Kluane Lake Research Station
NEWSLETTER

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INSIDE

Geomorphology Field Course at KLRS 2

Stress and the Lives of Mammals 4

KLRS Bibliography 5

Websites 5

Little Ice Age and the Kaskawulsh Glacier 6

Recent Publications 8

Plant Ecology and the Forest Understory 10

Forest Management and Climate Change 12

Photos from 2005 13

Upcoming Events 15

Northern research, and interest in Arctic regions in general, has experienced a resurgence of sorts in the past few years. This is due in large part to the rapid change these regions are experiencing. Climate warming is transforming natural environments as ice melts, permafrost thaws and species' ranges expand or contract. Devolution and land claims are transforming the social and political environments, providing more regional autonomy. And resource development such as mining and oil and gas exploration is having profound economic effects that bring social change throughout the North. Research to document and support adaptation strategies is one goal of the International Polar Year (IPY), a multi-national effort aimed at focusing the world's attention on Arctic and Antarctic regions in 2007 and 2008.

The Kluane region of southwest Yukon has a long history of hosting researchers working in the natural and social sciences. Given the resurgence in northern research and the upcoming IPY, this trend will continue. But research in the north has also changed. Now more than ever it is important that scientists working in the region communicate with regional authorities and agencies such as the Territorial Government, First Nations, and Parks Canada, and with local communities and residents. We hope this newsletter can act as one forum for such communication and, in turn, encourage interest and even collaboration in research activities. In addition, it is intended to foster cross-disciplinary communication among researchers and to help inform others ofn the type of work going on in the Kluane region.

We're open to ideas for future directions for the newsletter and welcome suggestions or submissions for future issues. Please feel free to get in touch with us if you see a section that you would like to contribute to.

Winter at the Kluane Lake Research Station, Mile

About Us

The Arctic Institute of North America (AINA) was created by an Act of Parliament in 1945. Its mandate is to advance the study of the Arctic through the natural and social sciences, the arts and humanities and to acquire, preserve and disseminate information on physical, environmental and social conditions in the North.

The Kluane Lake Research Station (KLRS) is managed and operated by AINA. Established at the south end of Kluane Lake in 1961, it supports the activities of scientists in disciplines such as glaciology, geomorphology, geology, biology, botany, zoology, hydrology, limnology, climatology, high-altitude physiology, anthropology and archaeology. This diversity, as well as the high calibre of work accomplished, has created a legacy unique in Canada. AINA provides support and access to the facility, but it does not design or supervise the research. KLRS attracts researchers and field schools from across Canada and around the world. Funding from the Natural Sciences and Engineering Research Council of Canada (NSERC) supports operation of KLRS.

Geomorphology Field Course at Kluane: An Historical Perspective

Peter Johnson, Professor, Department of Geography, University of Ottawa

Beginnings

Early in my research career undergraduate students were asking how they could become involved in northern research so in 1973 I persuaded my Department (Geography) at the University of Ottawa to grant course credit, under the title 'Field Research in Northern Canada', to students working with me on my research projects in the southern Yukon.

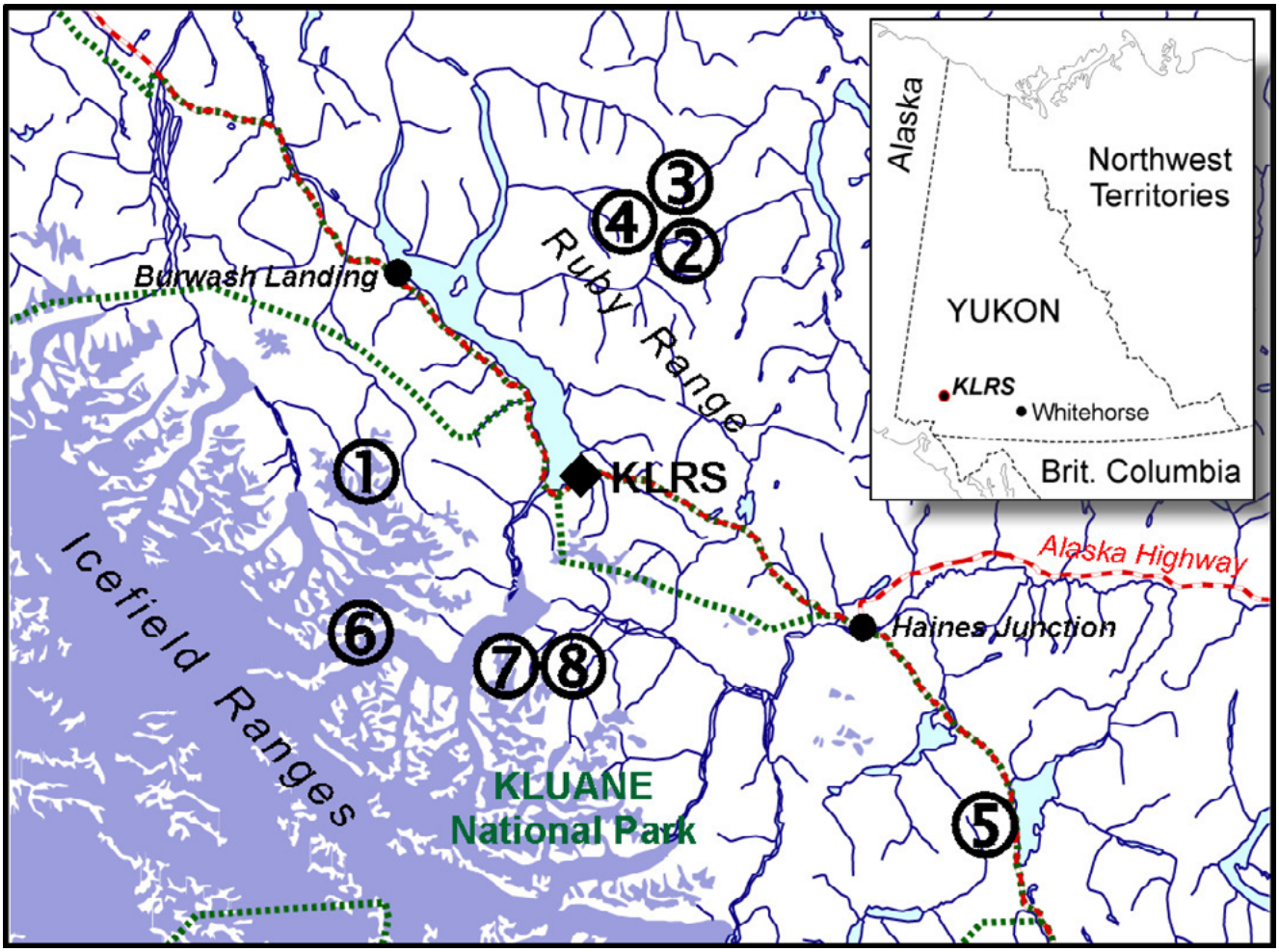
The objectives of the course were:

- To provide students with field experience in a remote location in the North
- To provide an environment where they would be working on an ongoing research project
- To encourage students to develop their own projects
- To provide a transition into post graduate programs

Environments

From 1974 to 1980 students participated in rock glacier and hydrology research in Grizzly Creek. A helicopter crash in 1979 followed by a grizzly encounter in 1980, events which became connected in northern folk lore, forced a relocation of research from Kluane National Park to Gladstone Creek and Talbot Creek in the Ruby Range. Research and the field course returned to the St. Elias in 1986 with 3 years at an ice-dammed lake site in the Kaskawulsh Basin and 3 years at a tributary glacier in the Maxwell Creek Basin. In 1992 the focus was on rock glaciers and mass movement in another tributary of Maxwell Creek, an excellent field site if for no other reason than the drainage being subsurface and creek crossing was not a factor. This brought the remote field site emphasis to an end. Rising logistics costs forced a re-evaluation of the course and at this time it became possible to use Kluane Lake Research Station as the base for the program rather than just the logistic hub.

Participation gradually increased from 1983 to a peak year of 22 students in 1999. This was too much of a strain for the camp, the camp manager, and for myself without TA support and from 2000 to the present enrolment has been kept to 12 – 15 students per year. In 2001, after the successful opening of the Icefield Discovery Eco-tourism Camp at the base of



Mount Queen Mary, 5 of the students went to this camp for a few days to test the potential for a field course on the glacier. In 2002 a Glaciology course was proposed to run for 10 days in June after the course at Kluane Lake. It was initially expected that an enrolment of 5 students might be attracted to this course, because of the extra cost and the unknown of working with a number of inexperienced students for 10 days in this environment. When the snowflakes had settled 10 students participated and the enrolment has continued at this level through 2005.

At Kluane Lake Research Station the course has focused on the hydrology of mountain streams and on lake environments. The former has introduced students to the challenges of working in a dynamic, and cold, environment and demonstrates the diurnal and seasonal variability of stream flow. The latter has combined introduction to palaeo-limnology with measurement of current lake conditions in three small lakes easily accessible from the base.

Training

The importance of the training can be illustrated statistically but also from the reactions of participants. Statistically more than 65% of the students have continued into post graduate study, with most of these in natural and physical sciences in the North. On a personal level the experience remains with the students for a lifetime and has been a major influence on careers and lifestyles. A number of the participants have become permanent residents of the North and some lifetime partnerships have developed between students. (peterj@uottawa.ca)

Map (above): Fieldwork Locations of the University of Ottawa Field School, 1974-2005
1. Grizzly Creek (Rock Glaciers/Hydrology)
2. Gladstone Creek (Rock Glaciers/Hydrology)
3. Talbot Creek (Rock Glaciers/Landslides)
4. Talbot Creek (Rock Glaciers/Quaternary)
5. Dalton Range (Rock Glaciers)
6. Kaskawulsh Basin (Ice-Dammed Lake)
7. Maxwell Creek (Glacier Site)
8. Maxwell Creek (Rock Glacier Site)
9. Icefield Ranges (Glaciology)

Photo (previous page): Members of the 2005 field-school sit atop a nunatak in the Icefield Ranges with Mount Logan in the background.

Aging and Death in Mammals: What Takes its Toll before the Grim Reaper Does?

Rudy Boonstra,
Centre for the Neurobiology of Stress
Department of Life Sciences, University of Toronto at Scarborough

A prerequisite in aging theory is that there is age-dependent decline in physiological function. Stress is a fundamental reality of existence and coping with it is crucial if we are to survive and get old. A declining ability to deal with stress, and thus in maintaining homeostasis, may play a major role in the physiological decline that accompanies aging. Laboratory rodents are central models in the research to understand how and why aging occurs, particularly as it applies to humans. A key finding, based heavily on the laboratory rodent model, is that aging animals show a marked deterioration in the ability to maintain homeostasis caused by an increasingly hyperresponsive and dysfunctional hypothalamic-pituitary-adrenal (HPA) axis. But does this occur in wild animals that have been selected to deal with a world that is infinitely more challenging and difficult than the benign conditions of the laboratory cage?

To test these ideas, we conducted two studies on wild microtines, the vole and lemming family. First, in the meadow vole (*Microtus pennslyvanicus*), a species that occurs throughout central and northern North America, we tested whether male meadow voles maintained in the lab showed any deterioration in their ability to handle stress over a 12 month period. Typically the summer breeding season lasts about 6 months in southern Ontario before winter sets in and all breeding animals die. Hence, to maximize fitness, males should live about that long to maximize their reproductive opportunities. The HPA axis changed markedly over the study, but only after 6 months of age. After 6 months, baseline levels of corticosterone (the major stress hormone in voles) declined, response to a stress challenge (restraint) was reduced, and recovery from the challenge was attenuated. The changes we observed were virtually opposite that of what has been seen in relatively unstressed laboratory rats. Thus male meadow voles showed strong evidence of deterioration in the HPA axis, but only after 6 months of age, the maximal reproductive lifespan in nature.

Second, Quinn Fletcher (a masters student) and I examined whether free-ranging northern red-backed voles (*Clethrionomys rutilus*) from the Yukon, Canada, showed any evidence of deterioration of their stress axis over time. Their breeding season is typically only about 3-4 months at this latitude. We examined the ability of male voles to respond to, and to recover from, a stress challenge and we examined what changes occurred at the level of the brain (the hippocampus, hypothalamus, and pituitary). Over the breeding season, we found no change in either the ability to handle stress or in the brain. We conclude that the HPA axis in the natural world is essential for survival given the extreme ecological pressures these animals face on a daily basis; any significant deterioration would rapidly be followed by death. Hence, none may occur until the fundamental purpose of life - reproduction - is complete. (boonstra@utsc.utoronto.ca)

The meadow vole, Microtus pennslyvanicus *(top) and the red-backed vole,* Clethrionomys rutilus *(bottom). Photos by Alice Kenney.*

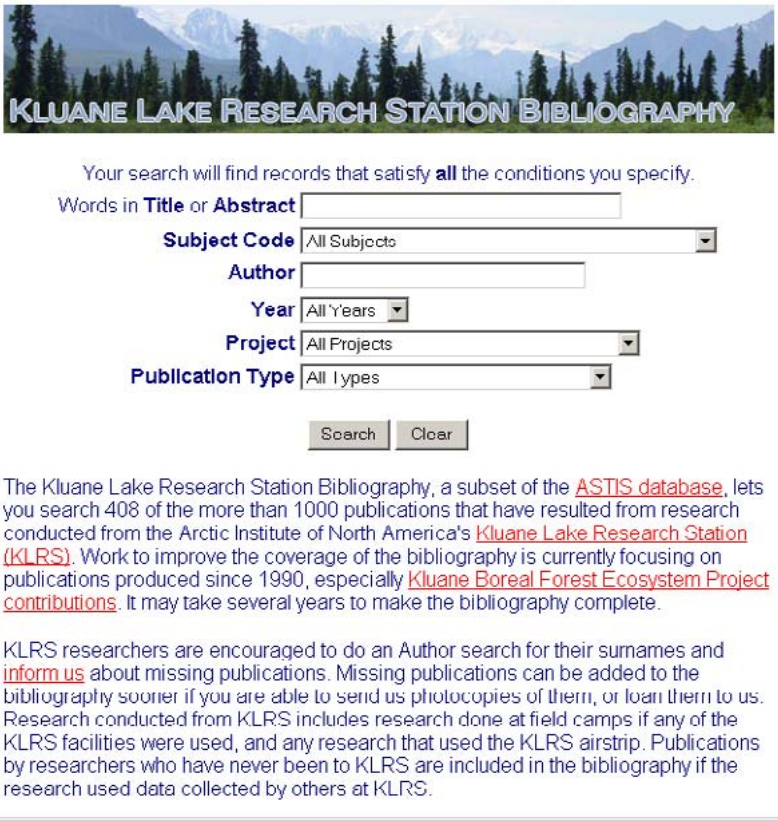
Kluane Lake Research Station Bibliography

Ross Goodwin, Arctic Institute of North America, University of Calgary

The Kluane Lake Research Station (KLRS) Bibliography now describes 503 publications, an increase of almost 100 publications since the last issue of the *KLRS Newsletter*. The bibliography is a searchable database available from the KLRS web page (see address on page 16).

The Kluane Alpine Ecosystem Project and the Kluane Ecological Monitoring Project have recently been added to the bibliography's Project list. Digital Object Identifiers (DOIs) have been added to 80 bibliography records to provide links to PDF files for people whose organizations have electronic journal subscriptions. A further 7 records provide links to PDF files using URLs.

AINA's ASTIS project depends on KLRS researchers to inform us about publications that are missing from the KLRS Bibliography. Because we are funded by contract work and are only able to devote a small amount of staff time to free projects it is going to take several more years to make the bibliography complete. KLRS researchers are encouraged to do an Author search for their surnames and inform us about missing publications. Missing publications can be added to the bibliography sooner if you are able to send us photocopies of them, or loan them to us. (rgoodwin@ucalgary.ca)



Websites of Interest

Arctic Institute of North America
http://www.arctic.ucalgary.ca
Our own website has been updated. Find information about AINA, listings of news, media, and events, profiles of research and education programs, and links to publications and collections, including the ASTIS database, the journal Arctic, an art collection, and photographic archives.

US Snow and Ice Data Center
http://nsidc.org/data/g00472.html
The US National Snow and Ice Data Center (NSIDC) has an online glacier photograph collection exceeding 3,000 images. Images of glaciers in the St. Elias Mountains include photographs by Walter Wood and Austin Post. You can search and order the high-resolution TIFF images, or download the lower-resolution JPEG images.

INSTAAR Alaska Climate Animations
http://instaar.colorado.edu/QGISL/AGCA/
Monthly weather station data from 1961-1990 from across Alaska was used to create map-based animations for temperature and precipitation. The animations reveal patterns in both time and space related to the seasons, latitude, elevation, coastal effects, and rain shadows.

http://www.ipy.org
http://www.ipy-api.ca
http://www.ipy.gc.ca
The International Polar Year (IPY) will be a two year program of science, research and education focused on the Arctic and Antarctic regions. See what Canada and the rest of the world is planning for this landmark event.

Dating the Little Ice Age Advance of the Kaskawulsh Glacier

Alberto Reyes, PhD student, Department of Earth and Atmospheric Sciences, University of Alberta

Visitors to the St. Elias Mountains who have been lucky enough to view the spectacular landscape from the air may have noticed the prominent mounds of fresh, rocky debris that fringe many glaciers in the region. These landforms, termed moraines by glacial geologists, were deposited when colder temperature, increased snowfall, or a combination of both factors caused many glaciers to advance. The most recent period of widespread glacier advance, which took place about 500 to 150 years ago, saw many glaciers in the Kluane region advance to their farthest downvalley positions since the end of the last ice age. This recent period of worldwide glacier advance has been affectionately termed the Little Ice Age.

In the Kluane region, the foundation for contemporary studies of past glacier fluctuations was laid in the 1960s, when geologists working with the Icefield Ranges Research Project explored moraines at several sites in the St. Elias Mountains. At Kaskawulsh and Donjek glaciers, two large glaciers in Kluane National Park, George Denton discovered tilted logs protruding from the outermost moraines. Establishing the time of death for logs caught up in glacial sediments is important to geologists because this provides a *maximum age* for the glacier advance that deposited the sediments (ie. the glacier could not have been advancing over a particular site prior to the kill date of the log). In some cases, for example where trees are tilted and killed by deposition of a moraine, the kill date of the tilted tree provides a *direct age* for the glacier advance. Denton and his colleagues used radiocarbon dating to estimate when the trees where killed, and thus when Donjek and Kaskawulsh glaciers were advancing. However, radiocarbon dates yield a broad range of possible calendar dates once inherent errors and assumptions in the method are taken into account. For example, a radiocarbon age of 270±60 years ago means that, in the absence of other evidence, the dated sample could be anywhere from about 530 to 50 years old!

Geologists and climate scientists require more precise knowledge of the timing of glacier fluctuations in order to further understand how they relate to climate change. With this in mind, I teamed up with John Clague of Simon Fraser University to try to re-locate the tilted logs that George Denton discovered at Kaskawulsh Glacier. To our surprise, in addition to several of Denton's radiocarbon dated logs, we located several new tilted logs that were clearly buried, tilted, and killed by deposition of Kaskawulsh Glacier moraines. We dated the logs using tree-ring crossdating, a well-established technique that, in brief, matches patterns of tree ring-width of an undated sample to a reference data set composed of ring-width measurements from many living trees. After careful measurement of tilted log ring widths at Dan Smith's lab at the University of Victoria, Brian Luckman and Richard Van Dorp, at the University of Western Ontario, crossdated the samples using a 1000+ year set of ring-width data compiled from a site near the south end of Kluane Lake. This long reference chronology is made possible by inclusion of long-dead logs, such as snags and driftwood, which were deposited when Kluane Lake water levels were much higher than present.

Left: One of the spruce trees tilted and partially buried in the outermost terminal moraine. This log was sampled and radiocarbon dated by George Denton and Minze Stuiver in the 1960s, and yielded a range of possible ages between AD 1470 and 1950. The tree-ring kill date for the log is AD 1706.

Opposite Page: The debris covered terminus and moraines of Kaskawulsh Glacier. Slims River flows north through a prominent breach in the terminal moraine. The forested hill at right foreground divides the glacier terminus into two lobes.

We were able to confidently crossdate six tilted spruce samples that had outer ring years that ranged from AD 1671 to 1757. The earliest ages are probably the result of trees that were killed when the glacier was advancing just shy of its maximum limit and subsequently transported and deposited in the moraine debris. Alternatively, the tilted trees may have originally been standing snags that had been dead for some time prior to deposition of the moraine. At one location, three tilted logs, one of which included bark, had kill dates between AD 1752 and 1757, suggesting that Kaskawulsh Glacier deposited its outermost moraine about this time. We crossdated one tilted log outside the Kaskawulsh Glacier moraine that fringes the east lobe of the glacier to AD 1717, suggesting that the east lobe may have reached its maximum extent somewhat earlier. However, additional crossdated samples will be required to confirm this.

The tree-ring crossdates for Kaskawulsh Glacier provide the first calendar-dating of a Little Ice Age glacier advance in the Canadian portion of the St. Elias Mountains. Our results are consistent with the chronology of Little Ice Age glacier activity in adjacent mountain ranges of Alaska, which show broadly synchronous advance of glaciers in the early 17th through early 18th centuries.

Our Kaskawulsh Glacier story may also help resolve the mysterious drainage and lake-level history of Kluane Lake. Hugh Bostock, a Geological Survey of Canada scientist in the mid-20th century, proposed that Little Ice Age advances of Kaskawulsh Glacier may have caused a south-flowing Slims River to reverse course, thus causing Kluane Lake to rise and eventually establish new drainage to the north via Kluane River. Drowned trees below present lake level and raised strandlines of driftwood attest to the high magnitude of lake level change, but early efforts to link these records were inconclusive due to the large errors inherent in radiocarbon dating. Our tree-ring dates for the Little Ice Age advance of Kaskawulsh Glacier, potentially a key event in the history of Kluane Lake, dramatically reduce the dating uncertainty associated with one piece of the Kluane Lake drainage history puzzle. Ongoing tree-ring studies of Kluane Lake drowned stumps and driftwood will shed even more detailed insight into the history of Kluane Lake. Future applications of tree-ring dating in southwest Yukon, using reference ring-width chronologies like the one we used to date the tilted trees at Kaskawulsh Glacier, should provide improved understanding of the timing of landscape response to recent climate change in the region. (alberto.reyes@ualberta.ca)

Recent Publications from the KLRS Community

A section of each newsletter issue is devoted to highlighting recent publications produced as a result of research based out of the KLRS. You can submit citations and very brief summaries to rdanby@ualberta.ca for inclusion in subsequent issues.

Barker, J.M. & R. Boonstra. 2005. Preparing for winter: divergence in the summer-autumn hematological profiles from representative species of the three tribes of the squirrel family. *Comparative Biochemistry and Physiology - Part A: Molecular & Integrative Physiology*, 142: 32-42.
Examines how key blood parameters varied in 4 related members of the squirrel family with different life styles (arboreal vs burrowing; hibernating vs active year around) (red squirrels and Arctic ground squirrels from the Yukon, yellow pine chipmunks from Alberta, and grey squirrels from Ontario). The year-around tree squirrels are much more similar to each other than the burrowing-hibernating species. However, there are marked individual differences that do not cluster into these major differences in life style.

Boonstra, R. 2005. Equipped for life: the adaptive role of the stress axis in male mammals. *Journal of Mammalogy,* 86: 236-247.
Examines the suite of traits of the stress axis associated with differences in breeding frequency in male mammals. Data collected near KLRS on Arctic Ground squirrels, snowshoe hares and red squirrels is combined with data from the literature to examine these differences. Causes are related to phylogeny (in marsupials) as well as to an interaction of environmental limitations on female reproduction, the mating system, the high costs of reproduction, and low adult survival during the nonbreeding season.

Boonstra, R. 2004. Coping with changing northern environments: the role of the stress axis in birds and mammals. *Integrative and Comparative Biology,* 44: 95-108.
Living in the north requires special adaptations to cope with the severity and unpredictability of the environment. I examine how the stress axis has been modified to allow birds and mammals to survive and breed in the north. I also explore how the stress axis will respond to and be affected by global change and persistent organochlorine pollutants. These may result in either adaptations or shifts in distribution and abundance.

Bunbury, J. & K. Gajewski. 2005. Quantitative analysis of freshwater ostracode assemblages in southwestern Yukon Territory, Canada. *Hydrobiologia*, 525: 117-128.
A total of 29 freshwater ostracode species representing 8 genera were identified from the sediments of 36 lakes. Mg/Ca ratio, depth and Sr are the environmental factors that are most highly correlated with species distributions in this region. (Link to data: http://www.lpc.uottawa.ca/data/limnology/index.html)

Danby,R.K. & D.S. Slocombe. 2005. Regional ecology, ecosystem geography, and transboundary protected areas in the St. Elias mountains. Ecological Applications, 15: 405-422.
Several resources are shared by Kluane National Park and the other units of the St. Elias World Heritage site. However, ecological connectivity is not distributed equally across the region, and the four protected areas have linkages with adjacent areas that are as strong, and in many cases stronger, than among themselves. The challenge in maintaining regional ecological integrity lies in integrating existing protected areas with surrounding areas and resisting small changes that have incremental and cumulative impacts.

Gillis, E.A., D.S. Hik, R. Boonstra, T.J. Karels, & C.J. Krebs. 2005. Being high is better: effects of elevation and habitat on arctic ground squirrel demography. *Oikos*, 108: 231-240.
Demography and population dynamics of forest and alpine arctic ground squirrels was compared. Reproduction was significantly lower in the forest and results indicate that this habitat may be a sink that relies on immigration from nearby grassy meadows. Arctic ground squirrels rely on sight to detect predators from a safe distance, and the boreal forest, with its lower visibility and higher predator density, appears to be suboptimal habitat.

Gillis E.A., S.F. Morrison, G.D. Zazula, & D.S. Hik. 2005. Evidence for selective caching by Arctic ground squirrels living in alpine meadows in the Yukon. *Arctic* 58, 354-360.
Male arctic ground squirrels carry material in their cheek pouches more frequently and later in the summer than females. They also carry different material: females carry material for immediate use in the nest, whereas males carry food for caching. Content analysis indicates that males are highly selective in the species they cache. Many of the same species have been found in Pleistocene fossil caches from central Yukon, indicating that food preferences may have remained stable over time.

Hodges, K.E., R. Boonstra, & C. J. Krebs 2006. Overwinter mass loss of snowshoe hares in Yukon: starvation, stress, adaptation or artifact? *Journal of Animal Ecology*, 75: 1-13.
Overwinter mass changes in snowshoe hares was examined using the data collected from the large-scale experiments of the Kluane Ecosystem Project of 1986-96. Mass loss was interactively explained by winter conditions, food supply, predation risk, and autumn mass. Some snowshoe hares lost mass overwinter in all years and on all treatments, suggesting that reducing body mass may facilitate survival, especially in cases where foraging costs are high energetically or increase predation risk.

Kinnard C. & A.G. Lewkowicz. 2005. Movement, moisture and thermal conditions at a turf-banked solifluction lobe, Kluane Range, Yukon territory, Canada. *Permafrost and Periglacial Processes,* 16: 261-275.
A turf-banked solifluction lobe was instrumented during the spring and summer of 2002. Most gelifluction events took place when thaw rates were high and the soil was saturated almost to the surface, but rain was also capable of inducing gelifluction at depth. The rapid and localized character of the observed displacements suggests that gelifluction results from micro-shearing of the soil, possibly along the interface of thawing ice lenses.

Slocombe, D.S., L. Hartley & M. Noonan. 2005. Environmental assessment in Yukon: History and current developments, pp. 212-228 in Kevin S. Hanna, ed. *Environmental Impact Assessment: Practice and Participation*. Oxford University Press, Toronto.
This paper examines the historical evolution of environmental impact assessment in Yukon, concluding with a prospective look at the new Yukon EA legislation. Key issues examined include federal/territorial relations and devolution, the effects of comprehensive land claims and TEK, mining, and cumulative effects assessment and land use planning.

Wilson, S.E. & K. Gajewski 2004. Modern chironomid assemblages and their relationship to physical and chemical variables in southwest Yukon and northern British Columbia. Arctic, Antarctic, and Alpine Research 36: 446-455.
Modern chironomid assemblages consisting of 68 taxa were extracted from the sediments of 39 lakes in southwest Yukon and northern BC. The results show the importance of organic matter, which is associated with water depth and lake productivity, in affecting chironomid community composition. Other important factors include sediment organic matter, total phosphorus, bottom water temperature, and lake alkalinity.

Zalatan, R. & K. Gajewski. 2005. Tree-ring analysis of five *Picea glauca*-dominated sites from the interior boreal forest in the Shakwak Trench, Yukon Territory, Canada. *Polar Geography*, 29: 26-41.
Five tree-ring chronologies were developed from low-elevation stands of white spruce situated in the interior boreal forest of the Shakwak Trench, Yukon Territory. The five chronologies depict similar trends in tree-ring width, suggesting a significant climatic influence on tree growth. This study demonstrates the importance of climate influences on tree growth within sites located in the interior of the boreal forest. (Link to data: http://www.lpc.uottawa.ca/data/reconstructions/index.html)

New Lab Building at KLRS

Construction on a new research building is well underway and completion is expected this coming summer. Facilities will include wet and dry labs, a library, and office and computer space. Below: Master-builder Lance Goodwin. Right: Sabine Nouvet paints the large service doors with help from Bronwyn.

The Understory Herbaceous Vegetation: Seventeen Years of Plant Ecology Research in the Yukon

Roy Turkington, Department of Botany and Biodiversity Research Centre, University of British Columbia

Plants in the boreal forest are an important component of the ecosystem for two main reasons. First, as vegetation, they form the physical surroundings for both herbivores and carnivores and are the basis of the physical structure of the community. Second, as primary producers, they provide the energy and nutrients to the herbivores on which higher trophic levels depend. Therefore, understanding the factors that limit the quantity and the quality of plants is fundamental. Our botanical studies focus on the herbaceous vegetation, the grasses and herbs, which are relatively abundant in the forest understory and are the primary summer food supply. These plants provide a source of relatively high quality food to herbivores. Soil nutrients, especially nitrogen, often limit the productivity of boreal forest vegetation, and may control vegetation biomass.

What Factors Control the Quantity and Quality of the Herbaceous Vegetation?

To understand some of the inter-trophic level linkages between components of the system, three hypotheses regarding the vegetation are being tested: that vegetation is controlled by (i) nutrient availability alone (bottom-up, or donor control), (ii) by herbivores alone (top-down control), and (iii) by both nutrient availability and herbivores. This involves three major experimental treatments - fertilization, herbivore exclusion using fences, and fertilization plus herbivore exclusion. These treatments allow us to make specific predictions about changes in plant biomass, or standing crop, under the three different hypotheses. Between 1990 and 2006 most of these hypotheses were directly tested in the field and have been the backbone of 6 M.Sc. and 3 PhD graduate programs.

The majority of our data support the bottom-up hypothesis that herbaceous vegetation standing crop is controlled by nutrient availability alone. With fertilization there was an overall increase in the amount, and quality, of herbaceous vegetation with grasses and some herbs increasing at the expense of low-growing woody ground cover species. The studies also indicate that the summer herbaceous vegetation is not under top-down control and that the impact of mammalian herbivory, primarily by snowshoe hares, on the vegetation is minimal. In addition we recorded a loss of seven species from our fertilized plots, and the evenness of the fertilized plots declined quite markedly. A low value of evenness indicates that some of the species are of much lower abundance than others. The repeated application of fertilizer will therefore drive many of the species to low abundance (reflected in low evenness values) and ultimately exclude some of the species from the plots as more aggressive species dominate the plots.

As global warming occurs it will have at least two direct effects - the growing season will be extended at both ends, and it will be warmer. It has been suggested that the application of nutrients to northern communities may stimulate some of the same effects in the plant community that might be produced by global environmental change. Global

Jen Mundy and Aimee Pelletier (photo Ben Gilbert)

Arctic lupine and soapberry (left); fireweed (right).

Kate Edwards gardening the boreal forest understory (photo by Mike Treberg) .

changes such as increasing CO_2 concentrations, increasing deposition of nitrogen pollutants, and rising temperatures will have crucial impacts on nutrient cycles consequently leading to changes in primary production and species composition. It has been argued that climate change will increase the supply of nutrients (both nitrogen and phosphorus), by stimulating decomposition processes, and increase the rate of soil carbon accumulation. Additionally, anthropogenic impacts on the global nitrogen cycle are occurring via combustion of fossil fuels, production of nitrogen fertilizers and cultivation of nitrogen fixing legumes. In our system at Kluane we might initially expect that bryophytes, lichens, prostrate growth forms, and low nutrient-requiring species will be suppressed or eliminated by faster-growing, more upright clonal species. Clearly species, and vegetation types, with low nutrient uptake demands will be the most sensitive to the predicted changes.

The Value of Long-Term Experiments

Initial responses to fertilizer and fencing treatments were species-specific, and transient. The short-term responses measured over the first few years were poor indicators of longer term changes in community composition, and perhaps the current 17 years will be a poor indicator of longer-term trends. It is quite likely that ecosystems such as the boreal forest understory, where the herbaceous community is characterized by slow-growing long-lived plants, never attain equilibrium because the density of hares fluctuates, forests burn and climate changes constantly and slowly. This means that transient responses may be the only ones we have to work with, because permanent shifts in vegetation composition may not be evident until many years later, or may never be attained.

How Does Biodiversity Determine Ecosystem Function?

Loss of biodiversity has likely been the most dramatic change that humans have induced on ecosystems in the past century; the current global extinction rate of species is 100 - 1000 times faster than pre-human levels. This loss of species will have important effects on ecosystem functioning and on the ability of a system to respond to disturbance. To investigate these questions, Jennie McLaren is using a removal experiment called "a functional group knock-out" to permit direct comparison of annual and perennial systems. She does this by removing plant functional groups (graminoids, leguminous forbs and non-leguminous forbs) individually and observing changes in community dynamics and ecosystem function. Response variables measured include both community dynamics (species frequency measures and leaf area index) and ecosystem function (above-ground biomass, above and below-ground decomposition rates [using litter bags], nutrient supply rates [using ion exchange membranes], light interception and soil water content).

Invasive Species And Invasibility Of Plant Communities

Much research on the conservation of species diversity focuses on its role as a mechanism for maintaining ecosystem functions, such as nutrient cycling, resilience following disturbance and resistance to invasion from exotic species. Species diversity results from mechanisms that promote species coexistence. A first step in conserving species diversity lies in identifying the mechanisms that allow species to coexist. The focus of Ben Gilbert's PhD research is to investigate how the composition of a community determines invasibility of that community. The research will focus on biodiversity loss, and how this alters a community's ability to resist invading species. (royt@interchange.ubc.ca)

http://www.interchange.ubc.ca/royt/royt.htm

Jennie McLaren's field site is located on the esker visible behind Emerald Lake, near the east shore of Kluane Lake (photo Jennie McLaren)

Forest Management in a Changing Climate: Building the Environmental Information Base for the Southwest Yukon

Aynslie Ogden, Sustainable Forest Management Lab, Faculty of Forestry, University of British Columbia

Healthy forests are the foundation of the Strategic Forest Management Plan for the Champagne and Aishihik Traditional Territory (CATT). It is therefore important to determine how forests in the region might be affected by climate change. Climate-associated impacts such as drought, wildfire, and insect outbreaks – already concerns in Southwestern Yukon – are projected to become more frequent and severe, affecting forest productivity, ecosystem functioning, and habitat values in the CATT. Therefore, the development of a sound, knowledge-based decision-making capacity for the region is critical. The Northern Climate Exchange, funded by Environment Canada's Northern Ecosystem Initiative, is currently coordinating a project to synthesize available information on climate change for the southwest Yukon to support informed forest management decision-making for the CATT in light of climate change. This project is intended to be the first step in a longer-term process of evaluating climate impacts, assessing risks to ecosystem and community values, and developing scenarios for adaptation.

A draft project website is now available for review, and we would greatly appreciate any comments that you may have on the information contained on this website. In particular, we are interested in refining the current list of indicators, and developing new indicators on glacial retreat, permafrost, streamflow, ice-free season, vegetation response, ecosystem dynamics and treeline movement. We are also interested in feedback on aspects of the local society and economy that are sensitive to changes in climate for which data exists and an indicator can be developed. Lastly, we are looking for assistance to ensure our compendium of information sources is complete. Please let us know if you have additional information to contribute to this effort to synthesize understanding of the relationship between climate change and forest resources in this region.

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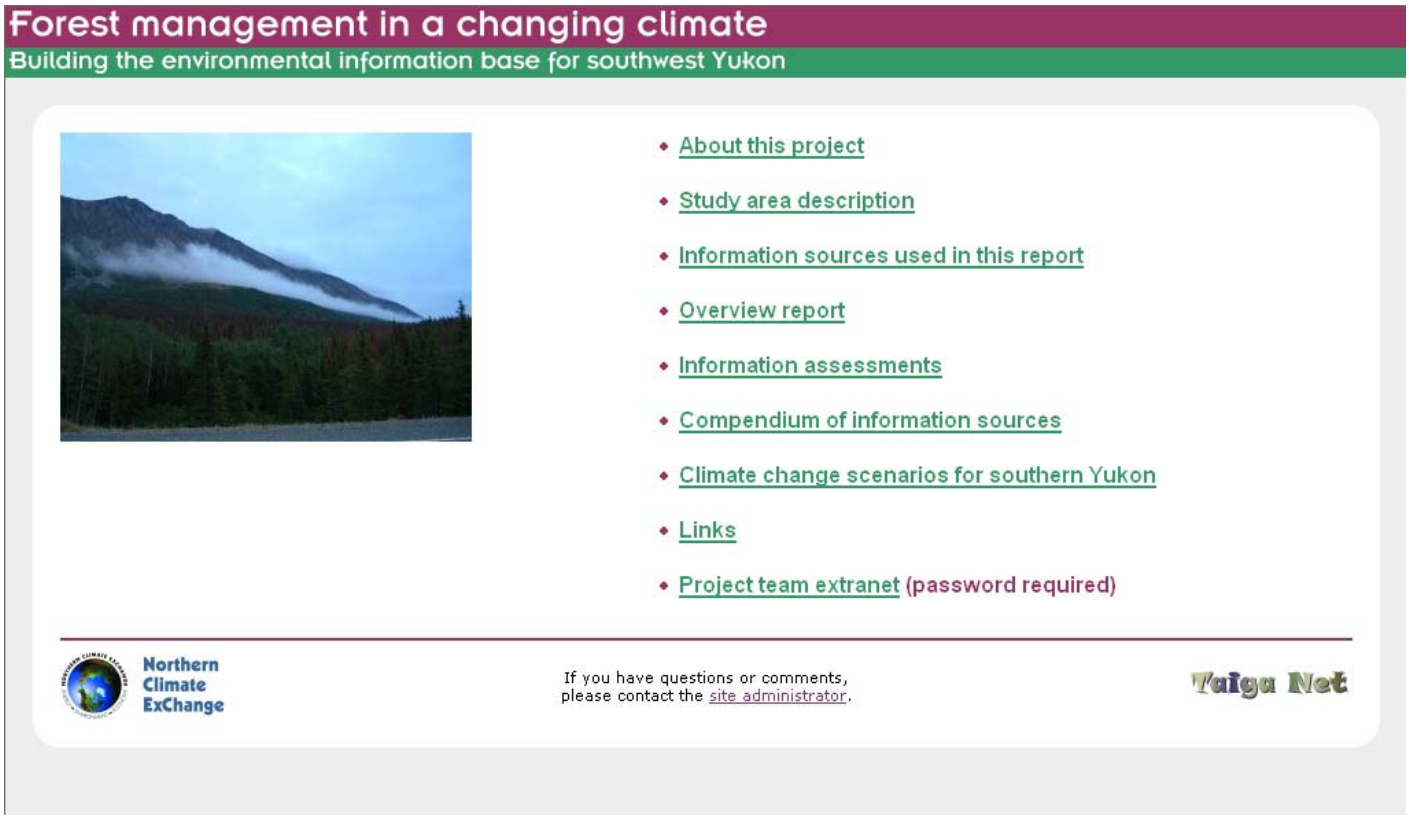

Project website: http://www.yukon.taiga.net/swyukon/index.cfm

Photos from 2005

The 2005 field season was busy at KLRS, including field schools, two "satellite" camps, and the regular host of researchers coming and going throughout the summer. Clockwise from right: (1) Arrival of the University of Ottawa field course (GEG 4001, Field Research in Northern Canada) in May. (2) Attending lecture in the Wood building. (3) At the KLRS entrance. (4) Dr. Scott Slocombe and members of the Wilfrid Laurier University field school (ES401, Theory and Practice of Ecosystem-Based Management) in July. (5) Dr. Brian Luckman (University of Western Ontario) speaking to participants of the Rapid Landscape Change conference in June about past levels of Kluane Lake.

1. Photo by Peter Johnson, University of Ottawa

5. Photo by Ryan Danby, University of Alberta

2. Photo by Peter Johnson, University of Ottawa

4. Photo by Barry Ries, Wilfrid Laurier University

3. Photo by Peter Johnson, University of Ottawa

Photos from 2005 (continued from page 11)

Clockwise from right. (1) Glaciology research camp at Trapridge Glacier. (2) The 2005 Trapridge Crew: Eric DeGiuli, Frank Wilschut, Jes Logher, Garry Clarke and Andrew Schaeffer. (3) Michaela Timciska videotapes animal behaviour near Pika Camp in the Ruby Range. (4) Sarah Trefry and Alex Taylor build grazing exclosures and greenhouses on the alpine tundra. (5) Matt Mitchell (upper left) talks about alpine plants at the Tachal Dhal rediscovery camp in July.

1. Photo courtesy Garry Clarke, UBC

2. Photo courtesty Garry Clarke, UBC

3. Photo by Saewan Koh, U Alberta

4. Photo by Saewan Koh, U Alberta

5. Photo by Ryan Danby, U Alberta

Recent and Upcoming Events

Climate Change Workshop, Mar 31-Apr 2, 2006
Haines Junction, St. Elias Convention Center
The first day of the three-day workshop focused on providing background information on climate change from scientific and traditional knowledge perspectives, and providing an opportunity for local residents to share their observations of changing climate and environmental conditions in the region. The second day was devoted to a discussion on "Our Changing Boreal Forest" where the results of the NEI climate change synthesis project were discussed. The last day of the workshop included a discussion on glaciers, and a broader discussion on research and monitoring needs and approaches in the region. For more information please contact Rose Kushniruk at 867-634-4233 or Aynslie Ogden at 867-633-7908.

KLRS Users Committee Meeting, Apr 10
University of Alberta, Edmonton
The KLRS users committee met in Edmonton at the beginning of April. Renewal of the NSERC MFA was a major topic of discussion. Other topics of discussion included expanding the user-base, enhancing partnerships, research permitting, and potential tie-in with efforts related to the International Polar Year. Please contact David Hik (dhik@ualberta.ca) for more information.

2006 Alaska Park Science Symposium, Sep 12-14, 2006
Murie Center, Denali National Park and Preserve
The biannual Alaska Park Science Symposium is presented by the U.S. National Park Service to highlight scientific endeavors focused on Alaska National Park regions. The 2006 Symposium will focus on research in interior Alaska as well as western Yukon. Papers are invited for this regional symposium from scientists and scholars working across many disciplines and the symposium will provide an outstanding opportunity to share results and collaborate with researchers working throughout Central Alaska Park areas and adjacent Yukon. A call for abstracts, as well as specific information regarding the symposium, keynote speakers, panel discussions, field trips, logistics and related events, can be found at the conference website: http://www.nps.gov/akso/Symposium

Highway Construction, Summer 2006
The Alaska Highway reconstruction project will run from Silver Creek to the Slims River Bridge this summer. Activities will include installation of a new culvert at Silver Creek and rock blasting activity close to the Slims River delta. Astute readers will realize that KLRS falls along this path of construction. Base manager Andy Williams is liaising with the contractor and will advise users of safety measures that will be in place. Activity is expected around the clock, seven days a week. All vehicle drivers will be required to exercise extreme caution.

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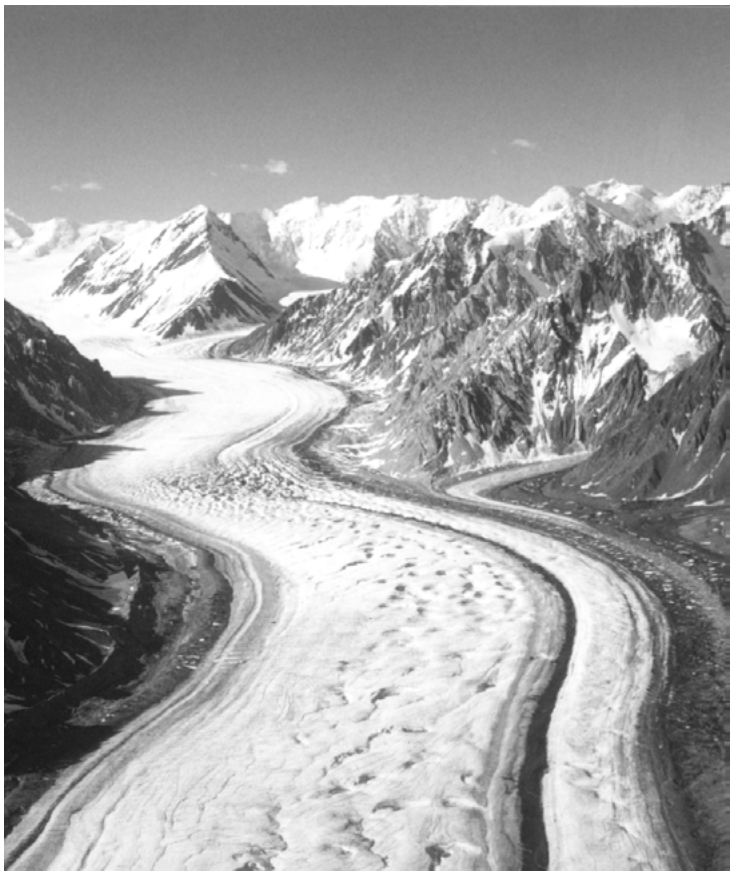

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http://www.arctic.ucalgary.ca/sections.php?sid=research&cid=kluane_station

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