Banks Island Expedition
July 2003

Field Report

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Summary

A group of 19 researchers and students from the University of Alaska Fairbanks and other U.S. and Canadian organizations gathered at Green Cabin, northern Banks Island in July 2003. We were interested in the interactions between the frost-boil heave processes, the soil, and the vegetation; and how complex interactions between these elements vary along the Arctic bioclimate gradient. A major goal of the project is to develop models that can help explain how frost heave patterns, soils and vegetation will respond to climate change.

This was the second year of a five-year research project. In 2002, we did similar work on the Alaskan North Slope, investigating frost boils in the Low Arctic (Bioclimate Subzones D and E). This year we began a 3-year investigation of the High Arctic frost boils, at Green Cabin, Thomsen River, northern Banks Island (Bioclimate Subzone C). We also spent half a day at Mould Bay, Prince Patrick Island (Bioclimate Subzone B). In 2004 and 2005 we will investigate sites in subzones B and A.

On Banks Island, we examined the frost patterning and hummocks near Green Cabin. We chose three areas that represent the common frost boil communities. At each area, we marked a 10 x 10 m grid and described and mapped the vegetation. We dug a soil pit near each grid to examine the soils. We erected a climate station at one of the grids which will measure snow depth; air, ground and soil temperatures; and soil moisture for several years.

Six students participated in the research as part of a Field Ecology course organized through the University of Minnesota. They spent 10 days in the Green Cabin area, working with the researchers, then continued their course as they floated down the Thomsen River to the Muskox River.

This work was funded by the U.S. National Science Foundation, grant #OPP-0120736. We also thank the Aurora Research Institute and Parks Canada in Inuvik, for help with logistics and information about Banks Island and Aulavik National Park.

Schedule and Logistics

The expedition originated in Fairbanks. A flatbed truck transported the field camp and scientific equipment to Inuvik and back to Fairbanks via the Dempster Highway (Figure 1). The members of the expedition met in Inuvik. The Aurora Institute and Parks Canada in Inuvik helped with the field arrangements and lodging in Inuvik.

The equipment and people were flown to Green Cabin, Banks Island on four Twin Otter flights chartered from Aklak and Kenn Borek Air. On 2 July, thirteen people flew from Green Cabin to Mould Bay on Prince Patrick Island for a half-day reconnaissance expedition. Camp facilities were mostly provided by VECO Polar Resources. These included a 12 ft. diameter Western Shelter yurt-style tent, which provided heated meeting, eating and work space. The camp had separate sleeping tents, a cook tent, and an outhouse tent (Photo 1).

On 12 July, most of the researchers and equipment returned to Invuvik via two Twin Otter charter flights. The class floated down the Thomsen River, and were picked up near Muskox River ten days later by a Twin Otter.

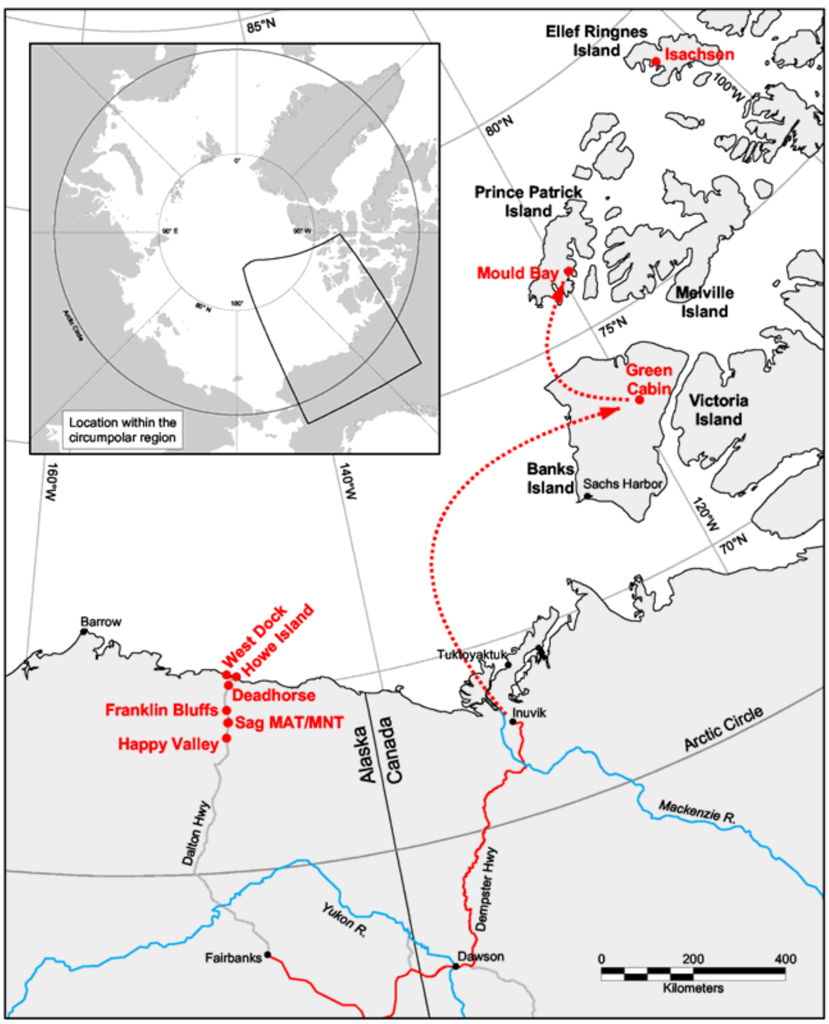

Figure 1. Map of 2003 Banks Island expedition route

Table 1. Banks Island Expedition Schedule

Saturday 28, June
Flatbed truck with camp gear, and crew-cab pickup with class gear drive to Inuvik
Sunday, 29 June
People fly from Fairbanks to Inuvik via Dawson City
Trucks arrives in Inuvik
Monday, 30 June
Class (8 people & gear) fly to Green Cabin, Banks Island
Tuesday, 1 July
Four people and camp gear fly to Green Cabin
Wednesday, 2 July
Two flights bring rest of people and gear to Green Cabin
Thirteen people fly to Mould Bay and back to Green Cabin
3-12 July – science camp
11-20 July – class floats down Thomsen River
Sunday, 13 July
Two flights bring people, camp and science gear back to Inuvik
Flatbed truck with camp and science gear drives to Fairbanks
Monday, 14 July
Researchers fly out of Inuvik
Sunday, 20 July
class (8 people & gear) picked up at Muskox River, near mouth of Thomsen River, and flow to Inuvik. This pickup was schedule for the previous day, but delayed due to unfavorable weather

Description of Site

Terrain and Bioclimate of the Green Cabin Area

Green Cabin is situated on a terrace of the Thomsen River. Soils on the terrace are sandy gravels that lack frost boils. The low hills near Green Cabin are composed of well-weathered glacial till that was deposited during the middle-Pleistocene (Vincent 1990) (cover photo and Photo 2). The soils on these hills have a large component of fine material, ideal for the formation of non-sorted circles, stripes, and hummocks.

The Green Cabin site is within Bioclimate Subzone C, as portrayed on the Circumpolar Arctic Vegetation Map (CAVM Team 2003 in press). Subzone C is more or less equivalent to the Middle Arctic as portrayed by Polunin (1951) or the Dwarf and Prostrate Shrub Subzone of Edlund (1990). The zonal vegetation at Green Cabin is a mixture of prostrate dwarf shrubs (mainly *Dryas integrifolia* and *Salix arctica*), sedges (e.g., *Carex rupestris*, *Kobresia myosuroides*), forbs (e.g., *Saxifraga oppositifolia*, *Oxytropis* spp., *Parrya arctica*), and small mosses (*Ditrichum flexicaule*, *Distichium* *capillaceum*, *Tortula ruralis*, *Sanionia uncinata*). Common lichens include *Thamnolia* sp., *Lecanora epibryon*, *Flavocetraria cucullata*, *F. nivalis*, *Vulcipida. tilesii*, and *Polyblastia* sp. The zonal vegetation, or climax vegetation, is the vegetation that ultimately develops on sites with average site conditions under the prevailing climate.

Hills in the Green Cabin region have slopes that exhibit the following toposequence of plant communities (Photo 2): (A) the ridge tops have dry patchy plant communities with abundant areas of nearly barren gravel (Photo 3), (B) slopes have a combination of turf hummocks (Photo 4) and non-sorted stripes, (C) drainages and valley bottoms have moist meadows (Photo 5), and wetlands. Streamsides within this subzone normally lack well-developed streamside willow communities, which are common in Subzone D to the south. Snowbeds in this subzone are often dominated by *Cassiope tetragona*, which is lacking in Subzone B to the north.

Study Sites:
Frost boils occur only on flat sites. (Photo 9). On hill slopes they become converted to stripes through a combination of frost-heave and colluvial processes. The project is studying frost boils at three locations with different soil moisture conditions: (1) a zonal site located in a small saddle between two hills (Photo 9, Grid 1 (zonal)), (2) a dry ridge (Grid 2, xeric), and (3) a wet meadow in the valley bottom (Photo 10, Grid 3 (hydric)) (see Figure 2 for locations of the grids with respect to Green Cabin).

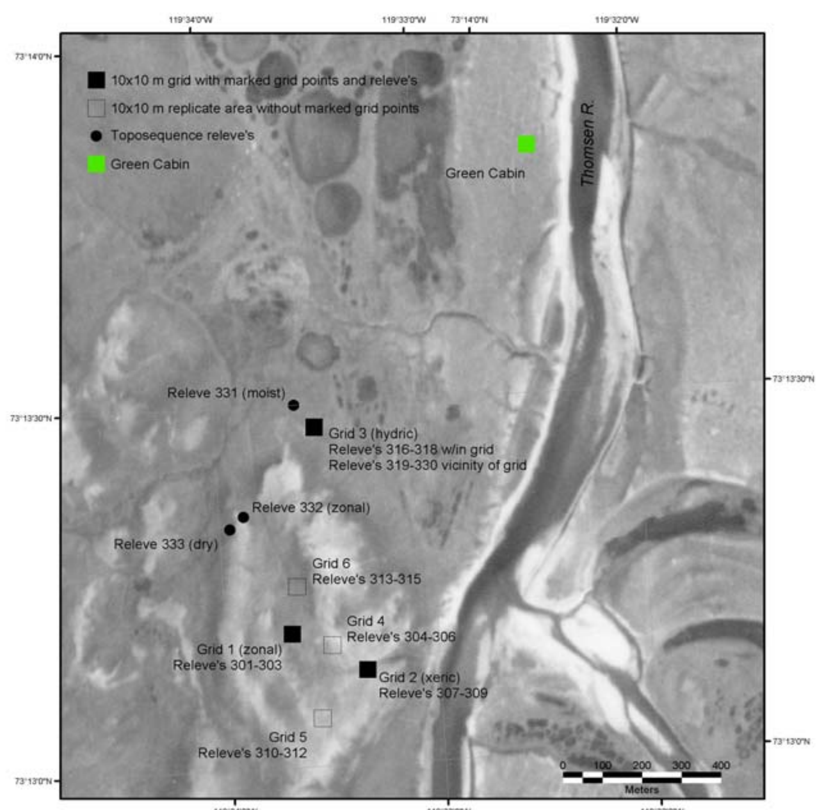

Figure 3. Aerial photo of Green Cabin area, with 2003 sampling sites marked

Projects

Climate- Permafrost Component - ***Vladimir Romanovsky and Bill Krantz***
A climate station was established near Grid 1 (Photo 6). This station will collect digital data that will be downloaded yearly. The data include snow depth (sonic sensor), air temperature, ground surface temperature, soil moisture and temperature at several depths. These data will be compared with sites in other bioclimate subzones. They will also be used to parameterize physical and biological models of frost boil processes.

Five heave scribers (Photo 7) were set up at each of the three grids, in both frost boil and inter-boil vegetation. Thaw depth was measured a 0.5 m spacing in the three grids. Thaw depths in the three grids are shown in Table 1.

Table 1. Thaw depths (cm ± standard error) at three 10x10 m grids

Grid	Frost boils	Inter-boil area	Grid mean (n = 441)
1 (zonal)	60 ± 0.4	57 ± 0.3	58 ± 0.2
2 (dry)	54 ± 0.2	51 ± 0.3	53 ± 0.2
3 (moist)	46 ±0.6	26 ± 0.4	31 ± 0.5

Soils Component - ***Chien-Lu Ping , Gary Michaelson and Charles Tarnocai***

Soil description

Purpose: The purpose of the soils study in the Green Cabin area, Auluvik National Park was to investigate soils associated with frost boils in different landforms (Photo 8).

Driving Questions:

1) Does the same kind of soil-vegetation relationship found in arctic Alaska exist in the Middle Arctic of Canada?
2) Is the frost boil process a controlling factor in sequestering the surface organic carbon into the lower part of the active layers and the upper permafrost?

Data Items: The data collected include physiographic characteristics of each study site and soil morphological properties. Soils samples from each horizon were collected and shipped to both the University of Alaska Fairbanks Palmer Research Center Laboratory and the USDA National Soil Survey Center for characterization analysis. The analytical items include soil physical, chemical and mineralogical properties.

Methods: Seven soil study sites were selected to be associated with the vegetation plots and also to be representative of the landform. At each site a 1x 2 m^2 trench was excavated to more than one meter deep. Soil horizons were delineated from the exposed profile. Soil morphological properties were described according to the USDA Soil Survey Manual. Soil samples were taken from each horizon and shipped to the laboratories for analyses.

The analytical procedures are according to the standard procedures of the USDA National Soil Survey Laboratory.

Preliminary Findings: Based on soil morphological study of one site in Mould Bay, Prince Patrick Island and 7 sites in Banks Island, soils associated with frost boils are highly cryoturbated. The soil horizons are broken or warped due to freeze and thaw cycles. On the well-drained and imperfectly drained upland soils, the frost boils are very active and soil types do not always corresponding to vegetation cover, although there is a general trend that humus rich soils occur under tundra vegetation. A highly cryoturbated organic rich horizon occurs at the lower active layer and upper permafrost. Thus, as in arctic Alaska, the frost boil process is a controlling factor for sequestering the surfaced formed organic matter into the lower part of the soil. In the poorly drained lowland sites, the soil types can be better predicted according to landforms and most of the organic matter is accumulated on the surface organic layer. There is more organic carbon stored in these soils than predicted.

<u>Turf hummocks</u>

Background: Turf hummocks are small, 11–20 cm high, 18–50 cm diameter mounds (Photo 4). They commonly occur on gently to steeply sloping Arctic terrain. Turf hummocks represent a unique ecosystem. They provide a nutritious and warm soil environment for plant growth, and readily available food source for small mammals and insects. During this fieldwork turf hummocks were studied at five locations on Banks Island in Bioclimate Subzone C.

Objectives: To examine their internal and external characteristics on the basis of soil analytical data, and moisture and temperature measurements.

1. To determine their age and genesis.
2. To establish the role they play in the Arctic ecosystems.

Information collected: Hummocks with two types of dominant vegetation were studied – those with *Dryas integrifolia* cover and those with *Cassiope tetragona*. Initially, pits were dug diagonally across the hummock to the adjacent interhummock troughs to expose the internal morphology (inset, Photo 4). Detailed cross section diagrams were prepared and the various soil horizons and layers were identified. Soil samples were collected for laboratory analysis to determine their chemical and physical properties. Additional samples were collected for bulk density determinations and samples also were collected from organic-rich horizons for radiocarbon dating. At each site, the heights and diameters of five hummocks were measured. In addition, soil temperature measurements were taken at depths of 2.5 and 5 cm on the tops of three hummocks and under the adjacent inter-hummock troughs.

The 28–36 cm diameter polygons at site 4 were also examined and sampled as described above. Some of these polygons were covered with bare soil, some were partially vegetated with *Dryas integrifolia* and some were completely vegetated . A thin layer of sandy materials was found under the Dryas mat and, as a result, these Dryas-covered polygons were elevated as much as 6 cm. It appears that site 4 represents the initial state of turf hummock development.

Vegetation Component - *Skip Walker, Howie Epstein, Anja Kade, Alexia Kelley, Martha Raynolds*

<u>Mapping</u>

Purpose: To map the distribution of different vegetation communities within frost boil landscapes.

Methods: Three 10 x 10-m grids were mapped (Photo 10). The different vegetation communities which occurred were defined, and their distribution mapped by hand. These maps will be used to quantify the amount of area covered by the different types, and to compared to similar maps of grids in other bioclimate subzones.

In addition, a 1 x 1 m grid was mapped to examine smaller scale patterns. Additional data were collected on this small plot, including micro-topography (every 10 cm) of the plot using a point frame, thaw depth at 20 cm intervals, volumetric soil moisture at 20 cm intervals, soil temperature at 1 cm depth within the different communities (measured over the course of 1 year). Soil samples of the upper 5 cm of soil were collected at 20 cm intervals, which will be analyzed for total C and N content in the lab.

<u>Relevés</u>

Purpose: To sample the vegetation communities that characterize the frost boil communities in the Green Cabin area.

Methods: Vegetation communities were described using Braun-Blanquet methods. Data collected included site factors that characterized the site, and lists of plant species (vascular and non-vascular) and their cover values. Thirty-three relevés were described, covering the range of different communities found on and between the frost boils, in sites ranging from dry, well-drained areas (Photo 3) to moist areas with saturated soils (Photo 5).

Dry frost boils: The frost boils in the drier grids (Grids 1 and 2), are 0.7 to 2 m in diameter, with a density of about 30 frost boils / 100 m2 (Photo 4). The inter-boil areas contain turf-hummocks, and are well vegetated with the zonal plant communities (see Site description section). Super-imposed on the barren soil of the frost boil surfaces are reticulate patterns of desiccation cracks that form small micro-polygons 10-20 cm in diameter. The frost boils have two primary vegetation types. The most active central parts of the boils are nearly totally barren, but have occasional scattered forbs (e.g., *Puccinellia cf. angustata*, *Potentilla vahliana, Parrya arctica*). The outer margins of the frost boils and some of the desiccation cracks within active portions of the frost boils have cryptogamic crusts, composed of a variety of crustose lichens, (including *Polyblastia* sp. and *Leconora epibryon*). Abundant fungal hyphae were evident within the crusts.

Collections of these crusts were sent to the Komarov Botanical Institute in St. Petersburg, Russia for identification. Several vascular plants are common on the cryptogamic crusts, including *Carex rupestris*, *Lesquerella arctica*, *Saxifraga oppositifolia*, *Oxytropis glutinosa*, *Agropyron violacium*, *Potentilla vahliana*, *Parrya arctica*, and *Draba* sp. Grid 2 (dry) is on a slightly drier location and has less vegetation cover, but is otherwise similar to Grid 1.

Wet frost boils: The frost boils in Grid 3 were very large, up to 3 m in diameter (Photo 10). Most of the boils were covered by calcium carbonate deposits (marl), with a large organic component, most likely composed of algae and fungal hyphae. Three vegetation types were recognized on the wet frost boils. (1) the most barren portions of the frost boils have only a few scattered plants, e.g. *Carex aquatilis*, *Braya purpurascens*, *Eriophorum angustifolium*, (2) more stable portions of the frost boils have denser cover of sedges (*Carex membranacea*, *C. aquatilis*, *E. triste*, *E. angustifolium*), mosses (*Drepanocladus* sp.) and other herbs (including *Pedicularis sudetica, Cardamine hyperboreum*, *Arctagrostis latifolium*), (3) slightly elevated sites within the frost boils are better drained and have a wider variety of species, including *Saxifraga oppositifolia*, *Dryas integrifolia*, *Salix arctica*, *Carex misandra*, *Braya purpurascens* and *Carex rupestris*.

<u>N-factor</u>

Objectives: To record close-to-surface soil temperatures for several plant communities associated with the frost-boil ecosystem over the course of 1 year. These data can be used to calculate N-factor (a measure of insulation) for each specific plant assemblage.

Data collection:

- All temperature sensors of the data loggers were buried in the soil at 1 cm depth.
- 3 data loggers (6 sensors) at Green Cabin mesic:
  - barren
  - lichen crust
  - *Dryas integrifolia* mat
- 2 data loggers (4 sensors) at Green Cabin dry:
  - barren
  - *Dryas integrifolia* mat
- 5 data loggers (10 sensors) at Green Cabin wet:
  - barren
  - sedge within frost-boil
  - *Dryas integrifolia/Saxifraga oppositifolia* mat within boil
  - frost-boil rim
  - interboil

Frost boils vs. inter-boil areas

Purpose: The purpose of the project was to determine the differences in plant community biomass, LAI, NDVI, and nitrogen cycling between frost boils and surrounding inter-boil areas. This study was conducted along a toposequence moisture gradient near Green Cabin, and is part of a larger study that looks at these differences along the complete arctic temperature gradient. Nitrogen has been shown to be one of the most important limiting factors in the production of tundra vegetation, and we are interested in the roles that nitrogen and climate play in controlling vegetation in frost boil ecosystems.

Methods: Three representative frost boils were chosen at each of the three main sites (xeric, zonal, and hydric), situated along a toposequence near Green Cabin. At each frost boil, several samples of soil were collected within the frost boil and also in the inter-boil area to determine the nitrogen and carbon content of the top 5 cm of soil in each area (frost boil vs. inter-boil). In order to determine the differences in nitrogen cycling, several processes were measured, including net nitrogen mineralization and nitrogen fixation. Net nitrogen mineralization was measured using the buried bag method over a period of 8 days. Nitrogen fixation was assessed via the acetylene reduction assay. The plant community at each site was characterized by taking measurements of the Normalized Difference Vegetation Index (NDVI; a measure of greenness) with a handheld spectro-radiometer and Leaf Area Index (LAI) with a plant canopy analyzer, as well as aboveground biomass clippings. Additional physical and micrometeorological properties of these areas were measured, including soil moisture and thaw depth. These methods are also being used on the Arctic Slope of Alaska, for the warmer zones of arctic vegetation.

Preliminary results: Initial results from the field expedition show that distinct differences do exist among the three sites at Green Cabin. These differences are especially obvious between the wet site and the other two sites. LAI was greatest in the inter-boil area of the hydric site, while the LAI of all the frost boils and the inter-boil areas of the zonal and xeric site were relatively low. This result can be attributed to the type of plant communities at each site. All of the frost boils were relatively bare, and therefore were expected to have low LAI levels. The inter-boil area of the hydric site contains several sedge species that made up a majority of the canopy structure. The inter-boil areas of both the xeric and zonal sites were comprised primarily of the evergreen shrub, *Dryas integrifolia*, which does not grow erect and therefore is not detected by the instrument used to measure LAI. Additional results show that thaw depth was greatest in the frost boils compared to the inter-boil areas. This is true at all three sites and can be attributed to the insulation to thaw provided by plant cover in the inter-boil areas. The greatest difference in thaw between frost boils and inter-boil areas existed at the hydric site. Again, this is because of differences in plant biomass, which was greatest at the inter-boil areas in the hydric site.

NDVI, LAI, biomass transects

The purpose of this analysis is to understand plant community properties in frost boil ecosystems along the complete arctic temperature gradient. We set up two 50-m line transects at each of the three sites (xeric, zonal, hydric) along the toposequence at Green

Cabin. For each of the transects, we measured the Normalized Difference Vegetation Index (NDVI) and the Leaf Area Index (LAI) every meter. We also harvested three 20cm x 50cm areas along each transect (one at the center and one at each end) for analysis of the biomass of different plant types.

Education Component - *Bill Gould and Grizelle Gonzalez*

Course goals and overview

Arctic Field Ecology introduces undergraduate and graduate students to field studies in the Arctic to give them an understanding of the structure and function of arctic ecosystems and the current state of Arctic research. This is accomplished through daily seminars on diverse aspects of arctic ecology, examination and discussion of important publications of Arctic research, integration of student activities with the Biocomplexity of Arctic Frostboil Ecosystems research team, and through active participation in field sampling and analyses for ongoing biodiversity and decomposition studies related to the biocomplexity research. By the end of the course each student develops and presents a research proposal focused on answering important ecological questions in the region.

This summer a group of 6 students from the US, Europe, and the Caribbean spent three weeks on Banks Island in the Canadian Arctic. The course had two sections - interacting with the research team investigating frost-boils during a two week field season (Photo 11), and investigating the ecology of Aulavik National Park while kayaking along the Thomsen River.

Research activities

Biodiversity transects: We established three 20 meter transects, adjacent to the 10 x 10 meter zonal grid. Each transect was selected to bisect at least 5 frost boils. Boil/interboil transitions (noted as shifts in vegetation cover) were flagged along the transect, and 5 boil and 5 interboil areas were selected for soil sampling, soil invertebrate sampling, and vegetation sampling. Soil samples are being analyzed at the International Institute of Tropical Forestry (IITF) for pH, C:N ratio, percent organic matter, and soil chemistry. . Pitfall traps using funnels and vials with ethanol were set out for four days to sample surface active invertebrates on the boil and interboil areas. Vegetation was sampled within 25 x 25 cm grids and species presence and abundance were recorded. Additionally, we measured thaw depth, micro relief, and vegetation cover type as vascular, moss, cryptogamic crust, or bare soil every 10 centimeters along each transect. These measures will be used to develop profiles of typical frost boils along the climatic gradient, and to look at differences in plant and insect community composition and diversity on boil and interboil areas. We predict that the maximum differences in community composition (*beta* diversity) will be greatest at an intermediate point of high habitat differentiation (bare soil versus vegetated surfaces) and warmer climates (higher regional diversity).

Decomposition experiments: We established a series of decomposition experiments to look at decay rates on boil and interboil areas along a toposequence at Green Cabin.

Experiment 1. In 2002 we collected recently senesced litter of *Luzula nivalis* from Satellite Bay, Prince Patrick Island and created 20 mesh litter bags (2x2 mm) for placement in the field. These were placed in the field in 2003 at Mould Bay, Prince Patrick Island on a series of boil and interboils within a 4 x 4 meter quadrat. A set of controls was will be analyzed for litter chemistry at the IITF chemistry lab. The remaining litterbags will be retrieved in 2004 and 2005 to determine boil and interboil variation in percent of mass loss, decay rate, and change in litter chemistry.

Experiment 2. We collected freshly senesced litter of *Carex misandra* at the Green Cabin site on Banks Island (subzone C) and created 60 mesh litterbags (2x2 mm). We took field weights and placed these along our biodiversity transects on boil and interboil surfaces and at 4 cm depths. A set of controls will be analyzed in the IITF chemistry lab. Remaining bags will be sampled in 2004 and 2005 to determine mass loss, decay rates and changes in litter chemistry.

Experiment 3. We prepared 107 additional litterbags of *Carex misandra* for placement in boil and interboil areas along a toposequence at the Green Cabin site. Three replicate litter bags were placed on the surface and below-ground at 4 cm depths within 3 replicate boils and interboils at ridge, slope and valley positions. These are at the same site s being used for nitrogen mineralization experiments by Alexia Kelly and Howie Epstein. Controls were retrieved after placement and additional bags will be retrieved in 2004 and 2005.

Seminars Presented at Green Cabin

During the expedition we had nightly seminars from the various researchers. Topics presented included:

Biocomplexity of Frost Boil Ecosystems - overview by Skip Walker
Geology and Soils , including Banks Island photos from 1981 by Charles Tarnocai
Morphogenesis of Soils Associated with Frost Boils by Chien-Lu Ping
Biogeochemistry of Soils Associated with Cryptogamic Crusts on Frost Boils by Gary Michaelson
Geophysical Self-Organization as an Indicator of Global Climate Change by Bill Krantz
Dynamics of Vegetation and Soils in Arctic Tundra Ecosystems by Howie Epstein
Plant Community and Nitrogen Cycling in Arctic Frost-Boil Ecosystems by Alexia Kelley
Experimental Alteration of Plant Canopy and the Effects on Cryoturbation Regime by Anja Kade
Biocomplexity of Frost Boil Ecosystems: Educational Component by Bill Gould and Grizelle Gonzalez .

These presentation can be viewed on the Alaska Geobotany Center web site (www.geobotany.uaf.edu).

Future Work and Products

The data collected at Green Cabin will be analyzed. The results will be compiled in a data report during the next year. The results will also be posted on the Alaska Geobotany Center web site (www.geobotany.uaf.edu).

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Photographs

Photo 1. Green Cabin camp, on terrace on the west bank of the Thomsen River. White meeting yurt in right background, with sleeping tents in front of it. The airstrip, Green Cabin, and the Thomsen River are to the right of the photo.

Photo 2. Landscape near Green Cabin, showing topsequence of vegetation communities, from dry gravel ridges (A), slopes with stripes of barren areas and turf hummock vegetation (B), and continuous vegetation at the base of the slopes with moist and wet meadows (C). These same assemblages of communities are repeated throughout the landscape and can be seen on the front cover photo.

Photo 3. Dry, mostly barren areas on well-drained ridges. Scattered plants form patches, of mostly *Dryas integrifolia*, and *Oxytropis* sp. *Carex rupestris, Kobresia myosuroides* and some lichens also occur.

Photo 4. Hill slope with turf hummocks. Inset shows a cross-section of a turf hummock. Most hill slopes have hummocks with varying degree of vertical relief, from 11-20 cm high and 18-50 cm in diameter. Steeper slopes have more pronounced hummocks. On hill slopes where snow accumulates*, Cassiope tetragona* is a common component of the turf-hummock plant communities. Areas with less snow usually have zonal plant communities (see Site description section).

Photo 5. Moist sedge meadow on an alluvial fan; found on moist areas in valleys and base of slopes. The major plant species include *Carex membranacea, Dryas integrifolia, Salix arctica, Carex misandra, Erioiphorum triste, Saxifraga oppositifolia, Pedicularis langsdorfii, Senecio atropurpureus, Tomentypnum niten, Ditrichum flexicaule, Drepanocladus* sp., *Distichium capillaceum*.

Photo 6. Vladimir Romanovsky installing a climate station. The tripod at right rear holds a sonic snow meter. The probe in his right hand was buried in the soil, and will measure temperature and moisture at a number of depths.


Photo 1

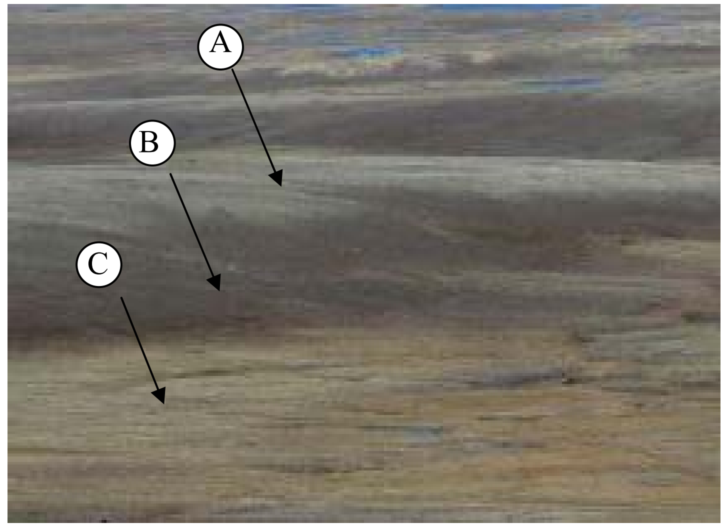
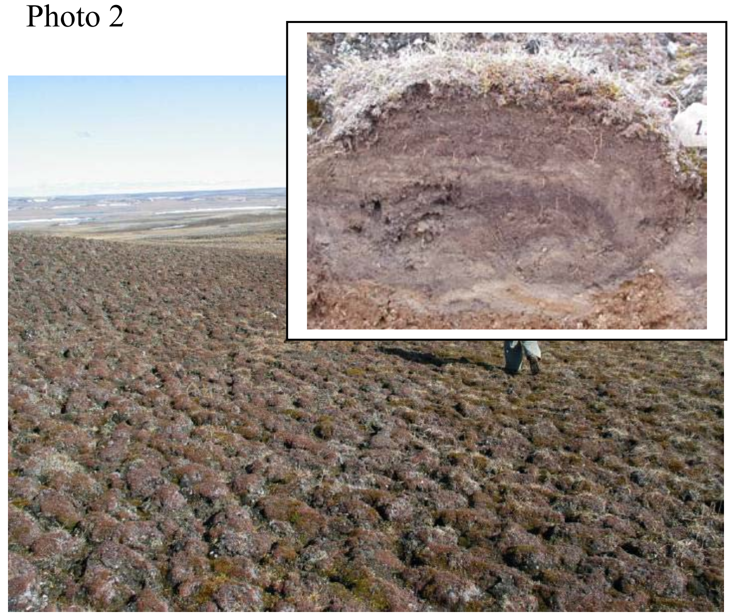


Photo 2


Photo 3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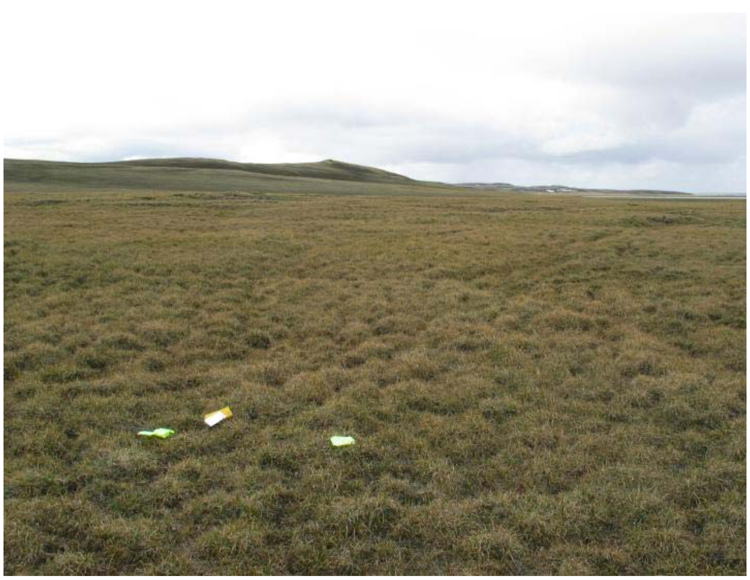
Photo 5


Photo 6

Photo 7. Frost heave scriber. The central post is a 2 m-long copper grounding rod, which was driven 1.5 m into the ground, anchoring it in the permafrost. The metal plate slides freely on the rod, rising with the frost heave in the fall, and falling back down with the spring thaw. The pointed curved scribe is attached to the metal plate, and scratches the soft copper rod. An initial starting line was scratched all the way around the rod.

Photo 8. Charles Tarnocai in a soil pit which cuts across a frost boil. The undisturbed half of the frost boil is visible in the background. A similar pit was dug at each of the grids, and at four additional sites. The black tapes are used to document the location of different soil horizons.

Photo 9. Zonal site with well-developed frost boils. The inter-boil plant community, *Dryas integrifolia-Carex rupestris* is the zonal vegetation for the region. It occurs in the inter-boils areas, between nonsorted stripes, and on turf hummocks on gentle slopes (see Photo 4). The vegetation on the frost boils is very sparse, with only scattered vascular plants (e.g., *Puccinellia cf. angustata*, *Potentilla vahliana, Parrya arctica*).

Photo 10. Grid 3 (hydric), 10 x 10 m grid, with green flags spaced every meter. Most of the boils were covered by calcium carbonate deposits (marl), with a large organic component, most likely composed of algae and fungal hyphae. The most barren portions of the frost boils have only a few scattered plants, e.g. *Carex aquatilis, Braya purpurascens, Eriophorum angustifolium*. Somewhat more stable sites have denser cover of sedges (*Carex membranacea*, *C. aquatilis*, *E. triste*, *E. angustifolium*) and mosses (*Drepanocladus* sp.) and more species (including *Pedicularis sudetica, Cardamine hyperboreum*, and *Arctagrostis latifolium*).

Photo 11. Students at work with researchers, digging a soil pit, sampling the soils, and recording the data.

Photo 12. Members of the 2003 Banks Island Expedition. Back row, left to right: Chien-Lu Ping, Sean Rea, Adriana Quijano, Noah Strom, Heather Fuller, Ronnie Daanan, Charles Tarnocai, Patrick Kuss, Vladimir Romanovsky, Bill Krantz, Howie Epstein, Anja Kade. Front row, left to right: Sarah Harvey, Gary Michaelson, Martha Raynolds, Alexia Kelley, Skip Walker, Bill Gould, Grizelle Gonzalez

Photo 7

Photo 8

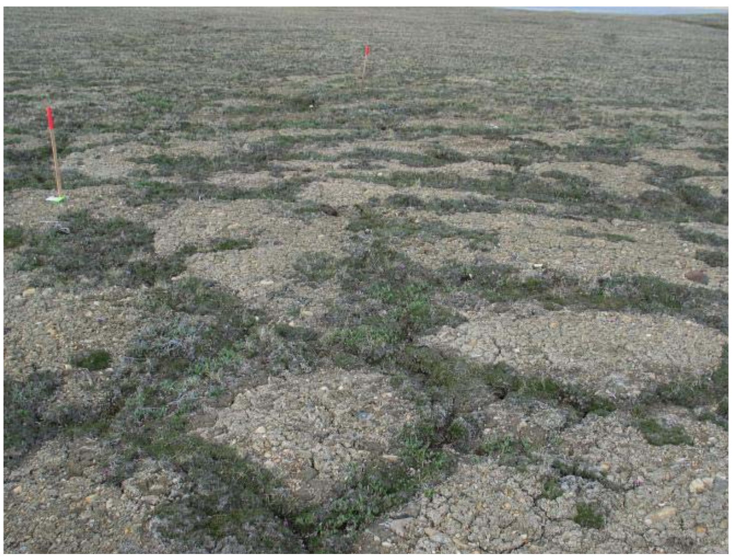
Photo 9

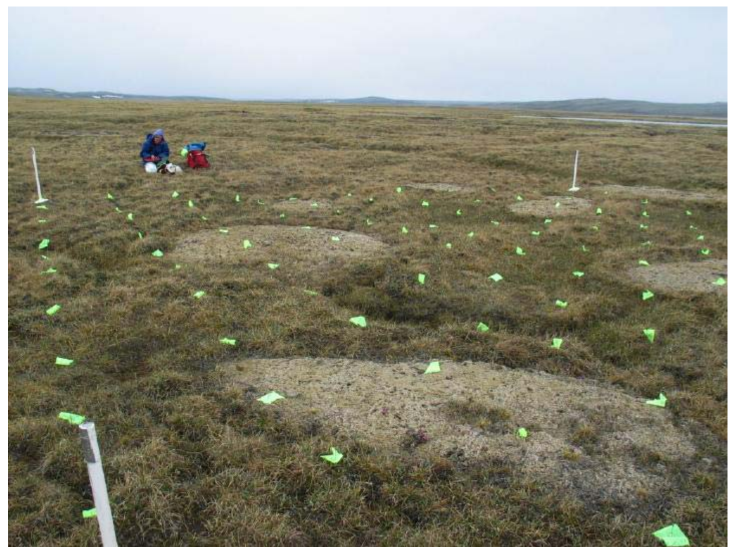
Photo 10


Photo 11


Photo 12