DATA REPORT

BIOCOMPLEXITY OF FROST-BOIL ECOSYSTEMS

July 2003 Banks Island Expedition

Vegetation, Biomass, NDVI, Soil, Thaw layer, Invertebrates, Decomposition, Biogeochemistry, and Turf-hummock Studies

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Introduction

This data report summarizes information collected during July 2003 near Green Cabin, northern Banks Island, Canada as part of the NSF-sponsored "Biocomplexity of Frostboil Ecosystems" project (grant #OPP-0120736). It also includes information about a half-day visit to Mould Bay on Prince Patrick Island (2 July 2003).

Description of the 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) (Figure 1). 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 Map Team 2003) . Subzone C is more or less equivalent to the Middle Arctic as portrayed by (Polunin 1951) and the Dwarf and Prostrate Shrub Subzone of (Edlund 1990). The zonal vegetation (the vegetation that ultimately develops on sites with average site conditions under the prevailing climate) at Green Cabin is a mixture of prostrate dwarf shrubs (mainly *Dryas integrifolia* and *Salix arctica*), sedges (e.g., *Carex rupestris*), forbs (e.g., *Saxifraga oppositifolia*, *Oxytropis* spp., *Parrya arctica*), and small mosses (*Ditrichum flexicaule*, *Distichium capillaceum*, *Hypnum procerrimum*, *Tortula ruralis*, *Sanionia uncinata*). Common lichens include *Thamnolia subuliformis*, *Lecanora epibryon*, and *Psora decipiens*.

Hills in the Green Cabin region have slopes that exhibit the following toposequence of plant communities (Figure 2): (A) the ridge tops have dry patchy plant communities with abundant areas of nearly barren gravel, (B) slopes have a combination of turf hummocks and non-sorted stripes, (C) drainages and valley bottoms have moist meadows 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. A few erect shrubs of *Salix lanata* ssp. *richardsonii* occur on favorable microsites near Green Cabin. This indicates that the site is marginally within subzone C. Mean July temperature from 1997 to 2002 for the site was 8.8˚ C. July mean temperatures for most subzone C sites are normally 5-7˚ C. The interior- island location gives Green Cabin a more continental climate than coastal sites such as Polar Bear Cabin near the north end of Banks Island with a mean July temperature of 6.2˚ C for the same 1997-2002 period.

Study Sites:

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 (Figure 3, Grid 1, zonal), (2) a dry ridge (Figure 3, Grid 2, xeric), and (3) a moist meadow in the valley bottom (Figure 3, Grid 3, hydric). See Figure 1 for aerial photo of locations of the grids

with respect to Green Cabin. Grids 4, 5, and 6 were temporary grids to count frost boils and obtain replicate plant-community data.

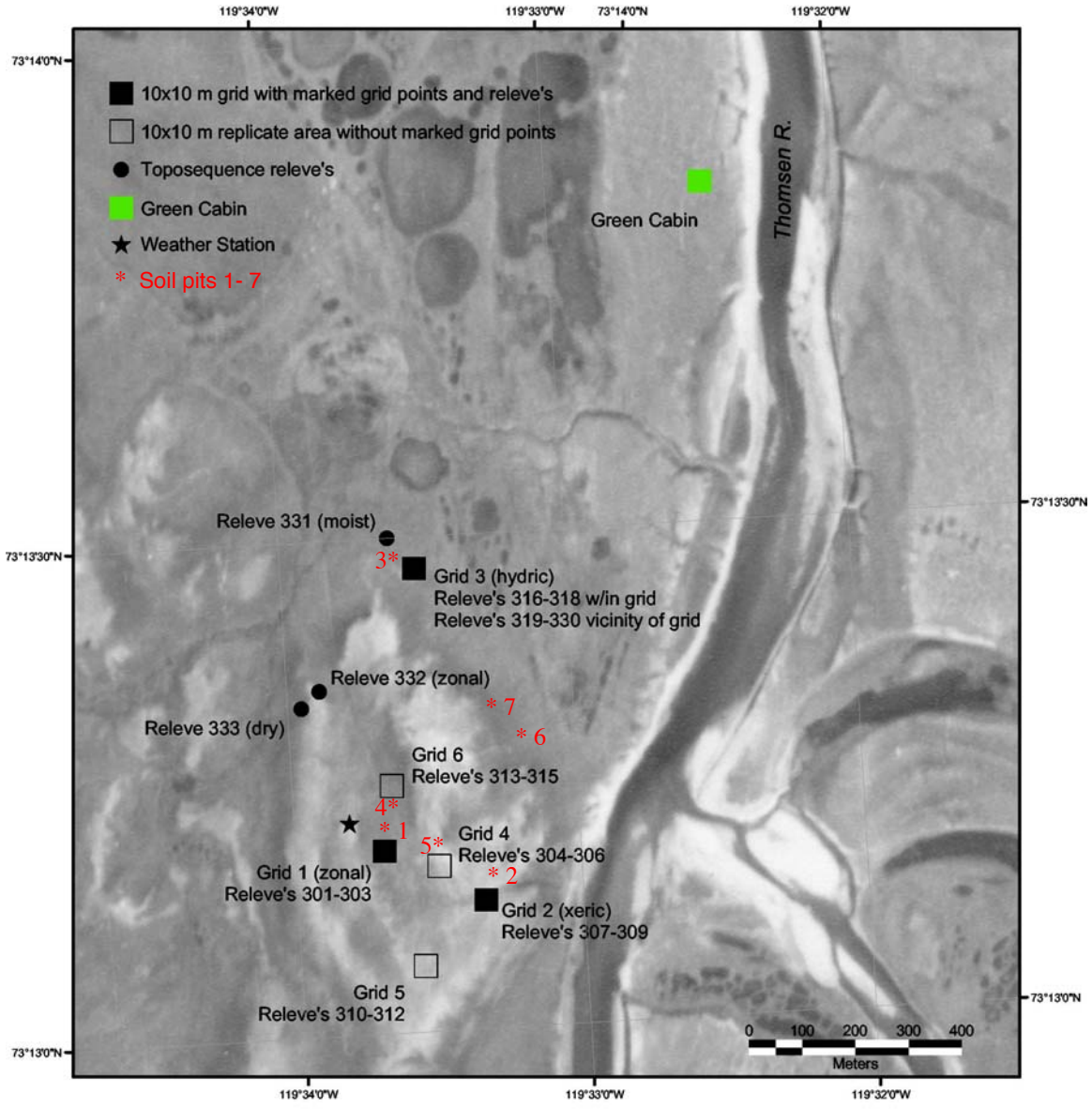


Figure 1. Aerial photo of Green Cabin area, with 2003 sampling sites marked

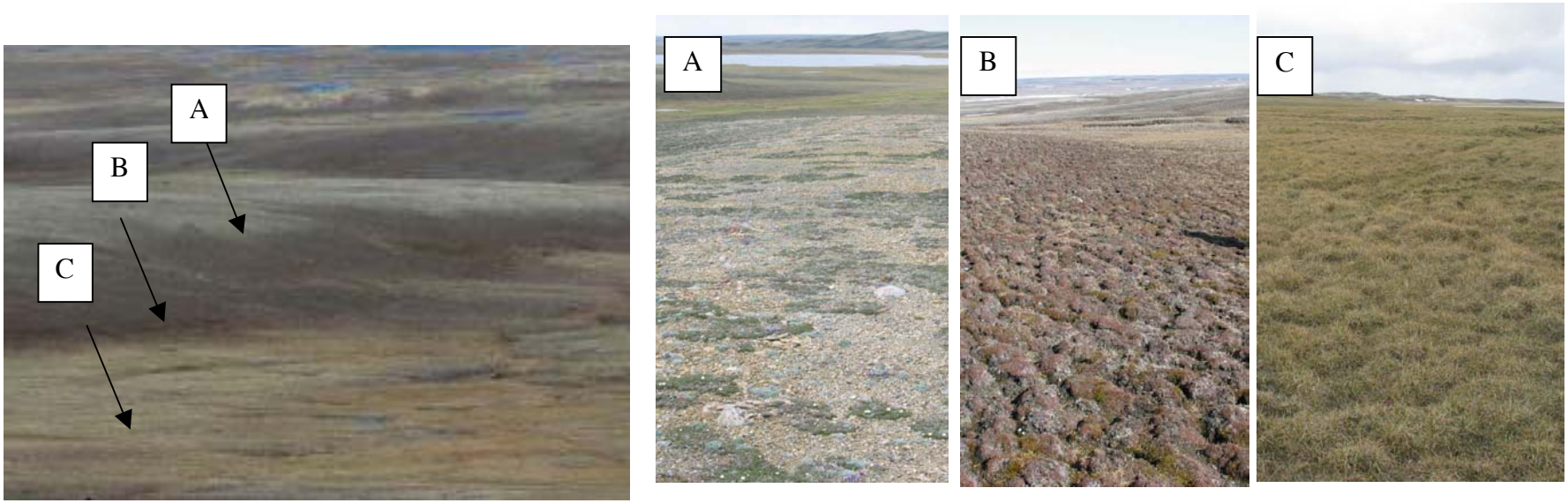


Figure 2. Typical toposequences, A: dry ridge, B: hillslope with hummocks, C: moist meadow

(a) (b) (c)

Figure 3. Green Cabin Grids, (a) Grid 1, zonal site; (b) Grid 2, xeric site; (c) Grid 3, hydric site

Methods & Types of Data Collected

Climate: Instruments were installed at Grid 1 to measure air temperature, ground surface temperature and ground temperature. Standard Campbell Scientific L107 thermistors were used for air and ground surface temperature, and MRC thermistor rods for ground temperature. Two sets of ground temperature sensors were installed six meters apart, one in a frost boil and another in an inter-boil area. After pre-installment calibration, the precision of the sensors is better than 0.02°C. Ground temperatures are collected at ten different depths down to 106 cm (roughly every 10 cm), measured every 5 minutes, and averaged and saved every hour.

Ground moisture (including the unfrozen water content in winter) is measured at two different depths within the frostboil and at two different depths in the inter-boil area. VITEL volumetric water content sensors (based on TDR technique) were used. Each of the VITEL sensors was paired with an additional L107 temperature probe. Moisture content is recorded hourly during the entire year. Two Campbell Scientific heat flux probes were also installed at 8 cm depth, one within the frost boil and another in the inter-boil area.

(a)

(b)

Figure 4. (a) Valdimir Romanovsky installing a climate station at the zonal grid site. The tripod behind him holds a sonic snow meter, solar panel, and air temperature sensor. The probe he is holding was buried in the soil, as shown in photo (b), and measures temperature and moisture at depth.

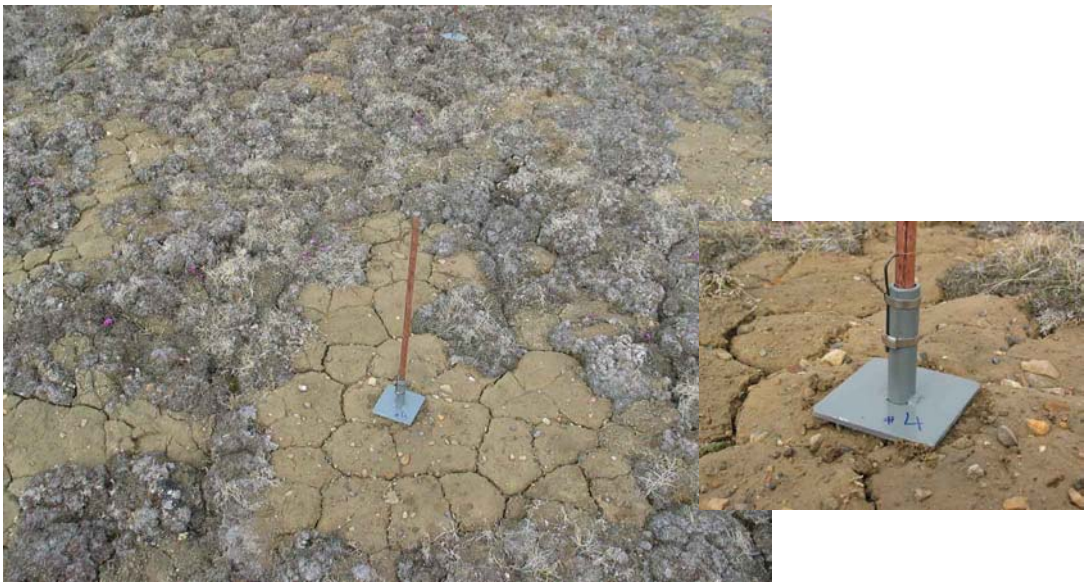


Figure 5. Frost heave scriber. The vertical copper rod is anchored in the permafrost. When the grey metal plate and sleeve slide up along the copper rod due to frost heaving of the soil, the curved scribe will scratch the copper, leaving a record of the height of the heave.

Snow depth is continuously recorded at the site (at hourly intervals) using a CSC Ultrasonic Distance Sensor. A Campbell Scientific CR10-X logger operates the station and saves the data. A 20-watt regulated solar panel coupled with a 12 v battery is used for power supply. The air temperature sensor, the ultrasonic snow sensor and the solar panel are mounted on a 3 m tripod (Figure 4).

Five heave scribers (Figure 5) were set up at each of the three grids, in both frost boil and inter-boil vegetation. Five were also placed around the grid in Mould Bay. The heave scribers consist of a 2 m-long 1.5 cm-diameter solid copper grounding rod, with a steel scriber. The copper rod was driven 1.5 m into the ground, anchoring it in the permafrost. The steel plate and sleeve were placed on the rod, with the plate resting on the ground. The steel plate slides freely on the rod, rising with the frost heave in the fall, and falling back down with the spring thaw. A sharp spring steel scriber is attached to the sleeve by hose clamps. Its tip scratches the copper rod. The steel plate was rotated to make a complete circular scratch around the copper rod, marking the initial position. Any heaving of the ground during the winter raises the plate, causing the scribe to scratch the rod. The length of this vertical scratch will be measured in following years to determine the amount of heave.

Grids: The three grids at Green Cabin (Figure 3), and one at Mould Bay (Figure 14) were marked by 1-m re-bar and 1.5-m PVC pipe at the four corners, and labeled with aluminum tags. Labeled pin-flags were placed every meter within the grid .

Vegetation mapping: Maps were made of the vegetation types within the three grids. First the different vegetation communities were identified, then their location within the marked grid was mapped by hand on a 15-cm paper grid (1:66.7 scale). In addition, two maps were made of 1-m^2 grids, using the same forms (1:6.7 scale), to show the cracking patterns and polygons which occur on the centimeter scale (Figure 6). The maps were hand-digitized as ARC/INFO polygon coverages.

Thaw depth: Thaw depths were sampled every half-meter within the grid with a metal probe (Figure 7). Vegetation community was noted at each point. The data were entered in an Excel spreadsheet, and summarized by vegetation type. The data were also used to create maps of thaw depth on the grids, using Transform software.

Plant Biomass: Biomass was collected at three random sites along two 50-m transects adjacent to each grid. All above-ground vegetation within a 20 x 50-cm frame was clipped (Figure 8). The clip harvests were sorted by major plant functional type (moss, lichen, forb, horsetail, deciduous shrub, evergreen shrub, graminoid) in the field. Mosses were clipped at the base of the green portion. The samples were frozen, then further sorted in Fairbanks into live and dead categories. Shrubs were divided into foliar, reproductive, and stem components. Biomass samples were then oven dried. The dry weights are reported.

LAI & NDVI: Leaf area index (LAI) was measured every meter along the two 50-m transects adjacent to each grid, using a LICOR LAI-2000 Plant Canopy Analyzer. An above-canopy reading (control) was followed by four below-canopy readings, taken above the moss layer along the axes of the grid at 20 cm from the center of the grid. The LAI sensor is built so that it lies approximately 2 cm above the ground, so any plant canopy that has a height ≤ 2 cm is not taken into account. All LAI measurements were in the observer's shadow to provide as consistent ambient light conditions as possible. A 90º field-of-view shield was used to prevent interference from the observer. The Normalized Difference Vegetation Index (NDVI) was measured using an Analytical Spectral Devices Field spectrometer. The sensor was held 90 cm above the ground to include an area of ~314cm^2. Cover at each point was noted as either vegetated, bare, mixed, or water.

Soil pits: Two soil pits were dug at the zonal grid site (Grid 1), and one at each of the other grids (Figure 9). Four additional pits were also dug, including one at Mould Bay on Prince Patrick Island, one on a dry ridge between Grids 1 and 2, and two in hummocky snowbed slopes. Cross-sections of the pits were drawn and the soil profiles described. Samples taken from these pits were analyzed for pH, bulk density, P, C, and N.

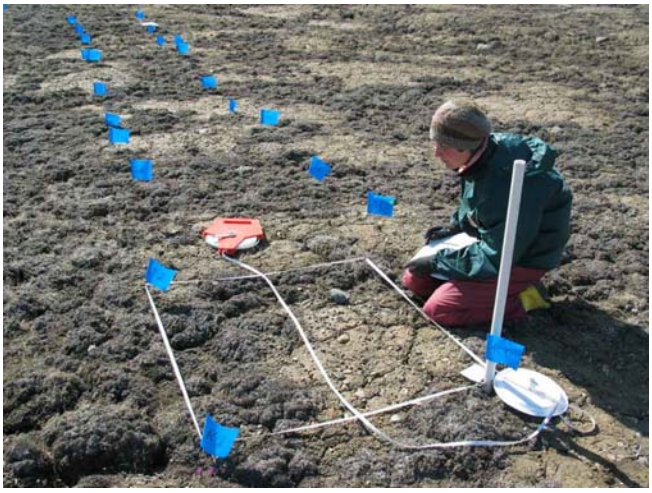


Figure 6. Anja Kade mapping 1-m grid.

Figure 7. Thaw depth probe.

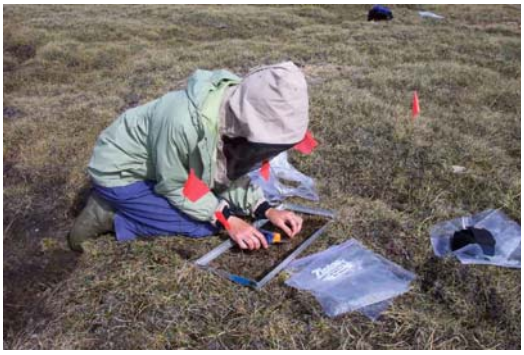


Figure 8. Alexia Kelley clipping biomass near Grid 3

Figure 9. Charles Tarnocai in soil pit near Grid 2.

(a) (b) (c) (d)

Figure 10. Soil crusts (a) Dry wrinkled mineralized crust on edge of frost boil in Grid 1 (b). Moist wrinkled crust on edge of wet frostboil in Grid 3 (c) Knife shows cross-section of moist crust in-situ. (d) Piece of moist crust, showing the sub-surface green algae layer.

Vegetation relevés: Thirty-three relevés were sampled, from the grids and other sites. Sites were chosen to represent the major plant community types in the Green Cabin area. Riparian and other less common vegetation types were not sampled. Three replicates were collected for each plant community described in the Green Cabin vicinity. Relevé location and environmental site descriptions were collected, as well as cover data for all growth forms and species. Nonvascular plant identification was verified by Mikhail Zhurbenk0, Olga Afonina, and Alexey Potemkin at the Komarov Botanical Institute, St. Petersburg, Russia. A complete plant species list was compiled for the relevés (Tables 14-16). Soil samples were collected at each relevé, at the top of the mineral horizon. These were analyzed for chemical and physical properties.

N-factor: Twenty temperature sensors were buried in the soil at 1 cm depth to record data for calculating the N-factor (a measure of insulation) of eight different cover types: barren, lichen crust, and *Dryas integrifolia* mat at Grids 1 and 2, and sedge within frost-boil, *Dryas integrifolia*/*Saxifraga oppositifolia* mat within boil, frost-boil rim and interboil at Grid 3. Data will be retrieved from the instruments during the summer of 2004.

Biogeochemistry: Three representative frost boils were selected at the three main sites (zonal (Grid 1), xeric (Grid 2), and hydric (Grid 3)). At each frost boil, several samples of soil were collected within the frost boil and also in the inter-boil area of each boil to determine the nitrogen and carbon content of the first 5 cm of soil in each area (frost boil vs. inter-boil area) (Figure 11 (a)). The samples were then analyzed for percent carbon and nitrogen using a Carlo Erba elemental analyzer.

In order to determine the differences in nitrogen cycling, several processes were measured, including net nitrogen mineralization and nitrogen fixation. Nitrogen mineralization was measured using the buried bag method (Eno 1960) over a period of 6 days. At four locations within each frost boil and inter-boil area, a soil core (2 cm in diameter and 5 cm in depth) was taken, and 10 g of the soil was extracted in 30 mL of 2M KCl (with phenylmercuric acetate (pma) to stabilize microorganism). Another soil core was taken as close as possible to the original core. This soil core was placed into a polyurethane plastic bag and incubated in the soil for six days. A 10 g sub-sample of the core was then extracted in 30 mL of 2 M KCl with pma. The samples were then mixed on a shaking table for 2 hours. The extracts were filtered and then analyzed for NO_3^- and NH_4^+ with an Alpchem autoanalyzer.

Nitrogen fixation was assessed via the acetylene reduction assay (Knowles 1980). A small core (approximately 2 cm in diameter and 0.5 cm deep) was removed from the surface of three locations within each frost boil: bare soil, crust, and inter-boil area. The soil was placed in an incubation chamber and 10% of the gas volume was replaced with acetylene (generated from calcium carbide and water) (Figure 11 (b)). The incubation vials were incubated for 48 hours and then a sample of gas was removed from the incubation vial and placed in a sample vial. The samples were then analyzed for ethylene with a gas chromatograph. Calculations of nitrogen fixation were made based on a standard conversion from acetylene reduction to nitrogen reduction.

Measurements of NDVI and LAI were made at three points within each frost boil and three points in the inter-boil area at each site, following the methods described above. Aboveground biomass clippings were also taken, one from each frost boil and each inter-boil area. These samples were sorted by plant functional type, dried at 50ºC and the dry weight was taken of each sample.

Physical properties of these areas were measured, including volumetric soil moisture, thaw depth, and soil temperature at a depth of 5 cm. These measurements were made at four points within each frost boil and inter-boil area.

(a) (b)

Figure 11. Sampling for soil nitrogen content. (a) Howie Epstein collecting small soil sample. (b) Alexia Kelley adding acetylene to samples.

Decomposition: 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 litter bags (2x2 mm mesh). 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 quadrant (Figure 14(b)). A set of controls were 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 litterbags (2x2 mm mesh). We weighed these and placed them along our biodiversity transects on boil and interboil ground

surface and at 4 cm depth. 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 litter bags 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 depth within 3 replicate boils and interboils at ridge, slope and valley positions. These are at the same sites being sampled for nitrogen mineralization by Alexia Kelly and Howie Epstein. Controls were retrieved after placement and additional bags will be retrieved in 2004 and 2005.

Class transects: We investigated three 20-m transects at six of the biocomplexity research sites, sampling in the southern three of five bioclimatic subzones in the Arctic. Each transect was selected to bisect at least 5 frost boil and interboil areas (figure 12). Thaw depth, microrelief, and vegetation cover were sampled at 10 cm intervals along the transect. Thaw depth was measured by pushing a thaw probe into the ground until reaching a layer of frozen soil below the permafrost. We sampled species composition in 25 cm^2 quadrants in each boil and interboil area and characterized the vegetation at each of our thaw probe positions as bare, cryptogamic crust, moss, or vascular-plant covered. The soil samples were taken at each boil and interboil area at a depth of 10 cm. These are being analyzed for pH and soil nutrients at the International Institute of Tropical Forestry in Puerto Rico. Pitfall traps were set up at each boil and interboil area for 1-4 days in order to collect surface active soil arthropods (Fig. 13). 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.

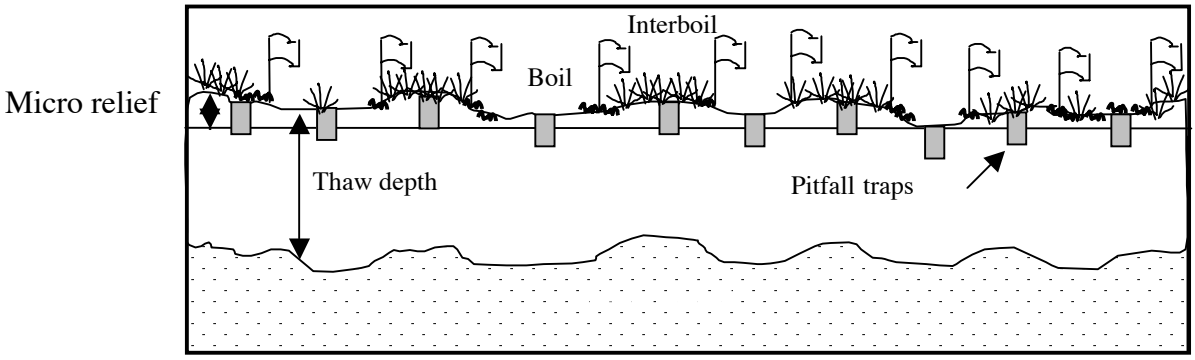


Figure 12. Transect sampling scheme. Thaw depth, microrelief, and vegetation cover were sampled at 10-cm intervals along the 20-meter transect. Ten soil samples were taken to 10-cm depths in boil and interboil areas and invertebrates were sampled using 10 pitfall traps in boil and interboil areas.

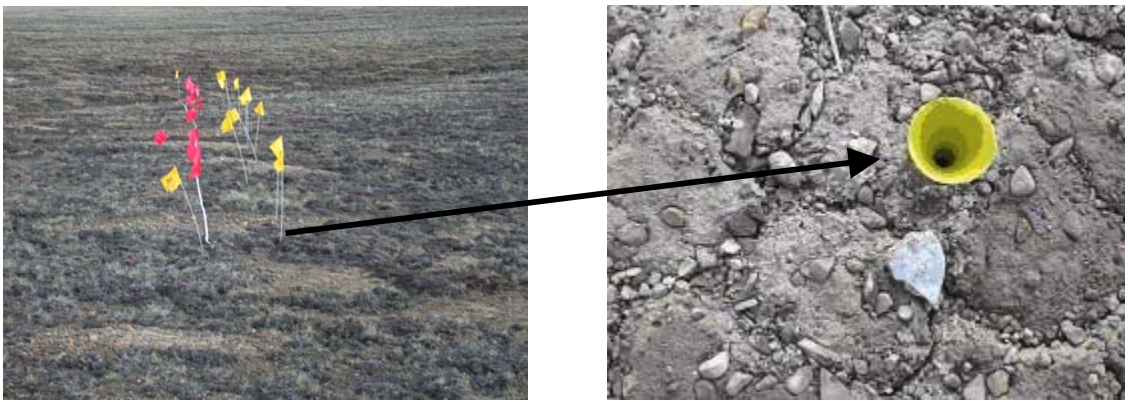


Figure 13. Biodiversity transect boils and interboils flagged in red and pitfall traps in yellow.

Turf hummocks: Turf hummocks were examined at five different locations along the ridge between Grids 1 and 2 and Grid 3. Trenches through the hummocks were dug, soil profiles were drawn, and soil samples taken. More details on the methods and results are presented below.

(a) (b)

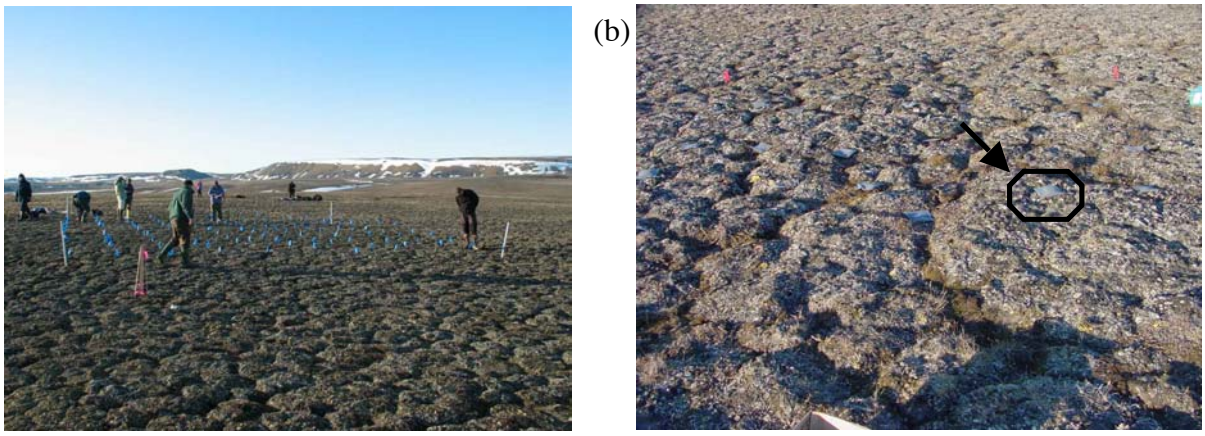


Figure 14. (a) Grid at Mould Bay. (b) Litter bags at Mould Bay, left on surface to measure the rate of decomposition over one year.

Results

Grid data

Maps of grid vegetation:

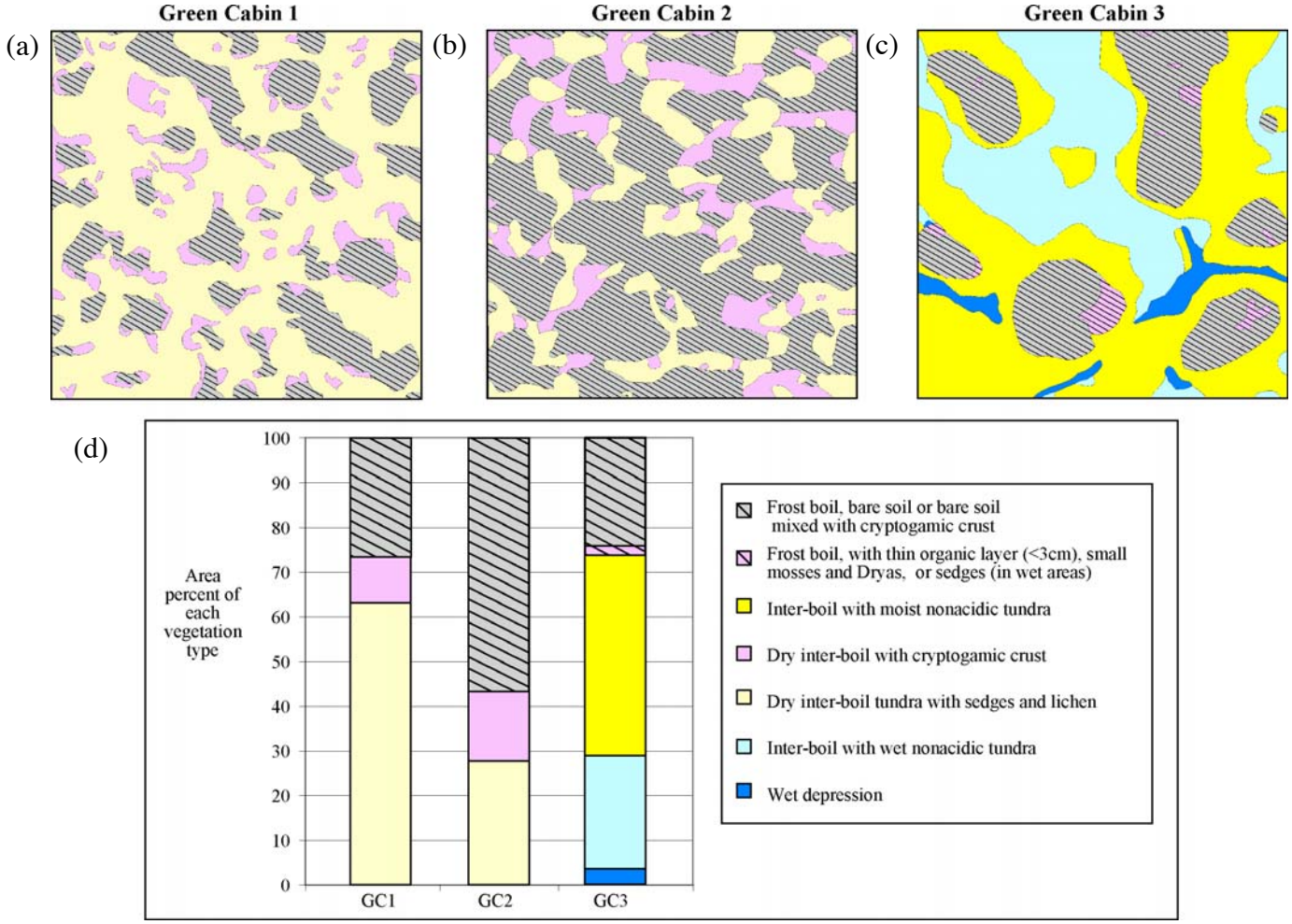


Figure 15. Plant community maps of 10 x 10 m grids: (a) Grid 1 - zonal, (b) Grid 2 - xeric, (c) Grid 3 - hydric, (d) Percent area of plant community types mapped on the 10x10-m grids

Photos of grid vegetation types:

(a) (b) (c)

Figure 16. Major types mapped on Grids 1 and 2: (a) Barren frostboil with frost cracks; (b) Edge of frostboil with cryptogamic crust and scattered Carex rupestris*; (c) Interboil* Dryas integrifolia, Saxifraga oppositifolia *community*.

(a) (b) (c)

Figure 17. Major types mapped on Grid 3: (a) Barren frostboil with wrinkled cryptogamic crust; (b) Moist sedge-shrub-moss interboil with Carex membranacea, Eriophorum triste, Dryas integrifolia, Salix arctica, and Hypnum bambergeri*; (c) Wet sedge-moss interboil with* Carex membranacea *and* Pseudocalliergon brevifolius.

Maps of Micro-grids:

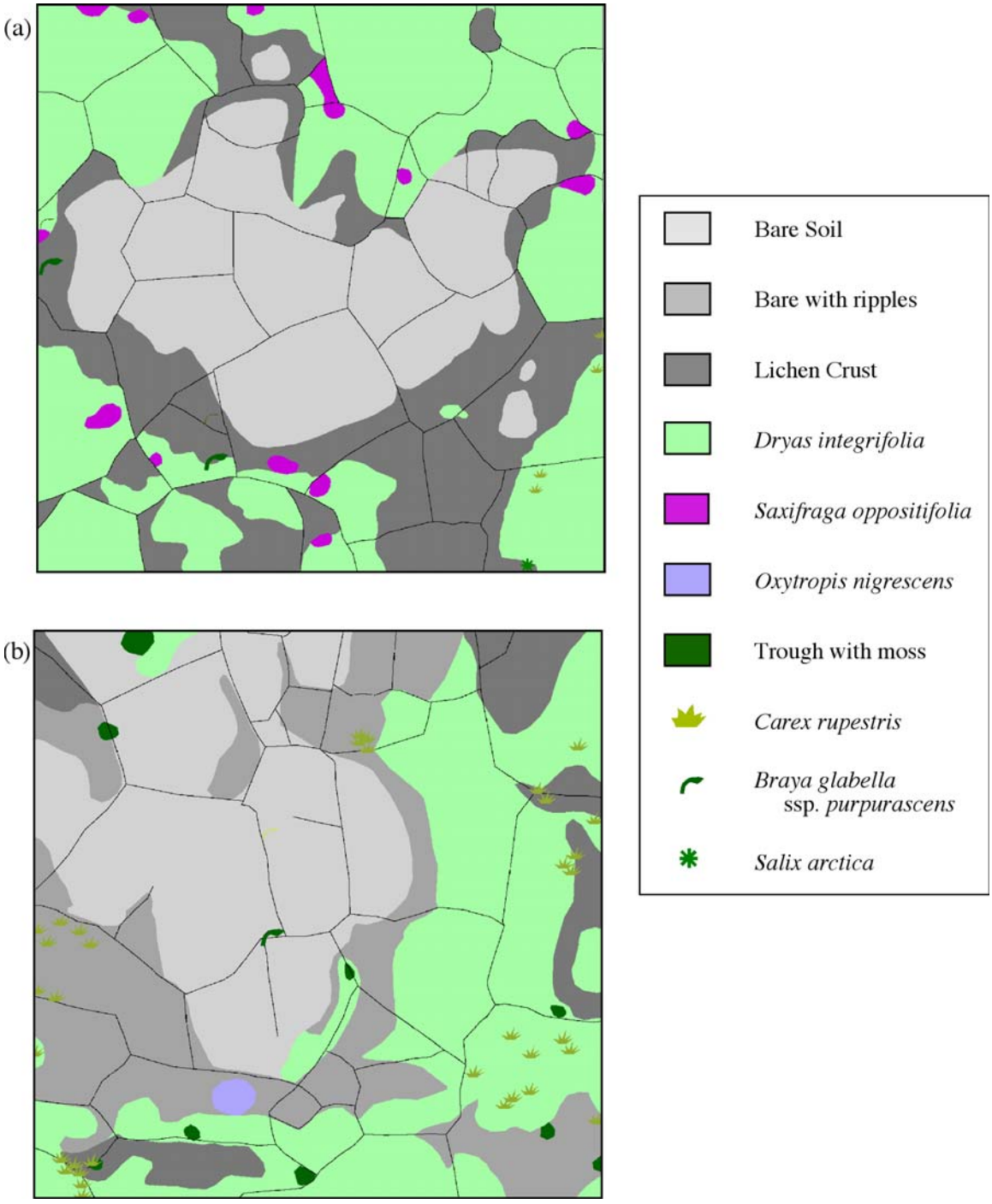


Figure 18. Maps of 1x1-m grids, showing polygonal cracking and vegetation. (a) Micro-grid 1. Located 20 m NW of mesic 10x10-m grid. (b) Micro-grid 2. Located within mesic 10x10-m grid

Maps of grid thaw depth:

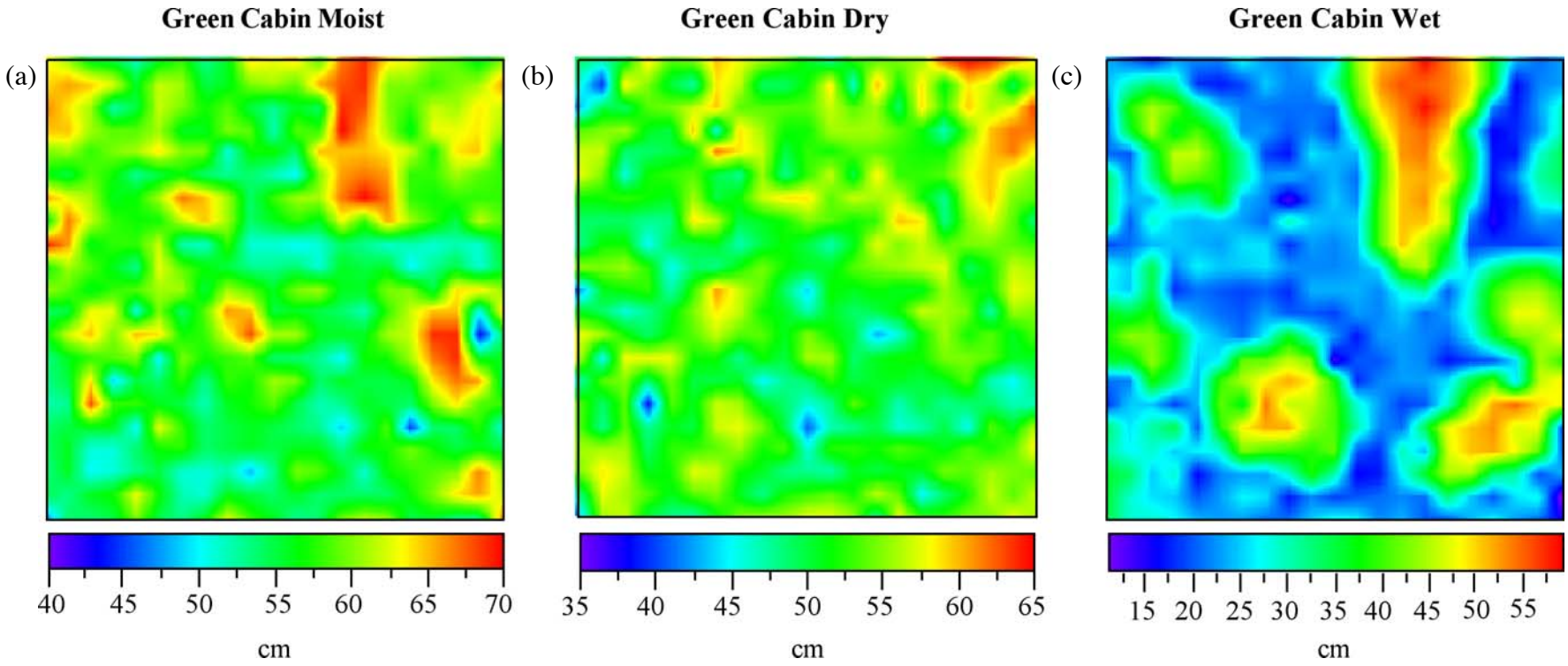


Figure 19. Maps of thaw depth on 10x10-m grids, (a) Grid 1, zonal; (b) Grid 2, xeric (c) Grid 3, hydric (Note different scales.) Measurements were taken July 9, 2003.

Table 1. Grid thaw depth data (cm).

Green Cabin 1		Green Cabin 2		Green Cabin 3	
bare (b)	Mean = 60.85	**bare (b)**	Mean = 54.20	**bare (b)**	Mean = 45.96
	s.d. = 4.90		s.d. = 4.07		s.d. = 6.34
	n = 111		n = 235		n = 97
	s.e. = 0.47		s.e. = 0.27		s.e. = 0.64
cryptogamic crust (c)	Mean = 59.02	**cryptogamic crust (c)**	Mean = 52.24	**Carrup colonizing frost boil (c)**	Mean = 42.33
	s.d. = 4.49		s.d. = 4.00		s.d. = 7.70
	n = 56		n = 78		n = 9
	s.e. = 0.60		s.e. = 0.45		s.e. = 2.57
inter- frost boil (i)	Mean = 56.66	***Dryas* inter-frost boil (d)**	Mean = 51.13	**Dryint/ Saxopp colonizing frost boil (d)**	Mean = 59.00
	s.d. = 4.19		s.d. = 3.71		s.d. =
	n = 274		n = 123		n = 1
	s.e. = 0.25		s.e. = 0.33		s.e. =
frost boil (b+c)	Mean = 60.23	***Salix* patch (s)**	Mean = 50.40	**moist interboil (m)**	Mean = 27.73
	s.d. = 4.83		s.d. = 2.30		s.d. = 8.03
	n = 167		n = 5		n = 205
	s.e. = 0.37		s.e. = 1.03		s.e. = 0.56
Total	Mean = 58.02	**frost boil (b+c)**	Mean = 53.71	**trough between polygons (t)**	Mean = 23.33
	s.d. = 4.76		s.d. = 4.13		s.d. = 5.77
	n = 441		n = 313		n = 21
	s.e. = 0.23		s.e. = 0.23		s.e. = 1.26
		Inter-boil (i+s)	Mean = 51.10	**wet interboil (w)**	Mean = 22.81
			s.d. = 3.66		s.d. = 3.06
			n = 128		n = 108
			s.e. = 0.32		s.e. = 0.29
		Total	Mean = 52.95		
			s.d. = 4.17	**frost boil (b+c+d)**	Mean = 45.78
			n = 441		s.d. = 6.60
			s.e. = 0.20		n = 107
					s.e. = 0.64
				interboil (m+t+w)	Mean = 25.86
					s.d. = 7.08
					n = 334
					s.e. = 0.39
				Total	Mean = 30.69
					s.d. = 11.02
					n = 441
					s.e. = 0.52

Table 2. Biomass data from transects adjacent to grids (g/m^2) (for each grid n=6)

	evergreen shrub				deciduous shrub			forb	equisetum	graminoid		moss	lichen	Total	litter
	stem	live foliar	dead foliar	repro.	stem	live foliar	repro.			live	dead				
GCm TI-1	2.8	13.9	46.1	0.0	0.0	0.0	0.0	7.0	0.0	0.4	1.2	0.0	1.2	72.6	0.0
GCm TI-2	45.2	59.3	183.7	0.5	0.0	0.0	0.0	10.5	0.0	2.0	8.1	38.5	3.5	351.3	16.0
GCm TI-3	59.2	60.8	383.5	0.0	0.0	0.0	0.0	80.1	0.0	2.8	6.4	4.5	0.5	597.8	0.5
GCm T2-1	37.0	45.2	310.2	0.9	0.0	0.0	0.0	4.1	0.0	1.7	5.4	0.0	0.0	404.5	0.0
GCm T2-2	87.5	53.4	216.4	0.0	0.0	0.0	0.0	22.8	0.0	1.7	5.1	0.5	0.5	387.9	0.0
GCm T2-3	84.7	43.3	169.2	0.0	0.0	0.0	0.0	35.6	0.0	2.2	8.4	11.3	4.3	359.0	0.8
Grid 1 mean	52.7	46.0	218.2	0.2	0.0	0.0	0.0	26.7	0.0	1.8	5.8	9.1	1.7	362.2	2.9
Standard deviation	31.8	17.3	117.5	0.4	0.0	0.0	0.0	28.7	0.0	0.8	2.6	15.0	1.8	168.5	6.4
Standard error	2.3	1.7	4.4	0.3	0.0	0.0	0.0	2.2	0.0	0.4	0.7	1.6	0.5	5.3	1.0
GCd TI-1	33.5	195.0	483.6	3.5	0.0	0.0	0.0	0.0	0.0	0.1	0.4	13.4	1.6	731.1	3.0
GCd TI-2	179.8	93.2	435.0	0.0	0.0	0.0	0.0	43.7	0.0	2.1	8.2	25.8	0.0	787.8	6.8
GCd TI-3	45.9	153.3	371.5	0.0	0.0	0.0	0.0	0.8	0.0	2.4	6.7	7.2	17.4	605.2	5.6
GCd T2-1	140.4	118.9	288.4	5.7	0.8	1.4	0.0	3.0	0.0	1.7	6.8	36.0	3.5	606.6	2.3
GCd T2-2	0.0	0.0	0.0	0.0	224.0	12.9	1.4	3.4	0.0	0.0	0.0	0.0	0.0	241.7	0.0
GCd T2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.9	1.5	132.0	13.6	150.9	9.6
Grid 2 mean	66.6	93.4	263.1	1.5	37.5	2.4	0.2	9.0	0.0	1.2	3.9	35.7	6.0	520.6	4.6
Standard deviation	75.7	80.0	214.0	2.5	91.4	5.2	0.6	17.1	0.0	1.0	3.7	48.9	7.6	262.6	3.5
Standard error	3.6	3.7	6.0	0.6	3.9	0.9	0.3	1.7	0.0	0.4	0.8	2.9	1.1	6.6	0.8
GCw TI-1	59.8	38.1	51.2	0.2	6.7	3.0	0.0	0.0	0.0	14.2	53.5	56.0	2.1	284.8	23.2
GCw TI-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	3.0	0.0	0.0	3.7	0.0
GCw TI-3	69.5	54.2	109.2	0.0	6.4	2.7	0.7	0.0	0.2	9.4	40.4	27.7	0.7	321.1	10.4
GCw T2-1	3.7	12.9	3.3	0.0	33.6	3.7	0.0	0.1	11.9	19.3	63.0	24.9	0.0	176.4	4.2
GCw T2-2	0.0	0.0	0.0	0.0	4.7	0.1	0.0	0.0	1.5	3.9	7.4	9.6	5.7	32.9	52.2
GCw T2-3	95.6	48.4	81.6	0.0	0.8	0.7	0.0	10.5	0.4	11.2	44.5	75.7	11.7	381.1	13.2
Grid 3 mean	38.1	25.6	40.9	0.0	8.7	1.7	0.1	1.8	2.3	9.8	35.3	32.3	3.4	200.0	17.2
Standard deviation	42.1	24.4	47.3	0.1	12.5	1.6	0.3	4.3	4.7	6.8	24.6	28.6	4.6	156.0	18.9
Standard error	2.6	2.0	2.8	0.1	1.4	0.5	0.2	0.8	0.9	1.1	2.0	2.2	0.9	5.1	1.8

NDVI & LAI

Table 3. NDVI and LAI data along transects adjacent to Grid 1, zonal site.

	Transect 1			Transect 2		
	N 73º 13' 09.3" W 119º 33' 41.7" N 73º 13' 10.9" W 119º 33' 41.1"			N 73º 13' 11.7" W 119º 33' 39.7" N 73º 13' 13.1" W 119º 33' 41.8"		
Location (m)	**Ground Cover***	**NDVI**	**LAI**	**Ground Cover***	**NDVI**	**LAI**
0	M	0.3015	0.06	M	0.1705	0.00
1	V	0.2288	0.00	V	0.3676	0.05
2	B	0.3103	0.00	M	0.3752	0.05
3	V	0.1075	0.02	M	0.2248	0.02
4	V	0.3914	0.03	B	0.0640	0.04
5	V	-0.0109	0.03	M	0.2373	0.03
6	V	0.4495	0.00	M	0.2577	0.04
7	M	0.1152	0.00	M	0.3729	0.05
8	M	0.4696	0.05	B	0.0790	0.00
9	M	0.1467	0.04	M	0.2262	0.03
10	M	0.0967	0.03	V	0.3959	0.05
11	M	0.3474	0.05	B	0.0677	0.04
12	M	0.0320	0.06	M	0.2159	0.03
13	M	0.3667	0.04	M	0.2027	0.08
14	V	0.5058	0.18	B	0.0655	0.00
15	V	0.4087	0.04	V	0.4075	0.00
16	M	0.4369	0.02	V	0.4306	0.02
17	M	0.3818	0.00	V	0.3880	0.03
18	V	0.0206	0.02	B	0.0877	0.05
19	M	0.0836	0.02	B	0.0529	0.00
20	M	0.1664	0.05	V	0.4215	0.05
21	M	0.1289	0.00	M	0.2525	0.00
22	B	0.1471	0.02	V	0.3669	0.00
23	V	0.1856	0.07	V	0.4420	0.03
24	V	0.4432	0.03	V	0.5017	0.04
25	V	0.4419	0.07	B	0.2161	0.05
26	M	0.4329	0.04	V	0.3279	0.00
27	M	0.1195	0.02	V	0.4221	0.04
28	B	0.3303	0.04	V	0.4729	0.00
29	B	0.2593	0.07	V	0.3852	0.03
30	M	0.0268	0.02	M	0.3623	0.00
31	B	0.2930	0.00	V	0.3851	0.00
32	M	0.2678	0.02	V	0.3928	0.03
33	V	0.2156	0.02	V	0.3793	0.02
34	M	0.3860	0.03	B	0.1028	0.00
35	V	0.3073	0.02	M	0.2918	0.02
36	M	0.1851	0.02	M	0.2382	0.07
37	M	0.1740	0.03	M	0.1121	0.07
38	B	0.0620	0.06	B	0.0755	0.00
39	V	0.1517	0.07	M	0.1515	0.03
40	M	*	0.04	M	0.2200	0.04

41	M	*	0.02	M	0.2055	0.00
42	V	*	0.06	M	0.1511	0.00
43	M	*	0.02	M	0.3214	0.03
44	V	*	0.00	V	0.4091	0.05
45	B	*	0.05	M	0.4773	0.00
46	V	*	0.00	V	0.4466	0.04
47	M	*	0.00	V	0.4745	0.04
48	V	*	0.07	M	0.4006	0.00
49	M	*	0.00	V	0.3826	0.00
50	M	*	0.02	V	0.3248	0.03
mean		0.2478	0.03		0.2903	0.03
SE		0.0233	0.00		0.0512	0.00

* B = bare, M = mixed, V = vegetated

Table 4. NDVI and LAI data along transects adjacent to Grid 2, xeric ridge.

	Transect 1			**Transect 2**		
	N 73º 13' 06.9" W 119º 33' 31.4"			N 73º 13' 09.0" W 119º 33' 28.1"		
	N 73º 13' 08.5" W 119º 33' 28.8"			N 73º 13' 10.5" W 119º 33' 25.5"		
Location (m)	**Ground Cover***	**NDVI**	**LAI**	**Ground Cover***	**NDVI**	**LAI**
0	V	0.3032	0.02	M	0.3398	0.03
1	M	0.2219	0.00	M	0.1702	0.00
2	V	0.2928	0.04	M	0.1518	0.02
3	V	0.3771	0.03	B	0.0979	0.03
4	V	0.4176	0.00	M	0.2274	0.00
5	M	0.2764	0.00	M	0.3421	0.02
6	V	0.5389	0.02	B	0.1000	0.00
7	B	0.1363	0.02	B	0.0923	0.02
8	V	0.4580	0.00	M	0.1776	0.02
9	M	0.2478	0.00	B	0.0602	0.02
10	M	0.1223	0.00	M	0.2542	0.00
11	V	0.4308	0.05	V	0.4509	0.02
12	M	0.1397	0.02	B	0.0741	0.00
13	V	0.4159	0.00	M	0.5252	0.00
14	V	0.4151	0.00	B	0.1171	0.00
15	B	0.0891	0.00	B	0.1304	0.02
16	M	0.3477	0.02	V	0.3901	0.02
17	B	0.1156	0.00	B	0.0932	0.00
18	V	0.5044	0.02	B	0.0625	0.00
19	M	0.2758	0.03	M	0.2194	0.00
20	V	0.0890	0.00	M	0.2362	0.07
21	M	0.4822	0.02	M	0.2573	0.00
22	V	0.2036	0.03	B	0.0997	0.02
23	V	0.4476	0.00	V	0.3311	0.00
24	M	0.4024	0.13	B	0.0987	0.03
25	M	0.3595	0.02	B	0.0822	0.00
26	M	0.1471	0.00	M	0.3206	0.03

27	M	0.1180	0.00	V	0.3108	0.00
28	M	0.2627	0.00	M	0.5729	0.00
29	V	0.2942	0.03	M	0.1084	0.00
30	M	0.5506	0.07	M	0.1823	0.00
31	V	0.4379	0.06	M	0.1397	0.02
32	V	0.3069	0.03	B	0.1311	0.00
33	M	0.4425	0.02	M	0.1742	0.00
34	M	0.3434	0.00	B	0.1730	0.00
35	B	0.3974	0.00	M	0.1937	0.00
36	B	0.0500	0.00	M	0.1375	0.02
37	M	0.2127	0.00	M	0.3413	0.00
38	M	0.4773	0.00	M	0.3452	0.02
39	M	0.4212	0.02	M	0.1921	0.02
40	B	0.0408	0.02	V	0.4314	0.00
41	M	0.2171	0.02	B	0.0567	0.00
42	V	0.4953	0.00	V	0.5130	0.00
43	M	0.2504	0.00	V	0.5452	0.00
44	M	0.3744	0.03	V	0.4105	0.02
45	V	0.5345	0.03	V	0.4014	0.00
46	M	0.3571	0.02	B	0.0957	0.00
47	M	0.3059	0.00	B	0.1646	0.00
48	V	0.3677	0.03	V	0.4695	0.00
49	M	0.2151	0.00	B	0.0606	0.00
50	V	0.3739	0.00	B	0.0926	0.00
mean		0.3158	0.02		0.2303	0.01
SE		0.0194	0.003		0.0207	0.002

* B = bare, M = mixed, V = vegetated

Table 5. NDVI and LAI data along transects adjacent to Grid 3, hydric site.

	Transect 1			**Transect 2**		
	N 73º 13' 28.2" W 119º 33' 28.9"			N 73º 13' 27.7" W 119º 33' 28.5"		
	N 73º 13' 29.1" W 119º 33' 32.9"			N 73º 13' 28.4" W 119º 33' 34.1"		
Location (m)	**Ground Cover***	**NDVI**	**LAI**	**Ground Cover***	**NDVI**	**LAI**
0	V	0.4194	0.10	V	0.4080	0.03
1	V	0.3462	0.11	M	0.5036	0.10
2	B	0.1426	0.02	B	0.1365	0.09
3	B	0.1966	0.00	B	0.1166	0.06
4	M	0.2619	0.02	V	0.5613	0.03
5	M	0.3304	0.05	V	0.3181	0.25
6	V	0.4416	0.16	V	0.4358	0.17
7	M	0.3947	0.00	B	0.1422	0.04
8	B	0.2206	0.00	B	0.2430	0.16
9	V	0.2820	0.00	B	0.1917	0.06
10	V	0.4687	0.06	M	0.2460	0.16
11	B	0.5449	0.00	V	0.4925	0.17
12	V	0.3912	0.04	V	0.5321	0.05
13	V	0.3711	0.23	V	0.4534	0.03

14	V	0.3571	0.09	V	0.4936	0.16
15	V	0.4240	0.16	V	0.4590	0.03
16	V	0.3606	0.12	V	0.4230	0.08
17	V	0.5153	0.14	V	0.3082	0.06
18	B	0.3209	0.00	V	0.1524	0.20
19	M	0.3519	0.23	M	0.4926	0.15
20	M	0.2687	0.06	M	0.4400	0.06
21	B	0.1443	0.20	M	0.4629	0.10
22	M	0.2202	0.13	B	0.1507	0.00
23	V	0.4586	0.13	B	0.1666	0.05
24	V	0.4488	0.04	V	0.2331	0.02
25	V	0.4007	0.06	V	-0.0003	0.10
26	V	0.4936	0.00	B	-0.0001	0.03
27	M	0.1846	0.03	V	-0.0001	0.08
28	V	0.5445	0.12	V	0.0000	0.05
29	M	0.4605	0.20	M	0.0000	0.06
30	V	0.4632	0.14	V	0.0000	0.10
31	V	0.4470	0.06	V	-0.0067	0.04
32	V	0.4541	0.03	V	-0.0001	0.00
33	V	0.4629	0.08	V	0.0000	0.09
34	V	0.3863	0.07	V	0.4316	0.00
35	V	0.3941	0.13	V	0.3136	0.03
36	V	0.3832	0.09	V	0.3763	0.02
37	V	0.3590	0.07	V	0.4024	0.02
38	M	0.3936	0.19	V	0.4608	0.02
39	B	0.2149	0.04	V	0.4700	0.12
40	V	0.4210	0.02	M	0.3530	0.02
41	V	0.4142	0.00	V	0.1767	0.05
42	V	0.3686	0.02	V	0.1344	0.11
43	V	0.4335	0.02	V	0.4123	0.03
44	V	0.4300	0.06	V	0.5081	0.16
45	V	0.4898	0.10	V	0.4439	0.04
46	V	0.3934	0.10	V	0.4195	0.08
47	M	0.3348	0.03	V	0.4978	0.02
48	B	0.1523	0.07	B	0.4307	0.03
49	V	0.6009	0.07	B	0.4964	0.02
50	V	0.3588	0.05	B	0.5204	0.00
mean		0.3749	0.08		0.3020	0.07
SE		0.0150	0.01		0.0263	0.01

* B = bare, M = mixed, V = vegetated, W = water

Soils description of studied sites:

Mould Bay and Banks Island,
NW Canada, June 29-July 12, 2003

Mould Bay Grid 1, Pit 1
USDA-NRCS-NSSC S 03-FN-260-001

Location: Mould Bay, Prince Patrick Island
GPS position: 76°13'42" N
119 °17'43.4" W
Elevation: 32m
Physiography: Arctic Lowland Province
Landform: Rolling hills
Landscape position: broad ridgetop
Micro relief: flat polygon, ave. dia. 40 cm (25-50 cm)
Slope: 3% SE, vertical: slightly convex, horizontal: slightly convex
Parent material: Alluvium over weathered shale (Beaufort Formation)
Climate: MAAT: - 17.8 (Mould Bay)
MAP: 8.7 cm
MAST: - 10°C, est.
Landcover type: Mesic non-acidic tundra, Bioclimate Subzone B
Vegetation: Crustose lichens, *Salix arctica, Luzula nivalis, Saxifraga oppositifolia, Hypogymnia subobscurum, Thamnolia* sp., *Papaver radicatum.*
Classification: Interboil – Corse-silty, mixed, superactive, hypergelic Mollic Aquiturbel
Boil - Coarse-silty, mixed, superactive, hypergelic Typic Aquiturbel
Described and sampled by: C.L. Ping, G.J. Michaelson, G. Gonzalez and C. Tarnocai

Boil:
0 – 14 cm; Bwjj; dark grayish brown (2.5Y4/2) very fine sandy loam; weak, fine lenticular and moderate medium granular structures; friable, slightly sticky and slightly plastic; few fine roots; common vesicular pores; silt coating around some granulars and ped faces; clear irregular boundary (0-15 cm) (#1)
14 – 32 cm; B&Ajj; olive brown (2.5Y4/3, 60%) with cryoturbated humus-rich very dark grayish brown (2.5Y 3/2) very fine sandy loam; moderate fine granular structures; friable, slightly sticky and slightly plastic; few fine roots; many fine vesicular pores; silt coating on ped faces; clear irregular boundary (14-22 cm) (#4)
32 – 50 cm; Bgf; dark gray (5Y4/1, 70%) and olive brown (2.5Y4/4) very fine sandy loam; frozen; very firm, slightly sticky and slightly plastic; (#5)

Interboil:
0 – 4 cm; Oi; very dark brown (10YR3/2) peat; common fine roots; (0-4 cm) (#6)
4 – 10 cm; Ajj1; olive brown (2.5Y4/3, 60%) and very dark grayish brown (2.5Y 3/2) very fine sandy loam; moderate fine granular structures; friable, slightly sticky and slightly plastic; few fine roots many fine vesicular pores; occurring around the boil; clear irregular boundary (0-4 cm) (#2)
4 – 15 cm; Ajj2; very dark grayish brown (10YR3/2, 60%), black (10YR2/1, 30%) and dark grayish brown (2.5Y4/2) very fine sandy loam; black humus-rich zones cryoturbated into B&Ajj; granular structure; friable, slightly sticky and slightly plastic; common fine roots; black humus, decayed vegetative part filled in voids; abrupt irregular boundary; (0-20 cm) (#3)

Photos of soil pits:

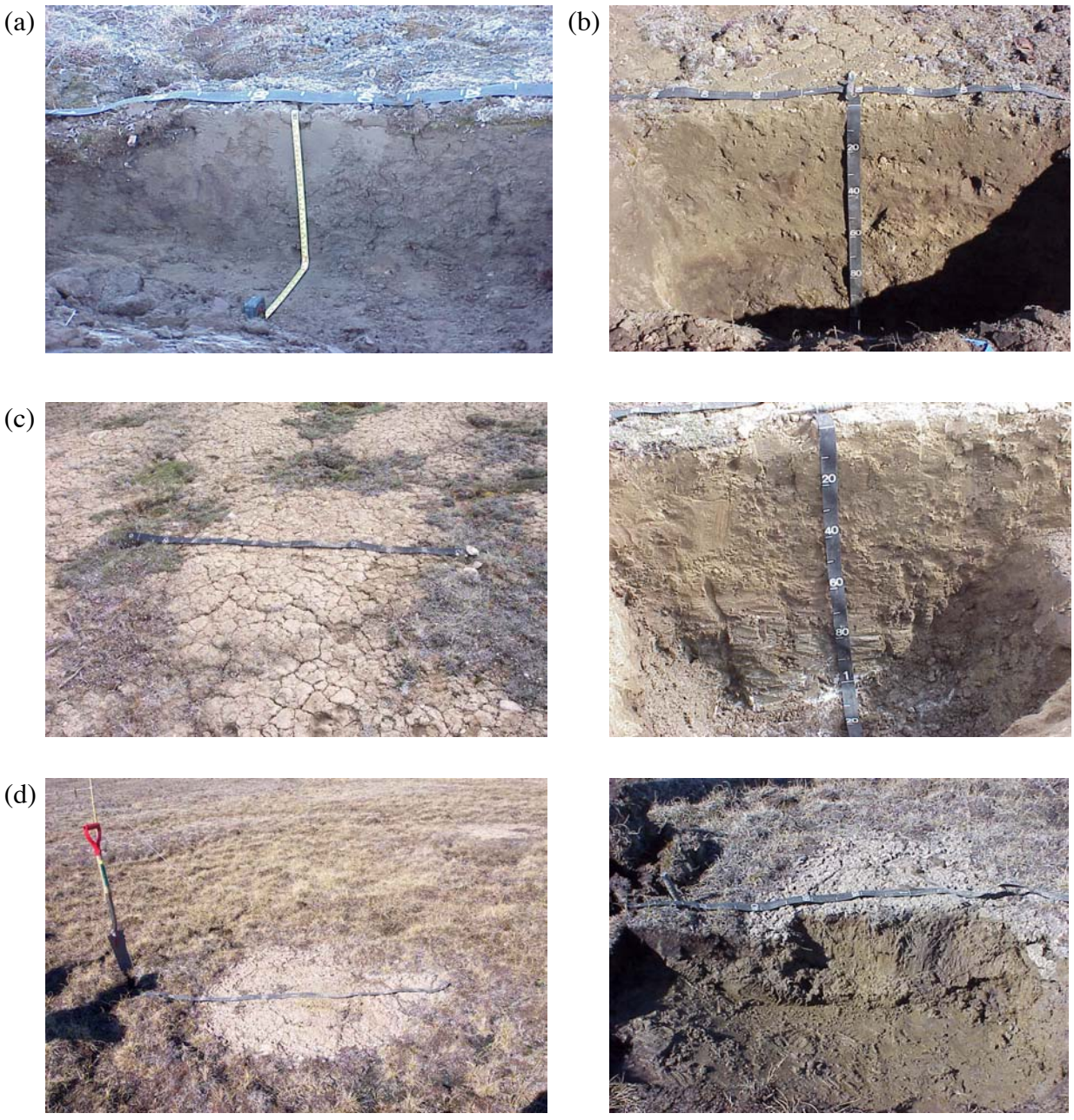
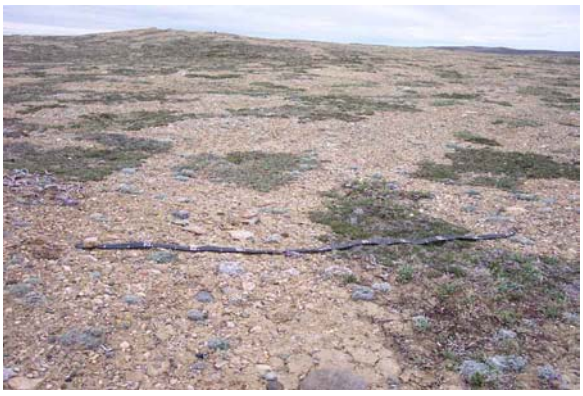


Figure 20. Soil pits. (a) Mould Bay Pit 1, Grid 1 (zonal site) dug to frozen soil. (b) Green Cabin Pit 1,Grid 1 (zonal site A). (c) Green Cabin Pit 2, Grid 2 (xeric site); before digging (left) and pit to >1m depth (right). (c) Green Cabin Pit 3, Grid 3 (hydric site); before digging (left) and dug to frozen soil (right).

(e)

(f)



(g)

(h)

Figure 20 (cont.) (e) Green Cabin Pit 4, Grid 1 (zonal site B); before digging (left) and dug to >80 cm. (right). (f) Green Cabin Pit 5 (dry barren ridge site); before digging (left) and dug to >80 cm. (right). (g) Green Cabin Pit 6 (snowbed hummock site). (h) Green Cabin Pit 7 (small hummock site).

Green Cabin Pit 1, Grid 1 (zonal site A)
USDA-NRCS-NSSC 03-FN-260-002

Location: Banks Island
GPS position: 73º13'17" N
119 º33'37" W
Elevation: 54m
Physiography: Arctic Lowland Province
Landform: Rolling hills
Landscape position: broad basin/saddle (speculated as old terrace, marine origin?)
Micro relief: frost polygons, ave. dia. 25 cm
Slope: 2% N, vertical: plane, horizontal: slightly concave
Parent material: Aeolian sand over marine sediments (?)
Climate: MAAT: - 13.7 (Sachs Stn.)
MAP: 10.2 cm
MAST: - 7ºC, est.
Landcover type: Mesic nonacidic tundra, Bioclimate Subzone C
Vegetation: *Dryas integrifolia, Carex rupestris, Salix arctica, Saxifraga oppositifolia; Oxytropis* sp., *Tortula ruralis, Sanionia uncinata, Thamnolia subuliformis, Psora decipiens*
Classification: Interboil - Sandy, mixed, active, hypergelic Typic Molliturbel
Boil - Sandy, mixed, active, hypergelic Typic Haploturbel
Described and sampled by: C.L. Ping, G.J. Michaelson, C. Tarnocai, W. Gould, Patrick Kuss, and G. Gonzalez

Boil:
0 – 35 cm; Bw; dark brown (10YR3/3) and dark yellowish brown (10YR3/4) sandy loam; 25% gravel on surface crust; 10% gravel in horizon; moderate medium subangular blocky breaking into weak thin platy structures; friable; slightly sticky, slightly plastic; weakly effervescence; few fine roots; clear irregular boundary; pH 6.2 (0-55 cm) (#8)
35 – 52 cm; Oajj; cryoturbated dark reddish brown (5YR3/2) mucky sandy loam; weak fine subangular blocky structure; very friable, nonsticky, nonplastic; few fine roots; abrupt irregular boundary (0-22cm) (#9)
52 – 60 cm; Bwjj; olive brown (2.5Y4/4) gravelly sandy loam; 16% gravel, est.; strong medium lenticular structures; frozen, very firm, slightly sticky, slightly plastic; strongly effervescence; abrupt wavy boundary (10 – 15cm) (#10)
60 – 75 cm; Oajjf; dark brown (10YR3/2) mucky sandy loam; weak granular and weak medium and fine subangular structures; very friable, nonsticky, nonplastic; abrupt irregular boundary (0-15cm) (#11)
75 – 90 cm; Cf/Oajj; dark grayish brown (2.5Y4/2) black (10YR2/1) and brown (10YR4/3) gravelly sandy loam; 10% cobble and 8% gravel; massive (frozen); extremely firm, slightly sticky, slightly plastic; weakly effervescence; abrupt wavy boundary (#12)
90 – 105 cm; Oajj/Cf; black (10YR2/1, 60%) muck and dark grayish brown (2.5Y4/2, 40%) gravelly sandy loam; massive (frozen); extremely firm, slightly sticky, slightly plastic; weakly effervescence. (#13)

Interboil:

0 – 45 cm; A; very dark grayish brown (10YR3/2) sandy loam; moderate medium angular blocky structure; 25% pebble and gravel on surface; slightly firm, slightly sticky, slightly plastic; weakly effervescence; common fine roots; many medium vesicular pores; abrupt irregular boundary (0 – 55 cm) (#7)
45 – 60 cm; Bwjj; olive brown (2.5Y4/4) gravelly sandy loam; 16% gravel, est.; strong medium lenticular structures; frozen, very firm, slightly sticky, slightly plastic; strongly effervescence; abrupt wavy

boundary (10 – 15cm) (#10)
55 – 90 cm; Cf/Oajj; dark grayish brown (2.5Y4/2) black (10YR2/1) and brown (10YR4/3) gravelly sandy loam; 10% cobble and 8% gravel; massive (frozen); extremely firm, slightly sticky, slightly plastic; weakly effervescence; abrupt wavy boundary (#12)
90 – 105 cm; Oajj/Cf; black (10YR2/1, 60%) muck and dark grayish brown (2.5Y4/2, 40%) gravelly sandy loam; massive (frozen); extremely firm, slightly sticky, slightly plastic; weakly effervescence. (#13)

Green Cabin Pit 2, Grid 2 (xeric site)
USDA-NRCS-NSSC 03-FN-260-003
Location: Banks Island
GPS position: 73º13'16" N
119 º33'26" W
Elevation: 59m
Physiography: Arctic Lowland Province
Landform: Rolling hills
Landscape position: broad shoulder slope
Micro relief: stripes and frost boils, most frost boils interconnecting with dia. 40 cm to 2 m. Barren surface 60% and vegetation 40%
Slope: 4% S, vertical: slightly convex, horizontal: plane
Parent material: glacial drift of Mid-Pleistocene (Thomson glaciation)
Periglacial features: 40% gravel on boil surface, and 10% in profile including 3 cobble stones dia. 12 – 20 cm, pointed rocks and flagstones, round and subround gravel, frost cracks reaching down 40 cm
Climate: MAAT: - 13.7 (Sachs Stn.)
MAP: 10.2 cm
MAST: - 7ºC, est.
Landcover type: Dry nonacidic tundra/barren land, Bioclimate Subzone C
Land use: prostrated shrubland, open range, wildlife grazing
Vegetation: *Dryas integrifolia, Carex rupestris, Salix arctica, Saxifraga oppositifolia;Oxytropis* sp., *Tortula ruralis, Sanionia uncinata, Thamnolia* sp.
Classification: Interboil - Sandy, mixed, active, hypergelic Typic Molliturbel
Boil - Sandy, mixed, active, hypergelic Typic Haploturbel
Described and sampled by: C.L. Ping, G.J. Michaelson, G. Gonzalez

Boil:

0 – 6 cm; Bw1; light olive brown (2.5Y5/4) silt loam; strong, medium to coarse angular columnar (due to desiccation) breaking into weak thin platy structures; structures diameters 7 – 12 cm; dry, slightly hard, slightly sticky, slightly plastic; common fine vesicular pores; few fine roots; strongly effervescence; abrupt smooth boundary (0 – 10 cm) (#14)
6 – 10 cm; Bw2; olive brown (2.5Y4/3) silt loam; weak fine platy structure; very friable, slightly sticky, plastic; few frost cracks running down with oxidized zone around (10YR4/3); common fine and medium roots; moderately effervescence; abrupt smooth boundary (0 – 6 cm) (#15)
10 – 26 cm; Bw3; olive brown (2.5Y4/4) silt loam; weak fine platy breaking into moderate fine granular structures; few frost cracks running down with oxidized zone around (10YR4/3); very friable, slightly sticky, plastic; few fine roots; moderately effervescence; abrupt smooth boundary (0 – 16 cm) (#15)
26 – 60 cm; Bw4; olive brown (2.5Y4/3) silt loam;; strong fine to medium lenticular breaking into moderate fine granular structures; few frost cracks running down with oxidized zone around (10YR4/3); friable, sticky, plastic; few fine roots; clear irregular boundary (0 – 24 cm) (#19)
28 – 55 cm; Bwjj; olive brown (2.5Y4/3) heavy silt loam; weak fine granular structure; few frost cracks running down with oxidized zone around (10YR4/3); very friable, sticky, plastic; common fine and medium roots; moderately effervescence; abrupt irregular boundary (0 – 28 cm) (#17)
42 – 55 cm; Bkjj: brown (7.5YR4/2) silty clay loam; moderate medium subangular blocky structure; friable, sticky, plastic; few fine roots; slightly effervescence; abrupt smooth boundary (0-14 cm) (#20)

55 – 70 cm; Oafjj; black (7.5YR2.4/1) mucky sandy loam; weak fine platy structure; very friable, nonplastic and nonsticky; common fine root channels and residues; slightly effervescence; abrupt wavy boundary (10 – 16 cm) (#21)
70 – 88 cm; Cf; dark grayish brown (10YR4/2) silt loam; strong medium lenticular structure; frozen, 40% ice; very firm, stick and plastic; no reaction to HCl; clear wavy (9 – 20 cm) (#22)
88 – 100 cm; Wf/Cf; dark olive brown (2.5Y3/3) silt loam; strong medium reticular structure; frozen, 60% ice; very firm, slightly sticky and plastic; no reaction to HCl. (#23)

Interboil:

0 – 40 cm; A; brown (10YR4/3) silty clay loam; weak, fine platy breaking into moderate fine granular structures; very friable, sticky and plastic; many fine and medium roots; clear irregular boundary (0 – 41 cm) (#18)
40 – 52 cm; Bwjj; olive brown (2.5Y4/3) heavy silt loam; weak fine granular structure; very friable, sticky, plastic; common fine and medium roots; moderately effervescence; abrupt irregular boundary (0 – 28 cm) (#17)
52 – 65 cm; Oafjj; black (7.5YR2.4/1) mucky sandy loam; weak fine platy structure; very friable, nonplastic and nonsticky; common fine root channels and residues; slightly effervescence; abrupt wavy boundary (10 – 16 cm) (#21)
65 – 80 cm; Cf; dark grayish brown (10YR4/2) silt loam; strong medium lenticular structure; frozen, 40% ice; very firm, stick and plastic; no reaction to HCl; clear wavy (9 – 20 cm) (#22)
80 – 100 cm; Wf/Cf; dark olive brown (2.5Y3/3) silt loam; strong medium reticular structure; frozen, 60% ice; very firm, slightly sticky and plastic; no reaction to HCl. (#23)

Green Cabin Pit 3, Grid 3 (hydric site)
USDA-NRCS-NSSC 03-FN-260-004

Location: Banks Island
GPS position: 73º13’35” N
119 º33’31” W
Elevation: 22m
Physiography: Arctic Lowland Province
Landform: Valley floor
Landscape position: toeslope
Micro relief: low-centered polygon, ave. 14 m across
Slope: 0%
Parent material: alluvium over river outwash
Climate: MAAT: - 13.7 (Sachs Stn.)
MAP: 10.2 cm
MAST: - 7ºC, est.
Drainage: poor, free water in polygon trough
Landcover type: Moist nonacidic sedge tundra, Bioclimate Subzone C
Vegetation: *Dryas integrifolia, Carex membranacea, C. misandra, Eriophorum triste, Salix arctica, Tomentypnum nitens, Hypnum bambergeri*
Classification: Interboil - Sandy, mixed, active, hypergelic Ruptic-Histic Aquiturbel
Boil - Sandy, mixed, active, hypergelic Psammentic Aquiturbel
Described and sampled by: C.L. Ping, G.J. Michaelson, C. Tarnocai

Boil:

0 – 2 cm; Bk; thin light brownish gray (10YR6/2) marl crust over dark grayish brown (2.5Y4/2) loamy sand; greenish algae mixed in marl deposit; 12% pebble; saturated, nonstick and nonplastic; few fine roots; violently effervescence; pH 7.2; abrupt smooth boundary (0 – 3 cm) (#24)
2 – 30 cm; Bw; dark yellowish brown (10YR4/3) loamy sand; streaks of organic rich, brown (10YR 4/3) muck sand protruding upward from lower horizon; 10% pebbles; saturated, nonsticky and nonplastic; common Fe concentrations around root channels (10YR5/6) and 5% Fe depletions

(2.5Y5/2); few fine roots; slightly effervescence; pH 7.1; abrupt wavy boundary (0 –28 cm) (#25)
30 – 40 cm; Oajj; brown (10YR4/3, 60%) and very dark grayish brown (10YR3/2, 40%) mucky sand; weak medium subangular blocky breaking into weak fine platy structures; saturated, nonstick and nonplastic; slightly effervescence; pH 7.1; abrupt irregular boundary (0 –11 cm) (#26)
40 –55 cm; A/Bwf; brown (10YR4/3, 60%) muck and light olive brown (2.5Y5/3) gravelly loamy sand; frozen, very firm, saturated, nonsticky; abrupt smooth boundary (0 –20 cm) (#27)
55 – 70 cm; Bw/Ajjf; light olive brown (2.5Y5/3, 60%) gravelly loamy sand and very dark gray (10YR2/2, 20%) and very dark grayish brown (10YR3/2, 20%) mucky sand; weak fine lenticular structure; very friable, nonsticky and nonplastic; est. 25% rock fragment including 8% cobble of 30 cm dia., channers of 15x25 cm, sedimentary origin, oriented channers of 2 cm thick, abrupt smooth boundary (#31)
70 – 105 cm; 2Cf; gray (2.5Y5/1) very stony loamy sand; moderate very fine platy and ice lens stratified, 65% ice; extremely firm, nonsticky and nonplastic; 30% stones and 20% gravel, est. (#32)

Interboil:
0 – 2 cm; Oi; dark brown (7.5YR3/2) peaty sand; abrupt smooth boundary (#28)
2 – 15 cm; Oa; dark brown (7.5YR3/2, 50%) black (7.5YR2.5/1, 40%) muck with a thin layer of strong brown (7.5YR5/6) mucky loamy sand on top of horizon; saturated; nonsticky and nonplastic; many very fine and fine roots; abrupt smooth boundary (7 – 14 cm) (#29)
15 – 32 cm; Bwf; dark grayish brown (10YR4/2) gravelly loamy sand; frozen, massive; very firm, nonsticky and nonplastic; few fine roots; 16% gravel; abrupt irregular boundary (0 – 17 cm) (#30)
32 – 70 cm; Bw/Ajjf; light olive brown (2.5Y5/3, 60%) gravelly loamy sand and very dark gray (10YR2/2, 20%) and very dark grayish brown (10YR3/2, 20%) mucky sand; weak fine lenticular structure; very friable, nonsticky and nonplastic; est. 25% rock fragment including 8% cobble of 30 cm dia., channers of 15x25 cm, sedimentary origin, oriented channers of 2 cm thick, abrupt smooth boundary (#31)
70 – 105 cm; 2Cf; gray (2.5Y5/1) very stony loamy sand; moderate very fine platy and ice lens stratified, 65% ice; extremely firm, nonsticky and nonplastic; 30% stones and 20% gravel, est. (#32)

Green Cabin Pit 4, Grid 1 (zonal site B)
USDA-NRCS-NSSC 03-FN-260-005

Location: Banks Island
GPS position: 73º13'11" N
119 º33'34" W
Elevation: 63m

Physiography: Arctic Lowland Province
Landform: Rolling hills
Landscape position: broad basin/saddle
Micro relief: low hummocks, ave. dia. 25 cm, relief 5 cm
Slope: 2% N, vertical: plane, horizontal: slightly concave
Parent material: Aeolian sand over marine sediments (?)
Climate: MAAT: - 13.7 (Sachs Stn.)
MAP: 10.2 cm
MAST: - 7ºC, est.
Landcover type: Mesic nonacidic tundra, Bioclimate Subzone C
Vegetation: *Dryas integrifolia, Carex rupestris, Salix arctica, Saxifraga oppositifolia, Oxytropis* sp., *Tortula ruralis, Sanionia uncinata, Thamnolia* sp.
Classification: Interboil - Sandy, mixed, active, hypergelic Typic Molliturbel
Boil - Sandy, mixed, active, hypergelic Typic Haploturbel
Described and sampled by: C.L. Ping, G.J. Michaelson, G. Gonzalez

Boil:
0 – 10 cm; Bw1; light olive brown (2.5Y4/3) loamy sand; 20% in thin olive brown bands (2.5Y4/3); surface crust; moderate coarse angular blocky structures; firm; sticky, plastic; few fine roots;

strongly effervescence; abrupt irregular boundary (0-10 cm) (#34)

0 – 10 cm; BC; olive brown (2.5y4/3) sand; single grained; loose, nonsticky, nonplastic; few fine roots; strongly effervescence; abrupt irregular boundary (0-10 cm) (#35)

10 – 26 cm; Bw2; olive brown (2.5Y4/4) fine sandy loam; massive structures; very friable, slightly sticky, slightly plastic; few fine roots; slightly effervescence; clear irregular boundary (0 – 17cm) (#36)

0 – 55 cm; Bwjj1; light olive brown (2.5Y5/4, 60%0 and olive brown (2.5Y4/4) very fine sandy loam; massive; soft, slightly sticky nonplastic; few fine roots, strongly effervescence; 10% gravel; abrupt irregular boundary (0 – 55 cm) (#37)

10 –50 cm; Bwjj2; olive brown (2.5Y4/4) gravelly sandy loam; weak fine lenticular structure; very friable, nonsticky, nonplastic; few fine roots; slightly effervescence; clear irregular boundary (0-40cm) (#38)

26 – 67 cm; Btjj1; dark grayish brown (10YR4/2) silty clay loam; moderate medium lenticular breaking into moderate medium granular structures; firm, sticky and very plastic; violently effervescence; few fine roots; abrupt irregular boundary (0 – 50 cm) (#39)

35 – 54 cm; A/Bwjj; black (10YR2/1, 60%) and olive brown (2.5Y4/4) fine sandy loam; massive; friable, slightly sticky and nonplastic; slightly effervescence; irregular masses in Btjj; abrupt irregular boundary (0 – 20 cm) (#45)

40 – 93 cm; Oajj/Cf; occurring at center of the boil; dark reddish brown (5YR3/2, 65%) muck protruding upward with vertical veins of yellowish brown (10YR5/4, 35%) sandy loam of 2 mm to 8 cm; frozen below 80 cm; massive; very friable slightly sticky and slightly plastic; strongly effervescence; abrupt irregular boundary (0 – 40 cm) (#44)

67 – 82 cm; Btjj2; dark grayish brown (2.5Y4/2) silt clay loam; strong fine to medium lenticular structure (2 –3 mm thick); friable, stick very plastic; few fine roots; slightly effervescence; abrupt irregular boundary (0 – 30 cm) (#42)

82 – 108 cm; Cf1; brown (10YR5/3) gravelly sandy loam; moderate medium lenticular structure between ice lenses; frozen, very firm, slightly sticky and slightly plastic; abrupt clear boubdary (22 – 30 cm) (#46)

108 – 110 cm; Wf/Cf2/Oajjf; 55% ice, ataxitic horizon; 25% very dark brown (10YR2/2) and 5 % black (10YR2/1) muck, 15% brown (10YR4/3) sandy loam; 10% pebble with carbonates and thick ice undercoatings; frozen, weak fine lenticular structures separated by ice lenses and vertical ice veins; slightly effervescence. Abrupt wavy boundary (#48)

110 – 130 cm; Cf3; brown (10YR5/3) fine sandy loam; frozen, massive; extremely firm, nonsticky and nonplastic; slightly effervescence (#47 and #49 combined)

Interboil:

0 – 12 cm; A; brown (10YR4/3) sand; single grained; loose, nonsticky, nonplastic; common fine, very fine and few medium roots; many root remains; violently effervescence; abrupt irregular boundary (0 – 20 cm) (#40)

12 – 33 cm; Ajj; dark brown (7.5YR 3/2) fine sand; 20% pebbles; single grains; loose, nonsticky, nonplastic; common fine roots; strongly effervescence; abrupt irregular boundary (0 – 25 cm) (#41)

33 – 50 cm; Btjj2; dark grayish brown (2.5Y4/2) silt clay loam; strong fine to medium lenticular structure (2 –3 mm thick); friable, stick very plastic; few fine roots; slightly effervescence; abrupt irregular boundary (0 – 30 cm) (#42)

50 – 66 cm; Bwjj3; olive brown (2.5Y4/4) loamy sand; weak fine platy breaking into weak fine granular structures; very friable, nonsticky, nonplastic; slightly effervescence; abrupt irregular boundary (#43)

66 – 94 cm; Cf1; brown (10YR5/3) gravelly sandy loam; moderate medium lenticular structure between ice lenses; frozen, very firm, slightly sticky and slightly plastic; abrupt clear boubdary (22 – 30 cm) (#46)

94 – 110 cm; Wf/Cf2/Oajjf; 55% ice, ataxitic horizon; 25% very dark brown (10YR2/2) and 5 % black (10YR2/1) muck, 15% brown (10YR4/3) sandy loam; 10% pebble with carbonates and thick ice undercoatings; frozen, weak fine lenticular structures separated by ice lenses and vertical ice veins; slightly effervescence. Abrupt wavy boundary (#48)

110 – 130 cm; Cf3; brown (10YR5/3) fine sandy loam; frozen, massive; extremely firm, nonsticky and

nonplastic; slightly effervescence (#47 & #49)

Green Cabin Pit 5 (dry barren ridge site)
USDA-NRCS-NSSC 03-FN-260-006

Location: Banks Island
GPS position: 73º12'08" N
119 º33'20" W
Elevation: m
Physiography: Arctic Lowland Province
Landform: Rolling hills
Landscape position: broad shoulder slope
Micro relief: slightly undulating, relief 5 cm
Slope: 3% SE, vertical: plane, horizontal: plane
Parent material: Aeolian sand over marine sediments (?)
Climate: MAAT:
MAP:
MAST:
Landcover type: Dry barren – vegetated patches (mostly *Dryas*) 35%, Bioclimate Subzone C
Vegetation: *Dryas integrifolia, Oxytropis arctobia, Oxytropis arctica, Saxifraga oppositifolia, Kobresia myosuroides, Thamnolia* sp., *Polyblastia gelatinosa*
Classification: Sandy, mixed, active, hypergelic Typic Molliturbel
Described and sampled by: C.L. Ping, G.J. Michaelson

0 – 4 cm; A1; brown (10YR4/3, moist; grayish brown 10YR5/3, dry) vary gravelly loamy sand; surface crust; moderate coarse angular blocky structures; firm; nonsticky, nonplastic; common fine roots; moderately effervescence; abrupt smooth boundary (0-5 cm) (#50)
4 – 20 cm; A2; dark brown (10YR 3/3) fine sandy loam; weak medium subangular blocky parting into weak medium granular structures; very friable, nonsticky, nonplastic; common fine roots; weakly effervescence; clear wavy boundary (0 – 17cm) (#51)
0 – 20 cm; A3; brown (10YR4/3) sandy loam; weak granular and weak medium and fine subangular structures; very friable, nonsticky, nonplastic; many fine, very fine and few medium roots; moderately effervescence; clear way boundary (0-30cm) (#52)
20 – 45 cm; Bw1; yellowish brown (10YR 5/3) gravelly sand; 20% pebbles; single grains; loose, nonsticky, nonplastic; common fine roots; strongly effervescence; abrupt irregular boundary (0 – 25cm) (#53)
20 – 45 cm; Bw2; olive brown (2.5Y4/4, 40%) and brown (10YR 4/3) sand; single grained; loose, nonsticky, nonplastic; few fine roots; slightly effervescence; abrupt irregular boundary (0-25cm) (#56)
45 – 88 cm; BW&Ajj; light olive brown (2.5Y5/3, 55%) and brown (10YR 4/3) sand; humus rich A materials cryoturbated toward the bottom of the frost bowl; single grained; loose, nonsticky, nonplastic; few fine roots; slightly effervescence; abrupt smooth boundary (32-48cm) (#54)
88 – 100cm; Cf1; brown (10YR4/3, 70%) sand with cryoturbated organics (10YR 3/2; 2/2); frozen and single grained when thawed; very firm and loose when thawed, nonsticky, nonplastic; slightly effervescence; clear smooth boundary (12-22cm) (#57)
100 – 110 cm; Cf2; brown (10YR5/3) sand; frozen, single grained when thawed; extremely firm and loose when thawed, nonsticky, nonplastic; weakly effervescence. (#58)

Green Cabin Pit 6 (snowbank hummock site)
USDA-NRCS-NSSC S03-FN-260-007

Location: Banks Island
GPS position: 73º13'22" N
119 º33'13" W
Elevation: 59m

Physiography: Arctic Lowland Province

Landform: Rolling hills
Landscape position: footslope
Microrelief: hummocks, ave. diameter 60 cm, relief 15 cm
Slope: est. 30% NW, vertical: slightly concave, horizontal: plane
Parent material: Aeolian sand over marine sediments (?)
Climate: MAAT:
MAP:
MAST:
Moist Dryas hummock snow bed tundra, Bioclimate Subzone C
Vegetation: *Cassiope tetragona; Dryas integrifolia, Saxifraga oppositifolia, Tortula ruralis*
Classification: Sandy, mixed, active, hypergelic Typic Molliturbel
Described and sampled by: C.L. Ping, G.J. Michaelson

0 – 8 cm; A; black (10YR2/2; 5/3) stratified loamy sand; weak fine subangular blocky parting into weak fine granular structures; very friable to loose; nonsticky, nonplastic; many fine and few medium roots; abrupt wavy boundary (8-12 cm) (#60)
8 – 35 cm; Ajj; dark gray (10YR3/2) loamy sand; weak medium platy and weak medium subangular blocky structure; very friable, nonsticky, nonplastic; many fine and few medium roots; 5% light-colored (10YR5/3) sand pockets, abrupt wavy boundary (0-30cm) (#61)
35 – 40 cm; Bwjj1; Olive brown (2.5Y 4/4) sandy loam; cryoturbated; weak fine lenticular structures; very friable, nonsticky, nonplastic; few fine roots; abrupt irregular boundary (0-5 cm) (#59)
40 – 52 cm; Bwjj2; (2.5Y5/4) sand; moderated cryoturbated; single grained; loose, nonsticky, nonplastic; 3 – 8 mm of organic streaks (10YR 3/2) across the horizon; abrupt irregular boundary (3–38 cm) (#62)
52 – 81 cm; A&Bjj; (10YR4/3, 60%), (10YR3/3, 30%) and (10YR3/2, 10%) sand; single grained; loose, nonsticky, nonplastic; strongly cryoturbated; 20% subrounded boulder, round cobble and gravel; abrupt, irregular boundary (15-40 cm) (#63)
81 – 106 cm; B&Afjj; (10YR4/3, 60%) and (10YR3/3, 40%) sand; strongly cryoturbated; single grained; loose, nonsticky, nonplastic; 25% ice by volume, ice lenses and ice veins of 3mm thick, 1 cm thick ice lens at the base of horizon; abrupt smooth boundary (15-40 cm) (#64)
106 – 120 cm; Cf/Wf; brown (10YR4/3) silty loam; moderate thin to medium lanticular structures under the hummock and strong medium reticulate structure (ice net) under inter hummocks; frozen, very firm, slightly sticky and plastic; >50% ice by volume, 40% ice in lenses; horizon in bowl shape with lowest part at the center of hummock at 108 cm and high portion under interhummock at 102 cm; abrupt wavy boundary (12 22 cm) (#65)
120 – 135 cm; 2Cf; very dark gray (5Y3/1,N3/) and dark olive gray (5Y5/3) silty clay loam; massive, frozen; extremely firm, sticky and plastic; 10% ice, few fine vein ice. (#66)

Green Cabin Pit 7 (small hummock site)
USDA-NRCS-NSSC 03-FN-260-008

Location: Banks Island
GPS position: 73º13’27” N
119 º33’21” W
Elevation: 50m
Physiography: Arctic Lowland Province
Landform: Rolling hills
Landscape position: lower footslope
Microrelief: ball-shaped *Dryas* tussocks, diameter 20 - 45 cm, relief 20 - 35 cm
Slope: 14º, vertical: slightly concave, horizontal: slightly undulating
Parent material: Aeolian sand over marine sediments (?)
Climate: MAAT:
MAP:
MAST:
Landcover type: Moist Dryas hummock snow bed tundra, Bioclimate Subzone C
Vegetation: *Dryas integrifolia, Oxytropis* sp.*, Tomentypnum nitens, Carex* sp.*, Lecanora*

epibryon, Polyblastia gelatinosa, Pertusaria dactylina
Classification: Sandy, mixed, active, hypergelic Typic Molliturbel
Described and sampled by: C.L. Ping, G.J. Michaelson, W. Krantz and V.E. Romanovsky

0 – 10 cm; Ajj1; black (10YR2/2) sand; weak fine granular structures; very friable to loose; nonsticky, nonplastic; many very fine, fine and medium roots; abrupt wavy boundary (0 - 22 cm) (#67)
10 – 30 cm; Ajj2; dark grayish brown (2.5Y4/2) loamy sand; weak medium subangular blocky structure; very friable, nonsticky, nonplastic; common fine and medium roots; abrupt irregular boundary (0-28cm) (#68)
30 – 36 cm; Ajj3; very dark brown (7.5Y 2.5/2) mucky sandy loam; weak medium granular structures; friable, nonsticky, nonplastic; common fine and medium roots; abrupt irregular boundary (0- 8 cm) (#69)
36 – 50 cm; Bwjj; olive brown (2.5Y4/3) sand; single grained; loose, nonsticky, nonplastic; 3 – 8 mm of organic streaks (10YR 3/2) across the horizon; abrupt irregular boundary (3–38 cm) (#70)
50 – 70 cm; Bw&Ajj; dark yellowish brown (10YR4/4 60%) sand, and very dark gray (2.5Y3/1, 40%) loam; sand, single grained; loose, nonsticky, nonplastic; loam, strong fine lenticular structure nonsticky, nonplastic; strongly cryoturbated; 20% subrounded boulder, round cobble and gravel; abrupt, irregular boundary (15-40 cm) (#71)
81 – 106 cm; B&Afjj; (10YR4/3, 60%) and (10YR3/3, 40%) sand; strongly cryoturbated; single grained; loose, nonsticky, nonplastic; 25% ice by volume, ice lenses and ice veins of 3mm thick, 1 cm thick ice lens at the base of horizon; abrupt smooth boundary (15-40 cm) (#64)
106 – 120 cm; Cf/Wf; brown (10YR4/3) silty loam; moderate thin to medium lenticular structures under the hummock and strong medium reticulate structure (ice net) under inter hummocks; frozen, very firm, slightly sticky and plastic; >50% ice by volume, 40% ice in lenses; horizon in bowl shape with lowest part at the center of hummock at 108 cm and high portion under interhummock at 102 cm; abrupt wavy boundary (12 22 cm) (#65)
120 – 135 cm; 2Cf; very dark gray (5Y3/1,N3/) and dark olive gray (5Y5/3) silty clay loam; massive, frozen; extremely firm, sticky and plastic; 10% ice, few fine vein ice. (#66)

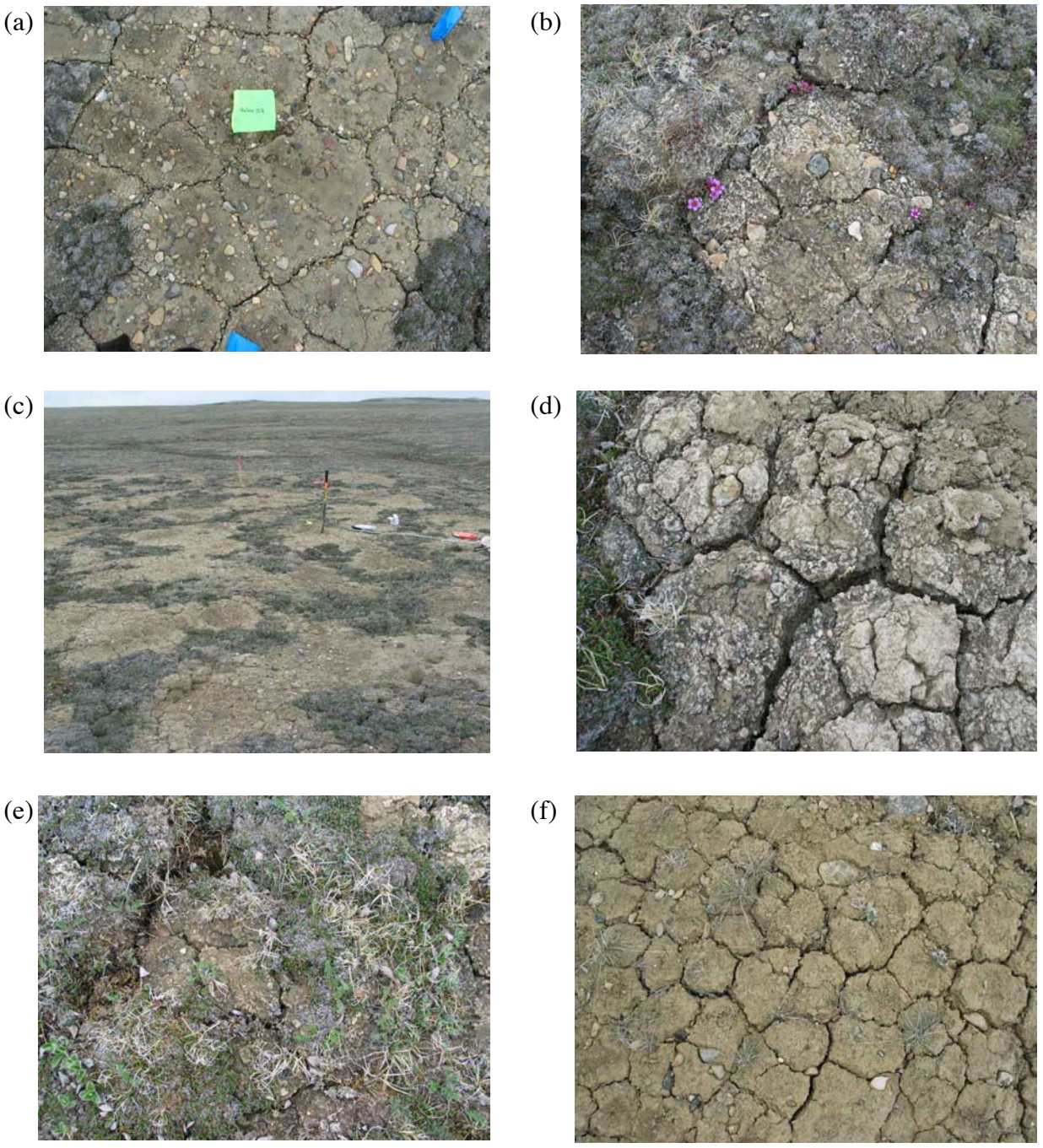


Figure 21. Photographs of relevés. (a) Relevé 301, bare soil; (b) Relevé 302, cryptogamic crust; (c) Relevé 304, bare soil; (d) Relevé 305, cryptogamic crust; (e) Relevé 306, dry interboil; (f) Relevé 307, bare soil.

(g)

(h)

(i)

(j)

(k)

(l)

Figure 21 (continued). (g) Relevé 308, cryptogamic crust; (h) Relevé 309, dry interboil; (i) Relevé 310, bare soil; (j) Relevé 311, cryptogamic crust; (k) Relevé 312, dry interboil; (l) Relevé 313, bare soil.

(m)

(n)

(o)

(p)

(q)

(r)

Figure 21 (continued). (m) Relevé 314, cryptogamic crust; (n) Relevé 315, dry interboil; (o) Relevé 316, wet bare soil; (p) Relevé 317, moist interboil; (q) Relevé 318, wet interboil; (r) Relevé 319, wet bare soil.

(s)

(t)

(u)

(v)

(w)

(x)

Figure 21 (continued). (s) Relevé 320, wet bare soill; (t) Relevé 321, wet boil with sedges; (u) Relevé 322, wet boil with sedges; (v) Relevé 323, wet boil with sedges; (w) Relevé 324, vegetated wet boil; (x) Relevé 325, vegetated wet boil.

(y)

(z)

(aa)

(ab)

(ac)

(ad)

Figure 21 (continued). (y) Relevé 326, vegetated wet boil; (z) Relevé 327, wet interboil; (aa) Relevé 328, wet interboil; (ab) Relevé 329, moist interboil; (ac) Relevé 330, moist interboil; (ad) Relevé 331, toposequence moist.

(ae)  (af) 

Figure 21 (continued). (ae) Relevé 332, toposequence, dry slope; (af) Relevé 333, toposequence, dry ridgetop.

Table 6. Analysis of soil pit samples.

Project Site ID#	Field#	Soil Horizon	depth cm	1:1 pH	E.C ds cm^{-1}	Extr.P mg kg^{-1}	Water Content %wt.	Bulk Density g cm^{-1}	C	N	IC	>2mm wt.
									%			
Mould Bay 07/03/03	1	Bwjj (boil)	0 – 14	7.79	0.83	16	23	1.47	8.45	0.62	0.07	0.2
	2	Ajj1 (interboil)	4 – 10	6.94	0.29	28	24	1.46	10.15	0.64	0.01	0.3
	3	Ajj2 (interboil)	4 – 15	6.95	0.23	49	38	1.31	17.51	1.38	<.01	0.9
	4	B&Ajj (boil)	14 – 32	7.74	0.35	70	16	1.64	6.93	0.11	0.12	1.3
	5	Bgf (boil)	32 – 50	7.57	0.77	38	19	1.48	7.58	0.21	0.15	1.2
	6	Oi (interboil)	0 – 4	6.75	0.44	209	59	0.44	25.35	1.44	0.01	<.01
Green Cabin 1 (zonal) 07/04/03	7	A (interboil)	0 – 45	7.71	0.52	8	19	1.15	52.75	1.86	1.76	5.1
	8	Bw (boil)	0 – 35	8.09	1.21	<1	11	1.62	34.66	0.54	1.80	11.3
	9	Oajj (boil)	35 – 52	7.47	0.54	15	19	1.56	59.96	3.35	1.45	4.5
	10	Bwjj (boil)	52 – 60	8.04	0.46	<1	6	1.76	43.99	0.23	1.15	18.1
	11	Oajjf (boil)	60 – 75	7.55	0.50	38	16	2.15	61.57	3.84	1.31	6.7
	12	Cf/Oajj (interboil)	55 – 90	7.47	0.79	30	31	1.34	67.34	3.68	1.41	39.7
	13	Oajj/Cf (boil)	90 – 105	7.36	1.04	44	48	1.17	70.63	4.22	1.32	27.0
Green Cabin 2 (xeric) 07/05/03	14	Bw1 (boil)	0 – 6	8.03	2.34	<1	6		29.74	0.37	1.67	7.4
	15	Bw2 (boil)	6 – 10	7.98	1.02	<1	8	1.93	29.75	0.28	1.60	10.7
	16	Bw3 (boil)	10-26	8.10	0.77	<1	8	1.95	22.35	0.20	1.45	6.2
	17	Bwjj (boil)	28 – 55	7.85	0.71	<1	14	1.20	43.02	1.77	1.24	14.7
	18	A (interboil)	0 – 40	7.91	0.46	16	14	1.25	47.62	1.84	1.61	7.3
	19	Bw4 (boil)	26 – 60	7.99	0.73	<1	12	1.94	32.43	0.59	1.49	6.9
	20	Bkjj (boil)	42 – 55	8.10	0.88	<1	15	1.61	37.07	1.08	1.48	3.1
	21	Oafjj (boil)	55 – 70	7.88	0.90	39	19	1.87	55.85	2.44	1.64	11.0
	22	Cf (boil)	70 – 88	7.69	2.11	46	70		23.69	0.40	1.45	0.1
	23	Wf/Cf (boil)	88 – 100	7.72	2.25	62	50		25.89	0.42	1.59	0.6
Green Cabin 3 (hydric) 07/06/03	24	Bk (boil)	0 – 2	8.32	1.50	<1	32	1.67	56.56	0.89	1.63	10.7
	25	Bw (boil)	2 – 30	8.22	0.35	<1	11	1.70	41.95	0.35	2.24	13.6
	26	Oajj (boil)	30 – 40	7.97	0.33	<1	12	1.50	49.00	0.84	1.26	5.3
	27	A/Bwf (boil)	40 –55	7.90	0.52	<1	11	2.36	52.54	1.00	1.20	8.7
	28	Oi (interboil)	0 – 2	7.60	0.62	53	112	0.46	84.82	4.40	2.06	<.01
	29	Oa (interboil)	2 – 15	7.45	0.46	15	264	0.68	82.77	5.37	1.42	<.01
	30	Bwf (interboil)	15 – 32	7.88	0.33	<1	15	1.71	44.00	0.53	2.03	6.4
	31	Bw/Ajjf (boil/interboil)	32 – 70	8.00	0.38	<1	12	1.75	56.67	1.28	1.82	8.4
	32 (no33)	2Cf (boil/interboil)	70 – 105	8.19	0.67	<1	33	1.89	62.69	1.58	1.66	2.1

Table 6 (continued).

Project Site ID#	Field#	Soil Horizon	depth cm	1:1 pH	E.C ds cm^{-1}	Extr.P mg kg^{-1}	Water Content %wt.	Bulk Density g cm^{-1}	C	N	IC	>2mm wt.
									%			
Green Cabin 4 (zonal 2) 07/07/03	34	Bw1 (boil)	0 – 10	8.28	2.04	<1	10		36.49	0.20	1.21	8.9
	35	BC (boil)	0 – 10	8.16	1.54	8	8	1.23	52.81	1.36	1.00	18.1
	36	Bw2 (boil)	10 – 26	8.30	0.58	<1	9	1.74	42.99	0.14	2.78	4.2
	37	Bwjj1 (boil)	0 – 55	8.12	0.81	<1	10	1.69	44.23	0.07	1.33	11.3
	38	Bwjj2 (boil)	10 –50	8.11	0.38	<1	7	1.90	40.97	0.07	1.39	11.1
	39	Btjj1 (boil)	26 – 67	8.14	0.33	<1	7	2.00	21.75	<.01	1.03	8.0
	40	A (interboil)	0 – 12	7.84	0.46	8	19	1.30	55.46	1.58	1.47	<.01
	41	Ajj (interboil)	12 – 33	7.98	0.42	<1	18	1.34	63.94	2.78	2.06	<.01
	42	Btjj2 (boil/inter boil)	33 – 82	8.04	0.27	8	14	1.90	30.08	0.23	1.87	1.3
	43	Bwjj3 (interboil)	50 – 66	8.19	0.23	<1	6	1.73	40.98	0.16	1.29	17.4
	44	Oajj/Cf (boil)	40 – 93	7.92	0.42	48	12	1.78	59.05	1.95	2.28	13.1
	45	A/bBwjj (boil)	35 – 54	8.03	0.46	<1	10	1.66	18.45	<.01	1.42	9.4
	46	Cf1 (boil/ interboil)	66 – 108	7.90	0.92	<1	14	1.72	41.78	<.01	1.68	4.3
	47	Cf3 (boil/ interboil)	110 – 130	8.04	0.46	<1	24	2.07	37.68	<.01	1.93	0.5
	48	Wf/Cf2/Oajjf (boil/ interboil)	94 – 110	7.63	1.92	61	30	1.22	55.30	1.67	1.62	3.8
	49	Cf3 (boil/ interboil)	110 – 130	7.73	2.71	<1	37		45.31	0.20	1.67	0.7
Green Cabin 5 (Barren Ridge-top) 07/08/03	50	A1	0 – 4	8.22	0.67	8	2	1.52	47.60	1.18	1.30	31.3
	51	A2	4 – 20	8.18	0.33	<1	6	2.06	50.99	1.43	2.36	28.1
	52	A3	0 – 20	8.12	0.35	<1	6	1.69	53.45	1.50	1.19	36.7
	53	Bw1	20 – 45	8.43	0.19	<1	2	1.67	45.04	0.18	1.38	16.7
	54/55	Bw & Ajj	45 – 88	8.20	0.33	16	8	2.20	35.27	0.22	1.45	16.4
	56	Bw2	20 – 45	8.42	0.21	<1	4	1.81	39.84	<.01	1.75	19.1
	57	Cf1	88 – 100	8.06	0.38	97	10	1.79	28.62	0.31	0.96	18.2
	58	Cf2	100 – 110	8.43	0.23	8	9	1.75	38.90	0.05	1.64	24.9
	77	3Cf	90-120	7.86	0.42	118	17	0.61	22.68	0.38	1.19	14.2
Green Cabin 6 (snowbank Hummock 1) 07/09/03	59	Bwjj1	35 – 40	7.80	0.31	<1	14	1.78	47.14	0.74	1.30	12.0
	60	A	0 – 8	7.58	0.44	15	24	1.28	48.47	1.63	1.14	<.01
	61	Ajj	8 – 35	7.53	0.33	23	26	1.42	47.27	2.63	0.60	11.9
	62	Bwjj2	40 – 52	8.16	0.19	8	5	1.84	51.65	0.20	1.55	5.2
	63	A&Bjj	52 – 81	8.05	0.23	24	10	1.81	57.42	0.08	1.47	16.0
	64	B&Afjj	81 – 106	8.08	0.31	24	16	2.05	52.67	0.20	1.23	1.8
	65	Cf/Wf	106 – 120	7.71	1.73	39	77		37.18	0.31	1.21	0.3
	66	2Cf	120 – 135	7.63	2.71	46	31	0.99	37.59	0.38	1.11	0.2
Green Cabin 7 (snowbank Hummock 2) 07/10/03	67	Ajj1	0 – 10	7.53	0.42	30	34	0.62	55.31	2.39	1.49	<.01
	68	Ajj2	10 – 30	7.75	0.31	23	17	1.29	45.41	1.67	1.81	6.8
	69	Ajj3	30 – 36	7.67	0.42	23	43	0.96	56.22	2.92	0.90	2.4
	70	Bwjj	36 – 50	7.91	0.38	8	10	1.65	42.83	1.13	1.24	9.1
	71	Bw&Ajj	50 – 70	7.64	0.94	15	9	1.69	42.00	0.49	0.50	39.0
	72	B&Ajj	70-90	7.86	1.04	8	12	1.99	35.27	0.07	1.21	2.0
	73	Bwf	90-108	7.88	2.65	<1	13	1.90	33.34	<.01	2.32	4.7
	74	Cf	108-160	7.65	2.08	54	16	1.92	31.88	<.01	1.93	0.2
	75	2Cf	145+	7.51	2.34	45	31	1.69	17.84	0.36	0.80	8.1
	76	Oi	0-20	7.71	0.56	39	61	1.46	77.06	3.80	1.19	<.01

Table 7. Correlation between Soil Taxonomy pre-1998 and 1999.

Soil Taxonomy Pre-1998	**Soil Taxonomy, 1999**
Histic Pergelic Cryaquept, acid (pH 5.5), nonacidic (pH> 5.5) permafrost with cryotubation	Rupic-Histic Aquiturbels (org. layer thickness changes 4 times within profiles)
Pergleic Cryaquept, acid (pH 5.5) nonacidic (pH >5.5) permafrost with cryoturbation	Psammentic Aquiturbels
Pergelic Cryochrept permafrost with cryoturbation	Typic Haploturbels
Histic Pergelic Cryaquoll	
Permafrost, no cryoturbation	Rupic-Histic Aquorthels
Permafrost with cryoturbation	Ruptic-Histic Aquiturbels

Relevé data

Table 8. Relevé type and location

Observers: DAW, MKR

Relevé #	Type	Characteristic species	Study site	Date	Photo (site/soil)	Plot size	GPS north	GPS west	Elev. (m)	Slope (º)	Aspect
301	Bare soil	PUCAND POTVAH	Grid 1	8-Jul-03	16-95 to 97	30 m2 in grid	73 13 10	119 33 33	63	1	NW
302	cryptogamic crust	POLGEL LECEPI CARRUP	Grid 1	8-Jul-03	16-101 to103	in 10x10m grid	73 13 10	119 33 33	63	1	NW
303	dry interboil	DRYINT SALARC SAXOPP	Grid 1	8-Jul-03	16-104,105	in 10x10m grid	73 13 10	119 33 33	63	1	NW
304	Bare soil	PUCAND POTVAH	between Grids 1 & 2	8-Jul-03	16-98, 99/100	55 m2	73 13 10	119 33 30	72	2	S
305	cryptogamic crust	POLGEL LECEPI CARRUP	between Grids 1 & 2	8-Jul-03	16-106 to108	25 m2	73 13 10	119 33 33	72	2	S
306	dry interboil	DRYINT SALARC SAXOPP	between Grids 1 & 2	8-Jul-03	16-109 to114	20 m2	73 13 10	119 33 33	72	2	S
307	Bare soil	PUCAND POTVAH	Grid 2	8-Jul-03	16-114,115	60 m2	73 13 08	119 33 20	75	1	NE
308	cryptogamic crust	POLGEL LECEPI CARRUP	Grid 2	8-Jul-03	16-116-119	15 m2	73 13 10	119 33 33	75	1	NE
309	dry interboil	DRYINT SALARC SAXOPP	Grid 2	8-Jul-03	16-120, 121,122	25 m2	73 13 10	119 33 33	75	1	NE
310	Bare soil	PUCAND POTVAH	S of Grid 2	9-Jul-03	24-1, 2, 3	40 m2	73 13 04	119 33 34	65	3	N
311	cryptogamic crust	POLGEL LECEPI CARRUP	S of Grid 2	9-Jul-03	24-4 to 6	-	73 13 10	119 33 33	65	3	N
312	dry interboil	DRYINT SALARC SAXOPP	S of Grid 2	9-Jul-03	24-7 to 9, 26-29	30 m2	73 13 10	119 33 33	68	3	N
313	Bare soil	PUCAND POTVAH	W of Grid 1	9-Jul-03	24-13 to 17	-	73 13 15	119 33 39	63	1	NW
314	cryptogamic crust	POLGEL LECEPI CARRUP	W of Grid 1	9-Jul-03	24-221 to 23	30 m2	73 13 15	119 33 39	63	1	NW
315	dry interboil	DRYINT SALARC SAXOPP	W of Grid 1	9-Jul-03	24-18, 19, 20	-	73 13 15	119 33 39	63	1	NW
316	wet bare soil - boil	SAXOPP CARMIS	Grid 3	10-Jul-03	24-43 to 49	30 m2 in grid	73 13 27	119 33 24	45	0	-
317	moist interboil	CARMIS DRYINT SALARC	Grid 3	10-Jul-03	24- 50 to 54	40 m2 in grid	73 13 27	119 33 24	45	0	-
318	wet interboil	CARMEM CARMIS NOSCOM DREBRE	Grid 3	10-Jul-03	24-55 to 57	30 m2 in grid	73 13 27	119 33 24	45	0	-
319	wet bare soil - boil	SAXOPP CARMIS	20m NNE of Grid 3	10-Jul-03	24-70	6 m2	73 13 28	119 33 20	50	0	-
320	wet bare soil - boil	SAXOPP CARMIS	just S of Grid 3	10-Jul-03	24-64, 65	4 m2	73 13 27	119 33 24	45	0	-
321	wet boil	ERIANG CARMIS CARAQU	10 m S of grid 3	10-Jul-03	24-66	3 m2	73 13 27	119 33 24	53	0	-
322	wet boil	ERIANG CARMIS CARAQU	10 m SW of Grid 3	10-Jul-03	24-67	4 m2	73 13 27	119 33 24	53	0	-
323	wet boil	ERIANG CARMIS CARAQU	just E of Grid 3	10-Jul-03	24-68	2 m2	73 13 27	119 33 22	53	0	-
324	vegetated wet boil	DRYINT SAXOPP	30 m NE of Grid 3	11-Jul-03	24-71	2 m2	73 13 29	119 33 22	50	0	-
325	vegetated wet boil	DRYINT SAXOPP	40 m NNW of Grid 3	10-Jul-03	24-69	1.5 m2	73 13 27	119 33 21	50	0	-
326	vegetated wet boil	DRYINT SAXOPP	40 m NNW of Grid 3	11-Jul-03	24-72	2 m2	73 13 29	119 33 22	50	0	-
327	wet interboil	CARMEM CARMIS NOSCOM DREBRE	50 m NNW of Grid 3	11-Jul-03	24-87	4 m2	73 13 30	119 33 27	50	0	-
328	wet interboil	CARMEM CARMIS NOSCOM DREBRE	20 m SSE of Grid 3	11-Jul-03	24-88	4 m2	73 13 28	119 33 31	50	0	-
329	moist interboil	CARMIS DRYINT SALARC	20 m ESE of Grid 3	11-Jul-03	24-89	3 m2	73 13 28	119 33 29	50	0	-
330	moist interboil	CARMIS DRYINT SALARC	70 m SE of Grid 3	11-Jul-03	24-90	4 m2	73 13 26	199 33 28	50	0	-
331	toposequence - moist	CARMIS DRYINT SALARC	80 m W of Grid 3	12-Jul-03	24-91, 92	-	73 13 30	119 33 37	55	0	-
332	toposequence - dry slope	DRYINT SALARC SAXOPP	S of Grid 3, W of Grid 1	12-Jul-03	24-93 to 97, 116 to125	10 m2	73 13 20	119 33 57	75	1	NE
333	toposequence - dry ridge top	DRYINT SALARC SAXOPP	S of Grid 3, W of Grid 1	12-Jul-03	24-103, 104,105	10 m2	73 13 21	119 33 53	65	1	NW

Table 9. Relevé species cover

Relevé number	**301**	**302**	**303**	**304**	**305**	**306**	**307**	**308**	**309**	**310**	**311**	**312**	**313**	**314**	**315**	**316**
Abietinella abietina	.	.	.	.	.	.	.	.	+	.	.	+	.	.	+	.
Alectoria ochroleuca	.	.	.	.	.	+	.	.	.	.	.	r	.	.	.	.
Amblystegium longicuspus	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Aneura pinguis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Arctagrostis latifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Arenaria humifusa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Artemisia campestr s. *borealis* v. *bor*	+	.	.	+	.	.	.	+	.	.	+	.	.	.	.	.
Astragalus alpinus	.	.	.	.	.	r	.	.	.	.	.	.	.	r	.	.
Astragalus australis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.
Aulacomnium acuminatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Braya glabella s. *purpurascens*	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+
Bryoerythrophyllum recurvirostre	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.
Bryum pseudotriquetrum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bryum species	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Bryum subneodamense	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bryum wrightii	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Caloplaca species	.	.	.	.	+	.	.	.	.	.	+	.	.	+	.	.
Caloplaca tiroliensis	.	+	.	.	.	+	.	.	.	.	.	+	.	.	.	.
Campylium polygamum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Campylium stellatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Candelariella species	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Cardamine digitata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex aquatilis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Carex atrofusca	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex bipartita	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex heleonastes	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex membranacea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Carex misandra	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex rupestris	.	1	2	.	1	2	.	2	1	.	2	1	+	1	2	.
Carex scirpoidea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cassiope tetragona	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Catapyrenium cinereum	.	.	+	.	+	.	.	+	.	.	.	+	.	.	.	+
Catapyrenium species	.	+	.	.	.	+	.	.	.	.	+	.	.	.	.	.
Cephaloziella varians	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+
Cerastium beeringianum	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.
Cinclidium arcticum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cinclidium latifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cladonia pocillum	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.
Cladonia pyxidata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Collema tenax	.	.	.	.	.	.	.	+	+	.	+	.	.	+	.	.
Cratoneuron species	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Dactylina arctica	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Dactylina madreporiformis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Didymodon asperifolius	.	.	+	.	.	+	.	.	.	.	.	.	.	.	+	.
Didymodon rigidulus v. *icmadophilus*	.	.	.	.	.	.	.	.	+	.	+	+	.	.	.	.
Distichium capillaceum	.	.	+	.	.	+	.	.	1	.	+	+	.	.	+	.
Distichium inclinatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Ditrichum flexicaule	.	.	1	.	.	1	.	+	2	.	+	1	.	.	1	.

Table 9 (cont.)

Relevé number	**301**	**302**	**303**	**304**	**305**	**306**	**307**	**308**	**309**	**310**	**311**	**312**	**313**	**314**	**315**	**316**
Draba alpina	.	.	.	.	.	.	.	r	+	.	+	r	.	.	.	.
Draba nivalis	.	.	.	.	.	.	.	+	1	.	+	.	.	.	.	.
Draba oblongata	+	+	+	+	+	.	.	.	.	+	+	.	r	.	.	.
Draba species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dryas integrifolia	.	.	4	.	.	4	.	.	4	.	r	4	.	+	4	+
Elymus alaskanus s. *alaskanus*	.	+	.	.	.	.	.	+	.	.	+	.	.	r	.	.
Elymus sajanensis s. *hyperarcticus*	.	.	.	+	.	.	+	.	.	+	.	.	.	.	.	.
Encalypta alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Encalypta species	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Encalypta vulgaris	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Equisetum variegatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Eriophorum angustifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Eriophorum angustifolium s. *triste*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eriophorum vaginatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eutrema edwardsii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Evernia perfragilis	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Flavocetraria cucullata	.	.	.	.	.	+	.	.	+	.	.	r	.	.	.	.
Flavocetraria nivalis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Fulgensia bracteata	.	r	+	.	+	+	.	+	+	.	+	.	.	.	.	.
Hymenostylium recurvirostre	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Hypnum bambergeri	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.
Hypnum cupressiforme	.	.	.	.	.	.	.	.	.	.	+	+	.	.	1	.
Hypnum procerrimum	.	.	2	.	.	2	.	.	2	.	+	1	.	.	+	.
Hypnum revolutum	.	.	+	.	.	+	.	.	+	.	+	.	.	.	.	.
Hypogymnia subobscura	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Juncus biglumis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Kobresia myosuroides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lecanora epibryon	.	1	+	.	+	1	.	1	+	.	1	+	.	+	+	.
Lecidea ramulosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Leiocolea collaris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Lepraria species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Leptobryum pyriforme	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lesquerella arctica	.	+	+	.	+	+	+	+	.	.	+	.	+	+	.	.
Leucanthemum integrifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Limprichtia cossonii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Meesia longiseta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Meesia species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Meesia triquetra	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Megaspora verrucosa	.	+	+	.	.	.	.	.	.	.	+	.	.	r	.	.
Minuartia rossii	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.
Mycobilimbia lobulata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Myurella julacea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Nostoc commune	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ochrolechia species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Orthotheciella varia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Orthothecium chryseum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Orthothecium strictum	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.
Oxytropis arctica	.	.	.	.	.	+	.	.	.	+	.	r	.	.	.	.

Table 9 (cont.)

Relevé number	**301**	**302**	**303**	**304**	**305**	**306**	**307**	**308**	**309**	**310**	**311**	**312**	**313**	**314**	**315**	**316**
Oxytropis borealis v. *borealis*	.	+	+	.	+	+	.	+	1	+	+	+	+	1	+	.
Oxytropis nigrescens v. *uniflora*	+	.	+	.	.	+	.	+	.	.	+	.	+	.	.	.
Parrya arctica	.	+	r	+	+	+	+	1	+	.	+	+	+	+	+	.
Pedicularis capitata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pedicularis kanei s. *kanei*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pedicularis langsdorfii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pedicularis species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pedicularis sudetica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Phaeorrhiza nimbosa	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Physconia muscigena	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Placidiopsis pseudocinerea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Placynthium nigrum	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Plagiochila asplenioides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Platydictya jungermannioides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Poa glauca	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Polyblastia gelatinosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Polyblastia sendtneri	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Polygonum viviparum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Potentilla nivea	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.
Potentilla vahliana	+	+	.	+	+	.	1	1	+	+	1	.	.	r	.	.
Protoblastemia siebenhaariana	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Pseudocalliergon brevifolius	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Pseudocalliergon turgescens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Psora decipiens	.	2	.	.	2	.	.	3	.	.	3	.	.	2	.	.
Psora vallesiaca	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Puccinellia angustata	+	.	.	+	.	.	1	+	+	+	.	.	+	.	.	.
Puccinellia species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rinodina roscida	.	+	+	.	.	+	.	+	+	.	+	+	.	.	+	.
Salix arctica	+	+	+	+	+	2	.	1	1	+	2	1	+	+	2	+
Sanionia uncinata v. *uncinata*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Saxifraga oppositifolia	.	1	1	.	+	1	.	1	1	.	+	+	+	+	1	+
Scapania gymnostomophila	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Scorpidium scorpioides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Senecio atropurpureus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Silene uralensis s. *uralensis*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Solorina bispora	.	+	+	.	+	.	.	.	.	.	.	+	.	.	.	.
Stellaria longipes s. *longipes*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Taraxacum species	.	.	.	.	.	.	+	+	+	r	+	.	.	.	.	.
Tetraplodon species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Thamnolia subuliformis	.	.	+	.	+	1	.	1	1	.	1	2	.	1	+	.
Timmia austriaca	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Tomentypnum nitens	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.
Toninia arctica	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.
Toninia sedifolia	.	+	+	.	+	.	.	+	+	.	1	.	.	+	.	.
Tortula mucronifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tortula norvegica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tortula ruralis	.	.	+	.	.	2	.	.	1	.	1	2	.	.	2	.
Vulpicida tilesii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 9 (cont.)

Relevé number	**317**	**318**	**319**	**320**	**321**	**322**	**323**	**324**	**325**	**326**	**327**	**328**	**329**	**330**	**331**	**332**	**333**
Abietinella abietina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Alectoria ochroleuca	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+
Amblystegium longicuspus	.	.	.	.	.	.	.	+	.	.	+	+	.	.	+	.	.
Aneura pinguis	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Arctagrostis latifolia	+	+	.	.	.	.	.	.	.	.	+	+	1	1	+	.	.
Arenaria humifusa	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.
Artemisia campestr s. *borealis*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Astragalus alpinus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Astragalus australis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aulacomnium acuminatum	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.
Braya glabella s. *purpurascens*	.	+	+	+	r	+	+	+	+	+	.	.	.	.	.	+	.
Bryoerythrophyllum recurvirostre	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	+	.
Bryum pseudotriquetrum	.	1	.	.	.	.	.	.	.	.	+	+	+	+	+	.	.
Bryum species	.	.	+	.	.	.	.	+	+	.	.	.	.	.	.	+	+
Bryum subneodamense	.	.	.	.	.	.	.	.	.	.	+	+	.	.	+	.	.
Bryum wrightii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Caloplaca species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Caloplaca tiroliensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.
Campylium polygamum	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Campylium stellatum	.	+	.	.	.	.	.	.	.	.	2	1	+	+	+	.	.
Candelariella species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cardamine digitata	.	+	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.
Carex aquatilis	+	+	+	+	+	1	2	.	.	.	2	2	1	1	+	.	.
Carex atrofusca	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex bipartita	+	+	.	.	1	.	.	.	.	.	.	.	.	+	.	.	.
Carex heleonastes	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex membranacea	2	2	.	+	1	1	.	+	.	+	2	1	2	2	3	.	.
Carex misandra	1	1	.	.	2	2	1	1	2	2	.	.	.	1	1	.	.
Carex rupestris	.	.	.	.	.	.	.	1	+	2	.	.	+	1	2	1	1
Carex scirpoidea	.	+	.	.	.	.	.	+	.	+	.	.	+	.	+	.	.
Cassiope tetragona	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r
Catapyrenium cinereum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Catapyrenium species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cephaloziella varians	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Cerastium beeringianum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cinclidium arcticum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Cinclidium latifolium	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.
Cladonia pocillum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Cladonia pyxidata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.
Collema tenax	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cratoneuron species	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Dactylina arctica	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Dactylina madreporiformis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Didymodon asperifolius	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Didymodon rigidulus	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Distichium capillaceum	+	.	.	.	.	.	.	.	.	.	+	1	+	.	1	.	.
Distichium inclinatum	.	1	.	+	.	.	.	+	+	+	.	.	.	.	.	.	+
Ditrichum flexicaule	1	.	.	.	.	.	.	+	.	1	+	+	1	3	1	+	2

Table 9 (cont.)

Relevé number	**317**	**318**	**319**	**320**	**321**	**322**	**323**	**324**	**325**	**326**	**327**	**328**	**329**	**330**	**331**	**332**	**333**
Draba alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.
Draba nivalis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Draba oblongata	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.
Draba species	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.
Dryas integrifolia	3	.	+	r	+	+	+	4	4	4	.	.	3	3	3	3	4
Elymus alaskanus s. *alaskanus*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Elymus sajanensis s. *hyperarcticus*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Encalypta alpina	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Encalypta species	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+
Encalypta vulgaris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Equisetum variegatum	+	+	.	.	+	.	.	.	.	.	+	+	+	+	+	.	.
Eriophorum angustifolium	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Eriophorum angustifolium s. *triste*	2	+	.	.	2	+	2	+	+	.	2	2	2	2	+	.	.
Eriophorum vaginatum	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.
Eutrema edwardsii	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Evernia perfragilis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Flavocetraria cucullata	+	.	.	.	.	.	.	.	.	+	.	.	r	.	+	+	+
Flavocetraria nivalis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+
Fulgensia bracteata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Hymenostylium recurvirostre	.	.	.	+	1	+	+	.	.	.	.	.	.	.	.	.	.
Hypnum bambergeri	2	2	.	.	.	.	.	+	.	.	3	3	2	2	1	.	+
Hypnum cupressiforme	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hypnum procerrimum	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	1	.
Hypnum revolutum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hypogymnia subobscura	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Juncus biglumis	.	+	.	.	+	+	.	.	.	.	.	.	.	.	+	.	.
Kobresia myosuroides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Lecanora epibryon	+	.	.	.	.	.	.	+	.	2	.	.	+	+	+	1	+
Lecidea ramulosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Leiocolea collaris	.	+	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.
Lepraria species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Leptobryum pyriforme	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Lesquerella arctica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	r
Leucanthemum integrifolium	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+
Limprichtia cossonii	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.
Meesia longiseta	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.
Meesia species	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+
Meesia triquetra	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.
Megaspora verrucosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Minuartia rossii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Mycobilimbia lobulata	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Myurella julacea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Nostoc commune	.	+	.	+	+	+	+	.	.	.	+	+	.	.	.	.	.
Ochrolechia species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Orthotheciella varia	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.
Orthothecium chryseum	+	.	.	.	.	.	.	.	.	.	+	+	+	+	+	.	+
Orthothecium strictum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Oxytropis arctica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+

Table 9 (cont.)

Relevé number	**317**	**318**	**319**	**320**	**321**	**322**	**323**	**324**	**325**	**326**	**327**	**328**	**329**	**330**	**331**	**332**	**333**
Oxytropis borealis v. *borealis*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Oxytropis nigrescens v. *uniflora*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	+
Parrya arctica	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	+	+
Pedicularis capitata	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Pedicularis kanei s. *kanei*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Pedicularis langsdorfii	+	.	.	.	.	.	.	.	+	.	.	.	+	.	+	.	.
Pedicularis species	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.
Pedicularis sudetica	.	+	.	.	+	+	.	.	.	.	+	.	.	.	+	.	.
Phaeorrhiza nimbosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Physconia muscigena	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Placidiopsis pseudocinerea	.	.	.	.	2	2	1	.	.	.	.	.	.	.	.	.	.
Placynthium nigrum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Plagiochila asplenioides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Platydictya jungermannioides	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.
Poa glauca	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Polyblastia gelatinosa	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Polyblastia sendtneri	1	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1
Polygonum viviparum	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.
Potentilla nivea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Potentilla vahliana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Protoblastemia siebenhaariana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pseudocalliergon brevifolius	+	+	.	.	.	.	.	.	.	.	+	+	+	+	+	.	.
Pseudocalliergon turgescens	.	+	.	.	.	.	.	.	.	.	+	+	.	.	+	.	.
Psora decipiens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Psora vallesiaca	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Puccinellia angustata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Puccinellia species	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rinodina roscida	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	+	.
Salix arctica	2	1	+	.	+	+	+	1	1	+	+	2	2	2	2	+	.
Sanionia uncinata v. uncinata	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Saxifraga oppositifolia	1	.	.	.	.	+	+	3	3	3	.	.	+	+	1	1	2
Scapania gymnostomophila	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Scorpidium scorpioides	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Senecio atropurpureus	+	.	.	.	r	r	.	.	.	.	.	.	+	+	+	.	.
Silene uralensis s. *uralensis*	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.
Solorina bispora	.	.	.	.	.	.	.	.	.	r	.	.	.	.	+	.	+
Stellaria longipes s. *longipes*	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Taraxacum species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tetraplodon species	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Thamnolia subuliformis	+	.	.	.	.	.	.	+	+	2	.	.	+	+	+	1	1
Timmia austriaca	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Tomentypnum nitens	2	.	.	.	.	.	.	.	.	.	.	.	2	3	2	.	+
Toninia arctica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Toninia sedifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Tortula mucronifolia	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Tortula norvegica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Tortula ruralis	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+
Vulpicida tilesii	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+

Table 10. Relevé lifeform percent cover

Releve #	Shrub			Forb		Non-tussock graminoid	Lichen			Bryophyte		Liver-worts	Horse-tail	Rock	Bare soil/marl crust/algal crust	Total dead
	Prostrate dwarf	Ever-green	Decid-uous	Erect	Mat & cushion		Foliose	Fruticose	Crustose	Pleuro-carpous	Acro-carpous					
301	+	0	+	+	+	+	0	0	0	0	0	0	0	20	80	0
302	+	0	+	+	2	+	+	0	10	0	0	0	0	15	75	+
303	70	70	+	+	5	8	+	0	5	3	5	0	0	5	+	20
304	+	0	+	+	+	+	0	0	0	0	0	0	0	10	90	0
305	+	0	+	+	+	+	+	0	10	0	0	0	0	7	80	+
306	60	60	15	+	3	10	+	+	10	7	10	0	0	5	5	15
307	0	0	0	0	+	1	0	0	0	0	0	0	0	10	90	0
308	1	0	1	3	1	10	0	10	30	0	0	0	0	5	20	+
309	75	75	5	3	2	3	0	2	5	7	5	0	0	+	2	25
310	+	0	+	+	+	+	0	0	0	0	0	0	0	10	90	0
311	7	+	7	+	+	10	0	0	40	3	3	0	0	5	15	+
312	70	70	10	+	1	4	0	7	3	5	5	0	0	+	5	30
313	+	0	+	+	+	+	0	0	0	0	0	0	0	30	70	0
314	+	+	+	+	+	3	0	0	20	0	0	0	0	20	70	+
315	65	65	20	+	3	3	0	+	2	8	7	0	0	+	+	30
316	+	+	+	+	+	+	0	0	2	0	+	0	+	5	90	+
317	30	25	5	+	2	50	0	+	5	20	10	0	+	0	0	30
318	10	0	10	+	0	70	0	0	0	40	20	0	+	0	40	20
319	+	+	+	+	0	+	0	0	15	0	+	0	0	5	95	+
320	+	+	0	1	0	+	0	0	2	0	+	0	+	5	95	+
321	+	+	+	+	0	35	0	0	15	0	+	0	+	2	45	20
322	+	+	+	+	+	30	0	0	10	0	+	0	0	2	50	17
323	+	+	+	+	+	25	0	0	5	0	1	0	0	5	70	10
324	65	60	5	+	25	10	0	+	10	1	1	0	0	1	5	40
325	70	69	1	+	25	15	0	+	5	2	1	0	0	1	2	40
326	70	70	+	+	25	20	+	8	8	+	+	0	0	0	+	35
327	2	0	2	+	0	80	0	0	0	60	10	5	+	0	+	40
328	10	0	10	+	0	70	0	0	0	60	10	5	+	0	2	30
329	50	30	20	+	+	60	0	+	+	70	10	0	+	0	0	35
330	25	15	10	+	+	50	0	+	+	60	10	0	+	0	0	30
331	35	28	7	+	3	40	0	+	+	20	10	0	+	0	0	40
332	40	40	+	+	20	5	0	2	3	+	2	0	0	25	25	25
333	70	70	0	+	10	3	+	7	10	2	15	0	0	+	5	35

Table 11. Relevé site characteristics form

Study Site: ***Site Description***

Relevé No.: _____ Date: _____ Recording personnel: _____ Weather: _____

Study area description: _____

Slope (deg): _____ Thaw depth (cm): A: _____

Aspect: _____ B: _____

Elevation: _____ C: _____

Record numbers for all microsites.

Landforms

1 Hills (including kames and moraines)
2 Talus slope
3 Colluvial basin
4 Glaciofluvial and other fluvial terraces
5 Marine terrace
6 Floodplains
7 Drained lakes and flat lake margins
8 Abandoned point bars and sloughs
9 Estuary
10 Lake or pond
11 Stream
12 Sea bluff
13 Lake bluff
14 Stream bluff
15 Sand dunes
16 Beach
17 Disturbed
18 _____
19 _____
20 _____
21 _____

Surficial Geology (Parent Material)

1 Glacial tills
2 Glaciofluvial deposits
3 Active alluvial sands
4 Active alluvial gravels
5 Stabilized alluvium (sands & gravels)
6 Undifferentiated hill slope colluvium
7 Basin colluvium and organic deposits
8 Drained lake or lacustrine organic deposits
9 Lake or pond organic, sand, or silt
10 Undifferentiated sands
11 Undifferentiated clay
12 Roads and gravel pads
13 _____
14 _____
15 _____
16 _____

Surficial Geomorphology

1 Frost scars
2 Wetland hummocks
3 Turf hummocks
4 Gelifluction features
5 Strangmoor or aligned hummocks
6 High- or flat-centered polygons
7 Mixed high- and low-centered polygons
8 Sorted and non-sorted stripes
9 Palsas
10 Thermokarst pits
11 Featureless or with less 20% frost scars
12 Well-developed hillslope water tracks and small streams > 50 cm deep
13 Poorly developed hillslope water tracks, < 50 cm deep
14 Gently rolling or irregular microrelief
15 Stoney surface
16 Lakes and ponds
17 Disturbed
18 _____
19 _____
20 _____
21 _____

Microsites

1 Frost-scar element
2 Inter-frost scar element
3 Strang or hummock
4 Flark, interstrang, or interhummock area
5 Polygon center
6 Polygon trough
7 Polygon rim
8 Stripe element
9 Inter-stripe element
10 Point bar (raised element)
11 Slough (wet element)
12 _____
13 _____
14 _____
15 _____

Site Moisture (modified from Komárková 1983)

1 Extremely xeric - almost no moisture; no plant growth
2 Very xeric - very little moisture; dry sand dunes
3 Xeric - little moisture; stabilized sand dunes, dry ridge tops
4 Subxeric - noticeable moisture; well-drained slopes, ridges
5 Subxeric to mesic - very noticeable moisture; flat to gently sloping
6 Mesic-moderate moisture; flat or shallow depressions
7 Mesic to subhygric - considerable moisture; depressions
8 Subhygric - very considerable moisture; saturated but with < 5% standing water < 10 cm deep
9 Hygric - much moisture; up to 100% of surface under water 10 to 50 cm deep; lake margins, shallow ponds, streams
10 Hydric - very much moisture; 100% of surface under water 50 to 150 cm deep; lakes, streams

Soil Moisture (from Komárková 1983)

1 Very dry - very little moisture; soil does not stick together
2 Dry - little moisture; soil somewhat sticks together
3 Damp - noticeable moisture; soil sticks together but crumbles
4 Damp to moist - very noticeable moisture; soil clumps
5 Moist - moderate moisture; soil binds but can be broken apart
6 Moist to wet - considerable moisture; soil binds and sticks to fingers
7 Wet - very considerable moisture; water drops can be squeezed out of soil
8 Very wet - much moisture can be squeezed out of soil
9 Saturated - very much moisture; water drips out of soil
10 Very saturated - extreme moisture; soil is more liquid than solid

Glacial Geology

1 Till
2 Outwash
3 Bedrock
4 _____
5 _____
6 _____
7 _____

Topographic Position

1 Hill crest or shoulder
2 Side slope
3 Footslope or toeslope
4 Flat
5 Drainage channel
6 Depression
7 Lake or pond

Soil Units

1 Pergelic Cryorthent, acid
2 Pergelic Cryopsamment
3 Pergelic Cryohemist, euic
4 Pergelic Cryosaprist, euic
5 Lithic Pergelic Cryosaprist
6 Pergelic Cryofibrist, euic
7 Histic Pergelic Cryaquept, acid
8 Histic Pergelic Cryaquept, nonacid
9 Pergelic Cryaquept, acid
10 Pergelic Cryaquept, nonacid
11 Pergelic Cryochrept
12 Pergelic Cryumbrept
13 Ruptic-Lithic Cryumbrept
14 Pergelic Cryaquoll
15 Histic Pergelic Cryaquoll
16 Pergelic Cryoboroll
17 _____
18 _____
19 _____
20 _____

Exposure Scale

1 Protected from winds
2 Moderate exposure to winds
3 Exposed to winds
4 Very exposed to winds

Estimated Snow Duration

1 Snow free all year
2 Snow free most of winter; some snow cover persistsafter storm but is blown free soon afterward
3 Snow free prior to melt out but with snow most of winter
4 Snow free immediately after melt out
5 Snow bank persists 1-2 weeks after melt out
6 Snow bank persists 3-4 weeks after melt out
7 Snow bank persists 4-8 weeks after melt out
8 Snow bank persists 8-12 weeks after melt out
9 Very short snow free period
10 Deep snow all year

Animal and Human Disturbance

0 No sign present
1 Some sign present; no disturbance
2 Minor disturbance or extensive sign
3 Moderate disturbance; small dens or light grazing
4 Major disturbance; multiple dens or noticeable trampling
5 Very major disturbance; very extensive tunneling or large pit

Stability

1 Stable
2 Subject to occasional disturbance
3 Subject to prolonged but slow disturbance such as solifluction
4 Annually disturbed
5 Disturbed more than once annually

Other notes: _____

Table 12. Relevé site characteristics

Relevé #	Height (cm)						Site Information													
	Veg. canopy	Moss	Organic	A horizon	Micro-relief	Mean thaw depth	Land-form	Surf. geol.	Surf. geom.	Micro-site	Site moist.	Soil moist.	Glacial geology	Topo-graphic position	Soil unit	Est. snow duration	Distur-bance degree	Distur-bance type	Stab-ility	Expo-sure
301	10	0	0	0	2	61	1	1	1	1	3	3	1	3saddle	17	4	3	2,3	5	2.5
302	0	0	0	0	5	59	1	1	1	1	3	3	1	3saddle	17	4	2	2	2	2
303	2	0.5	2	20	8	57	1	1	1	2	3	3	1	3 saddle	18	4	3	6	2	2
304	1	0	0	0	5	46	1	1	1	1	3	3	1	2	17	4	3	2	5	3
305	0	0	0	0	3	48	1	1	1	1	3	3	1	2	17	4	2	2	2	2
306	2	0.5	1	20+	12	46	1	1	1	2	3	3	1	2	18	4	2	6	2	2
307	0	0	0	0	5	54	1	1	1	1	3	2	1	1	17	3	4	2,3	5	3
308	0	0	0	0	5	52	1	1	1	1	3	2	1	1	17	3	2	2	2	3
309	2	1	2	20+	10	51	1	1	1	2	3	3	1	1	18	3	3	6	2	3
310	0	0	0	0	2	53	1	1	1/8	1	3	3	1	2	17	3	3	2,3	5	3
311	0	0	0	0	5	52	1	1	1	1	3	3	1	2	17	3	3	3	2	3
312	2	1	2	20+	10	40	1	1	1	2	3	3	1	2	18	3	4	1,3,6	2	3
313	0	0	0	0	3	-	1	1	1	1	3	4	1	3valley	17	4	1	2	5	3
314	0	0	0	0	2	-	1	1	1	1	3	4	1	3valley	17	4	1	2	2	3
315	2	0	1	40+	10	-	1	1	1	2	3	4	1	3 valley	18	4	3	6	2	3
316	0	0	0	0	2	46	18	6	1/7	1	8	8	2	3	-	4	1	2,3	5	2
317	5	1	2	15	15	28	18	6	1/7	2/12	6	6	2	3	19	4	1	3	1	2
318	8	0	5 sand	24	3	23	18	6	1/7	2/4	8	8	2	3	19	4	1	3	1	2
319	0	0	0	0	5	60	18	6	1/7	1	8	8	2	3	-	4	4	3	5	2
320	0	0	0	0	2	52	18	6	1/7	1	8	8	2	3	-	4	1	7	5	2
321	5	0	0	0	4	56	18	6	1/7	1	8	8	2	3	-	4	2	3	3	2
322	5	0	0	0	3	64	18	6	1/7	1	8	8	2	3	-	4	2	1,3	3	2
323	5	0	0	0	5	56	18	6	1/7	1	8	8	2	3	-	4	2	3	3	2
324	2	0	1	5	8	59	18	6	1	1	5	5	2	3	-	4	2	2	2	2
325	2	0.5	0	2	4	57	18	6	1	1	5	6	2	3	-	4	2	2	2	2
326	3	0	1	3	7	55	18	6	1	1	5	5	2	3	-	4	1	3	2	2
327	10	2	22+	-	4	23	18	6	1/7	2/4	8	8	2	3	19	4	2	3	1	2
328	10	2	1	25	3	21	18	6	1/7	2/4	8	8	2	3	19	4	1	3	1	2
329	10	2	12	0	10	20	18	6	1/7	2/12	6	6	2	3	19	4	0	-	1	2
330	10	1	25+	0	15	24	18	6	1/7	2/12	6	6	2	3	19	4	1	3,4,6	1	2
331	10	1	20+	0	12	23/13	18	6	6	5	5	6	2	3	14	4	1	6	1	2
332	2	0	0	15	3	70	1	1	11	50%bare 50% *Dryas*	3	2	1	1	17	2	2	3,6	1	4
333	2	1	0	7	10	65	1	1	18	-	3	4	1	2	M.O.	4	1	3	3	2

Table 13. Relevé soil analysis and moisture

Releve #	pH	meq/100					%								Bulk density (gm/cm^3)
		CEC	K	Ca	Mg	Na	C	N	Sand	Silt	Clay	Inorganic Carbon	Gravimetric water	Volumetric soil moisture	
301	8.61	7.12	0.25	24.50	13.00	0.24	5.10	0.03	41.6	32.8	25.6	0.52	0.09	0.11	1.24
302	8.79	8.84	0.25	27.42	12.29	0.47	6.81	0.21	65.6	20.8	13.6	1.05	0.08	0.11	1.37
303	7.76	30.93	0.32	34.15	8.39	0.10	8.75	0.40	77.6	16.8	5.6	0.54	0.31	0.27	0.88
304	8.38	10.03	0.32	36.37	15.10	0.22	4.38	0.09	41.6	32.8	25.6	0.97	0.11	0.12	1.08
305	8.33	9.68	0.33	28.76	8.43	0.13	5.89	0.15	61.6	20.8	17.6	0.96	0.09	0.09	1.09
306	7.92	17.89	0.28	32.42	6.75	0.06	7.08	0.27	73.6	16.8	9.6	2.18	0.21	0.22	1.06
307	8.30	12.17	0.41	26.72	12.75	0.22	4.52	0.12	41.6	32.8	25.6	1.81	0.07	0.08	1.15
308	8.22	14.40	0.36	22.28	7.68	0.07	6.53	0.27	69.6	20.8	9.6	1.98	0.09	0.10	1.13
309	8.06	13.96	0.40	27.27	8.21	0.09	6.12	0.21	56.8	20.8	22.4	1.62	0.14	0.13	0.91
310	8.44	10.96	0.41	24.90	16.04	0.22	4.13	0.06	36.8	36.8	26.4	1.79	0.12	0.16	1.32
311	7.93	19.34	0.40	27.73	10.94	0.10	6.25	0.23	64.8	20.8	14.4	1.77	0.15	0.13	0.89
312	7.82	25.83	0.33	26.64	10.30	0.10	7.75	0.34	68.8	20.8	10.4	1.42	0.26	0.21	0.81
313	8.23	16.24	0.44	33.53	11.89	0.13	4.69	0.16	48.8	24.8	26.4	0.52	0.11	0.14	1.26
314	8.19	14.23	0.31	37.46	9.74	0.09	6.12	0.21	72.8	8.8	18.4	1.66	0.14	0.17	1.22
315	8.03	18.80	0.32	40.20	9.15	0.10	6.68	0.26	60.8	20.8	18.4	0.62	0.19	0.18	0.97
317	7.36	40.39	0.11	47.46	12.79	0.14	12.52	0.85	72.8	24.8	2.4	0.50	1.15	0.68	0.59
318	7.51	26.00	0.08	24.80	10.90	0.07	9.47	0.43	76.8	21.6	1.6	2.08	1.01	0.61	0.61
319	8.84	5.59	0.09	28.12	10.25	0.09	6.65	0.07	72.8	17.6	9.6	1.02	0.18	0.25	1.37
320	8.51	5.00	0.06	19.52	8.44	0.05	5.55	0.03	76.8	17.6	5.6	0.54	0.13	0.17	1.32
321	8.18	7.29	0.12	40.10	4.48	0.08	7.22	0.14	72.8	21.6	5.6	2.16	0.35	0.33	0.96
322	8.24	5.76	0.09	41.11	3.29	0.09	7.85	0.13	73.6	16.8	9.6	1.10	0.32	0.32	0.99
323	8.52	4.99	0.08	34.37	7.71	0.05	6.19	0.04	77.6	10.8	11.6	1.72	0.91	0.81	0.89
324	8.01	16.95	0.13	39.90	9.93	0.07	8.46	0.28	73.6	16.8	9.6	1.21	0.38	0.37	0.96
325	8.22	10.75	0.13	37.98	10.76	0.11	9.30	0.29	81.6	12.8	5.6	1.30	0.27	0.27	1.01
326	8.15	13.68	0.08	30.70	8.49	0.06	6.95	0.17	73.6	16.8	9.6	0.75	0.21	0.23	1.08
327	7.43	28.00	0.28	29.95	9.00	0.06	11.82	0.66	79.6	16.4	4.0	0.86	1.68	0.69	0.41
328	7.55	14.91	0.11	14.37	5.47	0.02	7.68	0.29	85.6	12.8	1.6	0.90	1.21	0.69	0.57
329	7.15	32.08	0.24	26.87	7.86	0.05	7.55	0.53	88.4	9.8	1.8	0.39	1.52	0.58	0.38
330	7.34	40.65	0.17	34.22	9.89	0.05	10.04	0.68	85.6	12.8	1.6	0.50	1.29	0.68	0.53
331	7.25	44.09	0.10	34.52	11.56	0.07	8.81	0.59	77.6	16.8	5.6	0.48	1.13	0.70	0.62
332	8.23	10.70	0.25	22.44	5.61	0.03	6.84	0.22	89.6	4.8	5.6	1.41	0.09	0.11	1.22
333	8.03	14.66	0.15	22.80	5.71	0.06	7.30	0.32	81.6	8.8	9.6	1.87	0.19	0.22	1.16

Table 14. Vascular plant species list. Voucher relevé collections are stored at the Alaska Geobotany Center.

Artemisia campestris ssp. *borealis* var. *borealis* (Pallas) M.E. Peck

Arenaria humifusa Wahlenb.

Arctagrostis latifolia (R. Br.) Griseb.

Astragalus alpinus L.

Astragalus australis (L.) Lam. =*A. aboriginorum* Richards

Braya glabella ssp. *purpurascens* (R. Br.) Cody

Carex aquatilis Wahlenb.

Carex atrofusca Schkuhr

Carex bipartita All. = *Carex glareosa* Shkuhr

Cardamine digitata Richards.

Carex heleonastes L. f.

Carex membranacea Hook.

Carex misandra R. Br.

Carex rupestris All.

Carex scirpoidea Michx.

Cassiope tetragona (L.) D. Don

Cerastium beeringianum Cham. & Schlecht.

Draba sp.

Draba alpina L.

Dryas integrifolia Vahl

Draba nivalis Lilj.

Draba oblongata R. Br. ex DC.

Elymus alaskanus (Merr.) A. Love =*Agropyron violaceum* (Hornem) Lange

Equisetum variegatum Schleich. ex F. Weber & D.M.H. Mohr

Eriophorum angustifolium Honckeny

Eriophorum angustifolium ssp. *triste* (T. Fries) Hulten

Eriophorum vaginatum L.

Eutrema edwardsii R. Br.

Juncus biglumis L.

Kobresia myosuroides (Vill.) Fiori

Lesquerella arctica (Wormsk. ex Hornem.) S. Wats.

Leucanthemum integrifolium (Richards) DC =*Chrysanthemum integrifolium* Richards..

Minuartia rossii (R. Br. ex Richards.) Graebn.

Oxytropis arctica R. Br.

Oxytropis borealis var. *borealis* DC.

Oxytropis nigrescens var. *uniflora* (Hook.) Barneby

Parrya arctica R. Br.

Pedicularis capitata M.F. Adams

Pedicularis sp.

Pedicularis kanei ssp. *kanei* Dur.

Pedicularis langsdorfii Fisch. ex Stev.

Pedicularis sudetica Willd.

Poa glauca Vahl

Potentilla nivea L.

Potentilla vahliana Lehm.

Polygonum viviparum L.

Puccinellia angustata (R. Br.) Rand & Redf.

Puccinellia sp.

Salix arctica R. Br. ex Richards.

Saxifraga oppositifolia L.

Senecio atropurpureus (Ledeb.) Fedtsch.

Silene uralensis ssp. *uralensis* (Rupr.) Bocquet

Stellaria longipes ssp. *longipes* Goldie

Taraxacum sp.

Table 15. Moss and liverwort species list. Voucher relevé collections stored at the Komarov Botanical Institute, St. Petersburg, Russia.

Abietinella abietina (Hedw.) Fleisch.
Amblystegium longicuspus
Aneura pinguis (L.) Dum.
Aulacomnium acuminatum (Lindb. & Arnell) Kindb.
Bryoerythrophyllum recurvirostre (Hedw.) Chen
Bryum sp.
Bryum pseudotriquetrum (Hedw.) Gaertn. et. al.
Bryum subneodamense Kindb.
Bryum wrightii Sull. & Lesq.
Campylium polygamum (Schimp. in B.S.G.) C. Jens.
Campylium stellatum (Hedw.) C. Jens.
Cephaloziella varians (Gottsche) Steph.
Cinclidium arcticum Bruch & Schimp. in B.S.G.
Cinclidium latifolium Lindb.
Cratoneuron (Sull.) Spruce
Didymodon asperifolius (Mitt.) Crum et al.
Didymodon rigidulus var. *icmadophilus* (Schimp. ex C.
Distichium capillaceum (Hedw.) Bruch & Schimp. in B.S.G.
Distichium inclinatum (Hedw.) Bruch & Schimp. in B.S.G.
Ditrichum flexicaule (Schwaegr.) Hampe
Encalypta alpina Sm.
Encalypta Hedw.
Encalypta vulgaris Hedw.
Hymenostylium recurvirostre (Hedw.) Dix.
Hypnum bambergeri Schimp.
Hypnum cupressiforme Hedw.
Hypnum procerrimum Mol.
Hypnum revolutum (Mitt.) Lindb.
Leiocolea collaris (Nees) Schljakov
Leptobryum pyriforme (Hedw.) Wils.
Limprichtia cossonii (Schimp.) Anderson et al.
Meesia Hedw.
Meesia longiseta Hedw.
Meesia triquetra (Richt.) _ngstr.
Myurella julacea (Schwaegr.) Schimp. in B.S.G.
Orthotheciella sp.
Orthothecium chryseum (Schwaegr. in Schultes) Schimp
Orthothecium strictum Lor.
Plagiochila asplenioides (L.emend. Taylor) Dumort.
Platydictya jungermannioides (Brid.) Crum
Pseudocalliergon brevifolius
Pseudocalliergon turgescens (T. Jens.) Loeske
Sanionia uncinata var. *uncinata* (Hedw.) Loeske
Scapania gymnostomophia Kaal.
Scorpidium scorpioides (Hedw.) Limpr.
Tetraplodon sp.
Timmia austriaca Hedw.
Tomentypnum nitens (Hedw.) Loeske
Tortula mucronifolia Schwaegr.
Tortula norvegica (Web.) Wahlenb. ex Lindb.
Tortula ruralis (Hedw.) Gaertn. et al.

Table 16. Lichen species list.

Alectoria ochroleuca (Hoffm.) Massal.
Catapyrenium cinereum (Pers.) Korber
Caloplaca sp.
Candelariella Mull. Arg.
Catapyrenium sp.
Caloplaca tiroliensis Zahlbr.
Cladonia pocillum (Ach.) Grognot
Cladonia pyxidata (L.) Hoffm.
Collema tenax (Sw.) Ach.
Dactylina arctica (Richardson) Nyl.
Dactylina madreporiformis (Ach.) Tuck.
Evernia perfragilis Llano
Flavocetraria cucullata (Bellardi) Karnefelt & Thell
Flavocetraria nivalis (L.) Karnefelt & Thell
Fulgensia bracteata (Hoffm.) Rasanen
Hypogymnia subobscura (Vainio) Poelt
Lecanora epibryon (Ach.) Ach.
Lepraria sp.
Lecidea ramulosa
Megaspora verrucosa (Ach.) Hafellner & V. Wirth
Mycobilimbia lobulata (Sommerf.) Hafellner
Nostoc commune
Ochrolechia sp.
Physconia muscigena (Ach.) Poelt
Phaeorrhiza nimbosa (Fr.) H. Mayrh. & Poelt
Placynthium nigrum (Hudson) Gray
Placidiopsis pseudocinerea Breuss
Polyblastia gelatinosa (Ach.) Th. Fr.
Polyblastia sendtneri Krempelh.
Protoblastemia siebenhaariana
Psora decipiens (Hedwig) Hoffm.
Psora vallesiaca (Schaerer) Timdal
Rinodina roscida (Sommerf.) Arnold
Solorina bispora Nyl.
Thamnolia subuliformis (Ehrh.) Culb.
Toninia arctica Timdal
Toninia sedifolia (Scop.) Timdal
Vulpicida tilesii (Ach.) J.E. Mattsson & M. J. Lai

Biogeochemistry data

Table 17. Biogeochemistry data.

Measurement		Sites					
		Grid 1 - zonal		Grid 2 - xeric		Grid 3 - hydric	
		Frost Boil	Inter-boil	Frost Boil	Inter-boil	Frost Boil	Inter-boil
Rate of Nitrogen Mineralization * (micrograms N/g soil/day)	Mean	-0.0131	0.0060	0.2433	-0.1277	-0.8041	-1.1094
	Standard Error	0.0557	0.6064	0.2390	0.6047	0.2994	0.8880
Rate of Nitrogen Fixation ** (microequivalents of ethylene/hour)	Mean	**	**	**	**	**	**
	Standard Error						
Total Carbon ** (% Carbon)	Mean	**	**	**	**	**	**
	Standard Error						
Organic Carbon ** (% Carbon)	Mean	**	**	**	**	**	**
	Standard Error						
Total Nitrogen ** (% Nitrogen)	Mean	**	**	**	**	**	**
	Standard Error						
NDVI unitless	Mean	-0.0058	0.2997	0.0684	0.5395	0.2564	.03692
	Standard Error	0.0046	0.0082	0.0015	0.0291	0.0594	0.0231
LAI unitless	Mean	0	0.0167	0.0033	0.0089	0.0022	0.0778
	Standard Error	0	0.0094	0.0033	0.0035	0.0022	0.0163
Aboveground Biomass (g/m^2)	Mean	**	**	**	**	**	**
	Standard Error						
Volumetric Soil Moisture (% Volume)	Mean	24.6417	26.9167	16.0583	13.5667	32.2500	78.2333
	Standard Error	1.2442	0.9109	1.5736	1.4005	0.8278	1.1942
Thaw Depth (cm)	Mean	49.0833	42.9167	48.4167	43.0000	43.0833	22.0833
	Standard Error	1.2152	1.4059	1.4005	1.1547	0.7926	0.9330
Soil Temperature at 5cm (degree Celsius)	Mean	12.30	10.45	19.28	14.99	13.23	8.84
	Standard Error	0.05	0.24	0.32	0.46	0.16	0.35

* Data incomplete

** Data currently unavailable, analysis was not completed by publication date

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Class Transects data

Table 18. Mean thaw depth along 20-meter transect.

Transect thaw depth (cm)		Frostboil			Interboil			
		Bare	Crust	Vascular	Bare	Crust	Vascular	Moss
GC1	Mean	64.7	64.1	63	59.3	59.1	59.3	56.8
	n	32	23	5	3	52	80	6
GC2	Mean	55.9	56	52	48.5	53	53.2	54
	n	45	2	2	2	44	103	2
GC3	Mean	56.4	53.6	-	49.8	52.6	52.9	49.5
	n	40	12	-	8	50	87	4

Table 19. Data for decomposition experiment control samples.

Analysis of *Carex misandra* Collected July 10, 2003.

Lab #	Position	Plot ID	Sample #	%Carbon	%Sulfur	%Nitrogen	%Ash
1	Belowground	Mesic, GC 1, Boil 1	32	50.58	0.081	0.51	-
2	Belowground	Mesic, GC 1, Interboil 1	31	49.55	0.099	0.56	4.71
3	Belowground	Mesic, GC 2, Boil 1	42	49.57	0.119	0.63	4.93
4	Belowground	Mesic, GC 2, Interboil 1	41	49.20	0.145	0.65	4.87
5	Belowground	Mesic, GC 3, Boil 1	52	49.64	0.097	0.63	3.81
6	Belowground	Mesic, GC 3, Interboil 1	51	48.94	0.126	0.69	7.54
7	Surface	Mesic, GC 1, Boil 1	2	47.65	0.161	0.55	8.31
8	Surface	Mesic, GC 1, Interboil 1	1	50.34	0.103	0.38	3.48
9	Surface	Mesic, GC 2, Interboil 1	11	50.55	0.084	0.55	3.98
10	Surface	Mesic, GC 3, Boil 1	12	50.79	0.067	0.42	-
11	Surface	Mesic, GC 3, Boil 1	22	51.06	0.068	0.40	1.75
12	Surface	Mesic, GC 3, Interboil 1	21	50.83	0.072	0.43	1.72

Analysis of *Luzula nivalis* collected July 2, 2003.

Lab #	Plot ID	Sample #	%Carbon	%Sulfur	%Nitrogen	%Ash
1	Interboil	10	39.74	0.121	1.10	17.79
1'	Interboil	10	38.31	0.150	1.07	-
2	Boil	20	18.07	0.078	0.54	60.44
2'	Boil	20	18.78	0.055	0.56	-

Turf hummocks along the arctic bioclimate gradient: characteristics and development (Charles Tarnocai)

Background

Turf hummocks are small, 11–20 cm high, 18–50 cm diameter mounds. They commonly occur on gently to steeply sloping Arctic terrain (Figure 26 a,b).

Description of activities

The turf hummock sub-study is part of the soil study portion of the Biocomplexity of Frost Boils Ecosystem project (Walker et al, in press). Its purpose is to study the characteristics and genesis of turf hummocks in Arctic Bioclimate subzones A, B and C.

The objectives of this turf hummock sub-study are:

1. To examine their internal and external characteristics on the basis of soil analytical data, and moisture and temperature measurements.
2. To determine their age and genesis.
3. To establish the role they play in the Arctic ecosystems.

During this fieldwork turf hummocks were studied at five locations on Banks Island in bioclimate subzone C (Table 20).

Table 20. Locations of turf hummock study sites.

Site no.	Lat. (N)	Long. (W)	Elevation (m)	Slope (%)	Dominant vegetation
1A	73° 13' 43"	119° 32' 52"	32	28	*Dryas integrifolia* – moss
1B	73° 13' 43"	119° 32' 52"	32	28	*Dryas integrifolia* – moss
2	73° 13' 21"	119° 33' 09"	47	8	*Cassiope tetragona* – moss
3A	73° 13' 22"	119° 33' 13"	62	14	*Cassiope tetragona* – moss
3B	73° 13' 22"	119° 33' 13"	65	12	*Cassiope tetragona* – moss
4*	73° 13' 24"	119° 33' 14"	55	6	Dryas, crust and bare soil
5	73° 13' 27"	119° 33' 21"	50	20	*Dryas integrifolia* – moss

* Small polygons with frost cracks

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 (Figure 26 c). 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 (Table 21).

Table 21. Types and numbers of turf hummock soil samples collected.

Site no.	Soil	Bulk Density	Radiocarbon
1A	3	3	3
1B	8	4	2
2	n	n	n
3A	4	n	n
3B	5	2	2
4	3	1	n
5	4	4	1

n: no sample collected

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 interhummock 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 (Figure 26). 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.

Preliminary conclusions

1. The internal morphology of these turf hummocks shows multiple buried organic-rich layers (Ah), representing former hummock surfaces (Figures 22-25).

2. The turf hummocks are composed of gravel-free mineral materials deposited by eolian processes. The underlying material (2C) is gravelly and originated from fluvial or colluvial processes (Table 22 and Figures 22-25).

3. The vegetation growing on these turf hummocks plays a key role in their development by capturing windblown materials. The internal morphology, the role of eolian deposition in hummock genesis, and the role of the vegetation on the Banks Island turf hummocks are similar to that in turf hummocks studied on Ellesmere Island (Broll and Tarnocai, 2002).

4. The pH and $CaCO_3$ content of the turf hummock materials (eolian in origin) are similar to those of the underlying deposits. This suggests that the eolian material has originated from the surrounding surfaces (Table 23).

5. Organic carbon content is generally lower in the underlying paleo soil horizons (2Bm and 2C) than in the hummock materials, except for hummock 4. Hummock 4 is considered to be an example of the early stage of turf hummock development (Table 23).

6. No difference was noted in the chemical composition (pH, C% and N%) of the *Dryas integrifolia*-moss (1A, 1B and 5) and *Cassiope tetragona*-moss (2, 3A and 3B) types of hummocks (Table 2).

7. Radiocarbon dates from hummocks 1A and 3B (Figure 25) indicate a gradual build-up of the hummock by eolian deposition. The basal date from hummock 3B suggests that hummock development began about 2000 years ago. This basal date was slightly older than the 1230 and 1250 years BP found by Broll and Tarnocai (2002) on Ellesmere Island.

8. Zoltai et al. (1978) reported active cryoturbation between 2000 and 3500 years BP, based on radiocarbon dates obtained from earth hummocks in the Mackenzie River Valley. As Zoltai et al. (1978) stated, this period coincided with a cool period in the area. It is possible that active frost cracking occurred during this period, which then gave rise to turf hummock formation.

Turf hummocks, which are commonly found on gently or steeply sloping Arctic terrain, were examined at seven sites in the Green Cabin area of Aulavik National Park on Banks Island. All seven hummocks were excavated, their cross sections were examined, and soil samples were collected for laboratory analysis and radiocarbon dating. Turf hummocks represent a unique ecosystem. They provide a nutritious and warm soil environment for plant growth, and a habitat and readily available food source for small mammals and insects.

Results

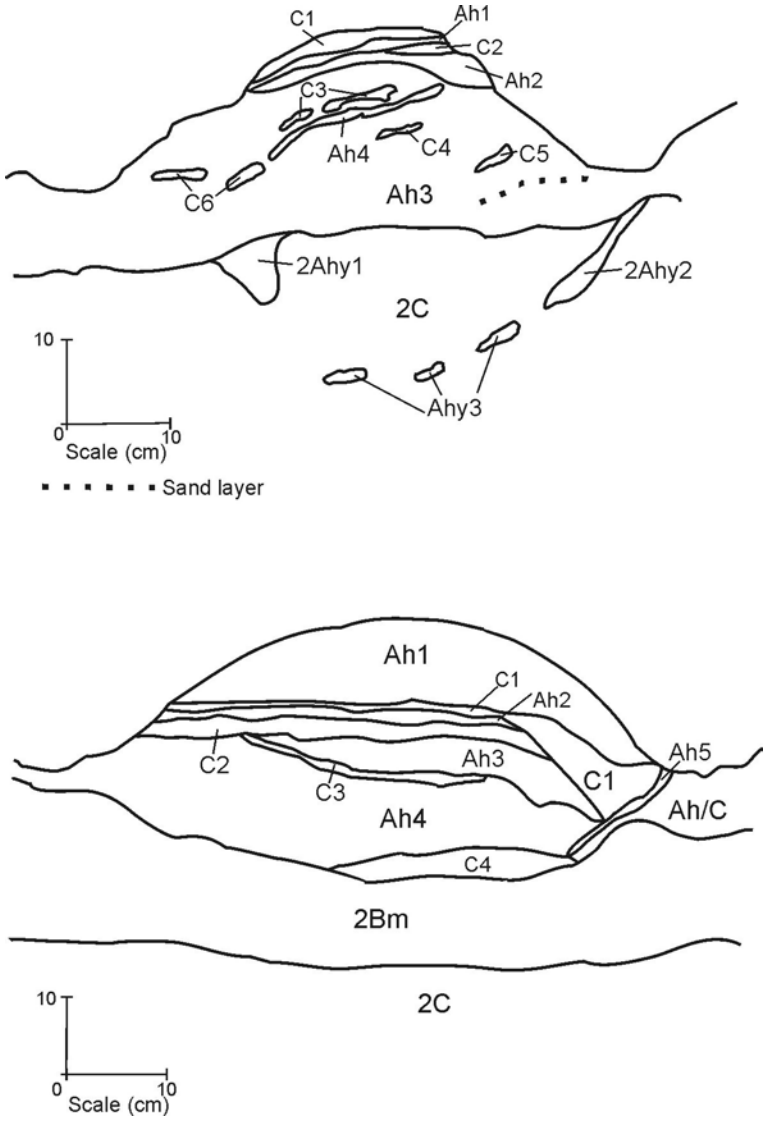

Figure 22. Turf hummocks 1A (upper) and 1B (lower).

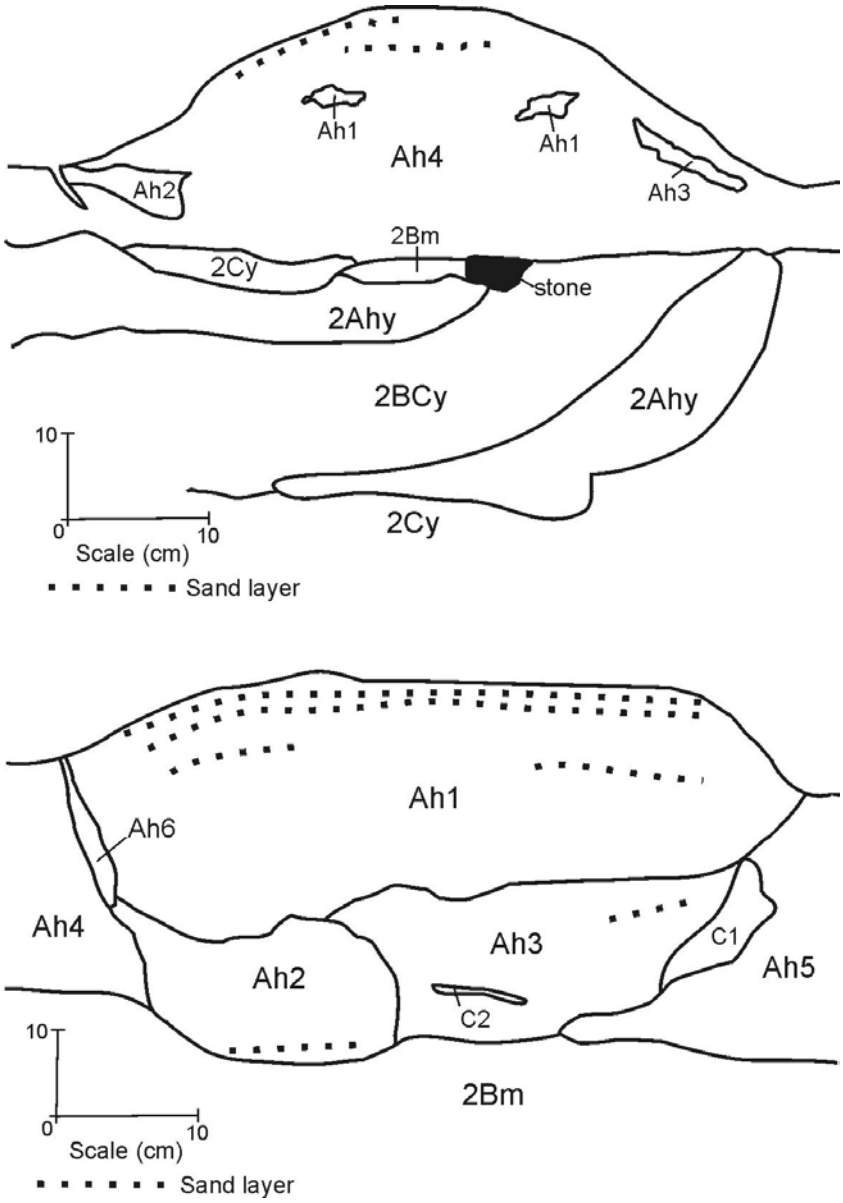

Figure 23. Turf hummocks 3A (upper) and 3B (lower).

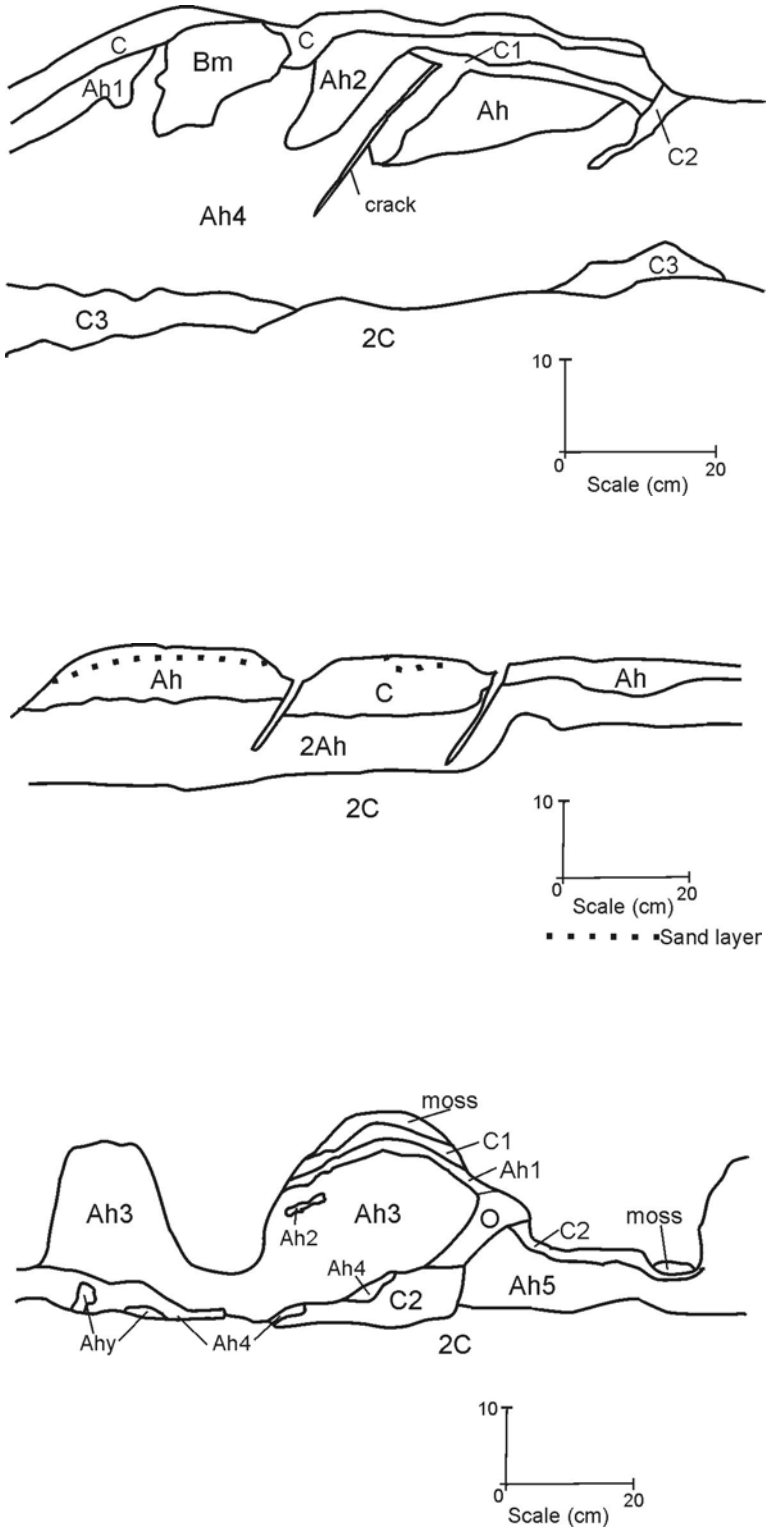

Figure 24. Turf hummocks 2 (upper), 4 (middle) and 5 (lower).

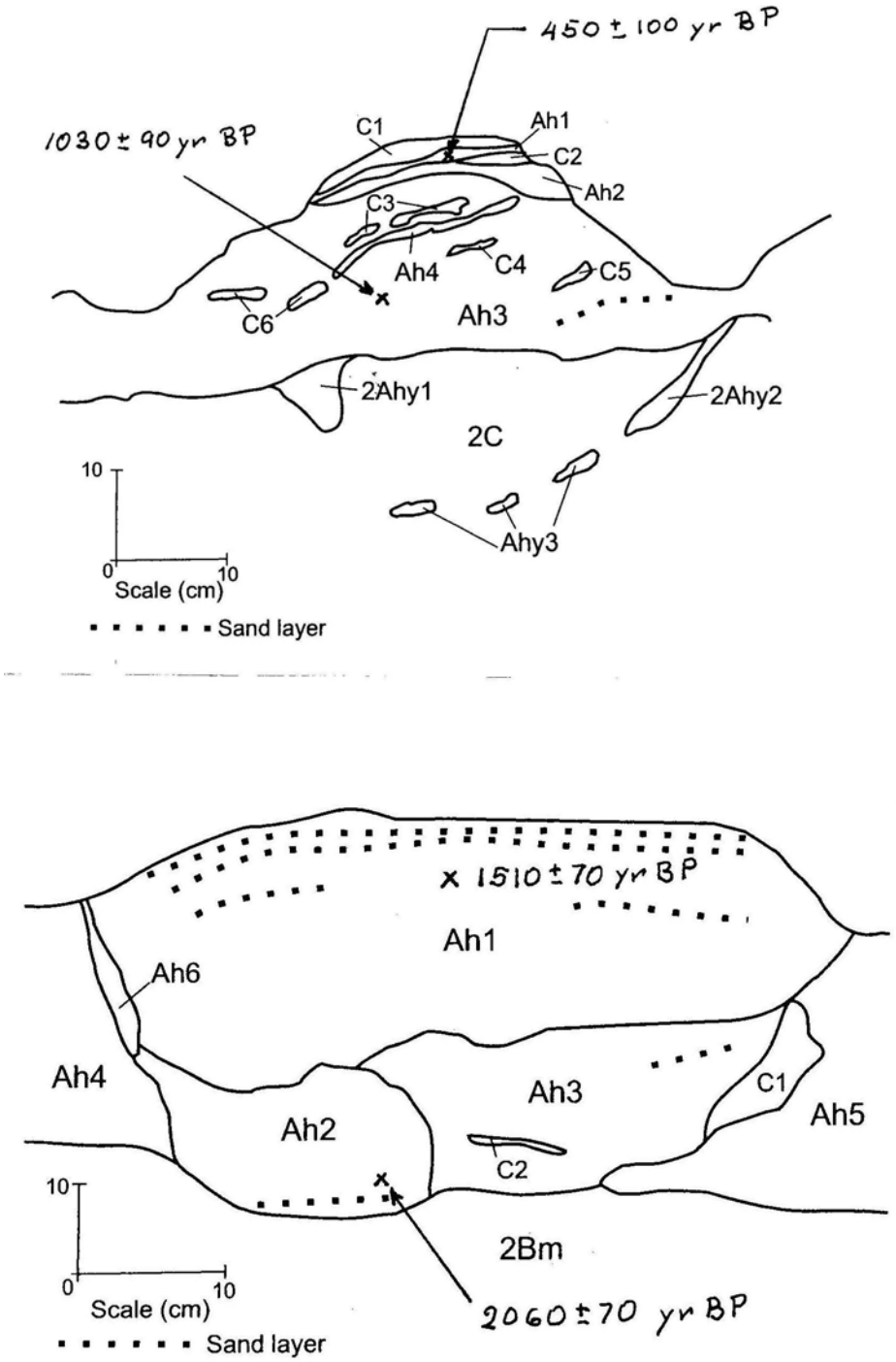

Figure 25. Locations and ages of radiocarbon samples from turf hummocks 1A (upper) and 3B (lower).

Table 22. Physical data for Banks Island turf hummocks.

Hummock	Horizon	Sand* (%)						Silt (%)	Clay (%)	Texture+
		VCS	CS	MS	FS	VFS	Total			
1A	Ah2	0	0.7	11.5	30.2	34.7	77.1	15.9	7.0	LFS
	Ah3	0.7	2.0	14.4	30.6	28.3	76.0	16.5	7.5	LFS
	2C	1.7	4.0	18.4	50.8	13.8	88.7	8.3	3.0	GFS
1B	Ah1	0.1	1.0	19.4	32.4	30.4	83.3	9.8	6.9	LFS
	Ah2	0.1	1.1	20.4	31.2	27.6	80.4	14.2	5.4	LFS
	C1	2.5	4.6	19.4	41.5	17.6	85.6	11.6	2.8	LS
	Ah3	1.6	3.3	19.8	39.9	16.2	80.8	12.6	6.6	LFS
	Ah4	1.6	3.4	19.8	42.7	16.3	83.8	10.7	5.5	LFS
	C4	0.5	2.7	22.2	33.0	21.9	80.3	11.0	8.7	LS
	2Bm	11.9	23.8	39.0	13.3	2.2	90.2	8.2	1.6	GCS
	2C	16.7	39.2	32.5	7.0	1.2	96.6	2.4	1.0	GCS
3A	Ah1	0.1	2.4	28.4	36.8	10.0	77.7	12.3	10.0	LS
	Ah2	0.2	3.1	31.0	35.7	11.6	81.6	8.0	10.4	LS
	Ah3	0.6	3.4	33.4	34.7	8.6	80.7	10.4	8.9	LS
	Ah4	0.7	4.0	36.0	29.4	8.6	78.7	11.5	9.8	LS
3B	Ah1	0	1.2	25.7	44.3	9.7	80.9	10.4	8.7	LS
	Ah2	0.2	1.6	24.3	40.2	9.3	75.6	16.5	7.9	LS
	Ah3	0.2	2.0	22.6	40.5	10.6	75.9	15.7	8.4	LFS
	Ah4	0.3	2.0	25.4	39.9	10.0	77.6	11.9	10.5	LS
	Ah5	0.7	5.0	33.0	22.6	7.5	68.8	17.5	13.7	SL
4	Ah	0.9	4.0	23.8	29.5	12.0	70.2	16.6	13.2	LS
	C	1.6	4.7	19.4	21.4	10.4	57.5	26.5	16.0	FSL
	2Ah	1.1	4.6	22.9	27.5	12.9	69.0	18.4	12.6	FSL
5	C1	0.3	2.1	18.8	34.2	14.5	69.9	17.9	12.2	FSL
	Ah1	0	1.7	18.3	30.4	14.4	64.8	18.9	16.3	FSL
	Ah2	1.0	4.9	23.0	37.6	8.6	75.1	13.5	11.4	LS
	2C	1.8	5.7	26.0	39.3	9.4	82.2	11.1	6.7	GLS

* Sand fractions: VCS – very coarse sand, CS – coarse sand, MS – medium sand, FS – fine sand, VFS – very fine sand.

+ Texture classes: GCS – gravelly coarse sand, GFS – gravelly fine sand, GLS – gravelly loamy sand, LFS – loamy fine sand, LS – loamy sand, FSL – fine sandy loam, SL – sandy loam.

Table 23. Chemical data for the Banks Island turf hummocks.

Hummock	Horizon	pH (H_2O)	pH ($CaCl_2$)	Org. C (%)	Tot. N (%)	$CaCO_3$ (%)
1A	Ah2	8.0	7.2	2.57	0.21	24.3
	Ah3	8.0	7.3	3.10	0.23	24.3
	2C	8.5	7.6	0.96	0.08	24.3
1B	Ah1	8.1	7.5	3.85	0.26	18.8
	Ah2	8.0	7.4	3.37	0.23	21.0
	C1	8.3	7.4	0.44	0.04	25.0
	Ah3	8.0	7.3	3.25	0.24	16.5
	Ah4	8.1	7.3	1.68	0.13	19.8
	C4	7.9	7.4	3.69	0.26	18.3
	2Bm	8.3	7.4	0.21	0.02	19.1
	2C	8.5	7.3	0.10	0.01	16.9
3A	Ah1	8.2	7.4	2.49	0.17	15.2
	Ah2	8.2	7.5	2.47	0.16	28.6
	Ah3	8.2	7.5	2.50	0.15	19.6
	Ah4	8.0	7.2	2.18	0.16	15.5
3B	Ah1	7.2	6.8	2.37	0.18	16.1
	Ah2	7.7	7.1	4.88	0.28	8.2
	Ah3	7.8	7.1	2.55	0.16	18.7
	Ah4	8.1	7.4	4.14	0.22	16.0
	Ah5	7.9	7.3	4.67	0.32	3.1
4	Ah	8.0	7.4	2.60	0.19	25.9
	C	8.2	7.6	1.47	0.12	23.8
	2Ah	8.2	7.5	2.30	0.19	15.9
5	C1	8.0	7.4	2.34	0.17	17.7
	Ah1	7.9	7.4	2.84	0.26	13.7
	Ah2	8.0	7.4	1.78	0.14	15.0
	2C	8.2	7.5	1.13	0.09	17.2

(a) (b)

(c) (d)

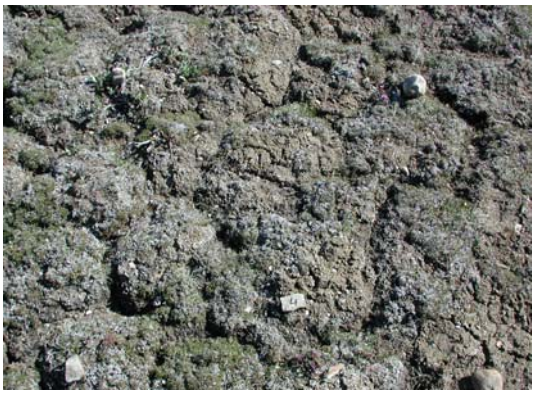

Figure 26. Photographs of Banks Island turf hummocks (a) Turf hummocks on slope; (b) Close-up of turf hummocks; (c) Cross section of a turf hummock at site 1B; (d) Small polygons with patchy Dryas integrifolia *vegetation.*

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References

Broll, G. and C. Tarnocai. 2002. Turf hummocks on Ellesmere Island, Canada. Transactions of the 17th World Congress of Soil Science, August 14-21, 2002, Bangkok, Thailand, Paper 1049, CD-ROM.

CAVM Map Team (2003). Circumpolar Arctic Vegetation Map, Scale 1:7,5,000,000. Conservation of Arctic Flora and Fauna (CAFF) Map No. 1. Anchorage, AK, U.S. Fish and Wildlife Service.

Edlund, S. A. (1990). Vegetation, Central Queen Elizabeth Islands, District of Franklin, Northwest Territories, Map 1755A, Geological Survey of Canada.

Polunin, N. (1951). "The real Arctic: suggestions for its delimitation, subdivision and characterization." Journal of Ecology **39**: 308-315.

Vincent, J. S. (1990). "Late Tertiary and early Pleistocene deposits and history of Banks Island, southwestern Canadian Archipelago." Arctic **43**(3): 339-363.

Walker, D. A., H. E. Epstein, W. A. Gould, A. M. Kelley, A. N. Kade, J. A. Knudson, W. B. Krantz, G. Michaleson, R. A. Peterson, C. L. Ping, M. A. Raynolds, V. E. Romanovsky, and Y. Shur. 2004 in press. Frost-boil ecosystems: complex interactions between landforms, soils, vegetation, and climate. Permafrost and Periglacial Processes.

Zoltai, S.C., C. Tarnocai and W.W. Pettapiece. 1978. Age of cryoturbated organic material in earth hummocks from the Canadian Arctic. Proceedings of the Third International Conference on Permafrost, Edmonton, Canada, p. 325-331.