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Microbial Response to Permafrost Thaw and Coalescence

Michelle Ramirez[1,2], Hannah Woody[2,4], Mario Muscarella[2,3,4]

[1]Biomedical Learning and Student Training [2]University of Alaska Fairbanks [3]Institute of Arctic Biology [4]Department of Biology and Wildlife

Introduction

Permafrost

- **27%** of the Earth's land surface contains permafrost[1].
- Permafrost contains **2X the amount of carbon than in the atmosphere,** when thawed, it releases carbon dioxide (CO_2) and methane (CH_4) known as greenhouse gases (GHGs) creating an **amplifying** (positive) feedback loop[1].
- Permafrost thaw is an ecosystem concern that is impacting human, animal, and environmental health.

Figure 1. A conceptual illustration of permafrost coalescence and the amplification feedback loop.[2]

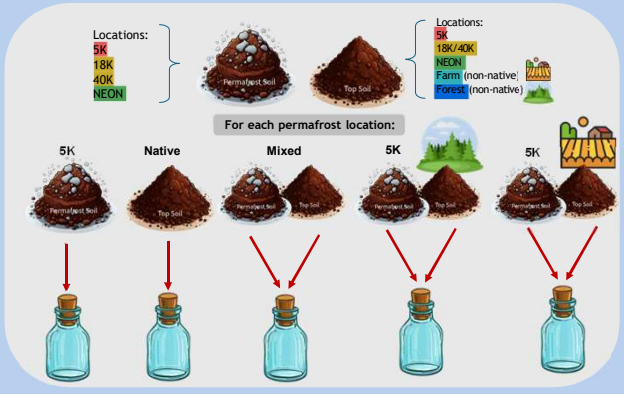
Microbes

- Control carbon, nitrogen, and methane cycling.
- Play an important role in the nutrient cycling, biogeochemical processes, and health of the soil ecosystem.
- Permafrost contains **diverse** microbial communities that may thrive upon thaw depending on moisture, temperature, and oxygen availability.

Coalescence

- Studies have characterized the microbial activity of permafrost soils, but there is a **knowledge gap** of what **new mixture of microbes** that could form or shift when **permafrost and active layer soils mix.**

Methods



Results

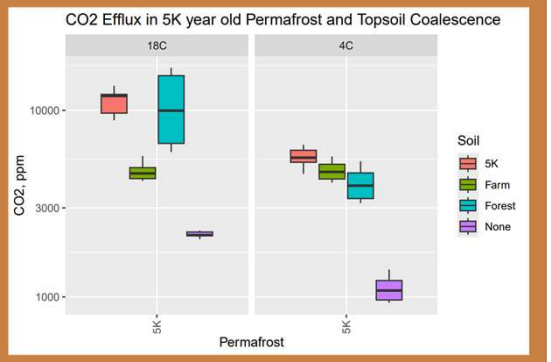


Figure 2. Carbon dioxide efflux in parts per million (ppm) of 5,000 (K) years old permafrost and topsoil sample combinations at 18°C and 4°C using Area Under Curve calculations.

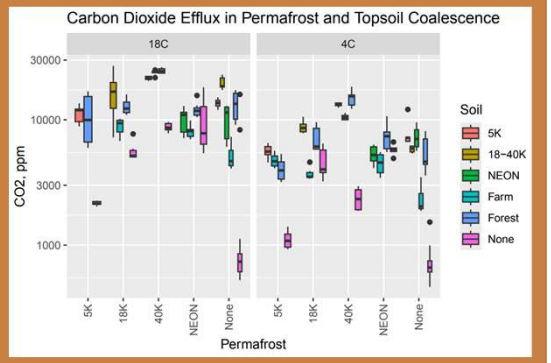


Figure 3. Carbon dioxide efflux in parts per million of permafrost and topsoil sample combinations at 18°C and 4°C using Area Under Curve calculations.

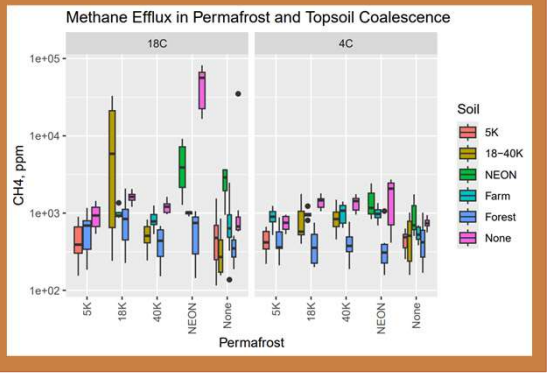
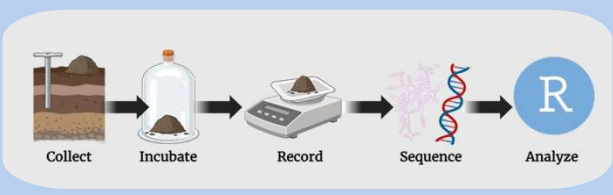


Figure 4. Methane efflux in parts per million of permafrost and topsoil sample combinations at 18°C and 4°C using Area Under Curve calculations.



Results Cont.

CO_2 Observations

- **40K permafrost produces the highest gas efflux.**
- **18°C have higher gas efflux** compared to 4°C.
- **Farm** soils may have **lower** gas efflux compared to other soil types.
- Permafrost alone produces less CO_2, excluding National Ecological Observatory Network (NEON) samples, compared to mixed or topsoil alone.

CH_4 Observations

- At 18°C , NEON permafrost produced **the highest CH_4 efflux**.
- At 18°C and 4 °C, **permafrost samples alone contain higher gas efflux** compared to mixed permafrost and soil.
- Controls are at similar ranges as samples.

Discussion

- **Higher temperatures and older permafrost relate to increased gas efflux** -> permafrost thaw will continue to support the amplifying feedback loop that will release more GHGs.
- Due **to permafrost and differing soil mixtures having varying gas efflux** -> certain microbial communities may have **specific suited conditions** for the organic decomposition of carbon compared to other soils.

Future Steps

- Analyze the microbial diversity and taxa relationship during coalescence.
- Compare response on differing permafrost features

References

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2. Ernakovich, J. G., Barbato, R. A., Rich, V. I., Schädel, C., Hewitt, R. E., Doherty, S. J., Whalen, E. D., Abbott, B. W., Barta, J., Biasi, C., Chabot, C. L., Hultman, J., Knoblauch, C., Vetter, M. C. Y. L., Leewis, M. C., Liebner, S., Mackelprang, R., Onstott, T. C., Richter, A., Schütte, U. M. E., ... Winkel, M. (2022). Microbiome assembly in thawing permafrost and its feedbacks to climate. *Global change biology*, *28*(17), 5007–5026. https://doi.org/10.1111/gcb.16231

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Contact Email: mrramirez2@alaska.edu