Vegetation and Cryoturbation Interactions in Alaskan Arctic Tundra

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Introduction

The vegetation pattern in arctic tundra is strongly influenced by the distribution of frost boils (Fig. 1), small landforms typical of many permafrost regions (Walker et al. 2001). Frost heave, caused by ice-lens formation, controls self-organization processes and results in frost boils, which are patterned, circular ground features (Washburn 1980). Once frost boils have formed, they are self-perpetuating in nature. They display tight linkages among vegetation, soil and cryoturbation. In theory, ice-lens formation and the degree of frost heave determine the type of vegetation and quantity of plant biomass that a frost boil can support. Fewer frost-heave disturbances should favor a thicker vegetation mat. In turn, the vegetation mat covering the frost boil should insulate and shade the soil, decreasing heat flux between the soil surface and air, thus decreasing the amount of frost heave.


Fig. 1. Typical frost-boil landscape

Frost boils seem to emerge only under certain environmental conditions and are therefore highly susceptible to environmental change. An alteration of the temperature regime caused by global climate change should result in changes of certain vegetation characteristics. In turn, a change of the vegetation mat and insulation value or a shift in plant functional types on frost boils should alter soil-surface temperature (Peterson and Krantz 1998) and soil-surface stability, cryoturbation activity and other soil characteristics. The following experiment was designed to investigate the influence of certain vegetation characteristics on cryoturbation activity.

Vegetation and Cryoturbation Interactions – An Experimental Approach

LOCATION

A field site near Sagwon Hills, Alaska along the Dalton Highway (mile marker 62) was chosen to experimentally manipulate the vegetation on frost boils. The site is located on the arctic coastal plain, and the vegetation is classified as erect dwarf-shrub tundra (Walker 2000). Twenty-eight well-vegetated frost boils in close proximity were selected and an area of 0.5 m^2 at each frost boil was marked to receive one out of four treatments.

TREATMENTS

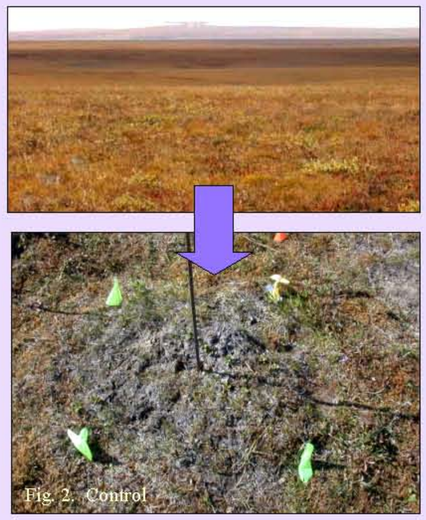
Fig. 2. Control

Control

No manipulation.

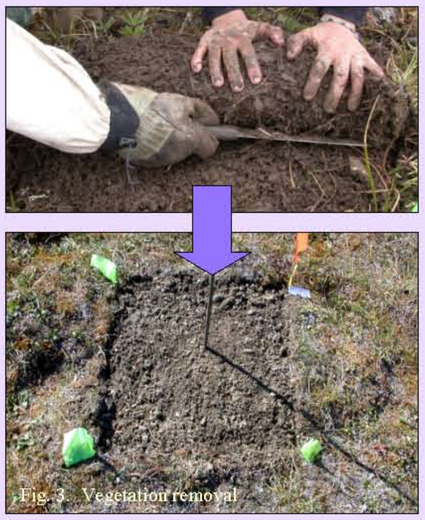
Fig. 3. Vegetation removal

Vegetation Removal

What influence does the lack of plant canopy have on thermal insulation and cryoturbation parameters of frost boils?

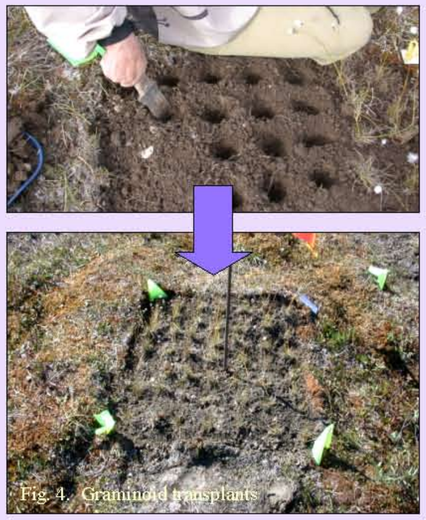
Fig. 4. Graminoid transplants

Graminoid Transplants

How do vascular plants with an extensive root system *(Eriophorum vaginatum)* affect cryoturbation activity?

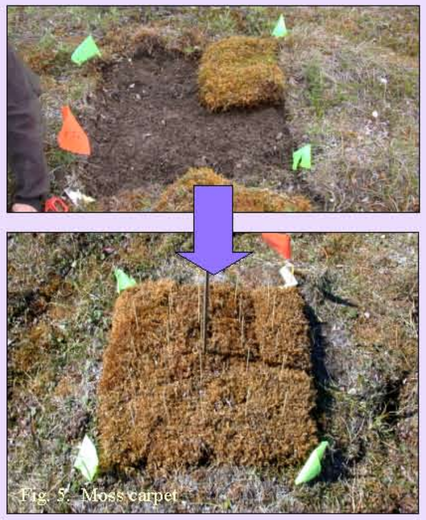
Fig. 5. Moss carpet

Moss Carpet

What effect does a thick moss carpet, transplanted from the surrounding inter-boil areas, have on cryoturbation activity?

RESPONSE VARIABLES

- **Frost heave** – measured along a pole anchored into the ground (Fig. 2 – 5).
- **Active layer & snow depth –** recorded with a probe pushed through the active layer or snow, depending on season.
- **Soil moisture** – determined through spot measurements with a ThetaProbe volumetric soil moisture sensor.
- **Soil temperature –** recorded with data loggers; thermistors placed 2 cm deep in the ground.
- **Soil-surface stability** – indicated by movement of toothpicks inserted halfway into the soil.

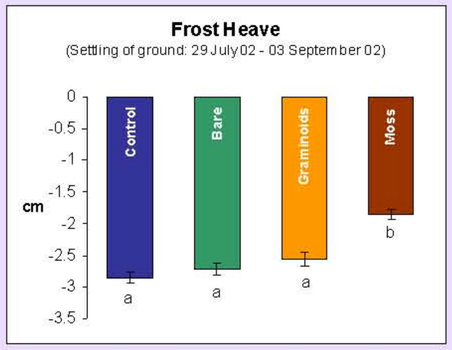

Fig. 6. Frost heave (cm) for control, vegetation removal, graminoid and moss plots 5 weeks after frost-boil manipulation.

PRELIMINARY RESULTS

Data on frost heave and thaw depth were collected five weeks after manipulation of the frost boils. The settling of the ground was most pronounced in the control plots, and control, bare and graminoid plots showed significantly greater settling than the moss treatment (Fig. 6). Similarly, thaw depth was greater for the control and bare plots, less for the graminoid manipulation and least for the moss treatment (Fig. 7). Although the data presented here are preliminary and should be viewed with caution, the moss carpet seems to insulate the frost boil and decrease cryoturbation activity. Vegetation removal might result in an increase in cryoturbation activity, although so far, it did not differ from the control in this respect. This experiment will be monitored over a two-year period and should give reliable results then.

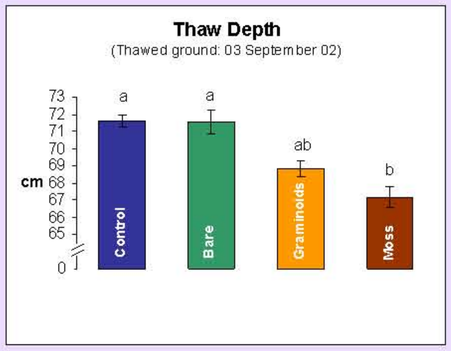

Fig. 7. Thaw depth (cm) for control, vegetation removal, graminoid and moss plots 5 weeks after frost-boil manipulation.

References

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