Fire Increases Plant-Mediated Methane Flux in Yukon-Kuskokwim Delta Wetlands

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Introduction

The Arctic is experiencing temperature increases in the face of anthropogenic climate change, which increases wildfire frequency and severity.. However, it is unclear how changes in the Arctic fire regime will impact different biogeochemical processes in Arctic ecosystems such as methane (CH_4) release from wetland systems. The release of CH_4 is typically accelerated by a warming climate, creating a positive feedback loop to climate change. In this study, we looked at the role of plant-mediated CH_4 release in tundra wetlands in the Yukon-Kuskokwim (Y-K) Delta and how this pathway of CH_4 emission is affected by fire.

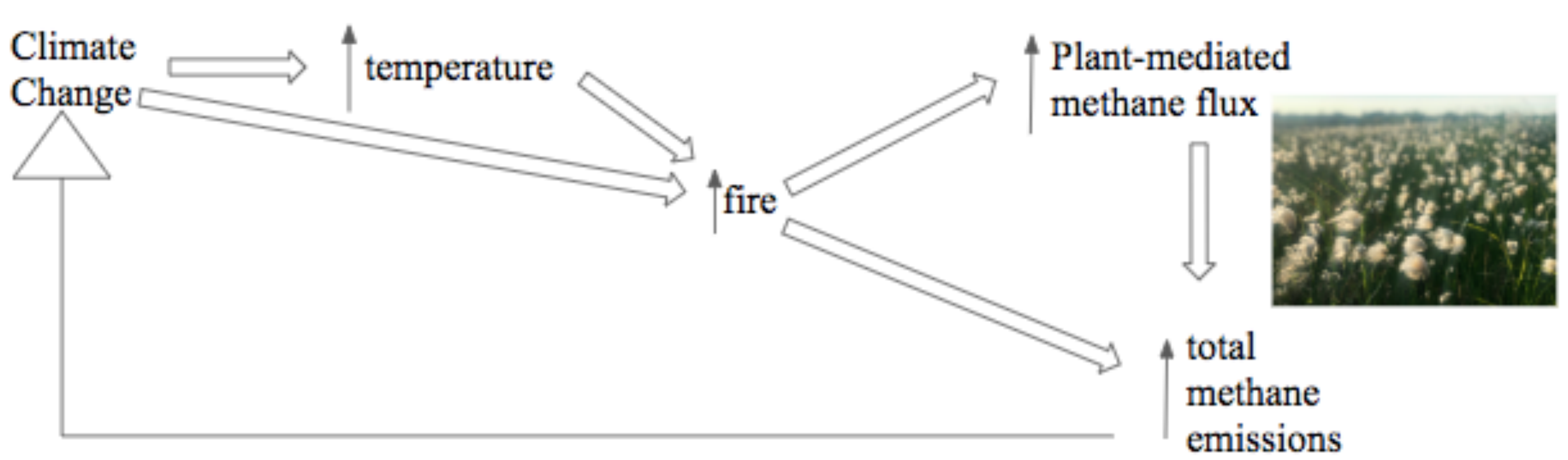


Fig 1. Conceptual model relating plant-mediated methane flux rates to fire and climate change.

Methods

In 2015, the Y-K Delta experienced extensive wildfires. In July 2019, we surveyed two wetlands—one in a burned watershed and one in an unburned watershed— that were dominated by *Eriophorum scheuchzeri* and *Sphagnum spp.* moss.

Experimental design

- Three sample blocks in each of the two wetlands (Figs 2a, 3).
- Three different treatments per block: Uncut *E. scheuchzeri*, Cut *E. scheuchzeri* (clipped to just above *Sphagnum* level), Cut *E. scheuchzeri* with stalks coated in Vaseline to block gas transport (Fig 2B).

Field Work

- CH_4 fluxes measured five times over the course of two weeks using a Los Gatos Research ultraportable greenhouse gas analyzer (LGR) (Fig 2C).
- Plant biomass was harvested and soil cores were collected for lab incubations and analysis.

Incubations

- Soil cores transported frozen to the lab where cores within each block were homogenized.
- 50g of field moist soil were placed into sealed and N_2-flushed jars to maintain anoxic conditions.
- Soil incubations were amended with 5mg C/g soil in the form of sodium acetate or with an equal volume of deionized water (control).
- Soil incubated at room temperature and CH_4 and CO_2 production measured over three days using the LGR.

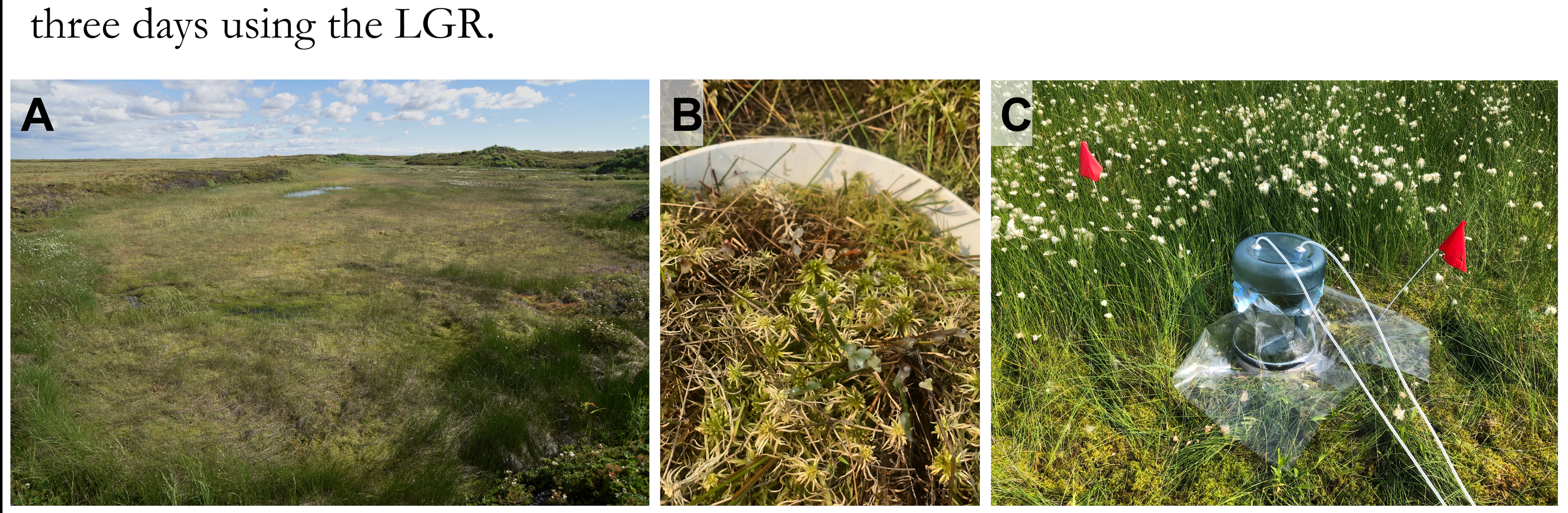
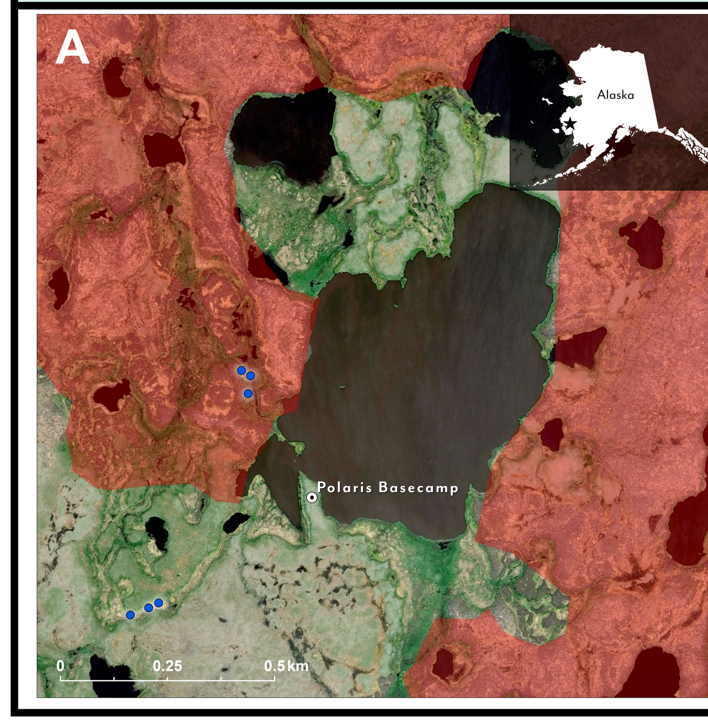


Fig 2. Wetland area (A), cut plants (B), flux chamber (C).

Study Sites



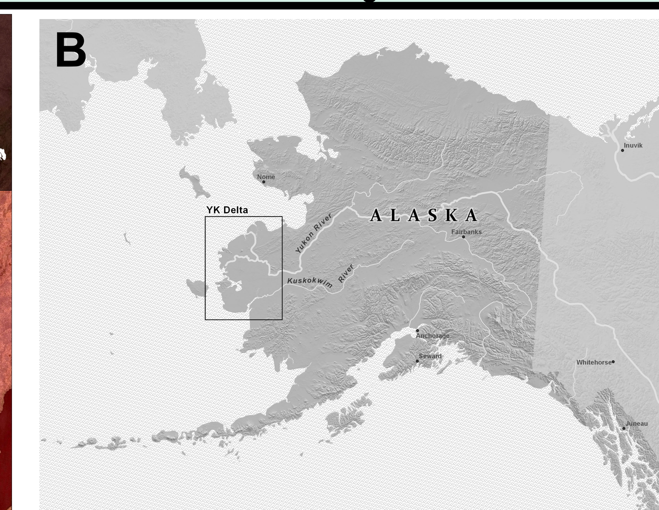


Fig 3. Map of study sites (blue circles) in the Y-K Delta with 2015 burn area indicated in red (A); location of the Y-K Delta (B); aerial view of the Y-K Delta (C).

Results

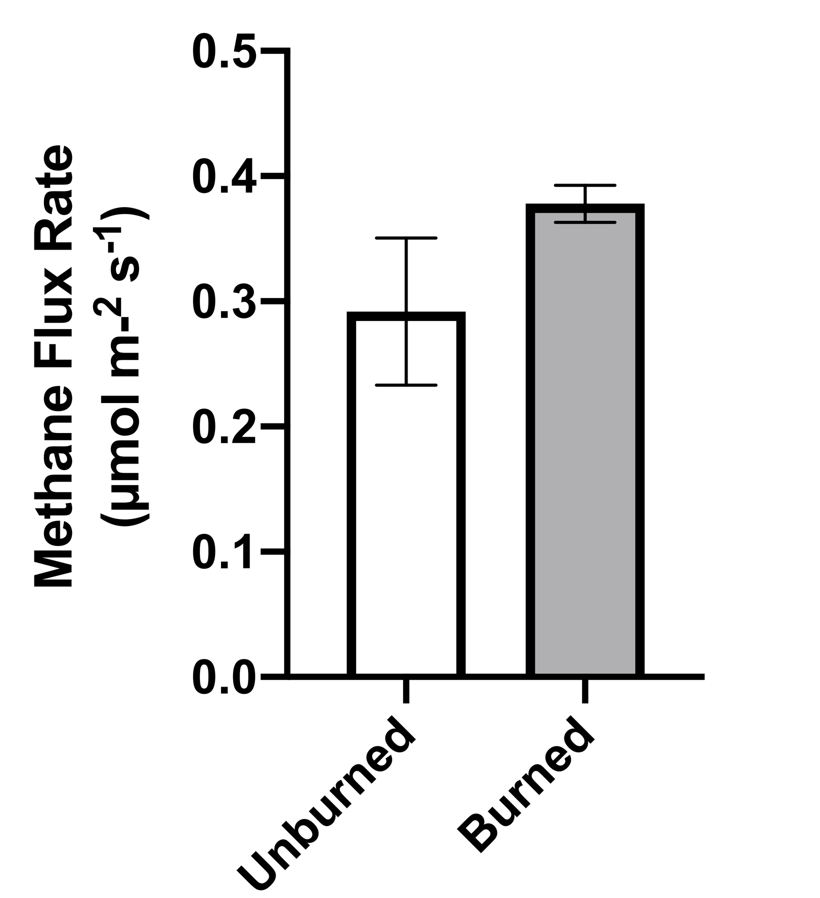


Fig 4. Methane flux rates (mean +/- SEM) were higher in *E. scheuchzeri* in Arctic tundra wetlands (unpaired t-test; p=0.23).

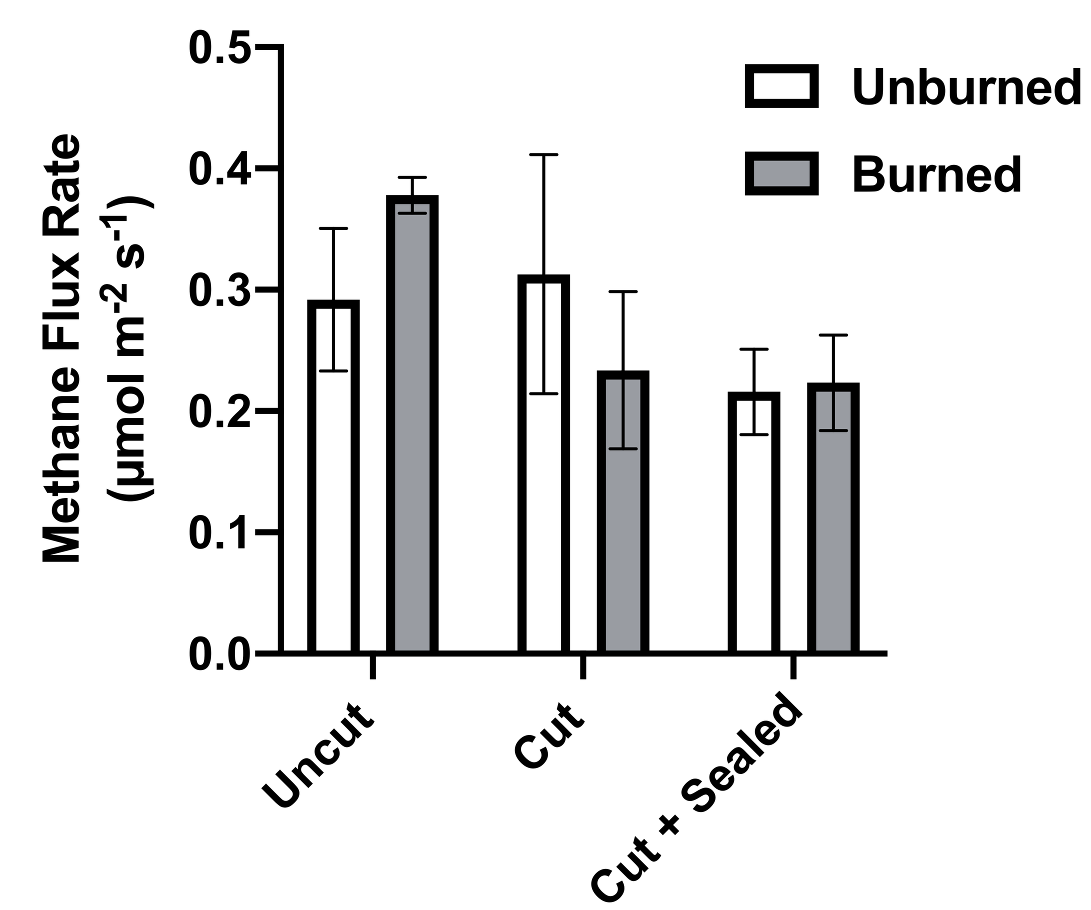


Fig 5. Vegetation removal reduced methane flux rates rates (mean +/- SEM) in *E. scheuchzeri* in the burned wetland but not the unburned wetland.

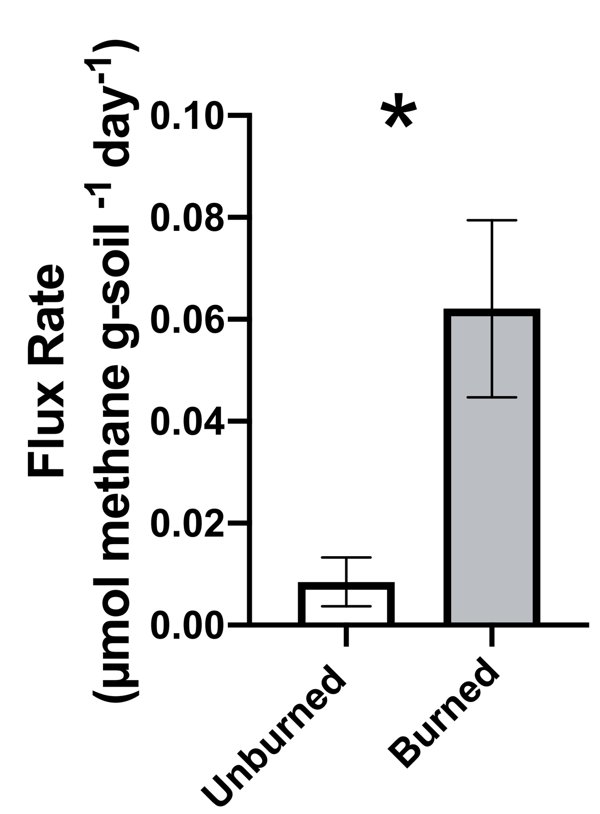


Fig 6. Potential methane production was significantly higher in soil from wetlands draining burned plateaus than wetlands draining unburned plateaus in the Yukon-Kuskokwim Delta, AK (unpaired t-test; p=0.04). * indicates p<0.05.

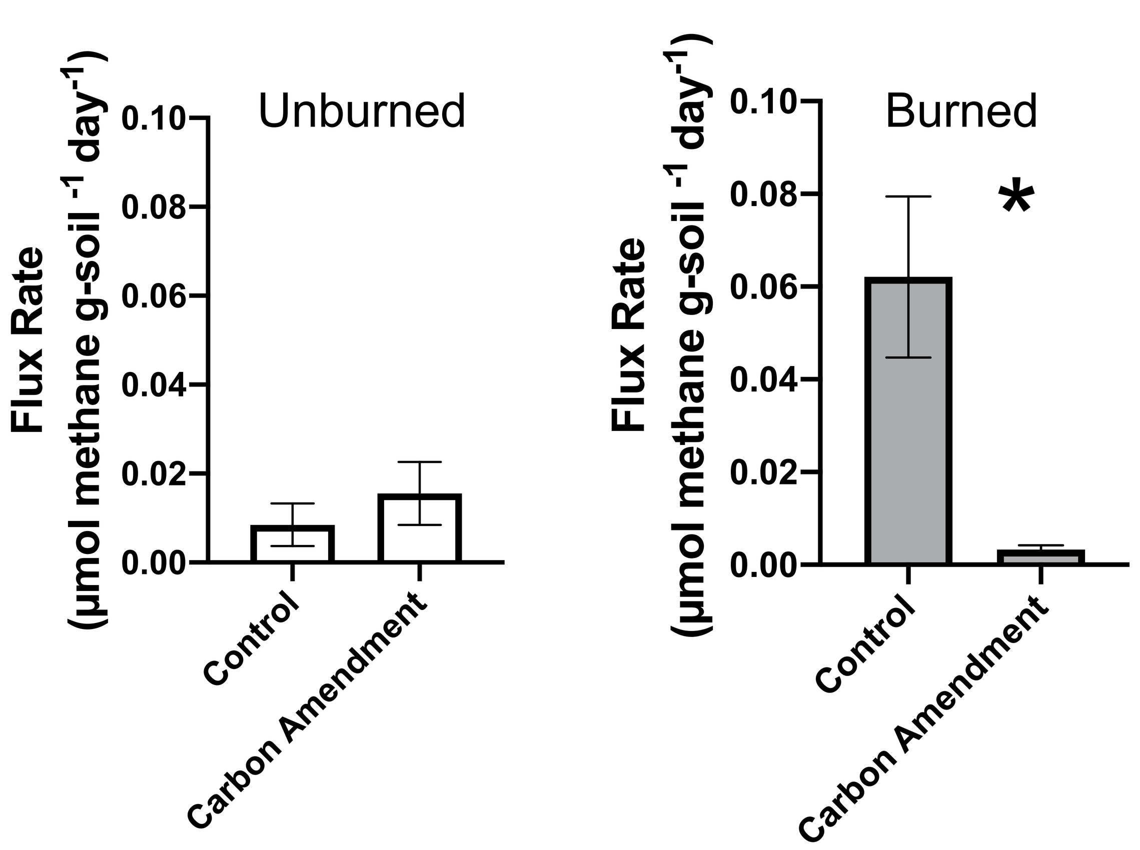


Fig 7. Potential methane production is higher in burned soils (unpaired t-test; p=0.04). Carbon amendment does not significantly change potential methane production in unburned soils (unpaired t-test; p=0.45). Carbon amendment significantly decreases potential methane production in burned soils (unpaired t-test; p=0.028). * indicates p<0.05.

Discussion

Figure 4

- *E. scheuzeri*-mediated methane emission is a potent source of methane release in Arctic tundra wetlands.
- Fire increases methane flux rates from *E. scheuzeri* in Arctic tundra wetlands.

Figure 5

- Vegetation removal reduced flux rates in the 2015 burn but not in the unburned wetland.
- Fire may affect the pH, carbon composition, organic matter, and nutrients of wetland ecosystems and these differences could explain the differences in plant response to treatment.

Figures 6 & 7

- Fire increases potential methane production from soil in Arctic tundra wetlands (Fig 6).
- There was no significant difference in potential methane production in unburned soils following carbon amendment though it trended toward increasing (Fig 7).
- Carbon amendment resulted in a significant decrease in potential methane production in burned soils suggesting a shift in metabolic activity of microbial communities (Fig 7).

Conclusions

Our results suggest that fire increases plant-mediated methane flux rates and potential methane production in Arctic tundra wetlands. This could contribute to a positive feedback loop that increases the vulnerability of these ecosystems to future fires. Climate warming is also increasing plant biomass in the Arctic. More biomass of plants capable of transporting methane from the soil into the atmosphere may further increase methane emissions in these tundra ecosystems.

Future Work

- Incubations looking at factors driving microbial metabolic activity in soils from areas with different burn history.
- Affect of fire on microbial community metabolism and size.
- Analyzing organic acid (OA) content within each wetland area and relating the availability of this type of substrate to the production of methane.
- Investigating the relationship between *E. scheuzeri* biomass and methane flux rates in Arctic tundra wetlands.

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