



EXPERT NETWORK MONITORING PLAN

INTERNATIONAL TUNDRA EXPERIMENT ITEX

SUPPORTING PUBLICATION TO THE
CIRCUMPOLAR BIODIVERSITY MONITORING PROGRAM
FRAMEWORK DOCUMENT



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Russian Federation Ministry of Natural Resources, Moscow, Russia
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Arctic poppy, found on the barren grounds of the high Arctic, North Greenland; photo courtesy of Carsten Egevang ARC-PIC.COM

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Introduction

Currently, the International Tundra Experiment, ITEX, is a collaborative effort involving scientists from more than 11 countries, including all the Arctic nations, and involves research teams at more than two dozen circumpolar and alpine tundra sites. After a successful decade where the focus has been on plants and plant communities, initiatives are now being encouraged within the network to consider other trophic levels and landscape diversity as a next step towards a better understanding of terrestrial ecosystem responses to climate change. From this perspective, participation in the Circumpolar Biodiversity Monitoring Program of CAFF (Conservation of Arctic Flora and Fauna Working Group of the Arctic Council), would match well with future long-term goals of ITEX.

ITEX is a scientific network of experiments focusing primarily on the impact of climate change on selected tundra plant species and vegetation. The ITEX research model combines long-term and short-term experimentation with monitoring, and is designed to examine the effects of temperature change by carrying out similar experiments at multiple sites. Participation in the network is flexible and at different levels of complexity and sophistication depending on interests and available funding at each time. Each ITEX site operates a warming experiment, usually utilising the technically simple device of open-top chambers to warm the tundra, and collects data according to common protocols (Molau and Mølgaard 1996). In this way, the geographic representation is maximised and annual variation in plant performance with respect to phenological response to climate conditions as well as plant community change is easily compared across multiple sites.

The ITEX network was initiated during a workshop held 2-5 December 1990, at Kellogg Biological Station, Michigan State University. The workshop agreed on a Founding Resolution

(Appendix I), which still serves as the ITEX foundation. The Founding Resolution was revisited during the 10th ITEX workshop in Abisko, Sweden, in September 2000 where an accord was made to supplement and extend the original Resolution (Appendix II). The network is coordinated through a steering committee, series of workshops and a website (<http://www.itex-science.net/>).



Cassiope tetragona (Arctic heather) Svalbard; photo courtesy of Ingibjörg Jónsdóttir

Goals and objectives of the ITEX network

The initial goal of ITEX was to determine the responses of tundra plants to climate change, primarily warming, across circumpolar sites. Objectives at different levels of complexity were defined in the beginning. First level objectives were to:

- Conduct a simple standardised experiment.
- Measure phenological, growth and reproductive responses of selected, widely distributed tundra plant species.

For this purpose, a list of taxonomically good circumpolar vascular species was made available (Murray 1997), and a basic warming experiment was designed enhancing average temperatures by 1-3°C (Marion et al. 1997). The focus of the two first ITEX syntheses was on responses of those and other tundra species to two to four years of warming (Henry 1997, Arft et al. 1999). Higher level objectives included:

- More sophisticated eco-physiological and ecosystem measurements
- Common garden experiments for studies of trait heritability

A large number of publications from individual research groups linked with ITEX is now available on ecophysiological responses as well as ecosystem responses to warming and climate-related changes, while trait heritability has received less attention.

The long-term goal implicit in the Founding Resolution is to understand responses of other components of tundra ecosystems to climate change. The third synthesis, analysing effects of climate warming on tundra plant communities (Walker, Wahren, Hollister et al., in preparation), was a step up the ladder of complexity towards this goal. The future steps will include analyses of long-term monitoring data (up to ten years) and studies considering plant interactions with other trophic levels.

Scientific achievements during the first decade of ITEX

The main scientific achievements during the first decade of ITEX were summarised in the two first syntheses mentioned above. In general, a meta-analysis based on 13 different ITEX sites and 61



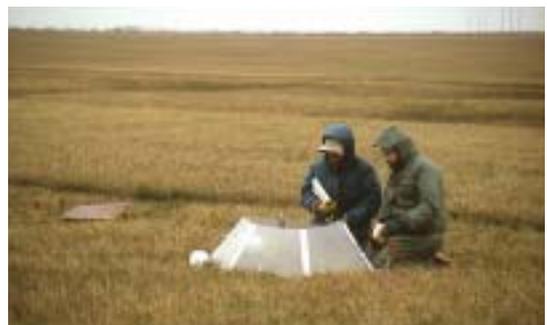
ITEX research area, Auðkúluheiði, Iceland; photo courtesy of Borgþór Magnússon

species showed that key phenological events such as leaf bud burst and flowering consistently occurred earlier in warmed plots than controls; while growth cessation late in season was not affected (Arft et al. 1999). This suggests an increased probability of successful seed set in a warmer climate. Furthermore, the results showed a shift from initial growth stimulation in response to warming towards increased reproductive effort in later years. This shift from an initial to secondary response may reflect a period of depletion of



The ITEX site at Toolik Lake in Alaska where it is combined with a snow manipulation experiment; photo courtesy of Philip A. Wookey

stored plant resources that coincided with a lag period of reproductive responses caused by the long developmental period of flowering buds as has been demonstrated for Alpine and Arctic plants. Although responses varied greatly among



Fieldwork at a wet meadow site at Barrow, Alaska; photo courtesy of Philip A. Wookey

plant species, herbaceous growth forms generally showed greater responsiveness than woody growth forms. There was also a pronounced response difference among sites. Plants at warmer Low-Arctic sites produced the strongest growth response, whereas the greatest reproductive response was found at cooler High-Arctic sites. This suggests an inherent difference in strategies among plants of the Low and High Arctic in response to the contrasting biotic and abiotic conditions.

The third synthesis analysed plant community responses to three to six years of warming, and was also based on meta-analysis (Walker Wahren, Hollister et al., in preparation). The synthesis demonstrated that individual plant responses translate into significant community change. In

spite of variable community response among sites, the meta-analysis detected an overall positive effect of warming on canopy height and dwarf-shrub cover, and a negative effect on cryptogam cover and community diversity.



ITEX research area, Barrow, Alaska; photo courtesy of ITEX

Beside these three syntheses, ITEX researchers have maintained high publication output from the individual sites they are responsible for (for overview, consult the ITEX bibliography: <http://www.itex-science.net/library/biblio1.cfm>). Many of these publications address more complicated aspects of ecosystem responses to climate change, such as gas exchange, soil nutrient mineralisation, plant-microbial interactions, i.e. questions that need more sophisticated instrumentation and approaches than the basic ITEX questions.



ITEX research area, Finse Norway; photo courtesy of ITEX

Moreover, the network has always emphasised participation of young scientists. This has resulted in numerous successful Masters and PhD dissertations based on ITEX-related research.

Current activity

The number of registered active ITEX sites was 42 at its height in mid-1990, representing 14 countries. After an initial funding period, a number of sites suffered from difficulties in raising funding for renewed periods. Today, the active sites are around 17, representing nine countries, the largest geographic gap being in the Russian Arctic. However, the ITEX network

is also a network among scientists engaged in climate-related research in the Arctic, and as such good Russian as well as broader international representation is maintained. The networking activity involves open workshops at 1-2 year intervals (the latest held in Alaska in September 2003), special synthesis workshops (two up to now), a mailing list and an interactive website. The website has taken over the secretariat functions previously housed at the Danish Polar Centre, and is maintained by the University of Alaska, Fairbanks.

The main scientific focus today is twofold:

1. Maintenance and monitoring of original ITEX sites and experiments to obtain long-term (more than 10 years) data on plant and vegetation responses to climate change.
2. Development and simulation of new initiatives, aimed at scaling up from plot-based plant observations to consider both landscape and food web variability, as well as functional aspects of biodiversity and ecosystem processes. Both the commitment of ITEX in participating in the Circumpolar Biodiversity Monitoring Program of CAFF, and the new IASC initiative - Circum-Arctic Terrestrial Biodiversity Initiative (CAT-B, for details see the IASC Catalogue), are examples of such activities.



May 2005 Endalen: A newly established ITEX site in Svalbard where the effects of open top chambers are explored in habitats of variable winter conditions; photo courtesy of Ingibjörg S. Jónsdóttir

Future goal

The future goal of ITEX is to provide better understanding of tundra ecosystems and how they respond to climate change. Of special interest is the functional role of biodiversity. The scientific results already produced by ITEX have fully demonstrated the tremendous value of having a circumpolar network. However, the success of ITEX is not only owing to involvement of a large number of sites, but also to a few, simple and well-focused questions that could be answered by designing a simple experiment and common protocols. When additional levels of complexity are added by scaling up to landscapes and higher trophic levels, it becomes more challenging to keep similar focus at multiple sites. This problem has been recognised and discussed during many ITEX workshops, and it has been concluded that monitoring across ecotones, e.g. treelines, and along environmental gradients should be a priority. The increase in

shrub cover and the melting of permafrost along the tundra-taiga interface in Alaska shows that these areas are already responding to climate change. The interface between the Low and High Arctic is another area that needs attention since it is delimited by the distribution of a large number of species.



ITEX research area, Alexandra Fjord, Ellesmere Island, Canada; photo courtesy of ITEX



Cotton grass (*Eriophorum* sp.); photo courtesy of Carsten Egevang ARC-PIC.COM

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Saxifraga oppositifolia (purple saxifage), Svalbard; photo courtesy of Ingibjörg Jónsdóttir

Appendix I

RESOLUTION INTERNATIONAL TUNDRA EXPERIMENT

As a result of deliberations and consensus achieved at a workshop to design an International Tundra Experiment (ITEX) on December 2-5, 1999, at the Kellogg Biological Station, Michigan State University, U.S.A., the participants from nine countries (Canada, Denmark, Finland, Great Britain, Iceland, Norway, Sweden, United States, USSR) have agreed to submit the following findings and recommendations to their respective organizations and scientific colleagues.

Taking into account

1. That the tundra regions represent an important component of the geosphere-biosphere, being a sensitive indicator of global change and contributing actively in the functioning of the global climate system;
2. That the understanding of the geophysical and ecological processes that occur in the tundra is an important objective of the international community concerned with global change, biodiversity, environmental protection, and sustainable development;
3. That recent acceleration of international interest and cooperation in arctic and alpine science has opened new possibilities for coordinated international research and analyses;

And recognizing

1. That carefully organized comparisons within and among tundra sites and over time will greatly increase understanding of the ecology of tundra species;
2. That coordinated observations and measurements of a few carefully selected arctic species populations occurring along circumpolar megatransects and environmental gradients are achievable;
3. That an experimental approach to a few selected manipulations of the environment is deemed desirable as a cost effective means to compare species responses to variables relevant to global change;
4. That international exchange of scientists, especially students, is highly desirable to enhance communication and training;

The participants therefore agree

That an initial set of selected tundra plant species, measurement protocols and manipulations have been specified for the ITEX experiments starting in 1991 as the result of this international meeting of experts. They, therefore, recommend

1. That the first ITEX experiment focuses on responses of vascular plant species;
2. That a set of abiotic observations and destructive and non-destructive measurements be carefully specified to determine phenological events, reproductive and vegetative effort, physiological responses, and genetic response to the manipulated and predominant environmental variables during the growing season and over a period of years;

3. That explicit protocols be developed for simple and relatively inexpensive manipulations of air temperature (such as by small greenhouses) and snow cover (as by snow fences) at participating sites;
4. That sets of selected individuals in field transplant gardens be subjected to a common garden (environmental) experiment and assessed in terms of genetic variation within each species population and its phenotypic response in order to evaluate probable adaptations to climate change;
5. The more complex or expensive experiments involving manipulations such as atmospheric CO₂, or soil temperature and reciprocal transplant gardens, fertilizer treatments, or even phytotron experiments may be desirable and practical for some sites;
6. That appropriate coordination of research, communication and synthesis of results be achieved by a small set of coordinators, and by convening of participating principal investigators for periodic assessment workshops, exchanges of scientists and students among sites will facilitate ITEX;
7. That development of an appropriate protocol for the exchange of ITEX data among participants is needed;
8. That funding for research is the responsibility of each participating county, and may utilize activities already underway, and including Biosphere Reserves, protected areas, and long-term ecological research areas, and;
9. That future experiments focusing on other taxa and ecological parameters, including animals, are desirable, and contact for ITEX established through the MAB Northern Sciences Network are encouraged.

Appendix II

Abisko Accord (25 September 2000)

Further to discussion at the 10th ITEX meeting in Abisko, Swedish Lapland, between 2-25 September 2000, the meeting participants hereby reaffirm our commitment to the continuation and further development of the International Tundra Experiment (ITEX)

We agree that:

- The original ITEX Resolution drafted at the Kellogg Biological Station, Michigan State University, USA, on 4 December 1990 remains valid.
- This Accord therefore supplements and extends (but does not replace) the 1990 Resolution
- ITEX is a working, viable, and dynamic international program.
- We will regularly re-evaluate the methods and goals of ITEX relative to current research developments and, where necessary, respond by modifying our activities accordingly.
- The scope of ITEX includes the tundra biome in general; it is not, therefore, restricted to arctic tundra but rightfully incorporates alpine and Antarctic tundras (inter alia the connection between ITEX and Regional Sensitivity to Climate Change in Antarctic Terrestrial and Limnetic Ecosystems /RiSCC)).

Key facets of ITEX after ten years include:

- the successful development and maintenance of an international network of research sites in the tundra biome;
- the continued use of common experiments and protocols to improve understanding of global change impacts upon biological processes in tundra ecosystems;
- the training and international exchange of young researchers (graduate and undergraduate);
- a continued focus upon biological responses to environment at the level of the species and the functional group;
- increasing emphasis upon population and community dynamics and medium- to longer-term system responses to change;
- increasing emphasis upon meta-analytical techniques, development of databases, and ecological modelling, and
- initiation of advisory activities in relation to international monitoring networks and scientific agencies (such as Conservation of Arctic Flora and Fauna (CAFF) of the Arctic Council and the Newsletter of the Global Change in Terrestrial Ecosystems Core Project of IGBP (International Geosphere- Biosphere Programme)).

We are committed to:

- retaining a flexible approach that allows for development of new research initiatives, but with a core of manipulation and monitoring activities at individual sites;
- exploring the relationship between species-specific responses to environmental change, and how these are modulated by community and site characteristics, and feedbacks on further change;
- evaluating ITEX investigations within the context of broader spatial scales, longer temporal scales, and higher trophic levels;
- exploring pragmatic approaches to long-term monitoring and measurement, designed to quantify and distinguish between (i) inter-annual variability in system state, and (ii) longer-term directional changes;
- development and implementation of an appropriate protocol for the exchange of ITEX data among participants and the broader community;
- development of thematic groups focused upon specific aspects of climate change impacts;
- development of procedures for sample collection, sharing and /or common analysis;
- regular meetings (yearly or biennial) with specific themes and progress reports;
- dissemination of data and research results to the broader community;
- development of a strong and active Steering Committee that will provide leadership and continuity and that will conduct business according to a set of by-laws.

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