Plant Community and Nitrogen Cycling in Arctic Frost-Boil Ecosystems

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Objectives

• We want to understand how cryoturbation and nitrogen cycling interact in frost boil ecosystems, and how this in turn affects the plant communities present in these areas.

• In order to understand the role of temperature in these processes, we want to examine the interactions among cryoturbation, nitrogen cycling, and plant communities across a climatic gradient in arctic tundra.
**VERY Generalized Arctic Nitrogen Cycle**

- **Nitrogen Fixation**: (cryptogamic crusts)
- **Nitrogen Deposition**
- **Active Layer**
- **NH$_4^+$** → **NO$_3^-$**
- **Organic Matter & Microbes**
- **Organic Nitrogen**
- **Mineralization**
- **Immobilization**

**Permafrost**
How does the nitrogen cycle in frost boils differ from inter-boil areas?

<table>
<thead>
<tr>
<th>Inter-boil Areas</th>
<th>Frost Boils</th>
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</thead>
<tbody>
<tr>
<td>• Soils contain more organic matter</td>
<td>• Mineral soil that contain less organic matter</td>
</tr>
<tr>
<td>– More plant available nitrogen</td>
<td>– Less plant available nitrogen</td>
</tr>
<tr>
<td>– Mineralization of nitrogen</td>
<td>– Nitrogen fixation is more important</td>
</tr>
<tr>
<td>– Organic nitrogen</td>
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</tbody>
</table>
Summer 2002

- Total Nitrogen and Carbon
- Rates of net Nitrogen mineralization every two week periods for a six-week period during the growing season and over the winter season
- Normalized Difference Vegetation Index (NDVI)
- Leaf Area Index (LAI)
- Aboveground plant biomass by plant functional type
- Thaw Depth
- Soil Moisture and Temperature
Field Set-up

Inter-Boil

Frost Boil

- NDVI & LAI
- Nutrient Sampling
- Plant Biomass Sampling
Additional Plans

- Nitrogen fixation (via the acetylene reduction assay)
- Organic Nitrogen (Free amino acids)
- Soil respiration
- Carbon and Nitrogen content of plant tissue
Thaw Depth

Thaw Depth (cm)

Happy Valley (Subzone E) South
Sagwon MNT (Subzone D)
Franklin Bluffs (Subzone D)
Howe Island (Subzone C) North

Boil
Interboil
Soil Moisture

Soil Moisture (% Volume)

Boil
Interboil

Happy Valley (Subzone E) South
Sagwon MNT (Subzone D)
Franklin Bluffs (Subzone D)
Howe Island (Subzone C) North
Soil Carbon Content (top 5 cm)

- Happy Valley (Subzone E)
- Sagwon Nonacidic (Subzone D)
- Franklin Bluffs (Subzone D)
- Howe Island (Subzone C)
Soil Nitrogen Content (top 5 cm)

- Happy Valley (Subzone E)
- Sagwon Nonacidic (Subzone D)
- Franklin Bluffs (Subzone D)
- Howe Island (Subzone C)
Analysis to come…

• Inorganic nitrogen, including net nitrogen mineralization
• Aboveground biomass by plant functional group
• Nitrogen Fixation (acetylene reduction)
Canada!

• Similar study along a toposquence in Subzone C
Green Cabin LAI

![Graph showing LAI for Dry, Mesic, and Wet areas with error bars. The graph indicates higher LAI values in the Wet area compared to Dry and Mesic areas.]

- **Dry** LAI values are relatively low.
- **Mesic** LAI values are slightly higher than Dry but still lower than Wet.
- **Wet** LAI values are significantly higher, indicating more vegetation or biomass.
Green Cabin – Soil Moisture

![Bar chart showing soil moisture in different conditions]

- **Dry**: Low moisture levels, with a significant portion of soil in the mesic category.
- **Mesic**: Moderate moisture levels, with a balance between frost boil and inter-boil conditions.
- **Wet**: High moisture levels, with a substantial increase in the inter-boil category.

The chart indicates a notable change in soil moisture conditions from dry to wet, with the wet condition showing a significant increase in the inter-boil category.
Green Cabin – Thaw Depth

![Bar chart showing thaw depth in Green Cabin for Dry, Mesic, and Wet conditions. The chart compares Frost Boil and Inter-boil categories.](image-url)
What’s next?

• The role of nitrogen availability in plant succession on frost boils – Nitrogen addition experiment
• Remote sensing of patterned ground cover across an arctic temperature gradient
• Incorporating frost boils into a vegetation dynamics model – ArcVeg (Epstein et al. 2000)