Addendum
to the

2003 Green Cabin, Banks Island Data Report

Photos by Sarah Harvey

Compiled February 2005 by M. K. Raynolds

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Contents

SOILS DESCRIPTION OF STUDIED SITES:

Banks Island, NWT, Canada, June 29-July 12, 2003

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

Location: Banks Island
GPS position: 73°13'17" N
119 °33'37" W
Elevation: 54m

Physiography: Arctic Lowland Province
Landform: Rolling hills
Landscape position: broad basin/saddle (speculated to be old terrace of 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: - 7°C, 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 subuliforis, 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; weak 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)
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)

Boil/Inter Boil:

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; strong 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; weak 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; weak 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; weak effervescence; common fine roots; many medium vesicular pores; abrupt irregular boundary (0 – 55 cm) (#7)

Green Cabin Pit 2 (xeric site)
USDA-NRCS-NSSC 03-FN-260-003


Location: Banks Island
GPS position: 73°13'16" N
119°33'26" 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 (Thomsen 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: - 7°C, est.
Landcover type: Dry nonacidic tundra/barren land, Bioclimate Subzone C
Land use: prostrated shrubland, open range, wildlife grazing
Vegetation: *Dryas integrifolia,Carix 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; strong 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; moderate 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; moderate effervescence; abrupt smooth boundary (0 – 16 cm) (#16)
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)
42 – 55 cm; Bkjj: brown (7.5YR4/2) silty clay loam; moderate medium subangular blocky structure; friable, sticky, plastic; few fine roots; slight effervescence; abrupt smooth boundary (0-14 cm) (#20)

Boil/Inter Boil:
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; moderate effervescence; abrupt irregular boundary (0 – 28 cm) (#17)
55 – 70 cm; Oajjf; black (7.5YR2.4/1) mucky sandy loam; weak fine platy structure; very friable, nonplastic and nonsticky; common fine root channels and residues; slight effervescence; abrupt wavy boundary (10 – 16 cm) (#21)
65 – 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)
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)

Inter Boil:
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)

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


Location: Banks Island
GPS position: 73°13'35" N
119°33'31" 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 (river bar)
Climate: MAAT: - 13.7 (Sachs Stn.)
MAP: 10.2 cm
MAST: - 7°C, est.
Drainage: poor, free water in polygon troughs
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; violent 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; slight 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; slight effervescence; pH 7.1; abrupt irregular boundary (0 –11 cm) (#26)
40 –55 cm; Ajj/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)

Boil/Inter Boil:
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)

Inter Boil:

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)

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


Location: Banks Island
GPS position: 73°13'11" N
119°33'34" 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: - 7°C, 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; strong 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; strong 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, strong 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; slight 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; violent effervescence; few fine roots; abrupt irregular boundary (0 – 50 cm) (#39)

35 – 54 cm; Ab/Bwjj; black (10YR2/1, 60%) and olive brown (2.5Y4/4) fine sandy loam; massive; friable, slightly sticky and nonplastic; slight 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; strong effervescence; abrupt irregular boundary (0 – 40 cm) (#44)

Boil/Inter Boil:

33 – 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)

66 – 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 boundary (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; slight effervescence. Abrupt wavy boundary (#48)

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

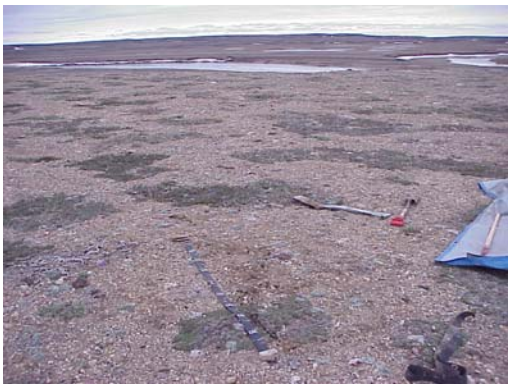
Inter Boil:

0 – 12 cm; A; brown (10YR4/3) sand; single grained; loose, nonsticky, nonplastic; common fine, very fine and few medium roots; many root remains; violent 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; strong effervescence; abrupt irregular boundary (0 – 25 cm) (#41)

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

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



Location: Banks Island
GPS position: 73°12'08" N
119°33'20" 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 structure; firm; nonsticky, nonplastic; common fine roots; moderate 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; weak effervescence; clear wavy boundary (0 – 17cm) (#51)
0 – 20 cm; A3; brown (10YR4/3) sandy loam; weak granular and weak medium and fine subangular structure; very friable, nonsticky, nonplastic; many fine, very fine and few medium roots; moderate 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; strong 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; slight 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; slight effervescence; abrupt smooth boundary (32-48cm) (#54)
88 – 100 cm; 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; slight 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; weak effervescence. (#58)

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

Location: Banks Island
GPS position: 73°13'22" N
119°33'13" W
Elevation: 59m

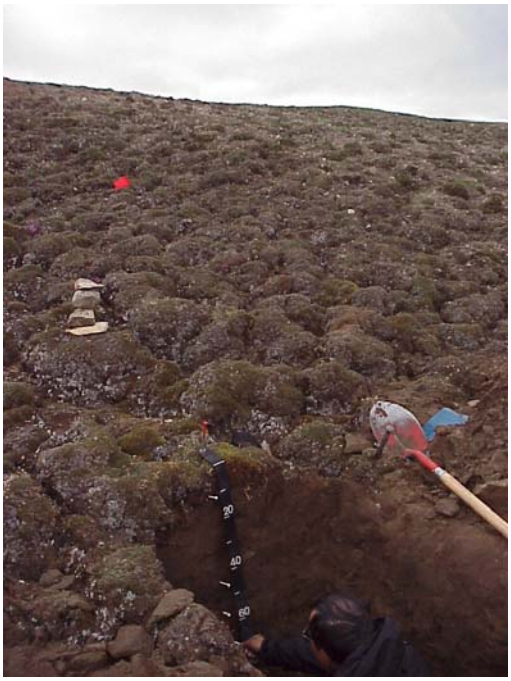
Physiography: Arctic Lowland Province
Landform: Rolling hills
Landscape position: footslope
Microrelief: hummocks, ave. diameter 60 cm, relief 15 cm
Slope: est. 30% NW, vertical: slightly concave, horizontal: plane
Parent material: Aeolian sand over marine sediments (?)
Climate: MAAT:
MAP:
MAST:
Vegetation: *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 structure; 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 boulders, round cobble and gravel; abrupt, irregular boundary (15-40 cm) (#63)
81 – 106 cm; B/Ajjf; (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 thickness, 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 structure 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- not sampled for (only UAF samples)



Location: Banks Island
GPS position: 73°13'27" N
119°33'21" 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: 14°, 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: Snow bed tundra - *Dryas integrifolia, Oxytopis* 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 (0-28 cm) (#68)
30 – 36 cm; Ajj3; very dark brown (7.5Y 2.5/2) mucky sandy loam; weak medium granular structure; 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 boulders, round cobble and gravel; abrupt, irregular boundary (15-40 cm) (#71)

70 – 87 cm; Bw/Ajjf; (10YR4/3, 60%) and (10YR4/2, 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) (#72)

87 – 106 cm; Bwf; brown (10YR4/3) sand; weak thin platy and lenticular structure; frozen, very firm, nonsticky and nonplastic; clear wavy boundary (#73)

106 – 150 cm; Cf1; olive brown (2.5Y4/3) sand; massive frozen; extremely firm, nonsticky, nonplastic; 10% ice, few fine vein ice. (#74)

150 – 170 cm; 2Cf2; dark grayish brown (2.5Y4/2) silt loam; ataxitic (ice-rich) horizon, 60% ice; extremely firm, frozen, slightly sticky and slightly plastic. (#75)

Analysis of pit soil samples

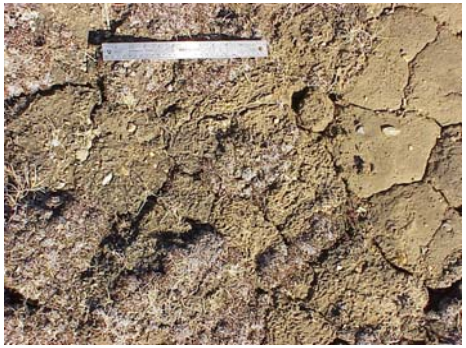
Site ID/date NRCS ID#	#	Soil Horizon	Depth Range	pH	EC	Mehlich3 Extr. P	Field H_2O	BD	TC	TN	TIC	>2 mm
			cm	1:1	ds cm^{-1}	mg kg^{-1}	% wt.	g cm^{-1}	%	%	%	% wt.
Green Cabin		Boil										
Pit 1	8	Bw	0 – 35	8.09	1.21	<1	11	1.62	4.34	0.07	1.80	
grid 1												11.3
(zonal site A)	9	Oajj	35 – 52	7.47	0.54	15	19	1.56	8.23	0.46	1.45	
												4.5
07/04/03	11	Oajjf	60 – 75	7.55	0.50	38	16	2.15	8.39	0.52	1.31	
												6.7
S 03-FN-260-002		**Boil/Inter Boil**										
	10	Bwjj	45 – 60	8.04	0.46	<1	6	1.76	5.51	0.03	1.15	18.1
	12	Cf/Oajj	55 – 90	7.47	0.79	30	31	1.34	9.27	0.51	1.41	39.7
	13	Oajj/Cf	90 – 105	7.36	1.04	44	48	1.17	9.89	0.59	1.32	27.0
		Inter Boil										
	7	A	0 – 45	7.71	0.52	8	19	1.15	6.95	0.24	1.76	5.1
Green Cabin		Boil										
Pit 2	14	Bw1	0 – 6	8.03	2.34	<1	6	1.93	3.75	0.05	1.67	7.4
(xeric site)	15	Bw2	6 – 10	7.98	1.02	<1	8	1.93	3.78	0.04	1.60	10.7
07/05/03	16	Bw3	10 – 26	8.10	0.77	<1	8	1.95	2.80	0.03	1.45	6.2
S 03-FN-260-003	19	Bw4	26 – 60	7.99	0.73	<1	12	1.94	4.12	0.07	1.49	6.9
	20	Bkjj	42 – 55	8.10	0.88	<1	15	1.61	4.65	0.14	1.48	3.1
		Boil/Inter Boil										
	17	Bwjj	28 – 55	7.85	0.71	<1	14	1.20	5.58	0.23	1.24	14.7
	21	Oajjf	55 – 70	7.88	0.90	39	19	1.87	7.24	0.32	1.64	11.0
	22	Cf	65 – 88	7.69	2.11	46	70	1.95	3.12	0.05	1.45	0.1
	23	Wf/Cf	80 – 100	7.72	2.25	62	50	1.95	3.39	0.06	1.59	0.6
		Inter Boil										
	18	A	0 – 40	7.91	0.46	16	14	1.25	6.11	0.24	1.61	7.3
Green Cabin		**Boil**										
Pit 3**,**	24	Bk	0 – 2	8.32	1.50	<1	32	1.67	6.85	0.11	1.63	10.7
Grid 3												
(hydric site)	25	Bw	2 – 30	8.22	0.35	<1	11	1.70	5.14	0.04	2.24	13.6
07/06/03	26	Oajj	30 – 40	7.97	0.33	<1	12	1.50	6.20	0.11	1.26	5.3

S 03-FN-260-004	27	Ajj/Bwf	40 –55	7.90	0.52	<1	11	2.36	6.71	0.13	1.20	8.7
		Boil/Inter Boil										
	31	Bw/Ajjf	32 – 70	8.00	0.38	<1	12	1.75	7.14	0.16	1.82	8.4
	32	2Cf	70 – 105	8.19	0.67	<1	33	1.89	7.73	0.19	1.66	2.1
		Inter Boil										
	28	Oi	0 – 2	7.60	0.62	53	112	0.46	11.4	0.59	2.06	<0.1
	29	Oa	2 – 15	7.45	0.46	15	264	0.68	11.4	0.74	1.42	<0.1
	30	Bwf	15 – 32	7.88	0.33	<1	15	1.71	5.62	0.07	2.03	6.4
Green Cabin Pit 4**, Grid 1** (zonal site B) 07/07/03 S 03-FN-260-005		Boil										
	34	Bw1	0 – 10	8.28	2.04	<1	10	1.23	4.43	0.02	1.21	8.9
	35	BC	0 – 10	8.16	1.54	8	8	1.23	6.54	0.17	1.00	18.1
	36	Bw2	10 – 26	8.30	0.58	<1	9	1.74	5.21	0.02	2.78	4.2
	37	Bwjj1	0 – 55	8.12	0.81	<1	10	1.69	5.47	0.01	1.33	11.3
	38	Bwjj2	10 –50	8.11	0.38	<1	7	1.90	5.08	0.01	1.39	11.1
	39	Btjj1	26 – 67	8.14	0.33	<1	7	2.00	2.69	<.01	1.03	8.0
	45	Ab/Bwjj	35 – 54	8.03	0.46	<1	10	1.66	2.31	<.01	1.42	9.4
	44	Oajj/Cf	40 – 93	7.92	0.42	48	12	1.78	7.55	0.25	2.28	13.1
		Boil/Inter Boil										
	42	Btjj2	33 – 82	8.04	0.27	8	14	1.90	3.78	0.03	1.87	1.3
	46	Cf1	66 – 108	7.90	0.92	<1	14	1.72	5.32	<.01	1.68	4.3
	48	Wf/Cf2/Oajjf	94 – 110	7.63	1.92	61	30	1.22	7.33	0.22	1.62	3.8
	49	Cf3	110 – 130	7.73	2.71	<1	37	1.72	5.88	0.03	1.67	0.7
		Inter Boil										
	40	A	0 – 12	7.84	0.46	8	19	1.30	7.15	0.20	1.47	<0.1
	41	Ajj	12 – 33	7.98	0.42	<1	18	1.34	8.15	0.35	2.06	<0.1
	43	Bwjj3	50 – 66	8.19	0.23	<1	6	1.73	5.03	0.02	1.29	17.4
Green Cabin Pit 5 **(dry** Barren ridge Site) 07/08/03 S 03-FN-260-006	50	A1	0 – 4	8.22	0.67	8	2	1.52	5.84	0.15	1.30	31.3
	51	A2	4 – 20	8.18	0.33	<1	6	2.06	6.29	0.18	2.36	28.1
	52	A3	0 – 20	8.12	0.35	<1	6	1.69	6.64	0.19	1.19	36.7
	53	Bw1	20 – 45	8.43	0.19	<1	2	1.67	5.36	0.02	1.38	16.7
	56	Bw2	20 – 45	8.42	0.21	<1	4	1.81	4.75	<.01	1.75	19.1
	54	Bw/Ajj	45 – 88	8.20	0.33	16	8	2.20	4.34	0.03	1.45	16.4
	57	Cf1	88 – 100	8.06	0.38	97	10	1.79	3.61	0.04	0.96	18.2

Site ID/date NRCS ID#	#	Soil Horizon	Depth Range	pH	EC	Mehlich3 Extr. P	Field H_2O	BD	TC	TN	TIC	>2 mm
			cm	1:1	ds cm^{-1}	mg kg^{-1}	% wt.	g cm^{-1}	%	%	%	% wt.
	58	Cf2	100 – 110	8.43	0.23	8	9	1.75	4.63	0.01	1.64	24.9
	77	3Cf	90-120	7.86	0.42	118	17	0.61	2.94	0.05	1.19	14.2
Green Cabin Pit 6 **(snow bank** hummock site) 07/09/03	60	A	0 – 8	7.58	0.44	15	24	1.28	6.47	0.22	1.14	<0.1
	61	Ajj	8 – 35	7.53	0.33	23	26	1.42	6.39	0.36	0.60	11.9
	59	Bwjj1	35 – 40	7.80	0.31	<1	14	1.78	6.10	0.10	1.30	12.0
	62	Bwjj2	40 – 52	8.16	0.19	8	5	1.84	6.36	0.02	1.55	5.2
	63	A/Bjj	52 – 81	8.05	0.23	24	10	1.81	7.17	0.01	1.47	16.0
	64	Bw/Ajjf	81 – 106	8.08	0.31	24	16	2.05	6.56	0.02	1.23	1.8
	65	Cf/Wf	106 – 120	7.71	1.73	39	77	0.99	4.87	0.04	1.21	0.3
	66	2Cf	120 – 135	7.63	2.71	46	31	0.99	4.97	0.05	1.11	0.2
Green Cabin Pit 7 **(small** hummock site) 0710/03	76	Oi	0-20	7.71	0.56	39	61	1.46	10.3	0.51	1.19	<0.1
	67	Ajj1	0 – 10	7.53	0.42	30	34	0.62	7.48	0.32	1.49	<0.1
	68	Ajj2	10 – 30	7.75	0.31	23	17	1.29	5.94	0.22	1.81	6.8
	69	Ajj3	30 – 36	7.67	0.42	23	43	0.96	7.48	0.39	0.90	2.4
	70	Bwjj	36 – 50	7.91	0.38	8	10	1.65	5.47	0.14	1.24	9.1
	71	Bw/Ajj	50 – 70	7.64	0.94	15	9	1.69	5.55	0.06	0.50	39.0
	72	Bw/Ajjf	70-87	7.86	1.04	8	12	1.99	4.52	0.01	1.21	2.0
	73	Bwf	87-106	7.88	2.65	<1	13	1.90	4.26	<.01	2.32	4.7
	74	Cf1	106-150	7.65	2.08	54	16	1.92	4.19	<.01	1.93	0.2
	75	2Cf2	150-170	7.51	2.34	45	31	1.69	2.41	0.05	0.80	8.1

SOIL CRUST SAMPLING SITES AND ANALYSIS:

Barren Center



Black Crust Boil Edge

Vegetated Inter Boil

SITE: Green Cabin Pit 1**, grid 1 (zonal site A) 07/04/03**

Boil Microsite	ID	Depth	pH	EC	Field H_2O	BD	KCl Extr. N	Mehlich-3 Extractable P	K	Ca	Mg	Na	Total IC	OC	N
		cm	*1:1*	*ds*	*% vol.*	*g cm^{-3}*	*mg kg^{-1}*	----------*mg kg^{-1}*----------					----------*%*----------		
Barren	6	0-1	8.3	5.1	24	1.84	4	<1	229	3481	2191	234	1.5	1.9	0.09
Center	7	1-2	8.4	1.4	14	1.04	4	<1	194	3148	1811	59	1.6	1.8	0.07
	8	2-4	8.3	1.5	22	1.56	5	<1	173	3028	1736	62	1.7	1.7	0.05
	9	4-6	8.3	1.4	23	1.56	5	<1	178	3439	1694	47	1.4	1.8	0.06
Black	10	0-1	7.8	0.8	19	0.85	4	1	149	4558	859	17	1.2	5.7	0.20
Crust	11	1-2	7.9	0.5	15	0.88	5	<1	127	4839	751	13	2.2	4.8	0.23
Boil edges	12	2-4	7.8	0.5	13	0.87	4	<1	113	5005	718	19	1.5	5.3	0.17
	13	4-6	7.8	0.5	14	1.03	2	<1	91	4352	615	11	1.9	4.7	0.11
Vegetate	14														
d		0-1	7.6	0.5	26	0.98	4	<1	150	3494	798	14	1.3	4.9	0.14
Inter boil	15	1-2	7.8	0.6	34	1.72	4	<1	132	3144	758	34	1.4	4.4	0.15
	16	2-4	7.8	0.5	33	1.62	5	<1	119	2816	918	19	2.0	4.1	0.20
	17	4-6	7.8	0.5	29	1.43	4	1	99	2914	1025	27	0.4	6.1	0.09

Barren Center

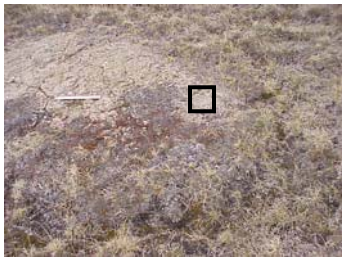
Cryptogamic Crust

Dryas Inter Boil

SITE: Green Cabin Pit 2 (xeric site) 07/05/03

Boil Microsite	ID	Depth	pH	EC	Field H_2O	BD	KCl Extr. N	Mehlich-3 Extractable P	K	Ca	Mg	Na	Total IC	OC	N
		cm	*1:1*	*ds*	*% vol.*	*g cm^{-3}*	*mg kg^{-1}*	----------*mg kg^{-1}*----------					----------*%*----------		
Barren	24	0-1	8.1	3.9	2	1.36	1	<1	176	2779	1721	118	1.6	2.4	0.05
Center	25	1-2	8.3	1.3	9	1.57	1	<1	156	2583	1454	76	1.4	2.4	0.04
	26	2-4	8.3	1.2	9	1.09	2	<1	136	2072	1384	58	1.5	2.1	0.04
	27	4-6	8.2	1.5	12	1.40	1	<1	131	2116	1425	64	1.8	2.0	0.05
Cryptogamic	28	0-1	7.8	1.2	6	0.96	4	2	259	3461	1100	63	1.7	4.2	0.20
Crust	29	1-2	8.0	0.8	8	0.96	5	2	231	3604	1034	48	1.9	3.6	0.18
Boil edges	30	2-4	7.9	0.6	15	1.24	5	1	184	3640	934	27	1.9	4.1	0.18
	31	4-6	8.0	0.5	11	0.83	4	1	156	3062	890	31	1.9	4.1	0.21
Dryas	32	0-2	7.7	0.6	16	1.15	3	2	211	3721	874	13	1.9	4.1	0.18
Inter boil	33	2-4	7.8	0.5	16	1.10	3	1	181	4154	918	17	1.3	4.9	0.19
	34	4-6	7.8	0.5	22	1.52	2	1	141	4030	842	22	2.0	4.5	0.20
	35	6-8	7.8	0.5	17	1.36	1	<1	112	4074	853	27	1.3	5.3	0.17


Thin White Crust


Thick White Crust


Black Crust


Vegetated Inter Boil

SITE: Green Cabin Pit 3, Grid 3 (hydric site) 07/06/03

Boil Microsite	ID	Depth	pH	EC	Field H_2O	BD	KCl Extr. N	Mehlich-3 Extractable P	K	Ca	Mg	Na	Total IC	OC	N
		cm	*1:1*	*ds*	*% vol.*	*g cm^{-3}*	*mg kg^{-1}*	----------*mg kg^{-1}*----------					----------*%*----------		
Thin White Crust	36	0-1	8.5	1.5	47	2.24	3	<1	56	8110	1600	30	2.5	3.1	0.08
	37	1-2	8.4	0.6	41	2.71	2	<1	37	2739	827	10	1.3	4.1	0.08
Center	38	2-4	8.2	0.6	20	1.36	2	<1	32	2209	635	14	2.3	3.0	0.07
	39	4-6	8.1	0.4	19	1.29	3	<1	34	2704	569	6	1.2	4.5	0.09
Thick White	40	0-1	8.4	1.2	74	1.76	20	<1	78	30181	2605	63	1.2	6.5	0.16
Crust	41	1-2	8.3	0.8	38	1.74	4	<1	64	27922	1699	45	2.8	4.6	0.13
Boil edges	42	2-4	8.2	0.6	38	2.39	2	<1	42	8784	875	17	2.2	3.8	0.06
	43	4-6	8.1	0.5	45	2.84	1	<1	33	3506	535	7	1.6	4.1	0.05
Black Crust	44	0-1	7.8	0.9	69	0.90	9	<1	98	17028	1761	29	2.3	7.4	0.41
Boil edges	45	1-2	7.8	0.4	51	1.50	3	<1	42	12432	876	10	0.7	6.8	0.21
	46	2-4	7.7	0.5	54	1.71	4	<1	36	4916	618	7	1.8	5.7	0.22
	47	4-6	7.9	0.4	32	2.16	1	<1	26	2056	561	5	1.2	5.4	0.12
Vegetated	48	0-1	7.8	1.2	64	0.51	15	15	265	10135	3343	35	1.5	14.0	0.72
Inter boil	49	1-2	7.8	0.7	73	0.86	4	<1	91	20844	1916	21	1.8	9.0	0.46
	50	2-4	7.7	0.5	58	0.90	4	<1	54	23506	1329	15	2.3	6.5	0.38
	51	4-6	7.6	0.4	88	1.21	3	<1	47	2852	833	8	1.5	6.9	0.45
	52	6-8	7.8	0.3	34	2.31	4	3	25	1381	592	5	2.1	4.1	0.08

TURF HUMMOCKS ALONG THE ARCTIC BIOCLIMATE GRADIENT: THEIR CHARACTERISTICS AND DEVELOPMENT

Charles Tarnocai

Background

Turf hummocks are small mounds that commonly occur on gently to steeply sloping Arctic terrain (Appendix 1, A and B).

Description of activities

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

The objectives of this turf hummock sub-study are:

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

During fieldwork in July 2003, turf hummocks were studied at five locations in the Green Cabin area on Banks Island in Bioclimate Subzone C (Table 1).

Table 1. 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 trough to expose the internal morphology (Appendix 1, C). Detailed cross section diagrams were prepared and the various soil horizons and layers were identified (Appendix 2). 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 (Appendix 3). Table 2 shows the number of each type of sample collected at each site.

Table 2. Numbers of samples collected at each site for various types of analysis.

Site no.	Type of Analysis		
	Soil	Bulk Density	Radiocarbon
1A	3	3	3
1B	8	4	2
2	–	–	–
3A	4	–	–
3B	5	2	2
4	3	1	–
5	4	4	1

– indicates 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.

At site 4 the polygons, which had diameters ranging from 28 to 36 cm, were also examined and sampled as described above. Some of these polygons were covered with bare soil, some were partially vegetated with *Dryas integrifolia* and some were completely vegetated. A thin layer of sandy materials was found under the Dryas mat and, as a result, these Dryas-covered polygons were elevated as much as 6 cm. It appears that site 4 represents an early stage of turf hummock development (Appendix 2).

Results

Landscape position: In a topographic sequence, turf hummocks commonly occur on 5–20% slopes and are associated with nonsorted circles, which occur on gently sloping to level (<5%) topographic positions (Figure 1). The steeper slopes are usually associated with snowbanks, which accumulate windblown organic and mineral materials throughout the winter.

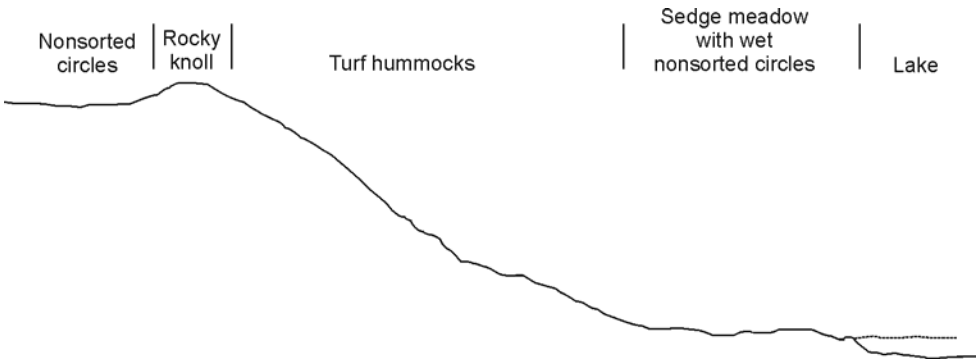


Figure 1. Schematic diagram showing a topographic sequence in the Green Cabin area.

External and internal morphology: In this area, turf hummocks are generally 11–20 cm high and 18–50 cm in diameter and are composed of gravel-free mineral materials deposited by eolian processes. The underlying material (2C), which is gravelly, was deposited by fluvial or colluvial processes. The internal morphology of these turf hummocks shows multiple buried organic-rich layers (Ah), representing former hummock surfaces (Appendix 2). The vegetation growing on these turf hummocks plays a key role in their development by capturing windblown materials.

Physical and chemical characteristics: Although the texture of the eolian material forming the hummocks was primarily loamy sand and loamy fine sand, the texture of the fluvial and colluvial material underlying the hummocks was more variable (Appendix 3). The clay content of the hummock materials was twofold or more higher than that of the underlying base material (2C). The pH and $CaCO_3$ content of the turf hummock materials (eolian in origin) are similar to those of the underlying deposits (Appendix 3). This suggests that the eolian material originated from the surrounding surfaces. The organic carbon content is generally lower in the underlying paleo soil horizons (2Bm and 2C) than in the hummock materials, except for the polygons at site 4, which are considered to be an example of the early stage of turf hummock development (Appendix 2). No differences were 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 (Appendix 3).

Radiocarbon dates: Radiocarbon dates of buried organic-rich layers are presented in Table 3 and on the cross sections of the corresponding turf hummocks in Appendix 2. These dates indicate a gradual build-up of the hummock by eolian deposition. The basal date from a hummock at site 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) for turf hummocks on Ellesmere Island.

Table 3. Radiocarbon dates of buried organic-rich layers in turf hummocks in the Green Cabin area.

Site No.	Depth* (cm)	Age (yr BP)	Lab No.
1A	7	450 ± 100	GSC-6812
	22	1030 ± 90	GSC-6809
1B	9	1270 ± 40	Beta-189706
	17	1340 ± 50	Beta-189707
3B	20	1510 ± 70	GSC-6811
	36	2060 ± 70	GSC-6810

* Depths measured from the soil surface at the top of the turf hummock

Zoltai et al. (1978) reported active cryoturbation slightly farther south 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.

Development: A model illustrating the four stages in the development of turf hummocks is shown in Figure 2. Initial development probably begins on either level ground or a surface that is associated with small polygons (stage 1). Vegetation then begins to develop on these surfaces (stage 2). The extent of the vegetation clump or diameter of the small polygon most likely determines the diameter of the hummock. As vegetation becomes established, it begins to trap eolian materials, initiating build-up of the hummock (stage 3). The presence of well-developed, organic-rich layers within the hummocks suggests that periods of heavy eolian deposition buried the surface. These periodic depositions, probably accompanied by some removal of materials from the interhummock area, are then responsible for the development of mature hummocks (stage 4).

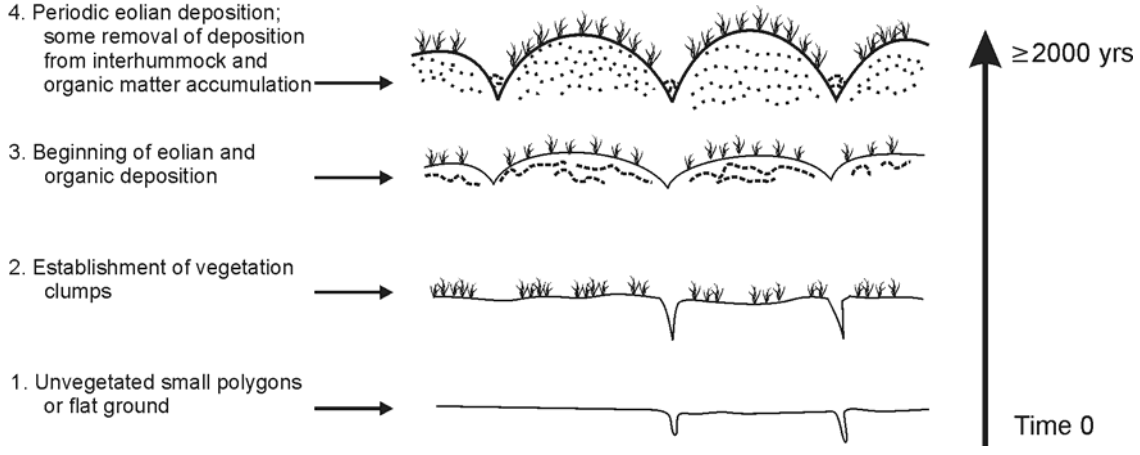


Figure 2. Schematic diagram showing the development of turf hummocks.

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.

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.

Walker, D.A. and others. Unpublished manuscript. Biocomplexity of frost-boil ecosystems: a conceptual model of frost-boil development in relationship to vegetation along the Arctic bioclimate gradient.

Appendix 1. Photographs of Turf Hummocks

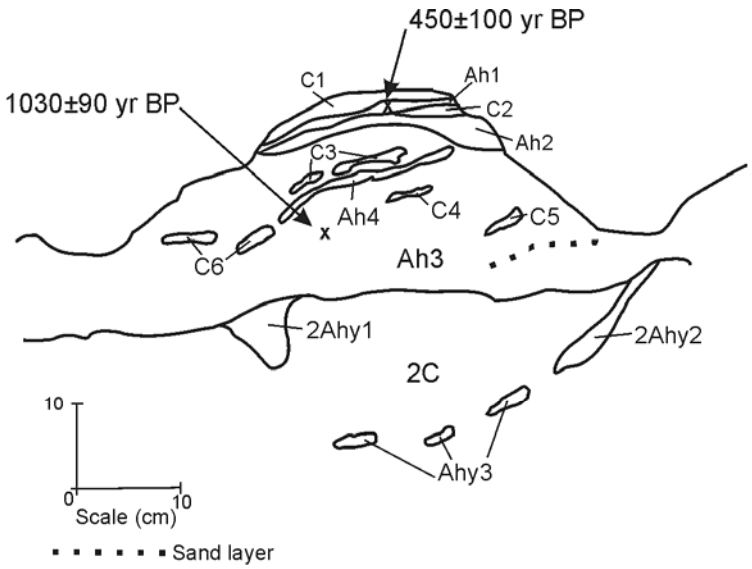
A. Turf hummocks on a slope.

B. Close-up of turf hummocks.

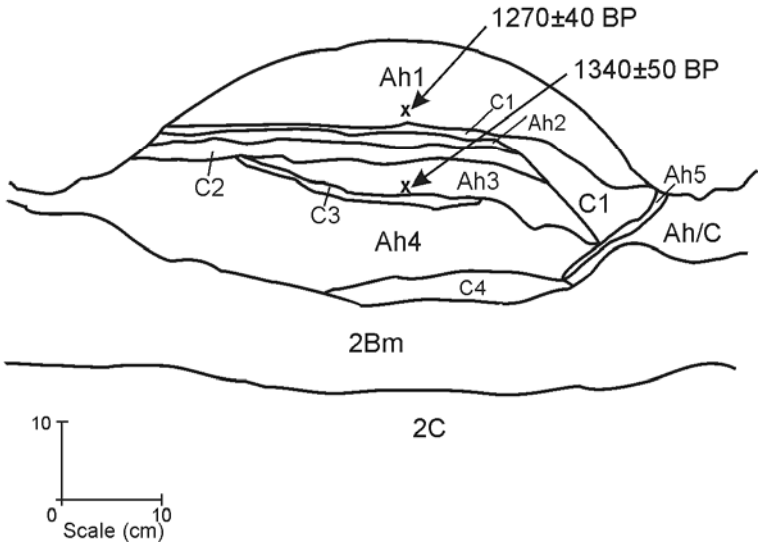
C. Cross section of a turf hummock at site 1B showing the multiple darker organic-rich layers and the underlying fluvial gravelly material.

D. Turf hummocks developed in an active windblown area. The well-developed *Dryas integrifolia* vegetation on the hummocks is responsible for capturing the windblown sand.

Appendix 2. Cross Sections of Turf Hummocks

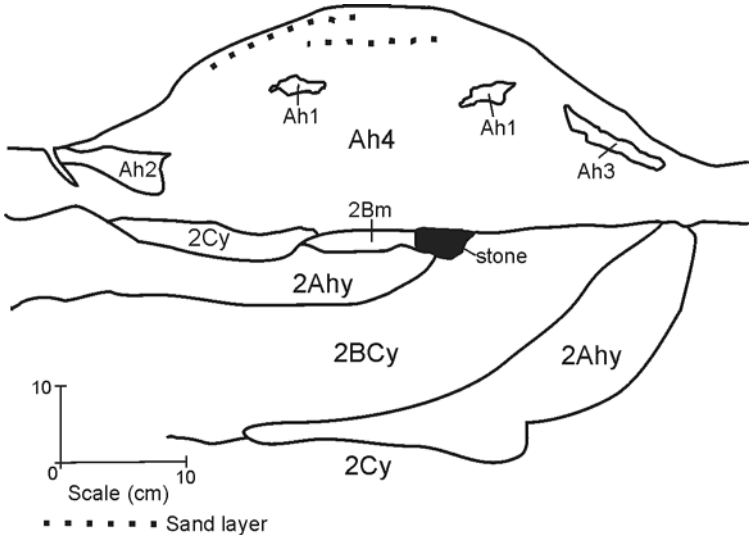


Turf hummock 1A

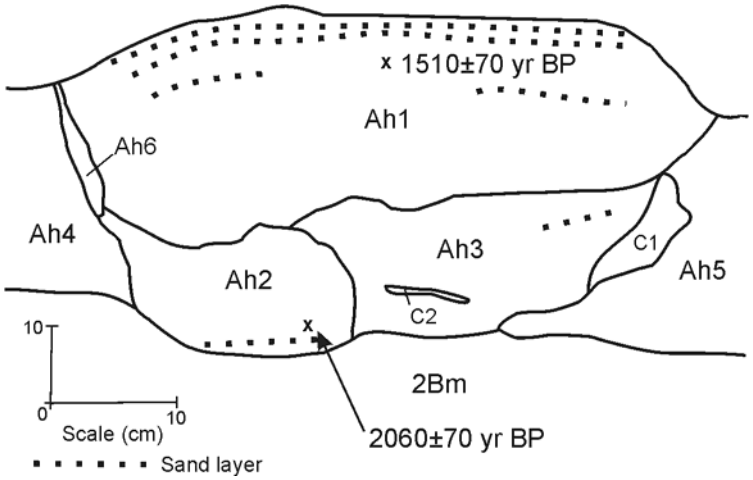


Turf hummock 1B

Appendix 2. Cross Sections of Turf Hummocks (cont.)

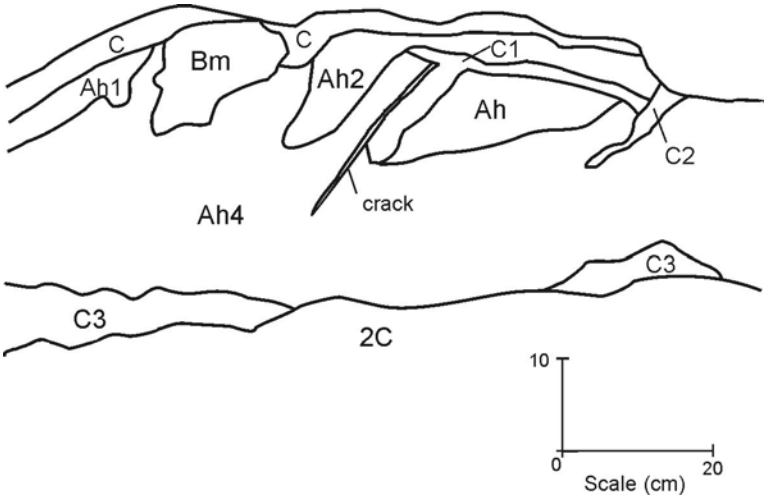


Turf hummock 3A

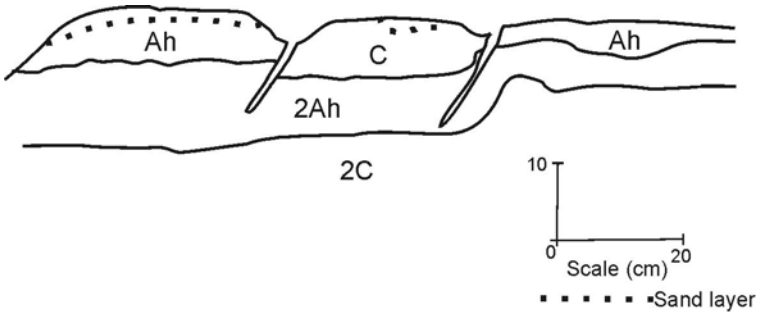


Turf hummock 3B

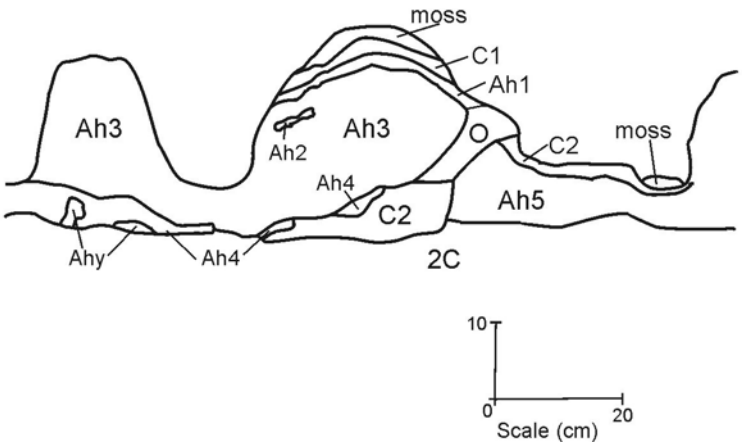
Appendix 2. Cross Sections of Turf Hummocks (cont.)



Turf hummock 2



Turf hummock 4



Turf hummock 5

Appendix 3. Analytical Data for Soils from Turf Hummocks

Physical data

Site	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.

Chemical data

Site	Horizon	pH		Org. C (%)	Tot. N (%)	$CaCO_3$ (%)
		(H_2O)	($CaCl_2$)			
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

Bulk density and moisture content data

Site	Sample No.	Bulk density (g/cm^3)	Moisture* (%)
1A	BD1	1.184	48
	BD2	1.153	46
	BD3	1.296	39
1B	BD1	1.247	43
	BD2	1.299	32
	BD3	1.306	33
	BD4	1.289	34
3B	BD1	1.089	34
	BD2	1.195	44
4	BD1	1.624	24

- on a volume basis

BIOMASS

Aboveground biomass (living and standing dead) was clipped within a 20 x 50 cm frame (0.1 m^2) at each of the relevés sampled in 2003 (see 2003 Data Report for description of relevé locations, site factors and species composition). Biomass clipping included all green moss and green graminoid shoots. Samples were frozen for storage, then sorted by growth form and plant part.

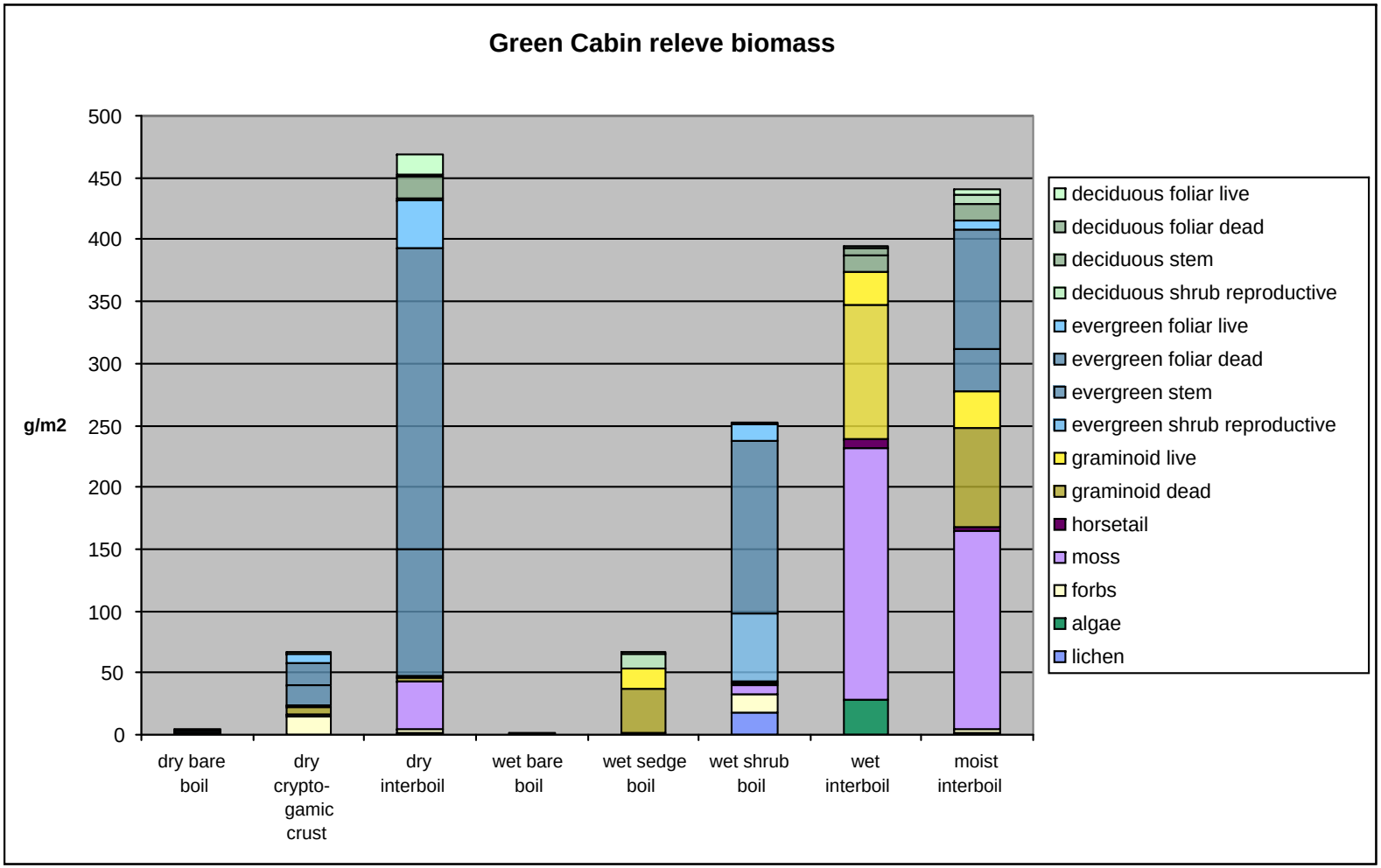


Figure 1. Biomass at different relevé types (g/m^2), Green Cabin, Banks Island, August 2005.

Table 1. Relevé biomass (g/m^2), Green Cabin, Banks Island, August 2005.

Releve #	Decid. live foliar	Decid. dead foliar	Decid. stem	Decid. repro.	E-green live foliar	E-green dead foliar	E-green stem	E-green repro.	Gram. live	Gram. dead	Horse-tail	Moss	Forb	Algae	Lichen	TOTAL g/m2
301	.	.	.	.	0.98	4.54	4.85	.	.	.	.	.	0.64	.	.	**11**
302	.	.	.	.	34.04	84.06	85.33	0.73	0.27	0.44	.	2.47	19.09	.	.	**226**
303	.	0.09	.	.	39.85	166.85	132.13	0.05	3.35	5.42	.	1.47	4.05	.	.	**353**
304	.	.	.	.	.	.	.	.	.	0.06	.	.	2.13	.	.	**2**
305	0.08	.	.	.	0.22	.	0.12	.	1	4.08	.	3.54	28.31	.	0.95	**38**
306	35.79	3.25	19.62	5.64	15.19	247.87	40.49	3.59	.	0.27	.	47.8	.	.	1.07	**421**
307	0.43	0.22	.	.	.	.	.	.	1.94	4.97	.	.	.	.	.	**8**
308	.	.	.	.	.	.	.	.	0.93	4.51	.	.	1.31	.	0.14	**7**
309	.	.	.	.	63.49	213.8	188.3	0.54	.	.	.	61.7	.	.	8	**536**
310	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**0**
311	5.81	0.15	.	.	1.77	1.85	1.94	.	3.52	18.46	.	0.2	0.12	.	0.44	**34**
312	31.57	.	49.69	1.77	37.11	188.07	100.39	.	0.71	1.42	..	20.8	5.9	.	1.08	**438**
313	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**0**
314	.	.	.	.	.	.	.	.	0.57	2.32	.	.	23.07	.	.	**26**
315	8.64	7.18	18.21	0.69	39.88	398.16	50.42	0.42	0.72	1.47	.	63.7	3.04	.	0.06	**593**
316	.	.	.	.	.	.	.	.	0.06	0.28	.	.	1.16	.	.	**2**
317	3.79	2.2	8.64	0.17	9.29	300.1	75.22	0.25	24.4	65.36	6.97	128	0.42	5.53	0.09	**631**
318	2.67	20.7	36.04	.	0.22	0.32	0.3	.	20.2	101.4	11.28	57.2	1.15	25.86	.	**277**
319	0.64	.	0.49	0.12	.	.	.	.	.	.	.	.	.	.	.	**1**
320	.	0.05	.	.	.	.	.	.	.	0.06	.	.	0.8	.	.	**1**
321	0.69	0.57	5.54	.	.	.	.	.	11.7	14.33	0.06	.	.	.	4.38	**37**
322	2.4	.	27.66	.	.	.	.	.	12	42.84	.	.	.	.	.	**85**
323	.	.	.	.	.	.	.	.	25.5	50.77	.	.	.	.	.	**76**
324	0.36	0.07	2.53	.	10.35	167	87.92	0.07	0.1	6.2	.	7.22	13.5	.	35.66	**331**
325	0.86	.	0.29	0.27	19.08	130.94	27.33	0.13	0.33	0.43	.	7.09	27.94	.	0.33	**215**
326	.	.	.	.	8.96	119.51	52.8	.	0.19	0.45	.	9.11	2.72	.	15.85	**210**
327	.	.	.	.	.	.	.	.	27.9	106.5	2.05	196	.	3.57	.	**337**
328	.	0.08	0.25	.	.	.	.	.	34	115.7	9.73	354	.	54.33	0.95	**569**
329	4.93	23.6	29.03	1.34	4.45	70.14	20.19	.	12.7	47.71	3.11	142	3.44	.	.	**363**
330	2.2	5.82	7.48	0.07	4.15	8.14	5.75	0.15	29.4	60.39	0.11	356	.	.	.	**479**
331	3.53	.	9.68	.	10.2	6.48	32.61	.	55.4	148.8	.	16.7	4.08	.	1.69	**289**
332	.	.	.	.	18	114.91	109.82	.	0.84	1.62	.	.	1.36	.	5.15	**252**
333	.	.	0.4	.	13.27	75.25	47.89	0.38	2.38	4.83	.	.	10.73	.	2.63	**158**

N-FACTOR

Anja Kade

Temperature sensors were buried at 1 cm depth in each vegetation type at the three grids at Green Cabin to record data for calculating the N-factor (a measure of insulation).

Table 1. N-factors for nonsorted circles and adjacent tundra plots at the dry, moist and wet grid. The n-factor represents the ratio of the degree-day sum at the soil surface to the air during the growing season (T > 0ºC).

Grid	*Plot type*	*Vegetation cover*	*Vegetation height (cm)*	*N-factor*
GC dry	nonsorted circle	bare	0	1.35
	stable tundra	vegetated	3	1.16
GC moist	nonsorted circle	bare	0	1.31
	nonsorted circle	lichen crust	0	1.33
	stable tundra	vegetated	3	1.12
GC wet	nonsorted circle	bare	0	1.09
	nonsorted circle	*Dryas integrifolia*	1	1.06
	nonsorted circle	*Carex* sp.	5	1.12

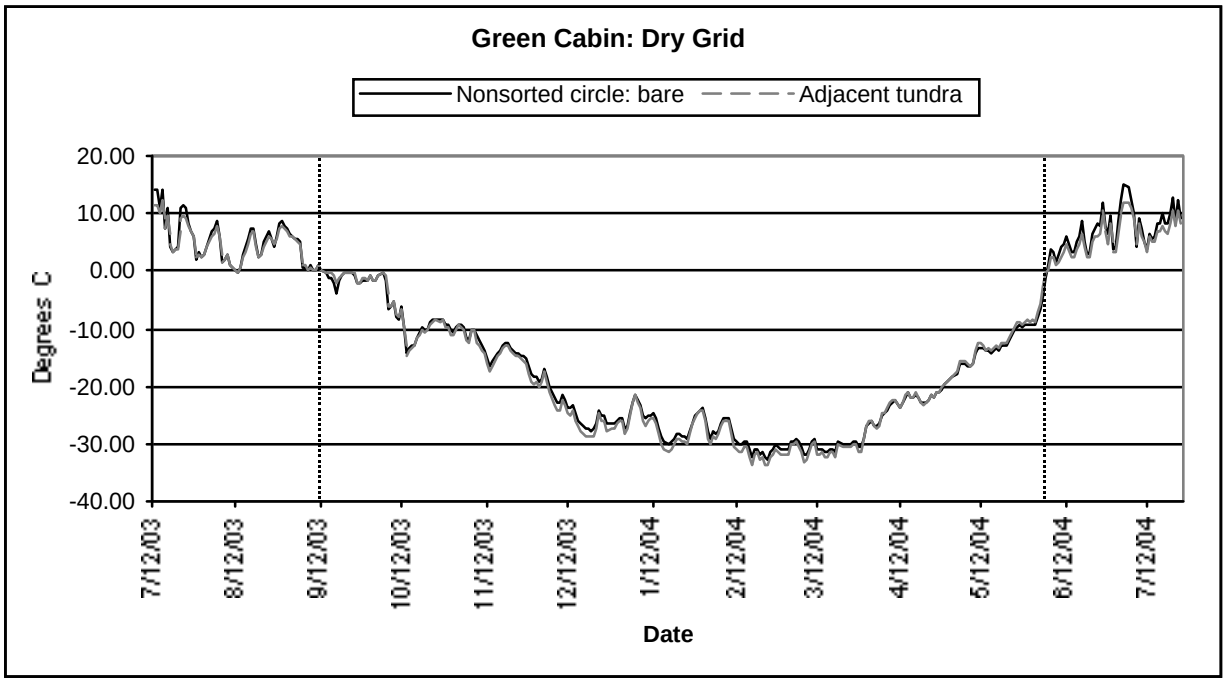


Figure 1. Daily mean soil-surface temperatures (1 cm depth) at the dry grid for bare nonsorted circles and the adjacent tundra. The dotted lines indicate freeze-up (12-Sep-03) and thaw (05-June-04) of the soil surface. Green Cabin, Banks Island, Canada.

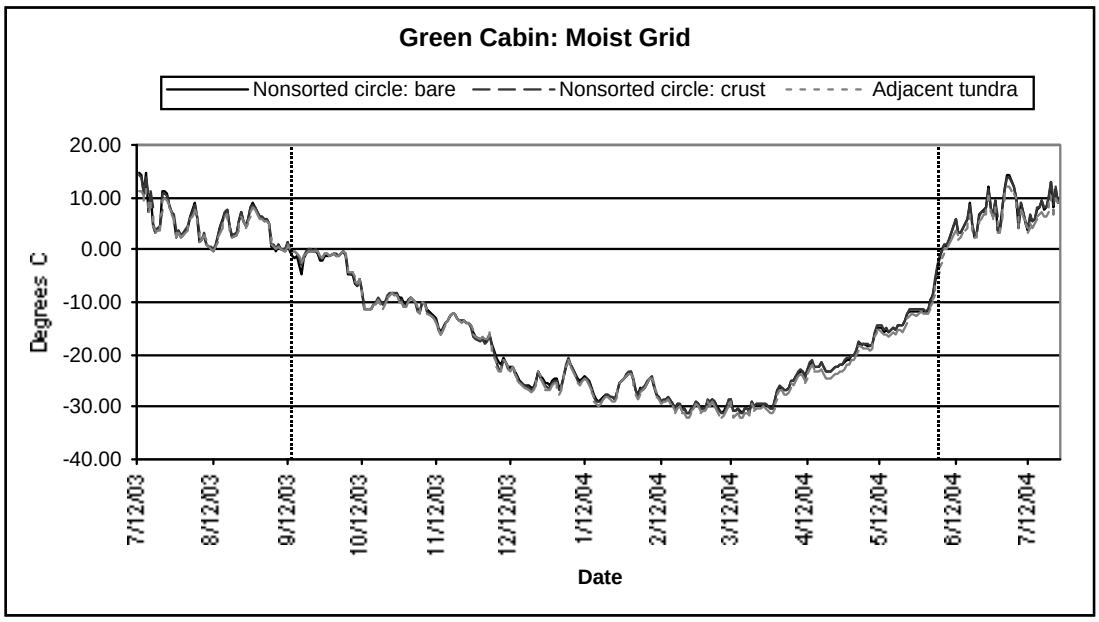


Figure 2. Daily mean soil-surface temperatures (1 cm depth) at the moist grid for bare nonsorted circles, nonsorted circles with a thick lichen crust and the adjacent tundra. The dotted lines indicate freeze-up (13-Sep-03) and thaw (07-June-04) of the soil surface. Green Cabin, Banks Island, Canada.

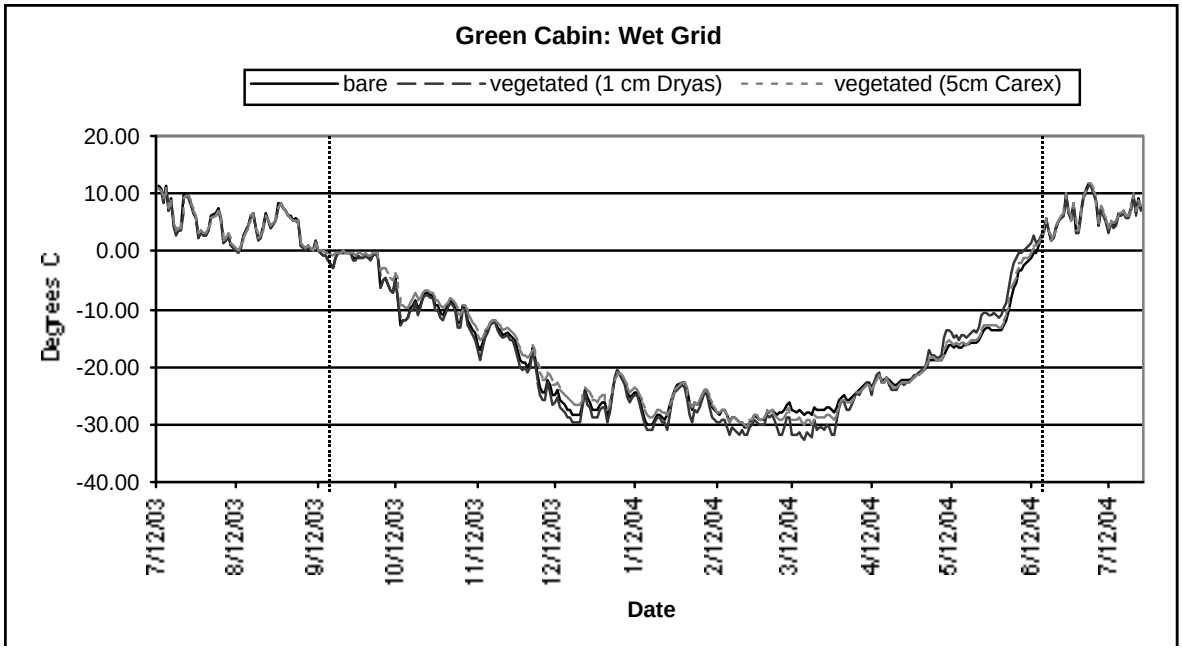


Figure 3. Daily mean soil-surface temperatures (1 cm depth) at the wet grid for nonsorted circles with following vegetation covers: bare, *Dryas integrifolia* (1 cm thick) and *Carex* sp. (5 cm thick). Data for the adjacent wet tundra was not available. The dotted lines indicate freeze-up (13-Sep-03) and thaw (13-June-04) of the soil surface. Green Cabin, Banks Island, Canada.

Temperature summary and data from heave scribers installed at Green Cabin

Vladimir Romanovsky

According to air and soil temperature measurements, the mean annual air temperature in 2003-2004 was -16.1^{o} C. The mean annual soil temperatures ranged between -12.5^{o} C at the frost boil surface and -12.8^{o} C at 1 m depth in the interboil area (Table 1). Soil temperatures lagged behind air temperatueres, with the lag increasing with depth (Fig. 1).Some of the heave rods, especially those in frost boils, may have heaved themselves (not just the scribes), so the readings record the minimum amount of heave.

		2003						2004						
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Air Temp		6.67	3.75	-1.79	-11.48	-21.42	-33.78	-31.16	-37.16	-35.07	-22.83	-12.11	2.40	6.50
InterBoil T	0.22 m	4.54	2.61	0.56	-5.90	-11.41	-20.35	-23.63	-26.34	-27.98	-23.58	-17.50	-2.79	3.96
InterBoil T	0.41 m	2.22	1.40	0.32	-4.70	-10.58	-18.68	-22.44	-25.03	-26.98	-23.51	-18.10	-5.31	1.41
Boil Temp	0.24 m	4.99	2.87	0.57	-5.41	-10.73	-20.19	-23.20	-25.93	-27.17	-23.65	-18.00	-3.10	4.58
Boil Temp	0.42 m	2.38	1.49	0.31	-4.48	-10.03	-18.42	-22.07	-24.65	-26.32	-23.49	-18.49	-5.61	1.47
InterBoil	Surface	7.55	4.43	0.47	-7.89	-13.08	-23.17	-25.44	-28.38	-29.43	-23.56	-16.17	1.55	7.53
InterBoil	0.087 m	6.05	3.40	0.57	-7.12	-12.58	-22.31	-24.82	-27.66	-28.93	-23.50	-16.49	-0.56	5.52
InterBoil	0.137 m	5.37	3.02	0.61	-6.74	-12.30	-21.80	-24.47	-27.27	-28.65	-23.48	-16.67	-1.48	4.72
InterBoil	0.213 m	4.22	2.40	0.58	-6.19	-11.85	-20.98	-23.87	-26.63	-28.14	-23.38	-16.90	-2.81	3.40
InterBoil	0.289 m	3.23	1.86	0.46	-5.72	-11.43	-20.14	-23.25	-25.91	-27.58	-23.28	-17.17	-3.91	2.29
InterBoil	0.363 m	2.24	1.35	0.36	-5.23	-10.98	-19.27	-22.65	-25.23	-27.08	-23.31	-17.63	-5.01	1.23
InterBoil	0.441 m	1.37	0.88	0.24	-4.85	-10.56	-18.37	-21.98	-24.49	-26.48	-23.18	-17.85	-6.01	0.40
InterBoil	0.517 m	0.43	0.40	0.12	-4.67	-10.32	-17.88	-21.62	-24.11	-26.18	-23.14	-18.01	-6.70	-0.32
InterBoil	0.594 m	-0.26	-0.05	-0.08	-4.58	-10.16	-17.53	-21.37	-23.83	-25.95	-23.12	-18.16	-7.25	-0.79
InterBoil	0.745 m	-1.10	-0.60	-0.48	-4.40	-9.82	-16.80	-20.81	-23.24	-25.45	-23.02	-18.37	-8.19	-1.59
InterBoil	0.899 m	-1.90	-1.11	-0.88	-4.30	-9.54	-16.19	-20.32	-22.74	-25.03	-22.93	-18.58	-9.04	-2.36
InterBoil	1.114 m	-3.01	-1.83	-1.44	-4.21	-9.15	-15.31	-19.59	-22.02	-24.38	-22.76	-18.81	-10.16	-3.44
InterBoil	Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Interboil	Flux 1	11.01	6.04	-0.40	-3.17	-2.04	-4.15	-2.76	-3.09	-1.96	0.06	1.51	24.07	16.62
Boil	Flux 2	12.32	4.01	-0.59	-3.05	-1.63	-3.59	-2.14	-2.56	-1.54	-0.25	1.23	23.98	22.01
Snow depth		0.00	0.00	0.01	0.04	0.13	0.13	0.15	0.15	0.15	0.14	0.16	0.04	0.00

Table 1. Temperatures at different depth (degrees C), flux (W/m^2)and snow depth (cm) at frost boil and interboil areas near Grid 1, Green Cabin, Mould Bay, July 2003-July 2004: .

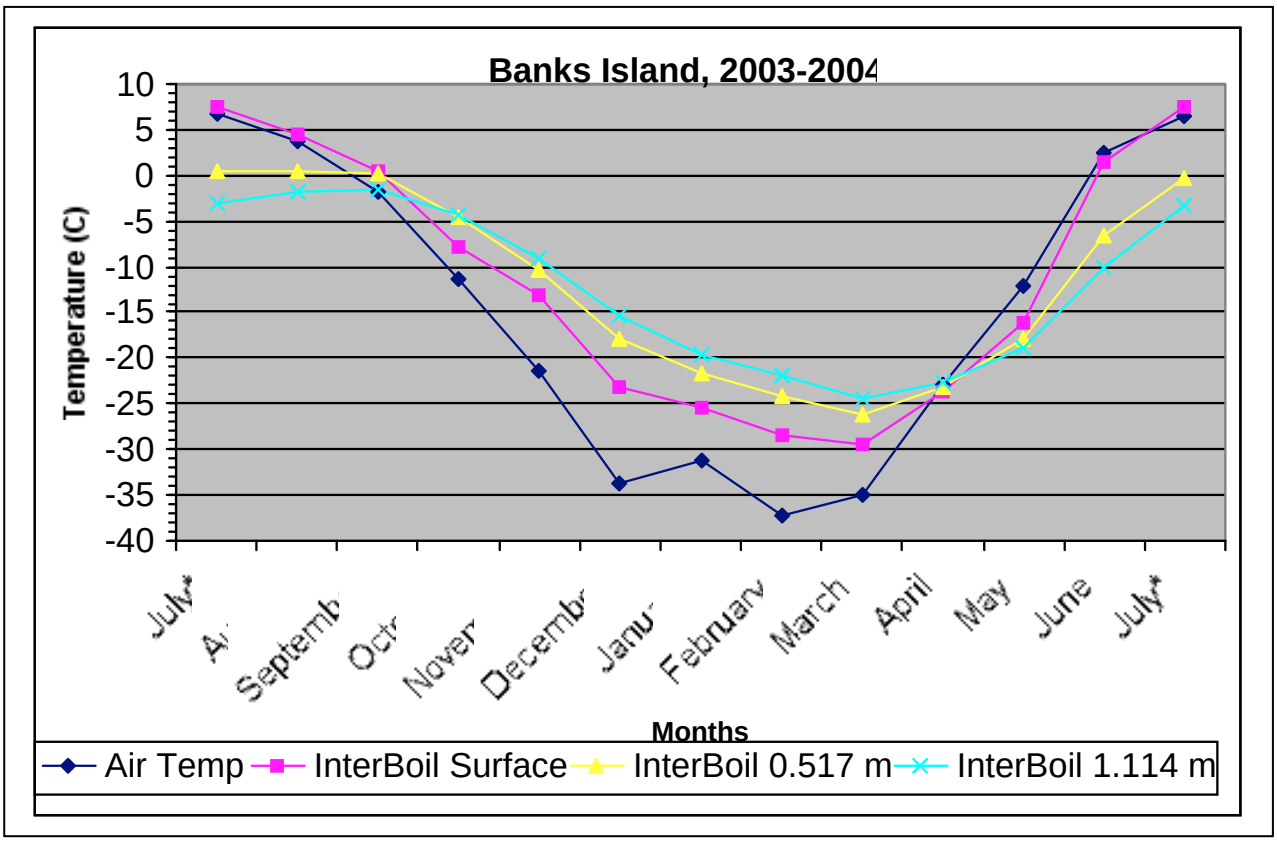


Figure 1. Air and soil temperatures at Green Cabin, Banks Island.

Table 1. Minimum frost heave at Green Cabin, 2003-2004, as measured by heave rods.

Grid	Vegetation cover	Height of heave (cm)	Mean
GC dry & moist	boil	3.4, 3.7, 4.7	3.9
	interboil	1.3, 2.1	1.7
GC wet	center of boil	6.5, 6.5, 8.5	7.2
	edge of boil	1.0	1.0
	interboil	0.3	0.3