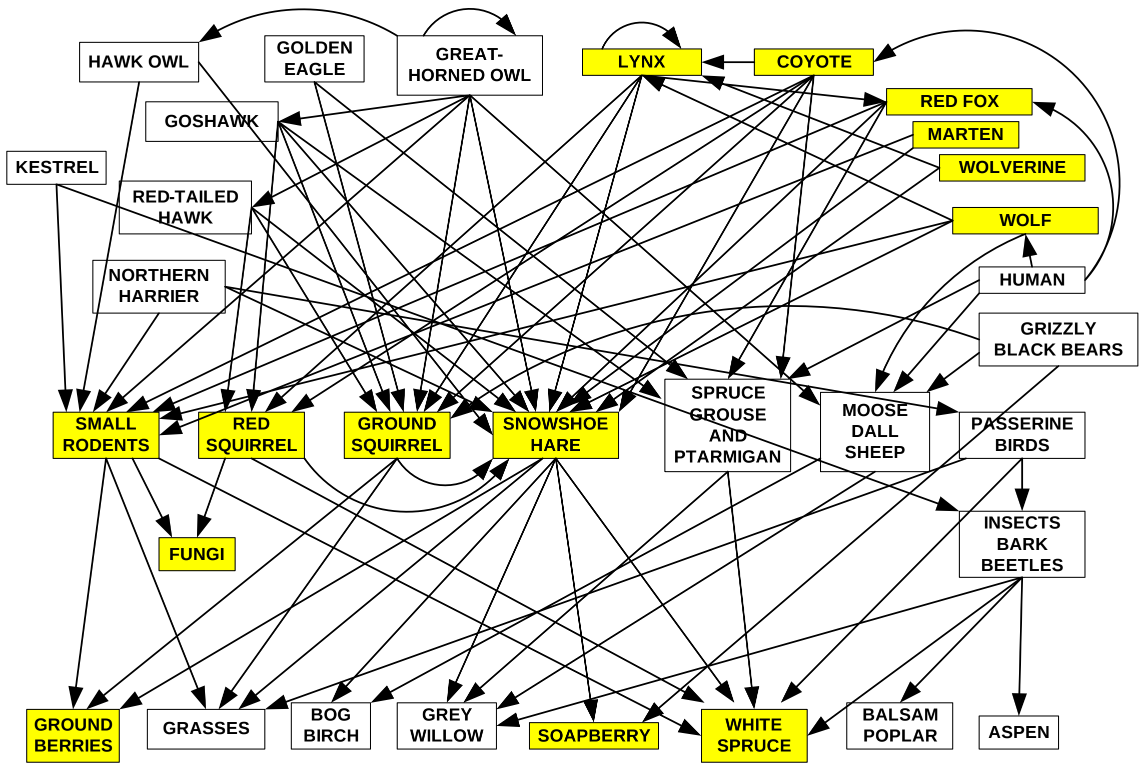
The key to these approaches is to have a comprehensive monitoring program in place that gathers data year after year. We cannot start and stop monitoring programs for a few years any more than we can stop and start reporting on the stock market for a few years. The need is thus for a commitment in funding 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 the significant indicators highlighted below. We believe that these indicators constitute a start for obtaining early warning of ecosystem change, establishing baseline data on the natural range of variation of key ecosystem components, evaluating forest management practices, and advancing our understanding of the dynamics of boreal ecosystems. The species that are being monitored are indicated by shading in Figure 1. We do not have the funding to monitor large mammals like bears, moose, caribou, and Dall sheep directly, and these large mammals are monitored by other programs in Environment Yukon and by First Nations.

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

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. Only the major feeding linkages are shown.



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

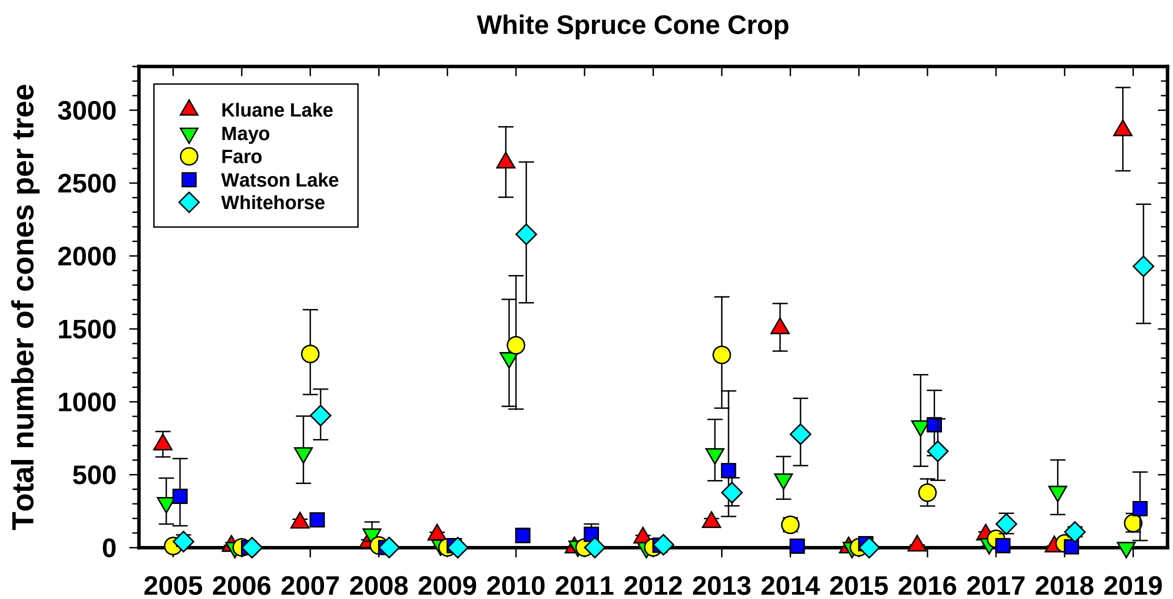
For the purpose of this Annual Report, we would like to discuss some of the findings from the main protocols. We maintain on the web site http://www.zoology.ubc.ca/~krebs/kluane.html a detailed EXCEL file (*monitor.xlsx*) that has all the summarized data from all our monitoring efforts at Kluane since 1973. In the figures that follow we report means and 95 % confidence limits unless indicated otherwise.

(a) White Spruce Cone Production

White spruce trees 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 1987, and Figure 2 shows the cone counts over the CEMP sampling sites since 2005. The 2005 and 2007 cone crops were moderate, but the 2006, 2008, 2009, 2011, 2012, 2015, and 2017 cone crops were nearly a complete failure at all our study sites. If years of high cone production are driven by weather variables, we should be able to correlate our weather data with these cone production events.

There is a suggestion that large cone crops in white spruce are occurring more frequently in recent years. Large cone crops since 2006 have tended to occur at intervals of 2-4 years while those prior to 2006 were 5-7 years apart. Based on this pattern we expected high cone counts on many sites in 2018 or 2019. The actual cone counts in 2019 followed the modelled predicted values fairly closely with low cone

Figure 2. Average white spruce cone counts on CEMP sites for 2005 to 2019. Green cones are counted from the top 3 m of a tagged set of trees each August. These index counts are converted to total cones per tree by the LaMontagne conversion (LaMontagne et al. 2005). There was a complete cone failure in 2006, 2008, 2009, 2011, 2012, 2015 and 2017 at all sites.



counts at Mayo, moderate counts at Faro and Watson Lake, and high cone counts at Kluane and Whitehorse (Figure 2). Red squirrels and seed-eating birds should provide a responsive index of more frequent cone crops. Crossbills were very common at Whitehorse and Kluane in 2019, in association with the high cone crop in those areas.

We recalculated the predictive regression for white spruce cone counts in 2016 (Krebs et al. 2017). The two key variables remain as the mean temperature in July of 1 and 2 years prior to the actual cone crop. No rainfall variable was a significant predictor. The cone crop predictions for 2019 were close to the observed counts. We used this regression to predict cone counts for 2020 from the weather data of 2018 and 2019 (see Table 2 on page 16). All areas should expect relatively low cone counts in 2020.

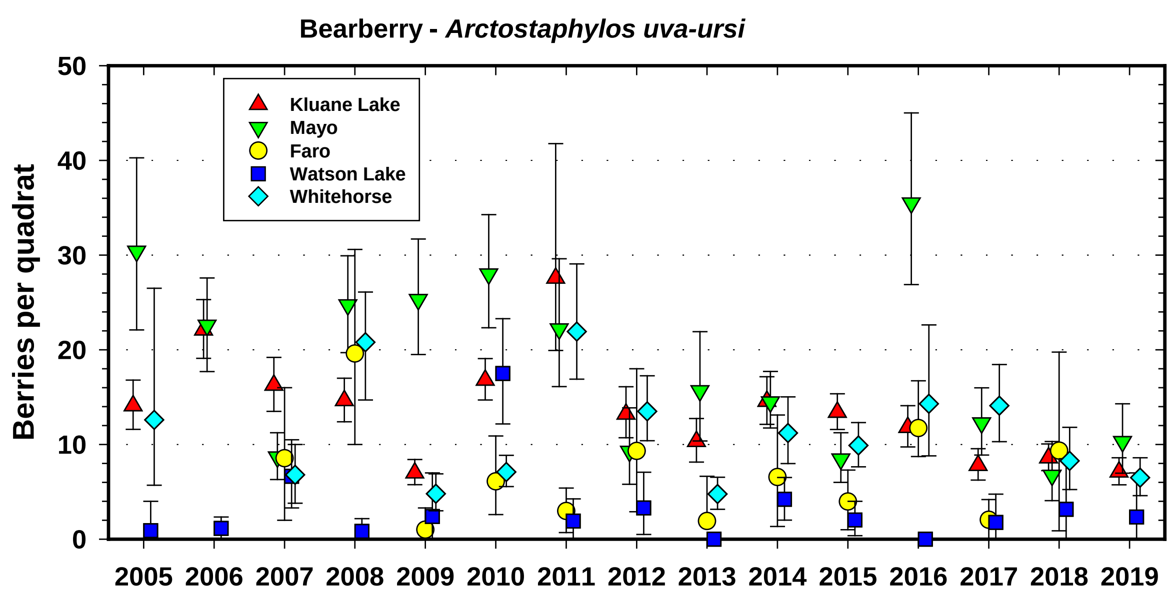
(b) Ground Berry Production

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*). We use permanent quadrats for our counts because in any particular area it is possible for some small patches of berries to be abundant when the general landscape has few berries overall. Figure 3 shows the data we have accumulated on three of the species of ground berries since 2005.

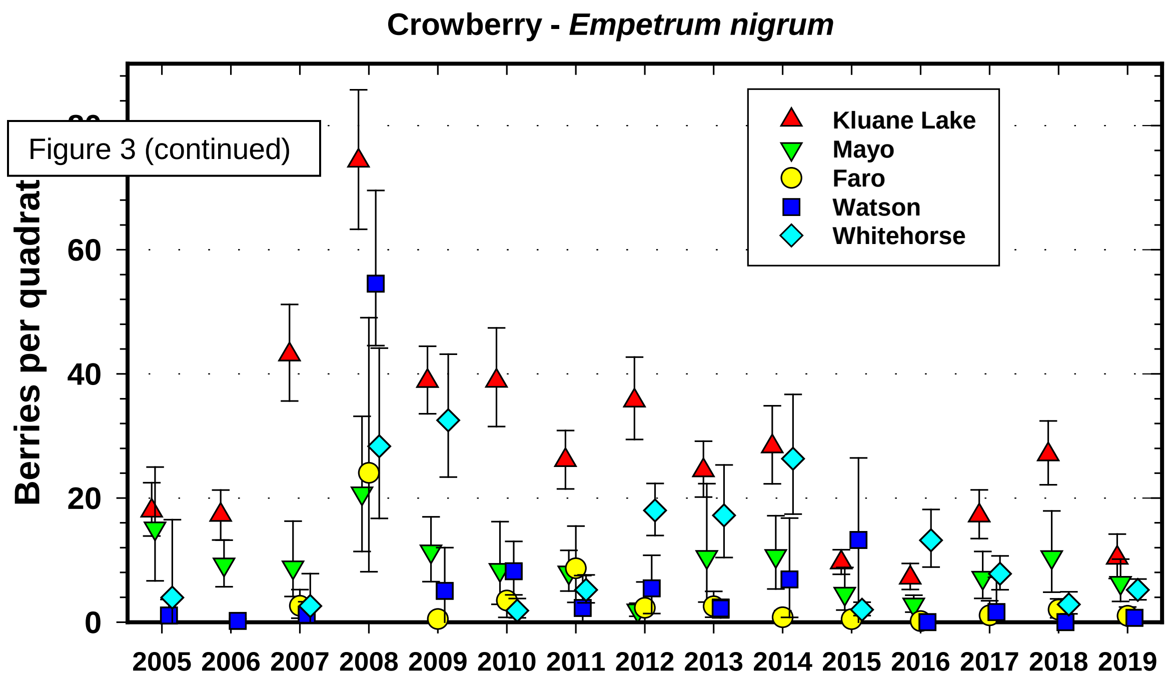
Bearberry counts can be highly variable among the monitoring areas but in 2019 all five sites had few bearberries, like 2018. The emerging pattern is a long-term trend toward reduced bearberry crops since 2011 (although Mayo had a high count in 2016).

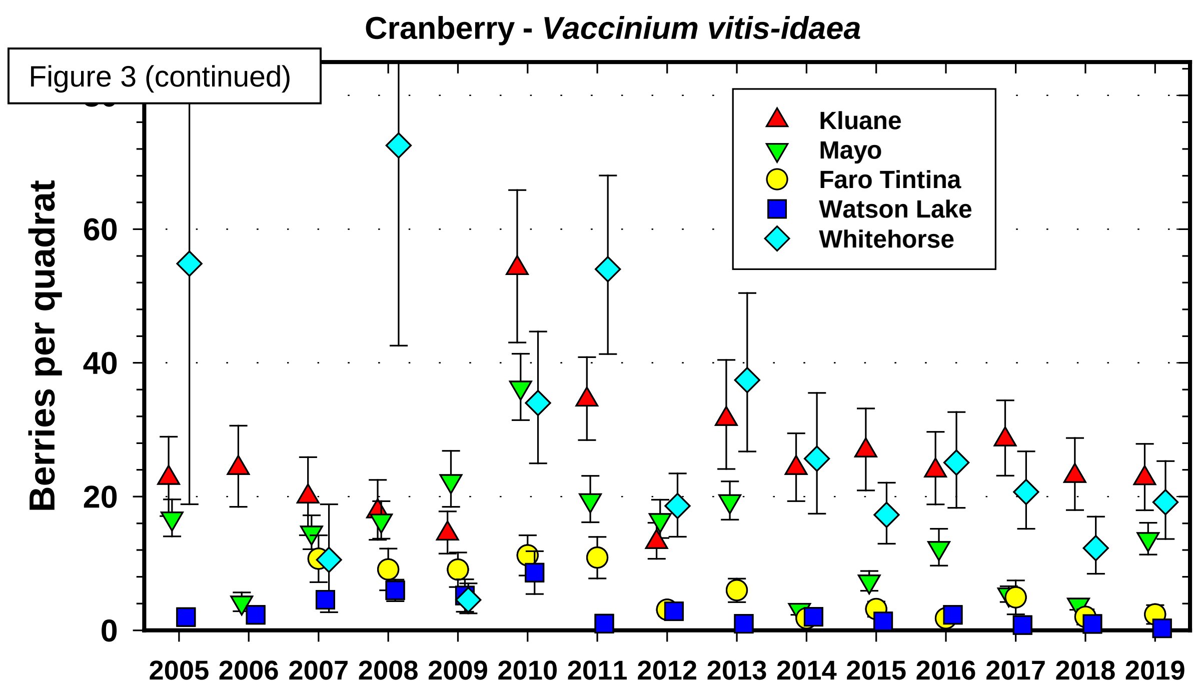
Crowberry counts show a clearer pattern of agreement among most of the sites with a high production year only in 2008 and lower counts in the last 10 years with a suggested continuing decrease in production in recent years all over the southern

Figure 3. Average berry counts for 3 species of ground berries at CEMP sites from 2005 to 2019 Quadrat size is 40 by 40 cm. Error bars are 95% confidence intervals.



Yukon. Crowberry counts on all sites were low in 2019.





Cranberry counts show yet a different pattern with moderate production at Whitehorse and Kluane in all the years from 2014 to 2019, and moderate counts at Mayo in 2019. Faro and Watson Lake counts were near zero in 2019. There is no clear general regional pattern to these cranberry counts. We have seen no repeat of the 2008 high cranberry counts in Whitehorse, and moderate counts were found only at Whitehorse and Kluane from 2014 to 2019. The only regional pattern for all these three species is the trend to lower counts over the last 4-5 years, compared with the previous 5 years, with an occasional good year in only one species at one site (like bearberry at Mayo in 2016). Red bearberry has been in decline at both Kluane and Mayo over the last 9 years.

We have re-analyzed the climatic controls of ground berry production in the Kluane region from data gathered over 1994 to 2016 resulting in equations relating berry production to climate that update those given in Krebs et al. (2009). Each species of ground berry in the Kluane area responded to different signals of temperature and rainfall, and there was no general climate pattern to which all the species of ground berries responded. 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. An alternative and important view is that pollinator abundance has a strong influence on berry crops in correlation with weather, but at present we have no data on pollinator abundance from the southern Yukon. A second alternative view is that small mammals feeding on berry flowers in spring reduce potential berry crops (S. Sotorra, video observations), which would lead to the prediction of high berry crops in low vole years.

(c) Small Rodent Numbers

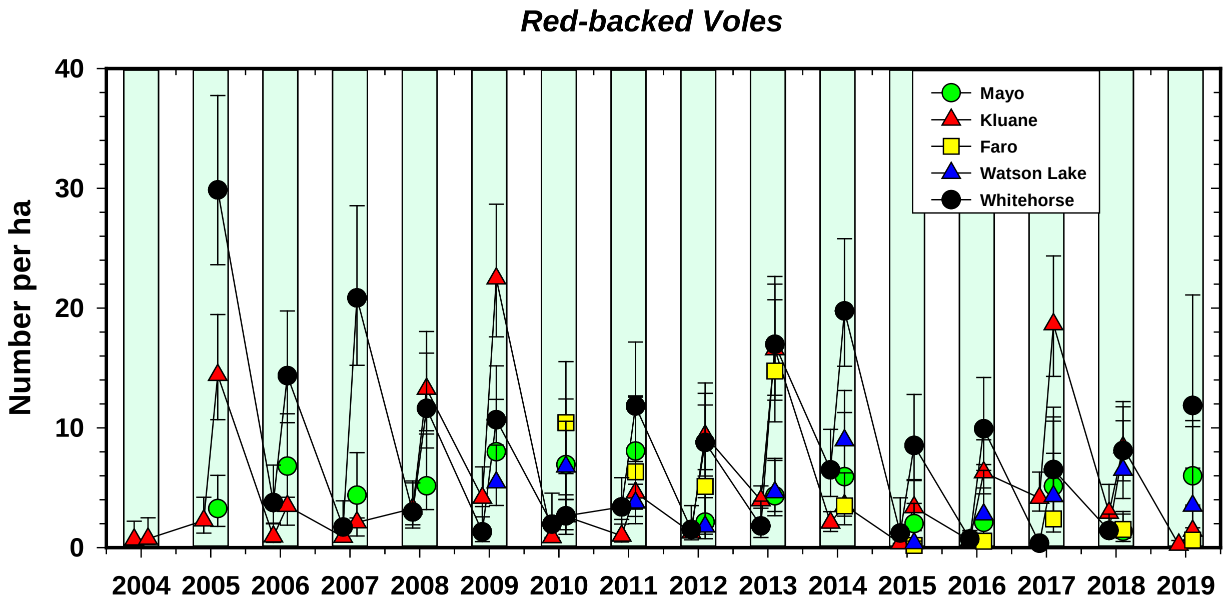
The most common rodent on all CEMP sites is the red-backed vole (*Myodes* = *Clethrionomys rutilus*), and we have estimated the abundance of this species by live trapping, marking, and releasing individuals. Live trapping at Kluane and Whitehorse is done in spring and late summer, and only in late summer at Mayo, Faro, and Watson Lake. Figure 4 shows the changes in red-backed vole numbers for the period 2004 to 2019. Kluane numbers reached a peak in 2017-18 but all other sites were at low numbers.

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, 2009, 2013 and 2017. Whitehorse populations were at low to moderate density from 2015-2018 coming off the last peak in 2014. Kluane, Faro, and Watson Lake populations were low in summer 2019, while numbers increased between 2018 and 2019 at Mayo and Whitehorse. The pattern to date does not suggest any close synchrony in fluctuations of red-backed vole numbers in the southern and central Yukon. Mayo populations have only rarely exceeded 6 per ha since 2005.

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 are too low on most of the sites to discuss any common patterns of population change. Deer mice remained between 1-4 per ha on all sites from 2005 to 2019, and in general tend to be stable in numbers from year to year.

Since most of these mice and voles weigh approximately 25 g, a density of 5/ha would provide a predator with only 125 g of potential food per day, assuming the predator could catch and eat all of them in 1 ha of habitat. A hypothetical coyote would in this simple model clean off all the small rodents in 1.5 km^2 per month. Simple calculations of this type suggest that medium to large sized predators in the boreal forest cannot make a living on small rodents which must be an incidental part of their diets.

Figure 4. Population estimates for red-backed voles in five CEMP areas, 2004-2019. Trapping grids have an effective trapping area of about 3 ha. Summer months are shaded green. Spring and late summer estimates are available only for Whitehorse and Kluane. Other areas have late summer estimates only.



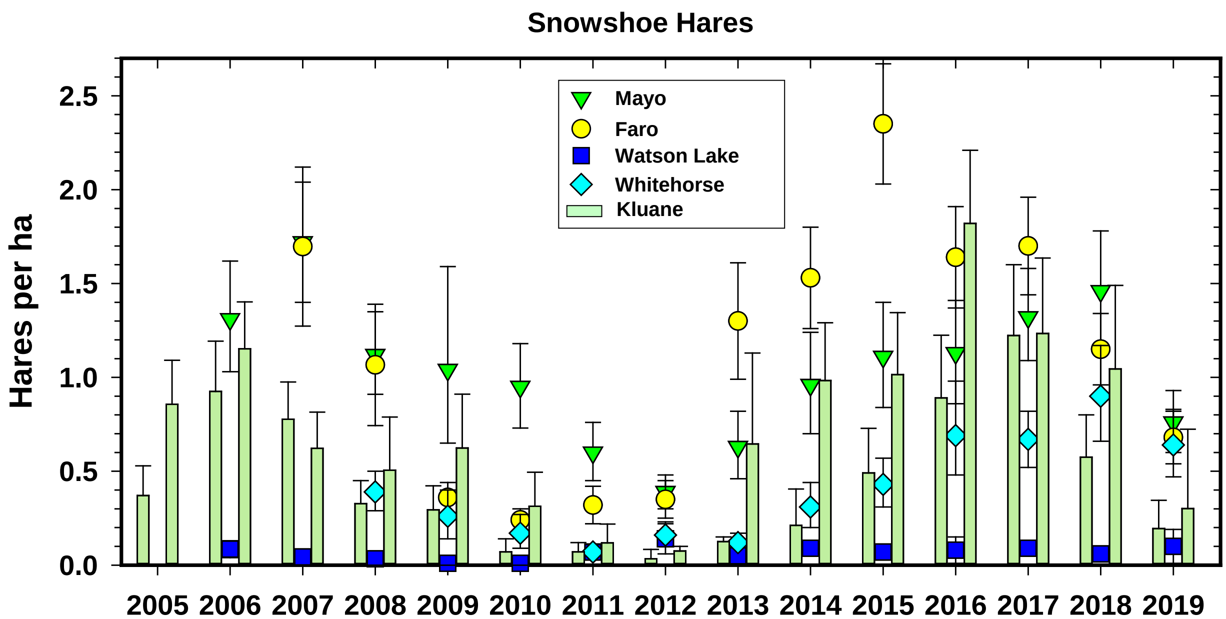
(d) Snowshoe Hare Numbers

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 have also developed a simple census method for hares by means of fecal pellet counts carried out once a year in 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 at the CEMP sites.

Two points stand out in Figure 5. First, Watson Lake sites had almost no snowshoe hares in any of the 13 years for which we have data. There is clear natural history information for Watson Lake that the hare cycle exists and that hares have been fluctuating in that area, so the problem is that the current hare monitoring sites are in poor hare habitat and need to be repositioned. A new site was established in 2019 to remedy this problem. Second, all other CEMP sites are following the Kluane hare cycle closely, with peak populations in 2006-7 and declining populations from 2008 to 2011-12. Faro hare numbers increased rapidly in the summers from 2013 to 2015 and have been declining slowly now for 5 years. Mayo hares (Rusty Creek site) have increased in close correlation to those at Kluane Lake and reached a peak in 2017-18 when they began to decline. Slower rates of growth at Whitehorse occurred in 2014 and 2015, and hares around Whitehorse appeared to be at peak levels from 2016 to 2018. The decrease phase of the hare cycle has been similar to the 2007-11 decline at Kluane, Mayo and Faro, and if these trends continue, we should have a further collapse of all hare populations in the southern and central Yukon during 2020.

Regional synchrony is well established in snowshoe hares in much of the Yukon, but as we get more regional details we find that not all areas in western Canada and Alaska tend to be in phase. We have summarized the hare data from Yukon, Alaska, northern BC and the NWT in Krebs et al. (2013, 2014). This analysis of regional synchrony strongly suggests a travelling wave of hare peaks that moves from northern BC into the Yukon one year later and then moves north in the Yukon with a further one-

Figure 5. Population density estimates for snowshoe hares in CEMP areas, 2005-2019. Mark-recapture data from Kluane are given as a bar graph for spring and fall of each year. Estimates from fecal pellet counts at CEMP sites are given as points (95% confidence limits). Note that the data from fecal pellet counts integrate hare density over the previous year. Mayo data from Rusty Creek site only.



year delay and west into Alaska to peak 2 years later than BC. As far as we can determine, this travelling wave is also occurring in the current hare peak of 2015 - 2019, and our colleagues in Alaska and the NWT are gathering hare data comparable to ours to answer this question whether the cyclic peak migrates west into Alaska.

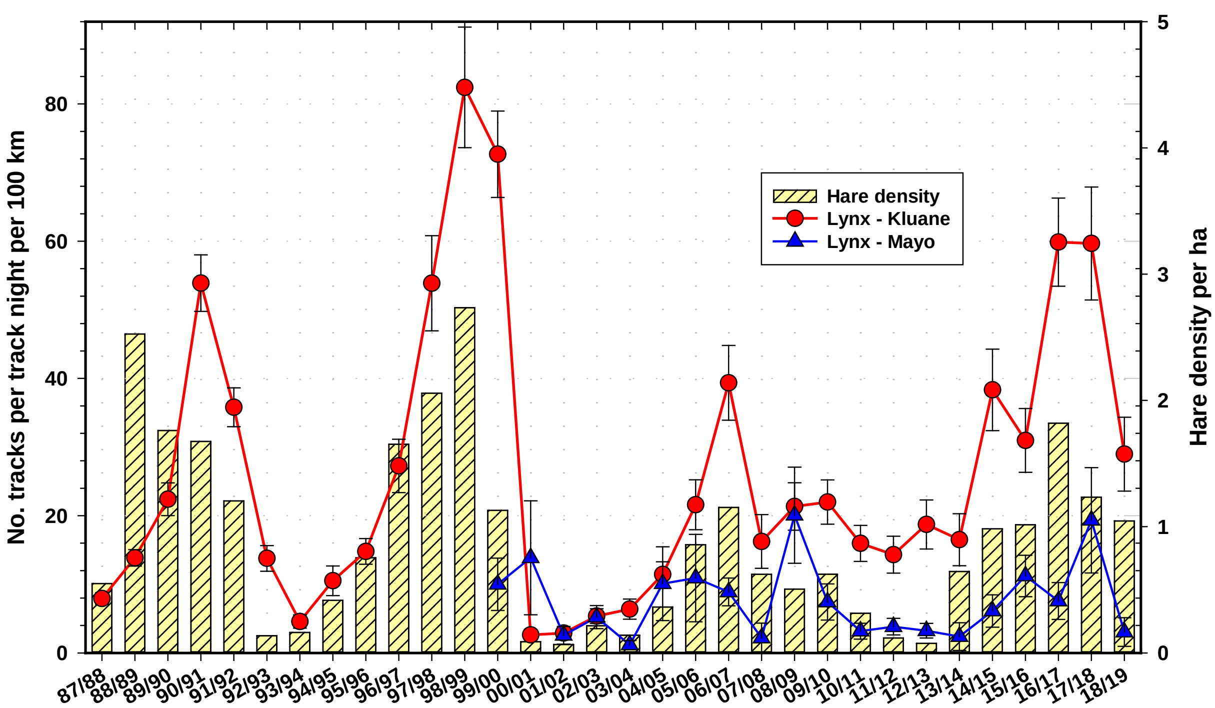
The most promising explanation for regional synchrony involves predator movements, particularly of lynx and great-horned owls, and depending on the geometry of the highs, such movements could produce a travelling wave of density changes.

(e) Lynx Abundance

We have been following lynx abundance in the Kluane region since 1987 by means of winter snow track counts along established routes. We expanded this predator tracking to Mayo in 1999 and to Whitehorse, Faro, and Watson Lake in 2009. We count lynx tracks crossing snowmobile routes after fresh snowfalls each winter, depending on wind conditions. On average about 200 km are tracked each winter at Kluane and about 200-250 km at Mayo. But during the last 3 years poor snow conditions in winter have limited our ability to use snow tracking for predator counts.

Figure 6 shows the changes in abundance of lynx in Mayo and Kluane as measured by snow tracks. Because our winter snow tracking cannot be done in identical habitats in all areas, we do not expect the absolute number of tracks to directly indicate lynx density but only trends in density. Two points are shown in this graph. First, the last lynx peak at Kluane in 2006-07 was the lowest we have seen, coincidental with the lowest hare peak we have seen at Kluane. Second, lynx at Mayo appear to be

Figure 6. Snow tracking abundance estimates for Canada lynx at Kluane and Mayo,1987 to 2019. Hare data are from Kluane in the autumn preceding the winter predator data.



out of phase with lynx at Kluane by a delay of 1 year. But in both areas lynx declined in 2019.

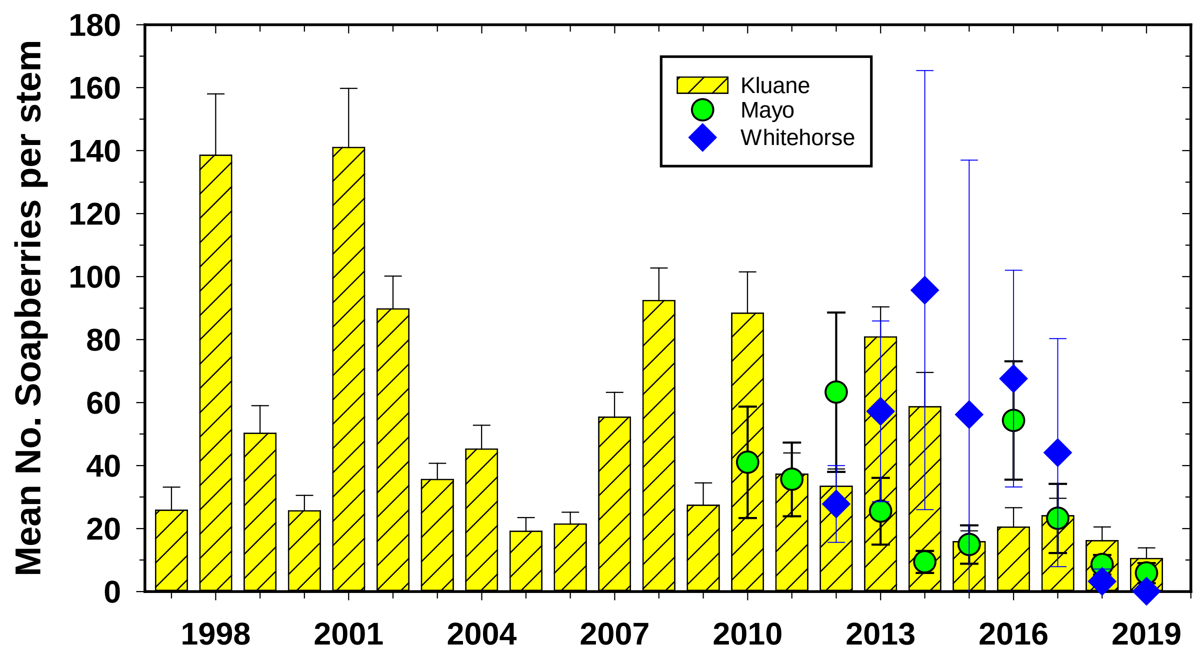
We do not have any snow tracking data from Faro, Whitehorse or Watson Lake for winter 2018-2019 because of a shortage of snow and the lack of personnel. Because this may become a more serious problem in future years, we began in autumn 2015 to install a set of trail cameras in the Kluane area to take automatic photos year-round of animals moving along game trails and paths. We will determine in the next 3 winters if this use of game cameras can potentially replace snow tracking in winter to obtain an index of predator abundance. To achieve this goal, we need 6 years of overlapping data from lynx snow track counts and lynx camera trap counts. Our preliminary results are very promising.

Lynx increased in numbers on all areas to a peak from 2016 to 2018 but did not seem to reach the high levels they were at in 1998-99 and visual field evidence from the summer and early winter of 2020 suggests that lynx and hares are both declining.

(f) Brief Notes on Other Monitoring Measurements

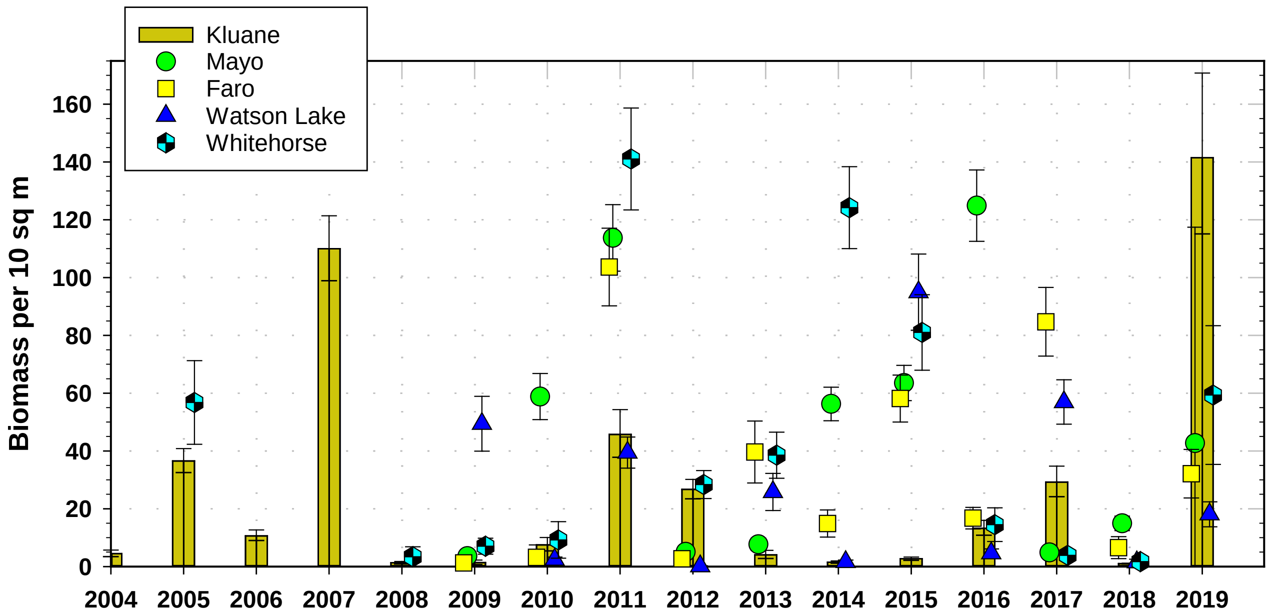
Soapberries are a favourite food of grizzly bears, and are being counted at Kluane, Mayo, and Whitehorse. We place a high priority on counting soapberries at all sites but there are few soapberries on some of our sites which makes this a challenge. In 2019 soapberries were at very low abundance at Whitehorse (less than 5% of the counts in the previous 4 years). Counts were low at many of the sites around Kluane Lake and low at Mayo and Whitehorse in 2019 (Figure 7).

Figure 7. Soapberry counts at Kluane, Mayo, and Whitehorse. Counts are the number of berries on an average 10 mm diameter stem.



In 2019 mushrooms were moderately abundant at Whitehorse, Mayo, Faro and Watson Lake, with a large crop at Kluane Lake, and all together a moderate to high year for above ground mushroom production (Figure 8). In previous years mushrooms have been highly variable among the 5 sites we monitor.

Figure 8. Mushroom biomass at Kluane, Mayo, Faro, Watson Lake and Whitehorse. Biomass wet weight per 10 sq. m.



Red squirrel numbers have been studied extensively at Kluane for years by Stan Boutin's group. In general, red squirrel numbers have been relatively stable in the boreal forest around Kluane at 2.25 per ha, but they increased rapidly in 2015 and remained high from 2016 to 2018 in response to a good spruce cone crop in 2014. Red squirrel populations collapsed rapidly in 2019 and are scarce in autumn 2019 at Kluane.

Canada lynx follow the hare cycle closely and have peaked in 2018 and are declining in winter 2019-20. Marten and weasels have become much more abundant since 2000 at Kluane and may be affecting the dynamics of the hare cycle. In winter 2015-16 and winter 2016-17 coyote, marten and weasel numbers at Kluane fell dramatically below 2014-2015 levels (Figure 9), which might be a result of intraguild predation (large predators killing smaller predators). In general, 2019 was a year of declining predator numbers at Kluane and Mayo. More information is being gathered from the other CEMP monitoring sites on predator numbers by means of snow tracking or camera trapping and this will give us regional patterns in the coming years.

Bird surveys in the Yukon are not being done on the CEMP sites, but we would like to get coverage at all CEMP sites. Mayo has carried out BC Owl Surveys since 2003, Breeding Bird Surveys since 2004, and Nighthawk Surveys since 2016. Other bird surveys would be desirable to put in place to obtain a better picture of regional trends for the southern Yukon. Natural history observations suggest increasing grouse

Figure 9. Snow tracking abundance estimates for coyote, Canada lynx, marten, weasel and red fox at Kluane, 1987 to 2019 and Mayo 1999 to 2019. Track counts are affected by activity as well as by abundance, so must be considered an index of abundance.

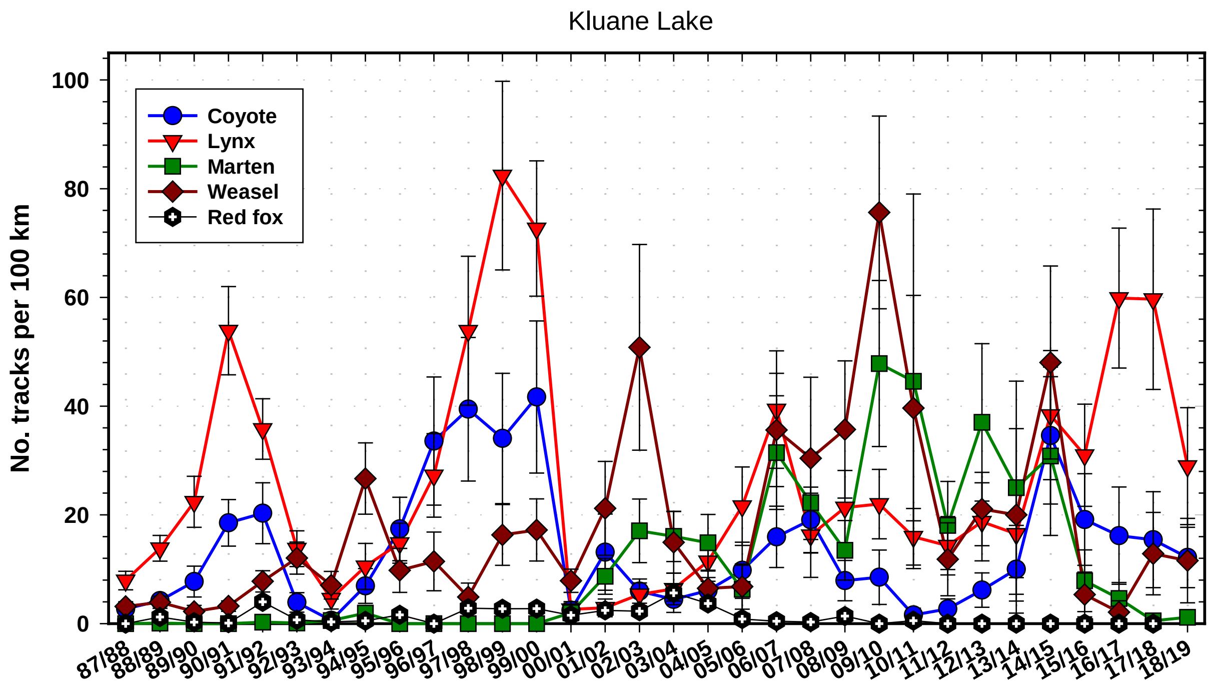
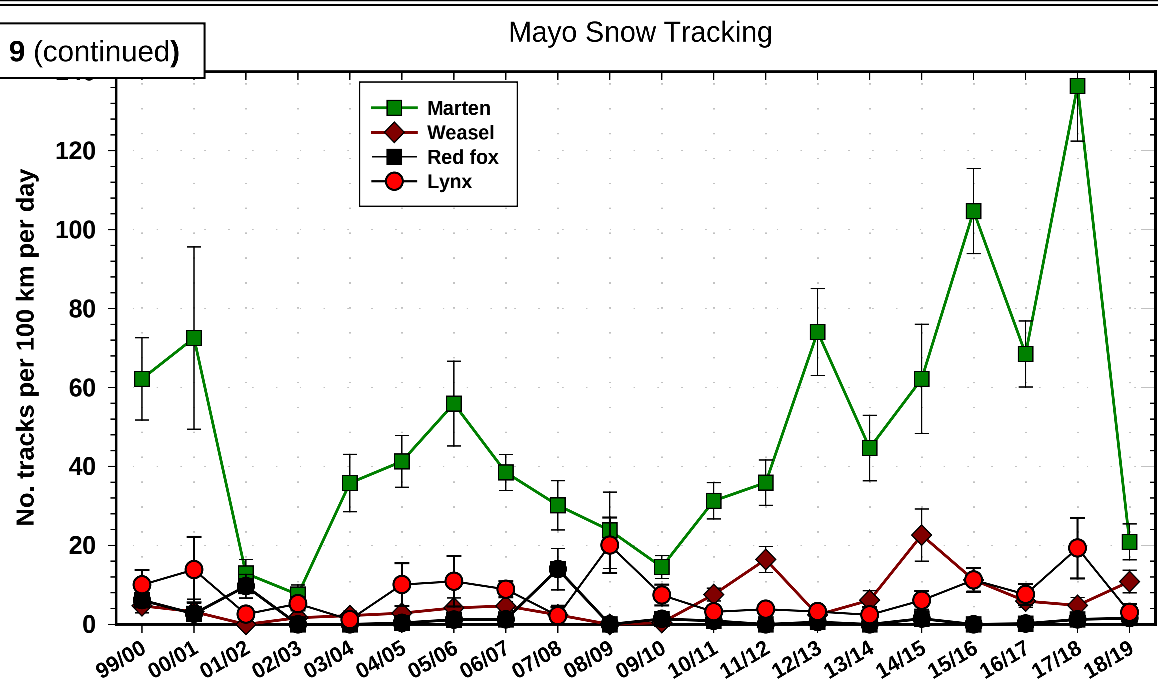


Figure 9 (continued)



populations at many of the CEMP sites in 2016, high grouse numbers in 2017, and declining numbers in 2019 except in Whitehorse where grouse were common in autumn 2019.

One major part of the food web shown in Figure 1 that is missing in our studies is shrub growth. We do not have any good measures of the increasing shrub growth that accompanies climatic warming and affects the winter food supply of snowshoe hares and moose.

There is general interest among Yukon and Alaskan biologists to implement a program of regional monitoring of the major mammal and bird predators of the boreal forest. It would require a large investment of time and money to analyze this large-scale monitoring of movements of major predators.

Our goal in this monitoring program is to develop statistical methods of estimating the abundance and productivity of our indicators of ecosystem health for the Yukon boreal forest. We expect all 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 three ways to determine the impact of climate change – to observe what happens, to monitor changes and try to explain them ecologically, and to develop and use models which include climatic variables to predict what will happen. Long-term data sets are essential to this endeavour and we learn as we go along from year to year.

(g) Predictions for Indicator Species in 2019 and 2020

We combined the statistical models we have for mushrooms and plant species and patterns we have seen for mammals to produce the predictions for 2019 shown in Table 1 and the resulting measured values for 2019. The model for spruce cones successfully predicted that cone crops at Mayo would be very low in 2019, whereas they would be high in the southern Yukon. Several errors are evident in the predictions given in Table 1. The largest ones occurred in mushroom predictions for Kluane and Watson Lake, possibly related to the lack of rainfall in May 2018. Rainfall on local areas is variable and the Yukon has a very sparse system of government weather stations. The question is always whether the monitoring plots received the rainfall measured at the standard weather stations. The data we have gathered suggests high variation in local rainfall in summer (Krebs et al. 2018).

Table 2 contains the predictions for many of our monitored species for 2020. The major plant prediction is for low to very low spruce cone crops for all areas in 2020. Very low mushroom crops should occur in all areas. Since we are in the decline phase of the snowshoe hare cycle, the predictions for all areas for hares and their predators are for rapid declines.

Testing all these models as the years go by will allow us to determine how reliable our understanding is of the boreal forest ecosystem.

Table 1. Predictions made in 2018 for 2019 for monitored species at all CEMP sites and actual measured values. Red = predicted from models for 2019, blue = actual observed values in 2019. Range in the comments refers to empirically measured range over all the years of measurement.

Species / Group	**Kluane**	**Faro**	**Mayo**	**Watson Lake**	**Whitehorse**	**Comments**
White spruce cone crop[1]	961 2584	320 166	86 1	518 268	688 1929	Historical range has been 0 to 2500 cones per tree
Above-ground mushrooms[2]	0 142	24 32	203 42	4 18	2 59	Grams per 10 m^2 Crops vary widely among regions. Range has been 1 to 125 g/10m^2
Soapberries[3]	84 10	–	26 6	–	9 0	Berries per 10 mm stem. Relatively low crop. Range has been 16 to 141
Small mammals	decline decline	decline decline	low abundant	decline decline	decline abundant	Red-backed voles only;
Snowshoe hares	decline decline	decline decline	decline decline	------[4]	decline decline	Peaks are traveling north and west
Lynx and other predators	decline **decline**	decline **decline**	decline **high**	low low	decline **decline**	All predators should begin declining in 2019 and breeding may cease or be unproductive

[1] Expected mean total number of cones for the entire tree
[2] Very large mushroom crop predicted for Mayo in 2019 but failed
[3] Tentative predictions from a new statistical model, Predictions not very reliable yet for soapberries
[4] Watson Lake hare sites need to be moved to more productive forest areas to detect hare population changes

Table 2. Predictions for 2020 for monitored species at all CEMP sites.

Species / Group	**Kluane**	**Faro**	**Mayo**	**Watson Lake**	**Whitehorse**	**Comments**
White spruce cone crop	**176**	**92**	**296**	**26**	**68**	Low to moderate crop in all sites. Historical range has been 0 to 2000 cones per tree
Above-ground mushrooms[1]	**0**	**3**	**2**	**0**	**3**	Grams per 10 m^2 Few mushrooms on all sites for 2020. Range has been 1 to 125 $g/10m^2$
Soapberries	**27**	-	**95**	-	**41**	High crop only at Mayo. Berries per 10 mm stem. Range has been 16 to 141
Small mammals	low ~ 2/ha	low ~ 1/ha	decline ~ 2/ha	low ~ 1-2/ha	low ~ 2-4/ha	Red-backed voles only;
Snowshoe hares	decline	decline	decline	decline[4]	decline	Peaks are traveling north and west
Lynx and other predators	**decline**	**decline**	**decline**	**low**	**decline**	All predators should continue to decline in 2020 and breeding may cease or be unproductive

[1] New 2019 predictive equation for mushrooms

Key predictions for 2020:
1 – Low spruce cone counts everywhere
2 – Low mushroom crops everywhere
3 – High soapberries at Mayo, low elsewhere
4 – Hares, rodents low and predators declining everywhere

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 16 years of data for our indicators, our conclusions to date must be tentative, but we have a firm foundation for coordinating these regional data sets. The boreal forest ecosystem is a boom-bust ecosystem with all the major components showing strong fluctuations in abundance. Determining the associations between these fluctuating components of the ecosystem is underway, and in the same way that we have needed a long time-series of weather data to recognize climate change, achieving an understanding of this northern ecosystem will require long-term ecological data.

We need to proceed in the short term to answer three 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, bearberry production (Figure 3) can vary greatly between sites, yet snowshoe hare numbers (Figure 5) 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 data that will apply across all CEMP sites? So far, we have achieved this for spruce cones, berries and mushrooms but more testing is needed.
3. How can we get a better index of changes in predator populations in a time when snowfall and winter conditions have become so variable? Can we utilize remote camera trapping (Meek et al. 2014, Abolaffio et al. 2019) as one way of spreading our sampling and overcoming weather changes? A test of this idea is underway at Kluane now.

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.

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