Insulating Effects of Ground Cover on Soil Temperature at Cripple Creek Diversion, Fairbanks, AK

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Introduction

- Growing season length, soil temperature, and nutrient availability are the main factors limiting boreal ecosystems.
- Northern subarctic boreal forest ecosystems are dominated by mosses that strongly affect temperature and hydrological regimes of the soil and key biological processes.
- Changes in moss layer depth have a substantial impact on the ecosystem's ability to function.
- We analyze moss depth variability and the potential effects on boreal ecosystem function and implications to Cripple Creek Diversion structure.
- Data from our experimental sites demonstrate that any disturbance that results in a decrease in the moss layer depth would relieve temperature and moisture limitations, impacting ecosystem processes.
- Field manipulations include a one-time measurement of soil temperatures at two different depths in a control area (ground cover) & a test site (minimal ground cover) during late fall of 2023. The average temperature and the amplitude of oscillations in the temperature of the soil were directly influenced by the depth of the moss.

Research Question

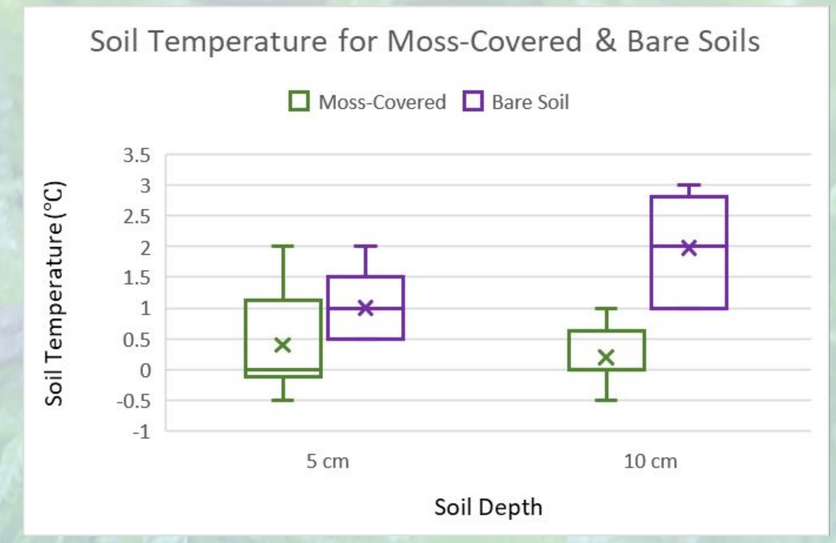
- What effect does moss depth have on soil temperature and active layer thickness?
- Prediction = soil temperature will be lower in areas with greater moss depths and active layer thickness will be less compared to areas with greater areas of exposed soil.
- Based on previous research showing moss as an insulating factor to underlying discontinuous permafrost.
  Null hypothesis = There is no difference in means between moss soil temperatures and bare ground soil temperatures.
- Alternative hypothesis = There is a significant difference in means.

Methods

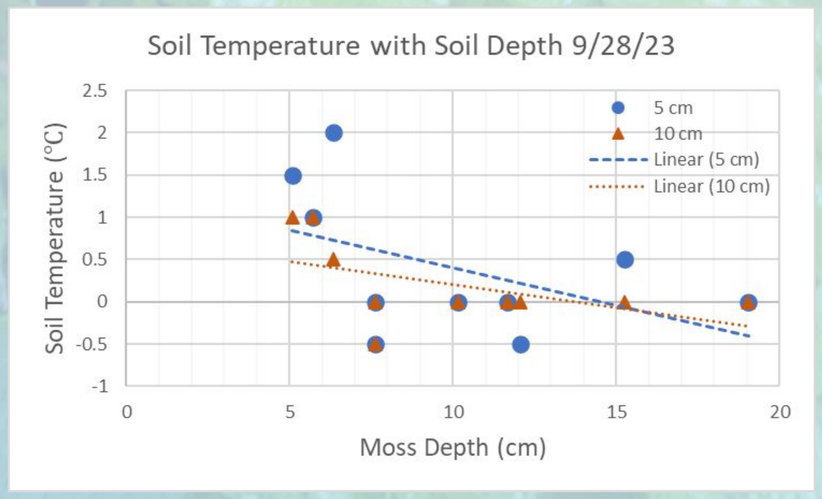
- 2 sample sites to the east and west of Cripple Creek diversion structure with similar tree canopy cover and solar radiation exposure to the ground surface.
- Ground cover varied with 50% average at test site and 25% at control site.
- Data from each site includes:
  - 10 soil temperature samples at 5 cm depth
  - 10 soil temperature samples at 10 cm depth
  - Air temperature
  - Tree canopy cover average
  - Shrub cover average
  - Ground cover average
  - Depth to permafrost (DTP) average
  - 2 soil samples (visual analysis only)
- Data collection followed the GLOBE® protocols for *Biosphere Land Cover, Soil Characteristics*, and *Soil Temperature*. All statistical analysis was performed in Microsoft Excel.

Results

- Soil temperatures, 5 cm depths = Ranged from -0.5 to 2°C for the moss plots and 0.5 to 2°C for non-moss plots.
- Soil temperatures, 10 cm depths = Ranged from -0.5 to 1°C in the moss plots and 1 to 3°C in bare-soil plots.
- No significant difference in soil temperatures at 5 cm, because of high variability (p=0.09). We cannot accept the alternative hypothesis at this depth.
- Significant difference in 10 cm soil temperature means (p=0.002). We reject the null hypothesis and accept the alternative hypothesis at this depth.



Soil temperature measurements collected from moss-covered soil and from bare soil. Soil temperatures were taken at 5 and 10 centimeters below soil surface and are shown in groups on the x-axis. Soil temperatures are shown on the y-axis. Box plots show upper and lower quartiles, means, and medians of soil temperatures in each group.



Moss depth and soil temperatures at Cripple Creek on 9/28/23.

THE GLOBE PROGRAM

Discussion

How did the results meet our expectations?

- Cooler soil temperatures and significant difference in means in mossy site at 10 cm depth

How did the results NOT meet our expectations?

- No significant difference in mean soil temperature at 5 cm depth between sites.

SURPRISE! Other Interesting Finds:

- Greater mean depth to permafrost in moss site (29.7 in.) compared to the site with exposed soil (11.25 in.). If moss insulates, how can we explain contradicting DTP?

Possible explanations/theories:

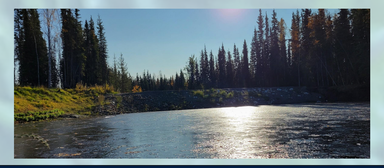
- Visual/physical analysis of soils showed higher moisture content in the moss site than the site with exposed soil. The insulating properties of the soil could be impacted by moisture differences between sites, resulting in deeper thaw beneath the moss site.
- Proximity to the Parks Highway–Historic clearing of the right of way could cause ground to thaw in adjacent forests.

Limitations/Future Research:

- Study may have been impacted by adjacent road/ground disturbance.
- Sites were too similar. Need different forest types (one with moss and the other with zero ground cover present) to effectively control for ground cover as a potential driving force for thermal insulation of discontinuous permafrost.
- Additional research is needed to study moisture content as a possible driver for active layer thickness under certain conditions.

A soil core collected from the mossy site east of the Cripple Creek diversion structure. We estimated soil structure, texture, consistency, color, carbonates, and root and rock quantities (K.Finnesand photo).

- Understanding the integrity of the soil ecosystem and permafrost layer near the Cripple Creek diversion structure is important
- Stable soil temperature ensures integrity of development.
- Thawing permafrost in close proximity to the highway could cause pollution of fish rearing habitat and undo the current restoration work at Cripple Creek.



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The Cripple Creek study site is located on the ancestral lands of the Dene people of the Lower Tanana River. We acknowledge their physical, cultural and spiritual connection to the land and the governing authority of the indigenous tribes.