17 BIODIVERSITY MONITORING IN CANADA'S YUKON: THE COMMUNITY ECOLOGICAL MONITORING PROGRAM

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Lesson # 1. Construct a food web for the system under study.

Lesson # 2. You cannot do everything so decide what is important.

Lesson # 3. You can add items to the monitoring list as you go.

Lesson # 4. You must standardise all the measurement protocols and publish them in a small handbook with photos and details of data entry.

Lesson # 5. Maintaining enthusiasm for the monitoring program is critical.

Lesson # 6. Enter the data immediately in the field if possible.

Lesson # 7. Communicate the results as widely and as much as you can.

Lesson # 8. Do not get discouraged.

Lesson # 9. Continue to take a long-term view of monitoring.

Introduction

In 1973 we began studies on small mammal populations in the boreal forest of the south-western Yukon of Canada. By 1984 we had realised that we needed to study community dynamics rather than single species dynamics, and our studies, while still based on experimental manipulations, broadened to monitor the ecosystem. We are now in year 38 of this monitoring program. The lessons we have learned can be condensed into nine key points.

Lessons

1. Construct a food web for the system under study

This exercise forces you to define the biological and geographical limits of what you are trying to monitor, and once the scale is set, practical decisions can be made about how much can be done. The food web for the Kluane ecosystem is shown in Figure 17.1 (Krebs *et al*. 2001). We see right away that things are missing from the food web. We are not monitoring passerine birds, or insects, or the soil fauna, or most of the herbaceous plants. The arrows arise from natural history data, and emphasise that to monitor any ecosystem you must have a great deal of

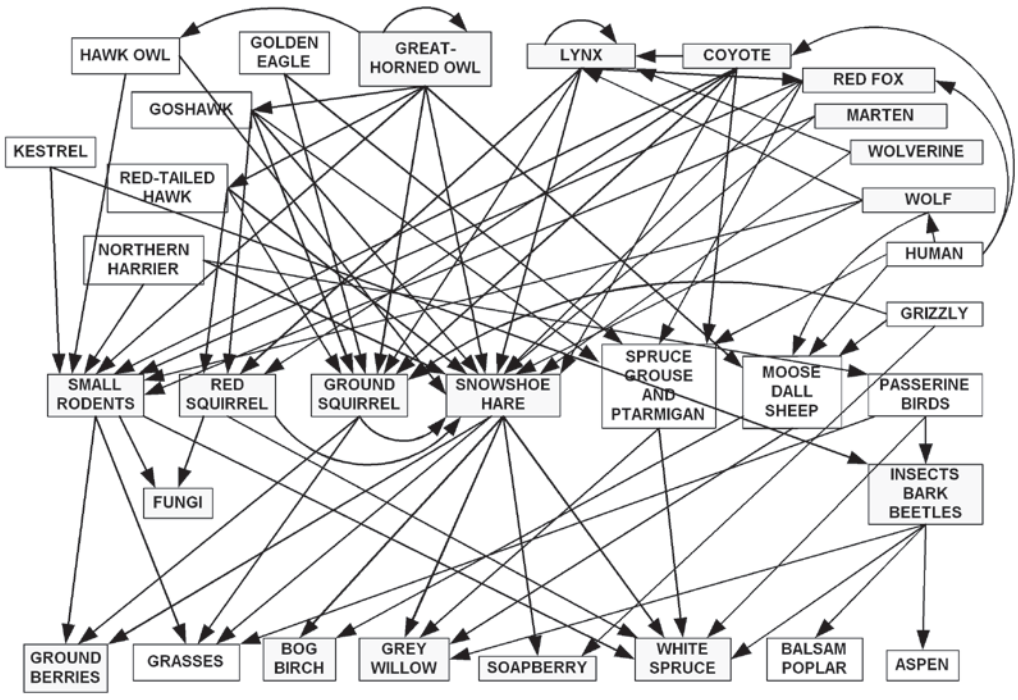

Figure 17.1. The terrestrial food web for the Kluane Lake region of the Yukon, focusing particularly on the mammals. The shaded boxes have been monitored annually for 18–37 years.

background data. Food webs are always constructed from some point of view, and many items are lumped into functional groups or ignored altogether.

2. You cannot do everything so decide what is important

No food web is complete, and all webs can be thought of as partial webs or sub-webs of the entire ecosystem. We have been interested in terrestrial mammal dynamics centred on the snowshoe hare (*Lepus americanus*) cycle, so we have picked elements to monitor in the ecosystem that somehow impinged on hares. We have some understanding of the dynamics of the mammals in the boreal forest, and thus the ability to construct hypotheses that monitoring can evaluate (Krebs 2011). You are also forced at this stage to define the frequency of monitoring and the spatial extent. In our Yukon studies, we range over valley forest sites spanning about 250 km along the Alaska Highway and Haines Road. We do not study the alpine zone; we do not study lakes and streams.

Critical decisions must be made about how many weather variables to monitor and with what level of resolution. If biotic interactions drive the system you are monitoring, less effort may need to be expended to monitor abiotic variables. Conversely, if your system is driven by weather, biotic interactions may be given less attention. These decisions come back to the hypotheses or questions you are addressing with the monitoring program (Lindenmayer and Likens 2010).

3. You can add items to the monitoring list as you go

As we progressed in the work at Kluane we added above-ground mushroom production (Krebs *et al*. 2008), and ground berry production (Krebs *et al*. 2009) to our list of entities being

monitored, since these are important food items for small mammals. When the spruce bark beetle began killing old growth white spruce trees, we started monitoring individual trees to measure attack rates with respect to tree age and size. The background to all the measurements in the Yukon is climate change which is rapid and extreme in north-western Canada. The monitoring program must not be set in stone and needs to be reassessed periodically.

4. You must standardise all the measurement protocols and publish them in a small handbook with photos and details of data entry

We started doing this after about 12 years of work once we realised that many different people would be doing the measuring, some with no prior experience, and the principal investigators could not do all the work themselves. The most important item in a monitoring program is to standardise the measurements and to teach new people how to do things in the field. You cannot learn field techniques on a computer. Our monitoring manual and all of our monitoring data are available on my website (http://www.zoology.ubc.ca/~krebs/kluane.html).

We have always adopted the philosophy that our data should be available to anyone for use, as long as acknowledgement is made. Partly because we set up a detailed monitoring handbook, National Parks in the boreal forests of Alaska have taken up our protocols for measuring the same ecosystem components that we measure at Kluane. We are also in the process of expanding the monitoring program to other sites in the southern and central Yukon with the assistance of biologists from the Yukon Territorial Government. We need to monitor whole landscapes rather than single small sites so that we can discuss large-scale patterns of change, and the difficulties of doing this are partly financial and partly having sufficient trained staff who know the protocols.

We have always been suspicious of monitoring programs that are not well standardised with many ecological measurements that are difficult to take precisely. The variance among observers must not be confounded with the variance due to ecological changes.

5. Maintaining enthusiasm for the monitoring program is critical

We found quickly that you could not 'farm out' the hard field work to undergraduates or hired hands, and it is essential for senior investigators and senior postgraduate students to be part of monitoring teams. If you prefer your air-conditioned office to doing field work, your monitoring program will be compromised. Field work allows time to talk to helpers about why we do what we do.

6. Enter the data immediately in the field if possible

We have tried to enter data in the field, if possible on the day they are collected, so that any simple errors can be corrected before they are forgotten. We set up detailed Access™ databases to enter and verify data. This allowed us to do simple and immediate error checks (e.g. this animal's tag number cannot be correct, or this animal was a female when last captured). It is possible to enter data electronically in the field with hand-held devices in some situations, but we are always happy we have a paper copy of data. And always remember to back-up, and then back-up data again.

7. Communicate the results as widely and as much as you can

We do an annual report to update graphs and to discuss time trends in the data. We write popular articles for local newspapers on topics of immediate interest (e.g. very high abundance of rodents this year) and try to explain why some things happen in the local environment. We talk to school groups in the Yukon and the public about our results as much as possible. We

have been less successful at public communication than we should have been, partly because with limited funds we prefer to spend the money on field work rather than communication professionals. We publish regularly in the scientific literature and this is essential to maintain the scientific credibility of the work.

8. Do not get discouraged

Funding for monitoring is pathetic and it is easy to get discouraged. It has taken us nearly 20 years to gain the interest of the Yukon Government in supporting and funding a monitoring program. Interesting results for many people only began to appear after about 10 years. Unfortunately, we have not had good rapport with the First Nations people, many of whom are not supportive of our monitoring because they believe that traditional knowledge is sufficient. We have worked hard to change this, and it is slowly improving.

Our federal science funding program in Canada does not recognise monitoring as a valuable research activity so we can continue to work in the field only by not telling them what we are doing. Parks Canada currently shows little interest in our monitoring program and seems to operate on the twin assumptions that Mother Nature will take care of things and that 'if we know grizzly bear numbers' we have an adequate measure of ecosystem integrity. Some government employees feel that counting and measuring mushrooms is not something a 'real man' should do. The stories are endless, but the main point is to persist. The Yukon Territorial Government is currently investing in, and supporting, our monitoring program – a good sign for the future. The public supports monitoring of the environment and in the long run we will be able to show trends that grow more valuable with each passing year.

9. Continue to take a long-term view of monitoring

Ecologists look beyond the next election to see ecosystems on a scale of hundreds of years. Our monitoring programs should have this time frame. This requires an institutional arrangement that does not disappear when the key players retire. I am not sure that this can be done by government agencies, given our present system of short-term governments. The problem remains to be solved. The storage of data for the long term is also a topic of concern to many people. At the moment, I have most of the Kluane Yukon data available in summary form on my website. Where this information will be in 100 years is not known. The problem with ecological data is that much is unreliable unless the methods are clearly defined and statistically rigorous. Consequently, metadata need to be combined with raw data for them to be useful. The rapid turnover of kinds of data storage in the last 20 years gives more worries to the whole issue of data storage. We have raw data from 50 years ago stored currently only because we were able to move from cards to magnetic tapes to 3.5 inch disks to CDs to DVDs before the old technology disappeared.

Conclusions

The Kluane monitoring program is the longest terrestrial ecosystem monitoring program in Canada but it is not secure, and for the present rests too much on a few shoulders. Others in Canada have monitored single species or groups of species, particularly birds and large mammals that can be hunted, and these data sets are valuable. But every analysis of community dynamics has emphasised that much of the action in the ecosystem is in species less charismatic than grizzly bears and moose. What is needed in Australia, as well as in Canada, is an extended discussion of the monitoring problem, what should be monitored, and what the costs will be. Lindenmayer and Likens (2010) begin this discussion. In their book they discuss some

of the problems with the large-scale Alberta Biodiversity Monitoring program, which began in 2003, and these critical discussions need to be more common, particularly when programs are being set up. No monitoring program is perfect and we should all seek to improve what we do so we can do it better.

Acknowledgements

I thank all my colleagues from the Kluane Project and all who have worked on the Kluane Ecosystem Monitoring Program over many years. This research has been a collaborative effort, and without the help of Rudy Boonstra, Tony Sinclair, Stan Boutin, the late Jamie Smith, Susan Hannon, Kathy Martin, Roy Turkington, and Mark Dale we would never have achieved our objectives. Our current monitoring is being supported by Alice Kenney, Mark O'Donoghue, Liz Hofer and a host of Yukon students, for whose help I am grateful.

Biography

Charles Krebs is Emeritus Professor of Zoology at the University of British Columbia and Adjunct Professor in the Institute for Applied Ecology, University of Canberra. He has studied the population and community ecology of vertebrates in the boreal forest and tundra ecosystems of northern Canada for 42 years, concentrating on voles, lemmings and snowshoe hares. His scientific passion is to carry out large-scale field experiments to test hypotheses about the ecological processes affecting populations and communities in northern Canada.

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