# THE CANADIAN TAIGA &TUNDRA EXPERIMENT:

## 2000 Workshop Report

*EMAN National Science Meeting, January 17, 2000, Toronto, Ontario*

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## *INTRODUCTION*

Forecasts of future global climate warming from general circulation models show that changes will be greatest at high latitudes and this has considerable implications for arctic ecosystems. In order to properly monitor the changes in arctic terrestrial ecosystems that will result from climate warming, and provide information for the assessment of the changes, the formation of a network of integrated research stations is essential. This led to the establishment of the Canadian Tundra Ecosystem Monitoring Network (CANTEM-Net) at a workshop during the EMAN National Science Meeting in 1999. This year the workshop was extended to a full day and the name of the group has been changed to the Canadian Taiga and Tundra Experiment (CANTTEX). The name reflects both the range of environments covered by the network of sites and scientists, and the fact that it includes the Canadian components of the International Tundra Experiment (ITEX).The aim of CANTTEX is to encourage and facilitate sharing ideas, data and information, and cooperation in research and monitoring initiatives in arctic taiga and tundra ecosystems.

This report serves as a summary of the CANTTEX Workshop held during the EMAN National Science Meeting in January, 2000. Further reports are planned from the CANTTEX network, as work begins on establishing protocols for ecological monitoring throughout the Arctic.

## *PRESENTATIONS*

### *Current Status of ITEX in Canada*

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The International Tundra Experiment (ITEX) was formed in 1990 to conduct research on responses of arctic tundra plants and ecosystems to the predicted climate change throughout the tundra biome. There are currently 16 active ITEX sites in arctic and alpine tundra. The studies involve a combination of long-term monitoring of key circumpolar plant species and their communities, simple experiments to simulate climate change, and more complex experimental manipulations. The standard manipulation in ITEX is a passive warming experiment using open-top chambers constructed from transparent fiber glass material, which raises mean near-surface temperatures by 1-3ºC during the growing season (Marion et al. 1997). The success of ITEX comes from the fact that it is a “bottom-up” network of scientists and sites, and has been maintained by the enthusiasm and collegiality of its members. One of the major contributions from ITEX is the ITEX Manual (Molau and Mølgaard 1996) with mutually developed protocols for common measurements, study design and analyses. This has allowed biome wide analysis of plant responses to climate variability and warming experiments (Henry 1997; Arft et al. 1999). Adoption and adaptation of the ITEX protocols for CANTTEX will be one of the major objectives for the Canadian tundra / taiga network over the next year.

The first ITEX site in Canada was established at Alexandra Fiord, Ellesmere Island in 1992, where there are currently six sites with warming experiments and two with monitoring only. Warming experiments are established at: Alexandra Fiord, Ellesmere Island; Baker Lake, Nunavut; Bylot Island, Nunavut; Churchill, Manitoba; Tanquary Fiord, Northern Ellesmere National Park; Kluane National Park, Yukon; and Wolf Creek Basin, Yukon. In addition, monitoring of plants in relation to climate

variability has been conducted at Churchill for the past six years, and at the Tundra Ecosystem Research Station, Daring Lake, NWT, for the past 3 years (See following notes on presentations from each of these sites). There is great potential to expand the monitoring aspects of CANTTEX throughout the North by including more community-based programs and incorporating studies from the expanding number of National and Territorial Parks. Such a network of dedicated sites and observers would provide unprecedented information on the response of tundra and taiga systems to climate variation, and give communities, scientists, land managers, and others timely indications of change in these sensitive ecosystems.

The objectives of the Workshop are:

1) Build on the momentum started at the inaugural workshop last year, and enhance the growing network of sites and observers through the exchange of information; and
2) Establish working groups to develop protocols for ecological monitoring across the North. Protocols will need to be tailored to the locations: e.g. protocols for community-based monitoring versus research at established ITEX sites, research stations and national parks.

### *EMAN-North: Current activities*

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The objectives of EMAN-North are to foster cooperation among agencies and researchers, and to ensure that information on arctic ecosystem research and monitoring is published and made available. EMAN-North currently encompasses the EMAN activities operating in Northwest Territories and Nunavut. There are 80 separate projects operating at 15 sites within six different networks including seven National Parks, two research stations, four research sites and two multi-site networks. Most sites conduct multi-disciplinary research and monitoring. Parks Canada is the most active agency with seven other agencies also participating in various projects. There is at least one EMAN site in all seven ecozones but the future of several of the sites is currently tenuous.

The primary issues of interest to EMAN-North are:

- biodiversity (birds, large terrestrial mammals, marine mammals, small mammals, insects, plants, and fish); the most frequent measures being changes in vegetation and in terrestrial bird populations;
- climate (weather, glaciers, snow, permafrost, active layer, plants, wetlands, and water); most often measured through changes in water flows and flood frequency, and through climate records;
- atmosphere (changes in aerosols and greenhouse gas concentrations);
- toxins (especially in “country food” used by native northerners);
- water (hydrology and water quality); and
- human use.

A brochure outlining the activities of EMAN-North has been produced but is out of date and in need of revisions. The EMAN-North website URL is: *www.nwtresearch/eman*. The website contains profiles of the 15 research and monitoring sites and a database describing over 80 long term monitoring projects in Northwest Territories and Nunavut. There are plans for increased activity in association with the CANTTEX group including updating the website, increased communication with Nunavut government, with land claims boards and communities, and increased involvement in the Nunavut General Monitoring Program and the Mackenzie Valley Cumulative Impact Monitoring Program.

### *The CANTEM-Net meta-data on taiga.net.*

*Joan Eamer*

*Environment Canada, Yukon*

An important resource that will facilitate cooperation and collaboration is the use and updating of a website that catalogues meta-data on ongoing research and monitoring programs. The current database for CANTTEX related meta-data is accessed at the URL: www.taiga.net/cantem-net. The database currently contains five fields with summary information on the nature of the research being pursued at each site. Twelve sites are currently registered on the web page and there are plans to update the database to make it more amenable to including descriptions of networks as well as descriptions of individual research sites.

### *The Wolf Creek Basin study, Yukon*

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The Wolf Creek Watershed near Whitehorse provides an excellent model of an integrated monitoring site where physical and biological variables are monitored by a group of scientists, all of whom benefit from the cooperation. Half of the basin is forested while the remainder is split between tundra and sub-alpine vegetation making it an ideal site for ecological investigations. The site was first used to monitor hydrological response to climate change. Later, a variation on the ITEX open top chamber (OTC) design was used to study the changes to vegetation composition and phenology that would occur under climate warming. Issues that have arisen from the Wolf Creek and other sites in the Yukon are: continuity / project management, non-expert field workers, funding sources, and uncertainty about where to focus the existing resources.

### *Kluane Alpine Ecosystem Project and YT2025 - St. Elias Climate Change Project*

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The Kluane Alpine Ecosystem Project focuses on the effects of mammalian herbivory in alpine ecosystems. There has been a significant change in small mammal populations this year and this should lead to valuable information on the response of vegetation to these changes. Modified ITEX OTCs have also been established at the site in conjunction with fertilization experiments.

The biophysical and socio-economic implications of climate change in the southwest Yukon are the foci of the YT2025 - St. Elias Climate Change Project. It is designed to coordinate the efforts of researchers working at the Kluane Lake Research Station.

### *Environmental monitoring at Daring Lake, NWT*

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The Tundra Ecosystem Research Station (TERS) at Daring Lake is located 300 km north of Yellowknife and 50 km north of treeline along the Bathurst caribou migration route. It was set up in 1994 during the rush of diamond exploration in the region to serve as a model field facility. The TERS facility is state-of-the-art and demonstrates proper camp design, alternate energy use, bear deterrence and waste management. It is powered by solar and wind energy with a gas generators for backup.

TERS supports ecological research, environmental monitoring, and migration programs related to development activities including:

- ITEX monitoring of eight plant species;
- bear population ecology;
- wolf denning habitats;

- wolverine ecology;
- caribou migration patterns;
- breeding birds/raptors;
- small mammals - index of population size;
- arctic hare populations;
- air quality - background levels of dust;
- hydrology of low arctic lakes;
- dwarf birch ecology; and
- contaminants in Daring Lake.

There are also seven cooperative programs that TERS is affiliated with:

- West Kitikmeot Slave Study (aboriginal, Environmental, industry and government partners);
- Tundra Science Camp (NWT schools);
- base camp for inspection and enforcement personnel (government);
- climate monitoring (DIAND);
- esker studies (DIAND and RWED);
- archaeological studies (PWNHC); and
- hydrology / water quality (EC and DIAND).

New projects are aimed at studying the effect of development on biodiversity, and assessing the impacts of climate change and contamination of the surrounding environment by toxic chemicals.

### *ITEX at Tanquary Fiord, Baker Lake and Churchill*

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The ITEX site at Tanquary Fiord, Ellesmere Island was established in 1994. Twenty five individual plants of two species, *Dryas integrifolia* and *Saxifraga oppositifolia* were marked and their spring phenology monitored every three days, beginning with snowmelt. The year 2000 season will be the 7th consecutive season there. The Parks Canada staff have been involved in collecting the data and these have been forwarded every season to the project's principle investigator.

The hamlet of Baker Lake, Nunavut is located approximately 350 km west of the Hudson Bay coast, at the northern rim of the lake. The locality was chosen as one of several circumpolar sites in Canada, Alaska, Scandinavia, Russia and elsewhere, designated to study the timing and flowering profusion of tundra plants in a response to global change. Tundra plants were deemed to be the best climate change integrators in the Arctic since they respond not only to the temperature change but also to other associated factors. In 1992, ITEX phenology monitoring was established at a site in heath tundra north of the hamlet. Three species, *Dryas integrifolia* (30 individuals), *Saxifraga tricuspidata* (25 clumps) and *Cassiope tetragona* (20 shrubs) were marked, each being a dominant species in a separate plant community. Their phenology has been recorded every two to three days after the snowmelt up to a seed ripening stage. Five open-top chambers (OTCs) were also constructed at a site near the Baker Lake weather station. Phenology of the same species inside and outside (controls) the OTCs was recorded from 1995 to 1998. Temperature differences in and out of the OTCs were also measured. Preliminary assessment of the data indicates high year-to-year variability with no obvious relationship with other factors. However, no conclusions can be made until more sophisticated treatment of the data is applied. The year 2000 will be the 9th of an originally contemplated 10 year project. The future of this program will depend on a renewed commitment of new ITEX torch bearers since one of the principle investigators, J. Svoboda, has long retired and will not be able to continue in the project.

Monitoring the impacts on vegetation of a 6 m tall wooden snow fence, under construction at the North side of the hamlet, began in 1992. The presence of the fence has resulted in a large snowdrift, up to 8

m high and 150 m wide, being deposited along its 2 km extent each winter. The drift melts very slowly until mid-August. The long-lying snow has caused great changes in the tundra plants growth and survival. Over the years many species died while others reduced their presence and vigour. A belt with no surviving vegetation developed along the fence, and bare ground, subject to erosion appeared. Since 1992, J. Svoboda and Richard Staniforth (U. Winnipeg) have monitored changes occurring in the affected zone and the unaffected vicinity. Since the fence was built over the span of seven years, a valuable time-series was created with segments of tundra having been gradually affected from two to eight years. This series has offered a unique opportunity to study the large-scale impact of the delayed snow-melt on tundra vegetation. This, in context with the climate change, has gained new significance, since the on-going climate warming is predicted to produce higher snowfalls and thus extended snow-melt periods. This, in turn, would affect the entire tundra ecosystem, especially its food base for the migrating caribou that still represent the staple for the Inuit people. Hence, the short-term (applied and practical) and the potential long-term scientific and socio-economic value the research.

An active layer and near surface permafrost temperature monitoring program was established in 1997 by Josef Svoboda (U.Toronto), Orin Durey (Baker Lake) and Margo Burgess (GSC, Ottawa). It is complementary to the previously described projects, and was also registered with the Circumpolar Active Layer Monitoring (CALM) program. Four bore-holes approximately 100m apart were drilled in a transect along a gentle south-facing slope north of the Baker Lake. The transect crosses the wide snowdrift formed behind the snow fence. While three boreholes were established in a tundra typical for the area, hole # 2 was drilled in the middle of the snowdrift zone. Here the annual snow deposition has significantly altered the course of ground temperatures within the 3 m deep ground profile. Shifts in temperature trends are being monitored with special interest.

The ITEX site at Churchill, Manitoba was established in 1995 in a coastal outcrop heath community. The lot is owned and the phenology has been recorded by Diane and Bill Eriksons, long time residents of the community. Three species have been included in the program: *Dryas intergrifolia*, *Saxifraga tricuspidata* and *S. oppositifoila*. The Churchill locality is the southern-most ITEX site along the gradient including Tanquary Fiord, Alexandra Fiord, Baker Lake and Churchill which have been in operation for more than five seasons and follow comparable protocols.

### *ITEX at Bylot Island, Nunavut*

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Bylot Island is the site of a bird sanctuary which is home to a large population of greater snow geese and cranes among others. The geese graze roughly 60% of the local biomass. There has been an automatic meteorological station at the site since 1990 and many variables are being studied. There are both large and small exclosures to study the effects of herbivory and ITEX open top chambers (OTCs) to explore the effects of warming.

### *Monitoring initiatives along the Newfoundland-Labrador-Baffin axis*

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There is an urgent need for CANTTEX to incorporate representation along the eastern axis of the continent from Island of Newfoundland, through Labrador and into southern Baffin Island. Due to the marine influence, the northeastern of Canada is responding very differently to hemispheric temperature trends than central and western areas of Northern Canada. Both Newfoundland and Labrador have significant arctic/alpine floral and faunal elements that are at the southern limit of their distribution, making them extremely sensitive to climatic change and important “bellwethers”.

There is a system of Protected Areas across the province that could act as foci for establishing monitoring sites. For example, on the southern coast of the Island is Cape St. Mary’s Ecological

Reserve where many arctic plants, such as arctic willow and moss campion, and insects are found. Further north is Gros Morne National Park where large arctic/alpine heaths exist on Big Level, as well as the serpentine Tablelands. On the Great Northern Peninsula, limestone barrens support many rare arctic species. In Labrador the proposed Mealy Mountains and Torngat Mountains National Parks could form the preliminary baseline for this large, biologically unknown landmass.

Currently there is an obvious gap in knowledge regarding the effects of climatic change in Labrador, and we are interested in expanding the tundra monitoring projects into Labrador. Establishment of monitoring regimes in Labrador would link Newfoundland to the northern Baffin Island sites. There are a number of established sites in southern Baffin Island, for example at Nettilling Lake, that have rich historical baseline data.

Projects underway on the Island of Newfoundland:

- Big Level Plateau in Gros Morne National Park:
    - Climate autostation operation;
    - Krummholz dynamics in relation to climate variability;
    - Local and regional studies of snow cover, including late-lasting snowbanks;
    - Atmospheric deposition of pollutants to snow cover and surface waters;
    - Permanent monitoring of rare plant recruitment and persistence; and
    - Monitoring the distributions of alien plants.

- Northern Peninsula (combination of National Historic Sites and provincial Ecological Reserves):
    - Population dynamics of the endangered *Braya longii* and the threatened *B. fernaldii* in relation to anthropogenic and natural disturbance; and
    - Population ecology and genetics of moss campion (*Silene acaulis*) persisting in glacial relicts throughout the Island of Newfoundland to study the effects of herbivores and pathogens in small, isolated populations.

The northern parts of Newfoundland and Labrador remain largely unexplored in terms of arctic and alpine ecology and should be incorporated into the CANTTEX network.

### *ITEX at Alexandra Fiord, Ellesmere Island*

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ITEX research was established at the Alexandra Fiord lowland in 1992, and warming experiments are now established in seven plant communities along a moisture/exposure gradient. The ITEX research builds on the previous ecological research at Alexandra Fiord, which has been ongoing since 1980. The Alexandra Fiord site is the major high arctic site in the ITEX network, and is now the high arctic end of a gradient of North American sites in a multi-investigator project comparing low and high arctic responses to climate variability and experimental warming: dubbed the North American Tundra Experiment (NATEX).

This past year (1999) was the 8th year for the warming experiments in four of the major plant communities at this high arctic oasis. Monitoring has been scaled back to include only dates of snow melt, and growth, phenology and flower density at mid-season. There continues to be significantly greater growth, and increased rates of development and flowering in the OTCs relative to the controls. However, there do not appear to be any cumulative effects of the warming on these variables. Warming has begun to alter the abundance (cover) and diversity of vascular plants, with increases in both cover and species density in the four major plant communities on the Alexandra Fiord lowland.

This was also the eighth season for a snow melt manipulation experiment in a snow bed community. Snow is removed, added or unaltered in plots arranged along the snow bed. One of the most striking

changes has been a dramatic increase in flower density in the early snow melt plots. However, neither species density nor cover has been significantly changed by the snow manipulations.

A set of warming + snow manipulation experiments has been established in a *Cassiope* heath community since 1995. Although full analyses of these experiments are not yet complete, preliminary analyses show that there may be an additive effect of early snow melt and warming. There are greater flower densities in those plots with OTCs in which snow is removed, relative to those with only OTCs or with snow removed. As in the snow manipulation plots at the snow bed community, the growth and reproductive effort in the major species does not appear to be significantly affected by snow addition and delay of the start of the growing season.

A study of the effects of warming on C:N ratios in tissues of major vascular species was completed over the last year with Dr Anne Tolvanen, University of Oulu. The dwarf shrub species showed an increase in C:N ratios, while there was no effect on forbs or graminoids. Given that plant growth was increased in the OTCs, the increased C:N in dwarf shrubs is likely due to inadequate absorption of N. Forbs and graminoids are able to increase their absorption of N to maintain the C:N ratios in the warmed plots. These results may have important implications for community diversity and ecosystem nutrient dynamics.

New ITEX research at Alexandra Fiord began this past summer in collaboration with Dr Keith Egger, University of Northern British Columbia. Dr Egger began a study of the effects of the warming experiments on the mycorrhizae associated with roots of the major vascular species in each of the communities at Alexandra Fiord. A new PhD student will examine the mycorrhizae diversity in and out of the OTCs next year. She will also determine the mycorrhizal associations in those vascular species with the highest ecological amplitude across all habitats. The mycorrhizae may be different in different communities, indicating that the vascular species may have the ability to use more than one fungal partner.

Alexandra Fiord also became the high arctic end of a transect of sites from Toolik Lake and Barrow in Alaska. The new study is funded by NSF and is the North American extension of ITEX, dubbed ”NATEX.” We will examine the responses of common species and community and ecosystem traits along the transect. Collaborative research began at Alexandra Fiord this past summer with Dr Jeff Welker, University of Wyoming, on effects of warming on net ecosystem production (NEP). Carbon dioxide flux measurements were made from large flux chambers (ca. 75 cm x 75 cm x 50 cm) temporarily installed on permanent bases established in OTC and control plots. In the short term measurements from the middle of the season, warming increased NEP in a wet sedge community but lowered NEP in a dry willow community. Measurements of nitrogen mineralization and soil carbon should help to explain the contrasting results. These studies will be carried on by a graduate student over the next two years. Over-winter losses of $CO_2$ will also be measured in $CO_2$ traps and in snow-depth profiles.

## *DISCUSSION GROUPS AND PROPOSED INITIATIVES: SUMMARY*

### *Site and Variable Selection*

Despite the need to integrate the research being done at each site, individual research programs should be self-contained and able to produce an independent product. Links should be strongest with sites that are in close proximity and have a similar focus in terms of both subject matter and time scale.

We need to reach agreement on which sites are most valuable as well as which variables must be considered. Establishment of sites along gradients should be a priority in the selection of new sites or maintenance of existing sites. The latitudinal gradients should include sites in taiga (forest-tundra ecozone) low arctic and high arctic tundra, preferably arranged along longitudinal gradients across the North. Within each site, monitoring and experimental studies should be established along moisture gradients, where possible.

The selection of variables to measure should also take into account the fact that in many cases non-specialists will be the ones making and recording the observations. There may be opportunities to take advantage of intensively studied sites by establishing easily monitored experiments or observation programs.

### *Synthesis of Existing Research*

It was agreed that the first act of cooperation within CANTTEX should be a synthesis of the research that has been carried out so far on environmental change in the North and its potential impacts. This report should provide a formal meta-analysis of the four oldest ITEX sites, present an analysis of trends at various scales based on predictor response variables, and identify significant gaps that need to be addressed. Such a report will show others that more research on environmental change in the Arctic is necessary and that integration among northern researchers is necessary. There are several target audiences for this summary and, as such, more than one report may have to be produced. Target audiences are: scientists, other known research groups, and northern communities. Once the analysis is complete, the predictors identified as being most important will be the foci of future research and emphasised in the methodological manuals described below.

### *Cooperation with Other Agencies and Communities*

ITEX has a published manual of protocols for monitoring climate and ecosystem variables (Molau and Mølgaard 1996; available at www.dpc.dk/About-us/NSN/itex). The protocols have been adopted and adapted for monitoring in other ecosystem types, and form the basis for much of the monitoring currently underway in the Canadian North under EMAN-North. However, there is a need to expand the number of sites using ITEX or similar protocols for tundra systems, and the suite of variables followed at each of the sites. The number of northern monitoring sites can be expanded by coordinating the monitoring at the research centres, national and territorial parks, and communities. The variables to follow will depend on the needs and interests of the group(s) or agencies responsible for the site, but a set of core variables need to be identified which will be followed at as many sites as possible. For example, berry production in commonly used plants such as species of blueberry (*Vaccinium* spp.) and cloud berry (*Rubus chamaemorus*).

The second objective is to produce a document, or set of documents, that will encourage other agencies and members of the general public to get involved in environmental monitoring. The Plant Watch program, maintained by E. Beaubien at University of Alberta, could be used as a model for a program that is understandable and accessible to the general public. Some still do not see climate change as a problem and the principle focus of the first booklet produced must address this issue such that people are encouraged to get involved in monitoring. Brochures or manual should be available to download and print off the internet to maximise accessibility. The explanations of monitoring methodology should incorporate considerable visual representation of techniques to minimise misinterpretation of explanations by participants.

One potentially major problem is that someone or some agency must take on the responsibility of accepting, managing, and archiving data from all the CANTTEX (and other) sources. Potential agencies for this data management task include the Canadian Parks Service and EMAN. The participants must be made aware of the results of their work and the significance of those results. The best method for accomplishing this goal would be the regular production of posters which would be delivered to all agencies and communities participating in ecological monitoring programs. This will show people that their efforts are leading to advancement of our collective knowledge and understanding of environmental change.

The currently proposed format of the manual consists of three separate documents. The first will be an introduction to CANTTEX and an explanation as to why agencies and members of the community

should be aware of and participate in organised environmental monitoring. This document should make clear the important place of humans in the ecosystem. The second document will be a manual on methods for recording simple environmental parameters such as snowdepth and ice formation/melt on lakes and rivers. The third document will outline methods for making observations on vegetation including phenological observations and measurements of flower density. This document can be produced by simplifying the contents of the ITEX manual such that it can be understood by a member of the general public. It is hoped that an added result of the promotion of this initiative will be the retrieval of existing sources of data, such as hunting camps at which the dates of ice formation and break-up have been recorded.

The production of these CANTTEX documents is to proceed over the next year, with publications available for review and editing before the start of the 2001 field season.

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