EARTHWATCH INSTITUTE ANNUAL FIELD REPORT

Date completed: 1 June 2008
Completed by: G. Peter Kershaw
Period covered by this report: June 2005 to February 2007

UNIVERSITY OF ALBERTA
Earth and Atmospheric Sciences
Faculty of Science

1-26 Earth Sciences Building
Edmonton, Alberta, Canada T6G 2E3
www.ualberta.ca/eas
eas.enquiries@ualberta.ca
Tel: 780.492.3265
Fax: 780.492.2030

Dear Earthwatch Volunteers,

Welcome to the *Climate Change at the Arctic's Edge* expedition, a multi-disciplinary research effort initiated in 1999. The short-term goal of this project was to establish a network of study plots representative of the dominant ecosystems in the Hudson Bay Lowlands (including those disturbed by human activities). We now have 11 permanent monitoring sites in representative ecosystems of the Hudson Bay Lowlands, 5 reclamation test sites and 7 International Polar Year transects that cross treeline. In the Mackenzie Mountains we have been working on 5 sites since 1990 and will have several IPY transects by the end of the 2008 field season. We have compiled a wealth of data on these sites which will be used to meet the long-term objective of quantifying environmental responses associated with climate change. Our efforts are directed at benchmarking current conditions in order to evaluate predicted future changes.

This project is one that requires a high investment of time in the field, something that I relish. The studies are labor-intensive and Earthwatch teams provide the people-power that makes it possible to collect high amounts of quality data in relatively small windows of time. Team members are provided with the necessary training and either I or the Earthwatch Field Team Leader is with them at all times. The outside work can be physically demanding and volunteers have to be able to deal with the weather that comes with the environment. In the thaw season (summer), it can be cold and wet with plenty of bugs. In the winter it can be extremely cold as a result of sub-zero temperatures and wind chill. Regardless of the conditions, we do our work and put up with the good, the bad and the ugly weather, knowing that there is snug comfort and good food at the end of the day.

Between the long days of data collection and lab work, we make time for the team members to take in some of the local attractions. At Churchill there is a surprising variety of activities available – beluga whale watching in the mouth of the Churchill River, tundra buggy touring in search of the elusive polar bear, mountain bike riding along raised beach ridges, helicopter touring along the coast, hearing about local history in the 18th century Hudson's Bay Company fort, viewing the Eskimo museum's amazing collection of Inuit art, or trekking over the sea ice to the ship wreck on Bird Cove. On the more isolated Mackenzie Mountains team one can watch herds of caribou and flocks of ptarmigan moving across the Mackenzie Mtn Barrens, while wolves and grizzly bears are less commonly seen. A day hike up one of the mountains is rewarded with alpine wildflowers and birds such as the Gyrfalcon on a hunting flight. In addition, we take time to catch sunsets, check out unusual bird sightings, caribou and other wildlife, participate in local festivals in Churchill (including the Canada Day Bay dip among the ice floes), enjoy the flowers and generally soak up as much of the local environment as time will permit. I strive for a balance between science and providing opportunities for team members to immerse themselves in these unique environments.

It has been my pleasure to work with Earthwatch volunteers, and their contributions have significantly and positively affected this research project. I also treasure the interactions, the camaraderie and the opportunity to learn from the dedicated people that selflessly contribute to the success of this project.

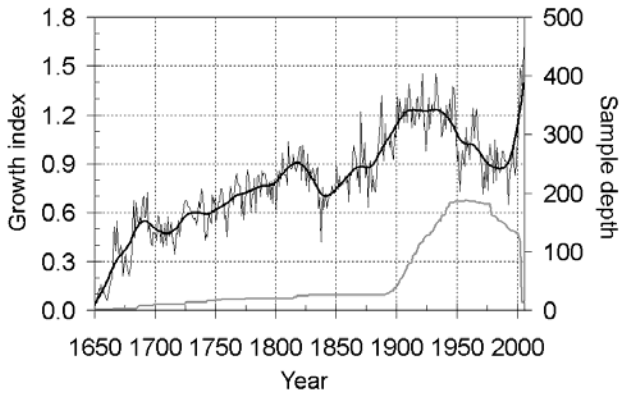
Yours Sincerely,

Pete Kershaw.

G. Peter Kershaw, BES, MES, PhD
Associate Professor

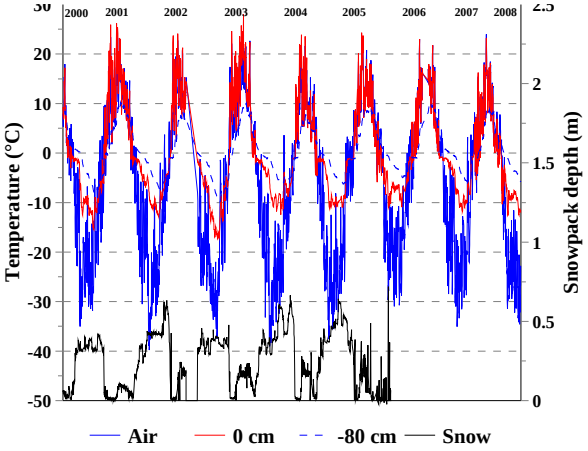
Reporting on research objectives

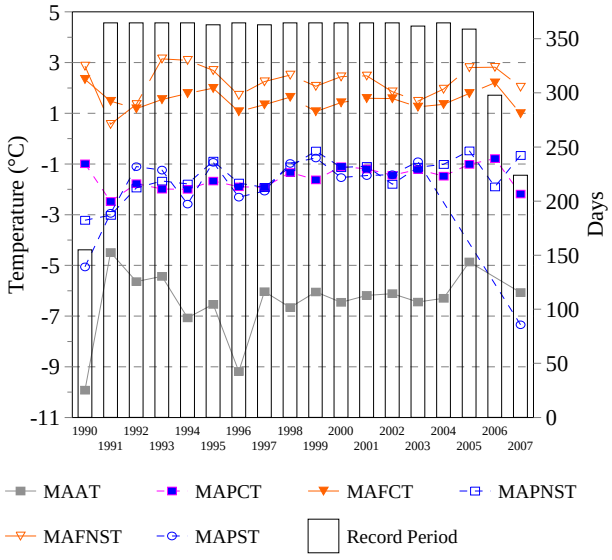
Dendroclimatology:
Objective 1: Build a multi-species proxy of past climate.
A regional chronology for Churchill and a proxy climate record using tree rings has been completed. Similar studies have been initiated in the Mackenzie Mountains.

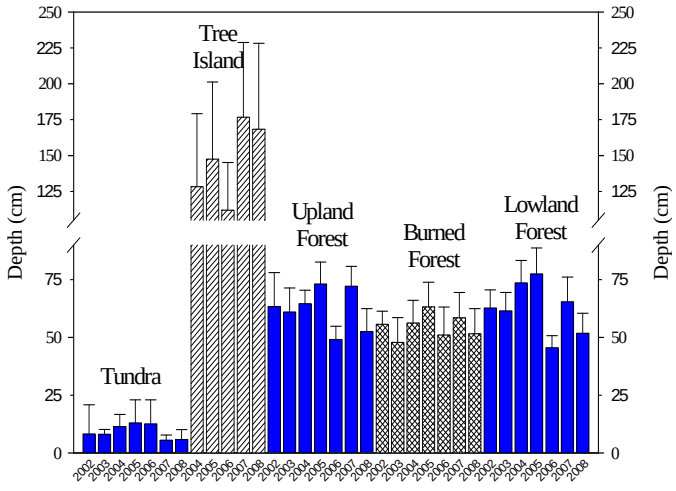


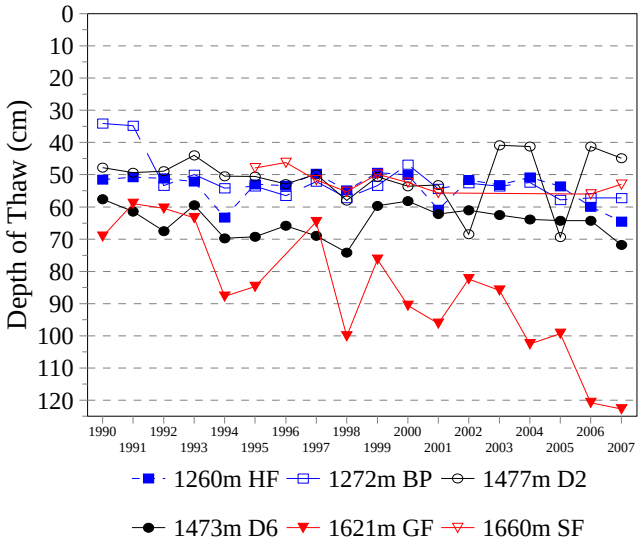
Steve Mamet's MSc thesis (Mamet 2007) partly addressed this objective. The tree ring chronologies reveal periods of enhanced and suppressed growth back to ~1650 (figure to left, bottom line is sample depth or sample size). Growth rates and origin dates confirm recent warming and past periods of tree recruitment in response to warming events.
Jeff Suter's MSc thesis (in progress) is addressing the dendroclimate topic but using shrub rings from dwarf birch and willow. The field collection phase of the research has been completed and specimens are being processed over the summer of 2008.

Microclimate:
Objective 2: Quantify the different microclimates and compile a continuous data base.
Variations in microclimate (left figure is an example of the type of data from one LTEMS – Planted Forest) among the Long-Term Environmental Monitoring Sites (LTEMS) affect soil, permafrost (Kershaw 2008 In Press), snowpack, soil processes (Edwards et al 2006), plant growth and reproduction, and small mammals. Analysis of the microclimate archive will vary with the end use.
The more than 15-yr-record from the Mackenzie Mountains (example on right from Hare Foot site) will facilitate correlation with permafrost, plant growth and reproduction characteristics.









Mid-Winter Snowpack:
Objective 6: Quantify the different snowpacks and compile an annual data base.
Mid-winter snowpack characteristics have been quantified within the 10 Churchill LTEMS and the five reclamation test treatment sites since 2002 (Kershaw In Press, Kershaw & McCulloch 2007). No trends are apparent over the seven years of the study (figure includes five of the LTEMS where depth has not changed statistically). Analysis has included chemical characteristics of the snow (Fishback & Kershaw 2005).

Permafrost:
Objective 3: Assess the past and current status of permafrost.
Seasonal active layer and permafrost depth variations among the LTEMS will continue to be measured in order to extend the existing data base and evaluate the impact of anticipated climate warming (Kershaw 2008 In Press). The active layer monitoring at the Mackenzie Mountains sites (Kershaw 2003b) continues with the 18th year of measurements completed in 2007 (on the figure to the left the depth of thaw at the Goose Flats site has doubled as the site is about to become permafrost-free while the other five sites appear stable).

Anthropogenic Disturbance Reclamation:
Objective 4: Test reclamation treatments.
The reclamation test treatments installed at Churchill in 2002 were evaluated over their first 2 growing seasons for Jennie Rausch's thesis (Rausch 2006). In addition to annual digital imaging, additional botanical assessments will be completed every few growing seasons (Rausch & Kershaw 2007).
Along the abandoned Canol Project in the Mackenzie Mountains, the natural recovery status of the 60-yr-old anthropogenic disturbances will continue to be monitored (Kershaw 2003a). In 2008 rephotography will be conducted to facilitate assessment of natural revegetation.

Small Mammals:
Objective 5: Determine the characteristics of small mammal communities.
Live trapping, mark and release studies have been conducted annually to determine species, population demographics, and home range data from the 10 LTEMS at Churchill. Because of other research commitments, no trapping will be conducted in 2008.

Soil Carbon Stores:
Objective 7: Quantify the amount and characteristics of organic C stores.

An archive of soil C values has been created for the Churchill LTEMS. New measurements will be conducted at the International Polar Year (IPY) sites during the 2008 season. In areas of thick peat, permafrost coring has been conducted to measure the C content with depth. Similar studies in the Mackenzie Mountains permit comparisons between mountainous and lowland environments.

Treeline Migration:
Objective 8: Assess the past and current status of treeline.
A multi-faceted approach is being taken to determine what the limits are to treeline/timberline migration. A set of experiments are underway and planned to assess the physical limitations affecting tree seedlings and mature trees within the tree islands and through the forest-tundra ecotone at treeline. Studies of timberline tree islands in the Mackenzie Mountains will parallel those at Churchill but without the environmental manipulations. These studies are part of an international research effort under the auspices of IPY – PPS Arctic.

Selected References:

Non-technical summary of results

Give an account of the data collected and results (inputs and data) for the period covered by this report, mentioning any emerging trends.

Over the past two years much data has been collected, some has formed the basis of graduate theses or refereed papers with all saved to a data archive. At Churchill, progress has been made on all the research objectives with some sites having seven years of measurements on many of the parameters being studied. In the Mackenzie Mountains, where the 18th year of research is about to begin, trends are apparent. In particular, permafrost is warming at most of the sites while it has disappeared at one. However, at Churchill it appears to be too early to discern if trends are apparent. The exception is with the tree ring data since it is evident that since 1650AD the past few decades have been warmer. Over the next few years we hope to determine if there is a response in permafrost characteristics or treeline shift. Meanwhile, the level of understanding of the environment in the Churchill and Mackenzie Mountains study areas probably surpasses most research sites in the circumpolar north. We have a unique and unparalleled record of conditions in these areas that will improve our ability to assess ecosystem responses to climate change in the future.

How do these data contribute to achieving conservation impacts? (e.g. actions based on results, management plans, site protection)

The studies conducted out of the CNSC are within the Churchill Wildlife Management Zone which is a buffer surrounding Wapusk National Park. A significant rationale for the creation of the park was to protect caribou and polar bear populations in the Hudson Bay Lowlands. This region has the highest density of polar bear maternity dens in the world and the Western Hudson Bay population is rapidly declining. Research in the region dealing with ecosystem integrity, which is highly dependent on permafrost status, is critical to planning conservation and management of such a high profile species. We have provided input to workshops hosted by Parks Canada which have the goal of collating the various research findings that relate to management of Wapusk National Park.
In the Northwest Territories the Canol Heritage Trail transects the study area and we are continuing our collaboration with government Parks staff as the Territorial Park is developed.

What is/ are the significance/ benefits of your research at the following levels?

- Local (to the area of the research site)

Local tour operators can and have used information gleaned from our studies to enhance the information they provide to clients.
Wapusk Parks staff have used the information we have provided to improve their understanding of the local ecosystems.

- National / Regional

The protocols for snowpack sampling that have been developed for Churchill have been incorporated into Parks Canada protocols to be used nationally.

- International

With the commencement of the IPY, Churchill and the Mackenzie Mountains have become critical in the circumpolar network of treeline research. Development of the sampling protocols incorporated pilot work done at Churchill and in the Mackenzies and these sites fill significant gaps in the network.

Communication of results

Printed:

Edwards K.A., McCulloch J., Kershaw G.P., Jefferies R.L. 2006. Soil microbial and nutrient dynamics in a wet Arctic sedge meadow in late winter and early spring. *Soil Biology and Biochemistry*. 38: 2843-51.

Kershaw G.P. 2008 In Press. Snow and temperature relationships on polygonal peat plateaus Churchill MB, Canada. In *Permafrost, Proceedings of Ninth International Conference on Permafrost*, Fairbanks USA, pp. 7 ms pages.

Kershaw G.P., Mamet S. 2006. *Dendroclimatological investigations, Wapusk National Park*. Edmonton: Department of Earth & Atmospheric Sciences, University of Alberta. 18 pp.

Kershaw G.P., McCulloch J. 2007. Winter snowpack variation across the Arctic treeline, Churchill, Manitoba, Canada. *Arctic, Antarctic, and Alpine Research*. 39: 9-15.

Mamet S.D. 2007. *Treeline dendroecology and dendroclimatology, Northeastern Manitoba, Canada*. MSc thesis. Alberta, Edmonton. 131 pp.

Mamet S.D., Kershaw G.P. 2006. Tree ring radial growth response to climate, Wapusk National Park, Manitoba Canada. In *3rd Annual Churchill Research Symposium*. Winnipeg, MB: University of Winnipeg.

Mamet S.D., Kershaw G.P. 2007. Dendrochronology and tree colonization: comparative analysis between wetland and upland localities in northern Manitoba. In *4th Annual Churchill Research Symposium*. Winnipeg, MB: University of Manitoba.

Mamet S.D., Kershaw G.P. 2008. *Climate forcing of tree growth across the forest-tundra of northeastern Manitoba*. Presented at 38th Annual International Arctic Workshop, Boulder, CO, pp. 87.

Mamet S.D., Kershaw G.P. 2008. *Winter desiccation and recent recruitment of conifers at treeline: preliminary methods and results*. Presented at IPY, PPS Arctic International Meeting, St. John's, NL.

Mamet S.D., Kershaw G.P. In review, submitted 7 January 2008. Radial-growth response of forest-tundra trees to climate: Subarctic Hudson Bay Lowlands *Dendrochronologia*. 44.

Rausch J., Kershaw G.P. 2007. Short-term revegetation performance on gravel-dominated, human-induced disturbances, Churchill, Manitoba, Canada. *Arctic, Antarctic, and Alpine Research*. 39: 16-24.
Rausch J.C. 2006. *Reclamation of gravel-dominated disturbances, Churchill, Manitoba, Canada*. MSc thesis. University of Alberta, Edmonton. 171 pp.

Visual: artwork; visitor centre, poster or display, slides, photographs

Edye E., Kershaw G.P. 2006. Environmental controls on white spruce (*Picea glauca*) survival and growth at the treeline, Churchill, MB, Canada. Poster at *Churchill Research Symposium*. University of Winnipeg, Winnipeg MB: Churchill Northern Studies Centre.
Edye, E., Kershaw, G.P. 2008. Modeling white spruce seedling site selection at the treeline. Poster at *IPY, PPS Arctic International Meeting*. St. John's, NL: Memorial University.
Mamet S.D., Kershaw G.P. 2008. Winter desiccation and recent recruitment of conifers at treeline: preliminary methods and results. Poster at *IPY, PPS Arctic International Meeting*. St. John's, NL: Memorial University.
Suter, J.A., Kershaw, G.P. 2008. The use of *Betula glandulosa* Michx. (dwarf birch) for Subarctic dendroecology. Poster at *IPY, PPS Arctic International Meeting*. St. John's, NL: Memorial University.

Digital:

http://faculty.eas.ualberta.ca/kershaw/

Meetings and conferences:
Kershaw G.P., Edye E., Mamet S.D., Suter J.A., Fishback L. 2008. Environmental change in the Churchill Region. Presented at Wapusk Research and Monitoring Conference, Winnipeg.

Invited Lectures:
- Wapusk National Park, 25 July 2007
- Brookfield Zoo, Chicago, 1 October 2007
- HSBC, Chicago, 1 October 2007

Educational Opportunities

Does your project directly or indirectly involve the following groups in your research topic?
- Local communities

I present talks in the community of Churchill and at the CNSC at least once and often several times a year.

- Students

I have given talks in the Prince of Wales Composite School in Churchill.

- Early career scientists

Each year I hire at least one undergraduate student as a field assistant and they commonly collect data that becomes the basis for a directed study course. Once these students have completed their degrees they often go on to graduate programmes. I currently have a PhD student that started work with me as an undergraduate field assistant. Over the last two years I have taken 2 undergraduate and 3 graduate students into the field and lab for training and mentoring.

- Other groups

Has your project contributed to the completion of Masters' or PhD theses or degrees, or other educational research findings?

Two students have defended MSc thesis since Feb 2006. My graduate students have conducted 3 oral and 5 poster presentations at regional and international meetings over this same period.

Other

Research at Churchill has confirmed the relationship between snowpack characteristics and permafrost status. Specifically, we have been able to describe a positive feedback between permafrost degradation, surface subsidence, and snow accumulation. More insulating snow reduces the loss of summer heat from permafrost which causes surface subsidence as the ice-rich permafrost melts which in turn leads to more snow accumulation. Based on our data it appears that under the new climate regime, areas that undergo thaw subsidence will not permit reestablishment of historical permafrost conditions.

Acknowledgements

Additional funding has been provided by the Government of Canada through their IPY Programme and the Canadian Circumpolar Institute partially supported Steven Mamet, Jennie Rausch, and Jeff Suter. Wapusk National Park provided In-kind and financial support.

Edwards K.A., McCulloch J., Kershaw G.P., Jefferies R.L. 2006. Soil microbial and nutrient dynamics in a wet Arctic sedge meadow in late winter and early spring. *Soil Biology and Biochemistry*. 38: 2843-51.

Fishback L., Kershaw G.P. 2005. *Snowpack geochemical loading in selected environments across the Arctic treeline near Churchill, Manitoba*. Presented at 62nd Eastern Snow Conference, Waterloo, pp. 26.

Kershaw G.P. 2003a. Long-term tundra disturbances: successful colonizers. In *Social and environmental impacts in the North: methods in evaluation of socio-economic and environmental consequences of mining and energy production in the arctic and subarctic*, ed. RO Rasmussen, NE Koroleva, pp. 159-71. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Kershaw G.P. 2003b. *Permafrost landform degradation over more than half a century, Macmillan Pass/Caribou Pass region, NWT/Yukon, Canada*. Presented at Proceedings of the Eighth International Conference on Permafrost, Zurich, pp. 543-8.

Kershaw G.P. 2008 In Press. *Snow and temperature relationships on polygonal peat plateaus Churchill MB, Canada*. Presented at Permafrost, Proceedings of Ninth International Conference on Permafrost, Fairbanks USA, pp. 7 ms pages.

Kershaw G.P. In Press. Headwater wetland storage changes following permafrost degradation, Mackenzie Mountains, Northwest Territories, Canada. In *The Environmental Role of Headwater Wetlands*, ed. M Haigh, J Krecek, pp. 8, 3 figs. Dordrecht: NATO Publishing Unit, Kluwer Academic Publishers.

Kershaw G.P., McCulloch J. 2007. Winter snowpack variation across the Arctic treeline, Churchill, Manitoba, Canada. *Arctic, Antarctic, and Alpine Research*. 39: 9-15.

Mamet S.D. 2007. *Treeline dendroecology and dendroclimatology, Northeastern Manitoba, Canada*. MSc thesis. Alberta, Edmonton. 131 pp.

Rausch J., Kershaw G.P. 2007. Short-term revegetation performance on gravel-dominated, human-induced disturbances, Churchill, Manitoba, Canada. *Arctic, Antarctic, and Alpine Research*. 39: 16-24.

Rausch J.C. 2006. *Reclamation of gravel-dominated disturbances, Churchill, Manitoba, Canada*. MSc thesis. University of Alberta, Edmonton. 171 pp.