# From Decade to Millennium: The 10th ITEX meeting

22nd – 25th September 2000,
Abisko Scientific Research Station, Abisko, Sweden

# Abstracts

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## Acknowledgements

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# Using digital images to evaluate NDVI on small plots

Lorraine E. Ahlquist and S. F. Oberbauer

Department of Biological Sciences, Florida International University, Miami FL 33199, USA

We used a digital camera (Dycam ADC) to monitor changes in Normalized Difference Vegetation Index (NDVI) on our extended season manipulation study plots at Toolik Field Station, Alaska, USA. The camera uses optical filters to select the desired wavelengths. Digital images were taken weekly throughout the growing season in 1999. The camera was calibrated to a white teflon reference plate. Images were analyzed using BRIV-32 which calculates NDVI of selected portions of the image and can generate false color index maps. We attempted to take images only under high sun conditions whenever possible, although some weeks images were taken under cloudy conditions. Values of NDVI calculated by the software were in the range previously reported for tussock tundra. Seasonal changes in NDVI matched seasonal changes in leaf development and greenup, although some variation was apparent, probably due to differences in light during image capture. The calculated NDVI also detected treatment differences on the study plots. We conclude that the digital technique offers a relatively simple and inexpensive measurement of NDVI as well as having the potential for fine-scale mapping of NDVI on small plots such as within ITEX chambers

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⇒ Poster

# Biotic processes in a changing climate: what to monitor?

Carsten Dormann

Department of Plant and Soil Science, University of Aberdeen, AB 24 3UU, Scotland

To understand a system and its response to environmental change, one can't get around investigating its essential processes. What "essential" is, depends on the questions one wants to address. My focus will be on competition and herbivory, but I will restrict myself to suggesting field methods applicable within the ITEX framework. Some results shall highlight the possibilities and problems of such endeavours.

⇒ Lecture

# Plant biodiversity across the Canadian Arctic: results from the Tundra Northwest 99

Greg Henry

Dept of Geography, University of British Columbia, Vancouver, BC, V6T 1Z2 Canada

⇒ Lecture

# RiSCC: the southern ITEX?!

Ad Huiskes

NIOO-CEMO, P.O. Box 140, 4400 AC Yerseke, the Netherlands

**RiSCC** (Regional Sensitivity to Climate Change in Antarctic Terrestrial and Limnetic Ecosystems) was conceived two years ago during the VIIth SCAR International Biology Symposium in Christchurch, New Zealand. Since then a scientific steering committee organised two workshops with the objective to draft a science plan and an implementation plan. During the last biennial meeting of the SCAR delegates in Tokyo (July 2000) these plans were approved and RiSCC is by now an offical SCAR program.

RiSCC aims to understand the interactions between biodiversity, functioning and climate of Antarctic terrestrial and limnetic ecosystems, and to predict regional sensitivity to the impacts of climate change by:

1. identifying and quantifying differences in environments and biodiversity within and between ecosystems;
2. understanding the potential for ecosystem processes to respond to changes in climate;
3. partitioning the effects of climate change among the key components of the ecosystems;
4. using new and existing data to provide a synthesis of the likely effects of climate change on Antarctic terrestrial and limnetic ecosystems to contribute to their management and conservation;
5. orienting the research to achieve links with other international programmes seeking to understand the implications of global changes.

The preliminary title of the program was SITEX (Southern ITEX). This title indicates that right from the start, the initiators of the program intended to establish close collaboration with the scientists involved in ITEX. The name of the program may have changed, the intentions remain the same.

We, the scientists involved in RiSCC (now listing 50-odd names), hope that this presentation will result in some first steps to effectuate this collaboration.

⇒ Lecture

# Effect of simulated warming on resource concentration in arctic sedge *Carex bigelowii.*

Olga Khitun[1], Ingibjörg S. Jónsdóttir[2,3] and Anna Stenström[2]

[1]Komarov Botanical Institute, prof. Popov str.,2, 197376 St.Petersburg, Russia, [2]Botanical Institute University of Göteborg, P.O. Box 461, SE 40530 Göteborg, Sweden, [3]UNIS, P.O. Box 156, N-9171 Longyearbyen, Norway

The aim of this study was to test the hypothesis that five years of climate warming, simulated by ITEX designed open top chambers, reduce the resource status of the clonal sedge, *Carex bigelowii.* Previous results have shown that the warming treatment speeded up phenology and enhanced vegetative aboveground growth as well as reproductive effort and and seed set (Stenström and Jónsdóttir 1997, Stenström 1999). We expect such responses to result from mobilisation of stored resources and internal recycling rather than comparable increase in resource uptake because soil temperatures are much less affected by the warming treatment than are air temperatures. Therefore, we predicted both lower concentration and pool sizes of N and P in treated plants compared to controls.

By the end of the fifth growing season the plants were destructively sampled from the 20 experimental plots at Latnjajaure field station in Swedish Lappland (68° 21'N, 18°21'E). Ten of the plots had open-top chambers (OTCs), where temperature was on average 2° C higher than outside temperatures and ten plots were controls with no warming. From each plot three randomly chosen clonal fragments, each consisting of 5-6 interconnected ramet generations were excavated and dissected into separate generations, which in turn, were dissected into different plant parts. A total of 900 samples were Kjeldahl digested and analysed photometrically by flow injection analysis FIAstar 5012 for nitrogen and phosphorus concentration. The effects of treatment, generation and plant part (factors) on nitrogen or phosphorus concentrations were analysed in 3-way ANOVAs and all factors had significant ($P<0,0001$) effects on concentration. However, ontogenetic (between different generations) and morphological (between different plant parts) variation in N and P concentration in tissues of *Carex bigelowii* is much greater than that caused by enhanced air temperatures. The general picture that emerged was as follows: The younger ramets had higher nutrient concentration than old ramets and within ramet leaves (where present) had higher concentration than rhizomes, leaf sheaths and roots and the concentrations tended to be slightly lower in the plants from OTCs than in controls. This indicates that although this plant may be able to buffer the level of N and P through mobilisation of stored resources and keep it more or less stable at least in certain plant parts long term warming may deteriorate the nutrient status of the plants.

⇒ Poster

# Warming effects on growth, production and vegetation structure of alpine shrubs in the Taisetsu Mts., northern Japan

Gaku Kudo & Shizuo Suzuki

Graduate School of Environmental Earth Science, Hokkaido University, Sapporo 060-0810, Japan

Shoot growth, production, reproductive activity, and vegetation structure were compared in five shrub species (*Ledum palustre*, *Empetrum nigrum*, *Vaccinium vitis-idaea*, *Vaccinium uliginosum*, and *Arctous alpinus*) during five years between OTC and control. By setting OTC, daily mean temperature increased 1.4 to 3.3 degrees during growth season. Evergreen shrubs tended to increase the vegetative growth such as stem elongation, branch number, annual production and biomass accumulation within the OTC, but flower production was not affected by the OTC. Whereas, deciduous shrubs did not increase the vegetative growth but they increased the flower production within the OTC. These contrastive responses between evergreen and deciduous shrubs may reflect the differences in physiological traits and life-history strategies. Most species increased the plant height within the OTC but the extent of growth rate differed among species. As a result, canopy overlaps among species were increased and some plants decreased the activity due to severe shade stress. Thus, acceleration of species competition for height growth caused by environmental mitigation may change the vegetation structure of alpine plant communities.

⇒ Lecture

# Dynamics in vegetation communities in tundra landscape under Global Change.

Karin Lindblad

Botanical Institute, Gothenburg University, P.O. Box 461, SE 405 30 Gothenburg, Sweden

The Tundra Landscape Dynamics (TLD) project started in the beginning of 1998. The aim of the study is to create a dynamic vegetation model including the arctic valley Latnjajaure, approximately 10 square kilometres, using Geographical Information Systems (GIS) and Arc View. TLD accommodates previous results within ITEX and related research concerning dynamics of the arctic/alpine tree line at Latnjajaure. With the concept of Hierarchical GIS (HGIS), a nested set of GIS databases at several spatial scales, the database will be prepared for running dynamic vegetation models under different climate change scenarios, warming as well as cooling. The GIS database will include digital terrain model (DTM) developed from aerial photographs, taken during the summer of 1998 and 2000. To be able to link ecological data to the model, one grid of 50 x 50-meter plots and four grids of 25 x 25-meter plots have been placed in the valley at different altitudes in an attempt to incorporate al major vegetation types within the area. During the summer of 1999 and 2000, vegetation type, soil moisture, snow depth, snow duration, rock/stone frequency, and soil properties has been recorded at each point within three of the grids. This summer extensive mapping of vegetation communities within the valley was done as a first step in developing regressions for calculation of ground primary production at landscape level. I have also used a digital camera (Power Shot Pro 70) to monitor different vegetation types for further analysis on biodiversity and biomass. The geophysical part of the GIS database encompasses more detailed information on soil properties and processes, hydrology and permafrost.

⇒ Poster

# Impacts of induced environmental press and pulse on a tundra meadow community

Ulf Molau

Botanical Institute, Götebotg University, P.O. Box 461, SE 405 30 Göteborg, Sweden

During the 6th ITEX workshop in Ottawa 1995, the validity of the biotic results generated by experiments involving OTCs were discussed. It was proposed that some of the questions raised could be elucidated by implementing a well-designed experiment where one tried to distinguish between short-term inductions and the results of more long-term, stable alterations in the microenvironment ("environmental pulse" vs. "environmental press"). With this background, I outlined an experiment designed to detect differences between "press" and "pulse" in the ITEX program, which was carried out at the Latnajaure Field Station in northernmost Swedish Lapland in 1995–98. A 4x4 randomized block design was employed. In each block there was a control plot (1 m$^2$), a standard ITEX open-top chamber (OTC), a "press" plot, and a "pulse" plot. All plots were mapped with a grid frame in year 1 (1995); manipulation started in year 2 (1996); thus, the design follows the BACI (Before-After-Control-Impact) approach. In the Press plots, an OTC ventilated below was implemented in year 2, put firmly on the ground in year 3 (as in a normal OTC plot), and covered by a transparent roof in year 4, i.e., a closed-top chamber (CTC). In the Pulse plots, a CTC was implemented at thawing in year 2 and removed at the end of August the same year; no further manipulation was undertaken in year 3 and 4. All plots were mapped at the end of each summer throughout the experiment. The experimental temperature enhancement can be classified into three temperature equivalents of ca. 1 degree C each, where the cumulative sum after the entire experiment was equal for the OTC and Press treatments with a total of six units, whereas the Pulse treatment received only three units above the control, although in one single season.

The resulting picture is rather complex, and many responses were species-specific, even though some trends can be ascribed to functional types. The dominant deciduous dwarf-shrubs (*Salix reticulata* and *Vaccinium uliginosum*) showed a marked biomass increase in the Pulse treatment year (1996), both of which then declined until 1998. A more delayed effect was seen in the evergreen *Dryas octopetala*, where biomass peaked in 1997, the year after the Pulse treatment, but declined again in 1998. With the exception of *Carex vaginata*, (peaking in 1997 and then declining) sedge biomass decreased throughout the course of the experiment in the Pulse treatments. The most obvious response was brought about by a single herbaceous species, viz., *Astragalus alpinus*. Biomass in this species increased dramatically already in the Pulse treatment year (1996), and then continued to grow. The increase was entirely brought about by individual plants present in the plots at the onset of the experiment changing their performance, not by establishment of new plant individuals. Interestingly, the abandoned Pulse plots are now (July 2000) mere *Astragalus* gardens!

When the Press treatment became significantly superior in terms of biomass in

Vegetative and reproductive responses of Cassiope tetragona to experimental warming: 1986-1998 at Alexandra Fiord, Ellesmere Island, Canada.

Shelly Rayback and Greg Henry

Dept of Geography, University of British Columbia, Vancouver, Canada.

The best design for the ITEX field studies is a before-after controlled intervention (BACI), with variables measured in each plot at least one season prior to establishment of treatments. However, funding cycles and logistic requirements usually preclude this approach. Rather, treatment plots are established, and responses are compared to untreated controls. A modified BACI analysis may be possible using a retrospective analysis, provided there was a sufficiently long record before the establishment of the treatments to determine temporal and spatial variability. In this paper, we present a retrospective analysis of Cassiope tetragona shoots in and out warming treatments established in 1992 at Alexandra Fiord, Ellesmere Island, in the Canadian High Arctic. Shoots of Cassiope were harvested at the end of the 1998 growing season from 4 plot pairs (OTCs and controls) in a mesic tundra community. Annual growth increments (AGI) were determined from leaf internode distance measurements, following the method of Johnstone and Henry (1997). Reproductive effort was determined by counting the number of peduncle scars and flower buds in each AGI. There were no significant differences in AGI between years or between before and after treatment periods (1986-1991 vs 1992-1998). However, flowering rates were variable among years, and were greater in the post-treatment years than in the pre-treatment period. These results confirm the observations made in the plots between 1992-1998, and those presented by Johnstone and Henry (1997), that reproductive effort in Cassiope is highly variable and more sensitive to temperature changes than stem growth.

⇒ Lecture

# The effect of ITEX open topped chambers and between site differences on seed production in *Cassiope tetragona* and *Eriophorum triste* on the North Slope of Alaska: implications for climate change

Steven P. Rewa, Robert D. Hollister and Patrick J. Webber

Arctic Ecology Laboratory, Dept of Botany and Plant Pathology, 100 North Kedzie Hall, Michigan State University, East Lansing, MI 48824-1032, USA.

This research examined the seed production in the ITEX chambers. Sexual reproduction is infrequent in arctic systems, yet it is important for maintaining genetic diversity. Several studies have shown that tundra plant growth is increased by warming; therefore, it is likely that increased temperature would increase seed production, which may lead to higher reproductive success (e.g., Chapin and Shaver 1985, Alatalo and Totland 1997, Molau and Shaver 1997, Hollister and Webber 2000).

Studies on seed production were carried out over the summer of 1999 by harvesting fruiting units of *Cassiope tetragona* from sites in Atqasuk and Barrow, Alaska, and *Eriophorum triste* from Barrow. Barrow is situated on the coast of the Arctic Ocean, and is much colder than the more inland site, Atqasuk. The number of seeds per fruiting unit (capsules for *C. tetragona* and spikelets for *E. triste*) was significantly increased due to chambers for both species and at both sites. Seed weights were also significantly greater in chamber plots for both species except in Atqasuk where weights of *C. tetragona* seeds were not significantly different between chambers and ambient control plots.

Thus, the increased temperature within chambers does appear to affect seed production, but the effects are less pronounced in Atqasuk. A likely explanation is that although temperature plays a strong role, there is a point of diminishing returns.

We are interested in testing the germinability of seeds collected from the various treatments. We have fresh seed collected from 1999 and 2000. However, to date, we have been unable to persuade the seeds to germinate and we hereby solicit suggestions from colleagues as to how we can achieve our goal.

Alatalo, J. M., Totland, O. 1997. Response to simulated climate change in an alpine and subarctic pollen-risk strategist, *Silene acaulis*. Global Change Biology, 3 (suppl. 1.), 74-79.

Chapin, F. S., G. R. Shaver. 1985. Arctic In: Physiological Ecology of North American Plant Communities (Eds.: B. F. Chabot, H. A. Mooney). Chapman and Hall, New York. Pp. 16-40.

Molau, U., G. R. Shaver. 1997. Controls on seed production and seed germinability in *Eriophorum vaginatum*. Global Change Biology, 3 (suppl. 1.), 80-88.

Hollister, R. D., P. J. Webber. 2000. Biotic validation of small open-top chambers in tundra ecosystems. Global Change Biology *In press*.

⇒ Poster

# Physiological response of two arctic sedges to changes in soil temperature

Gregory Starr[1], Steven F. Oberbauer[1] and Dawn S. Newman[2]

[1]Department of Biological Sciences, Florida International University, Miami FL 33199, USA,
[2]Department of Biological Sciences, University of Nevada Las Vegas, LasVegas, NV 89154, USA

Large temperature differences exist between the root and shoot systems of arctic vascular plants. These differences may have direct effects on the shoot physiology of arctic plants through restriction of root function by low soil temperatures. Here we report on a study in which we altered the root temperature of two tundra sedges, *Eriophorum vaginatum* and *Carex bigellowii* under constant air temperature. Root and shoot tissues were assayed for the stress hormone, abscisic acid (ABA), to test for its role in any soil temperature response. Increases in soil temperature caused a significant increase in photosynthetic uptake for both *Eriophorum* and *Carex*. Variable to maximum fluorescence (Fv/Fm), however, was relatively unaffected by soil temperature suggesting that the photosynthetic response was largely due to stomatal changes. The increase photosynthesis was coupled with a decrease in ABA in both leaf and root tissues. These findings suggest that low soil temperatures may limit shoot photosynthesis of tundra plants through stomatal closure mediated by ABA. We conclude that measurement of soil temperature in ITEX experiments is critical as it appears to have direct effects on shoot physiology independent of air temperature.

⇒ Lecture

# Carbon and nitrogen concentrations at increased temperature in high arctic plants of different life forms

Anne Tolvanen[1] and Gregory H.R. Henry[2]

[1]Depertment of Biology, University of Oulu, FIN-90014 Oulu yliopisto, Finland, [2]Department of Geography, University of British Colubia, Vanvouver, BC, V6T !Z2 Canada

We investigated carbon and nitrogen allocation patterns in five arctic plant species in response to increased temperature during the fifth season after the beginning of the experiment. The aim is to provide ecophysiological understanding to the varying response patterns reported in plants in climate change studies. The species investigated were: *Cassiope tetragona* (evergreen dwarf shrub), *Dryas integrifolia* (semi-evergreen dwarf shrub), *Salix arctica* (deciduous, dioecious dwarf shrub), *Oxyria digyna* (forb), and *Carex stans* (graminoid, sedge). Sampling was carried out in different community types on central Ellesmere Island, Canada (79?N), three times during the growing season 1996.

The seasonal pattern of resource allocation was similar across all species, even though the absolute concentrations differed. Temperature enhancement decreased the nitrogen concentration and increased the C:N ratio in the three woody plants, whereas the concentrations in the forb and the sedge remained unaffected. Changes in concentrations apparently resulted from the weaker response in the growth and nutrient uptake rate in the dwarf shrubs, whereas the forb and the sedge likely could take up more nutrients to meet the needs of increased growth rate in the warmed environment. Habitats did not influence the concentrations due to their apparent similarity in soil moisture. In *S. arctica*, the sexes behaved similarly in response to warming despite the differences in their allocation patterns. Females had generally a lower nitrogen level and a higher C:N ratio in reproductive parts than males, while the concentrations were the same in vegetative parts. Males may 'waste' some nitrogen in the short-lived catkins, whereas the females allocate only the required amount of resources in catkins and are able to allocate more to vegetative tissue, which contributes to plant growth.

The results suggest that the difference between plant species in their ability to respond in a plastic manner to rapid environmental change may determine their survival in the habitat. Slowly responding dwarf shrubs may stand the risk of becoming outcompeted by more responsive and faster-growing species, such as forbs and graminoids.

⇒ Lecture

# Change in community composition of tundra on the Alaskan North Slope that has undergone simulated and observed climate change.

Craig E. Tweedie, Robert D. Hollister and Patrick J. Webber

Arctic Ecology Laboratory, Dept of Botany and Plant Pathology, 100 North Kedzie Hall, Michigan State University, East Lansing, MI 48824-103, USA.

Most forecasts of vegetation community change with climate change in arctic tundra have been derived from examinations of vegetation change across different ecological gradients and or manipulative experiments including warming chambers and the addition of nutrients and water. Another approach to this challenge is to assess long-term (greater than 25 years) community change by following changes on marked plots. The Arctic Ecology Laboratory at Michigan State University is aiming to do this by integrating several studies currently being conducted as part of two NSF ARCSS/LAII (National Science Foundation Arctic System Science/Land Atmosphere Ice Interactions) awards. Our findings presented at this meeting are an insight into our ongoing research. We sampled our dry heath and wet meadow ITEX sites at Barrow and Atqasuk in Alaska using the standardized ITEX point-frame method soon after our sites were established between 1994 and 1996 (192 plots total) and again this past summer. We have developed an efficient relational database to manage our data using Microsoft Access. To a certain degree, forecasts of vegetation community change derived from gradient analysis and manipulative experimentation remain unverified. Our re-sampling of long term marked plots has been completed in Barrow where plots were established as part of the US Tundra Biome Program (part of the International Biological Program) in 1972 and in Atqasuk where plots were established as part of the RATE (Research in Arctic Tundra Environments) program in 1975. Our presentation will include preliminary analyses of community response and detail several new lines of research we are currently investigating to expand our ITEX program and integration potential with other research currently being conducted on the Alaskan North Slope coastal plain. These include summertime measurement of $CO_2$ flux, plot scale hyperspectral (narrow band) reflectance and IKONOS satellite imagery.

⇒ Lecture

# Long and short-term responses to warming: Can we sort them out?

Marilyn Walker

BECRU, Univ. of Alaska, PO Box 756780, Fairbanks AK 99775-6780, USA

⇒ Lecture