

# Impacts of Rapidly Collapsing Permafrost Thaw on Carbon Dioxide and Methane Emissions in Stordalen Mire, Sweden

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## Research Question

How does time since thaw alter emissions of CH<sub>4</sub> and CO<sub>2</sub> from a collapsed permafrost mire?

## Background

- Northern wetlands are a significant source of methane (CH<sub>4</sub>)<sup>1</sup>.
- As the region warms permafrost thaw is accelerated, and wetlands are becoming more widespread<sup>2</sup>.
- Here we investigated the impacts of collapsing permafrost on CH<sub>4</sub> and CO<sub>2</sub> emissions across a thaw gradient at Stordalen Mire
- We sampled a permafrost thaw gradient from palsa (intact permafrost) to fen (completely thawed with a high water table).

## Study Design

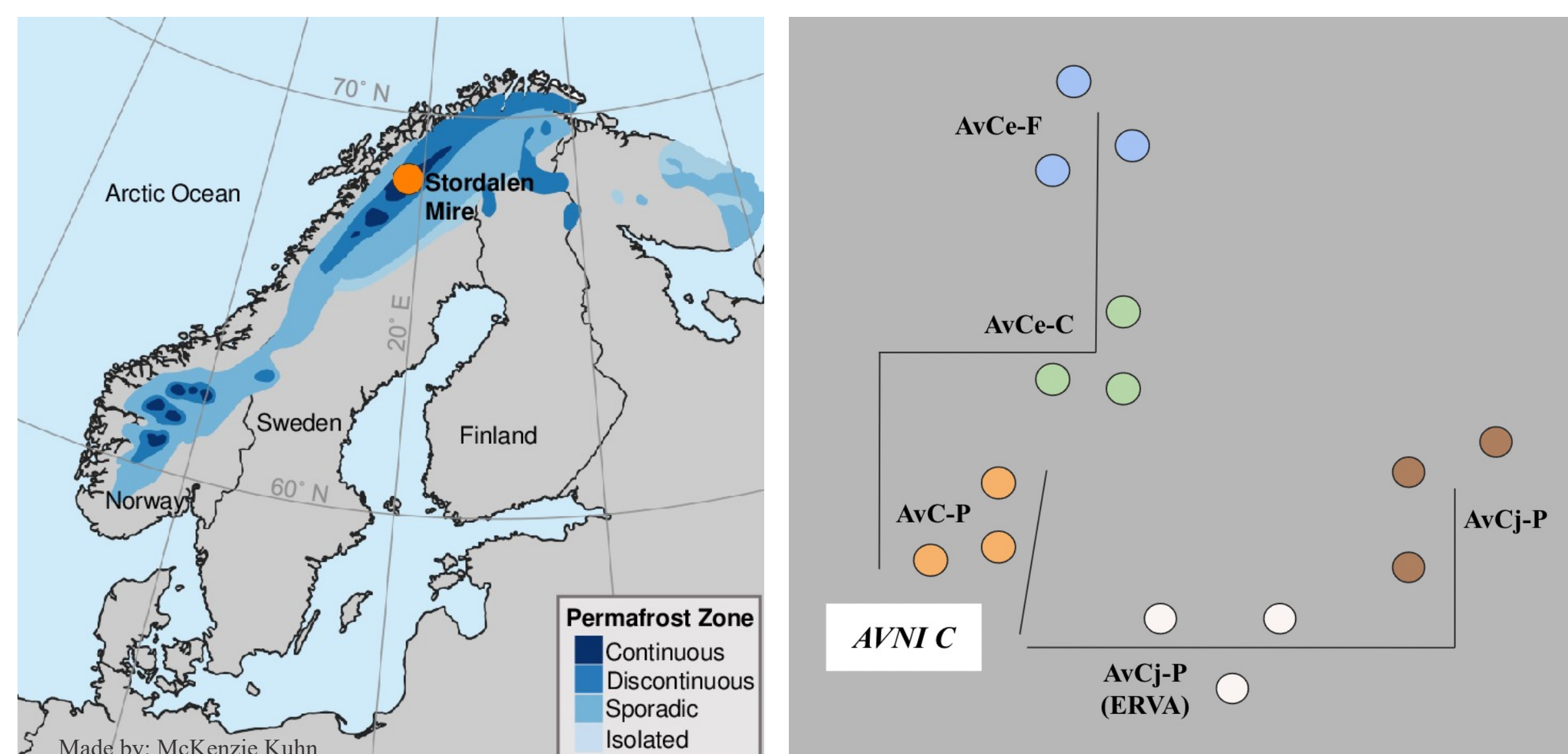
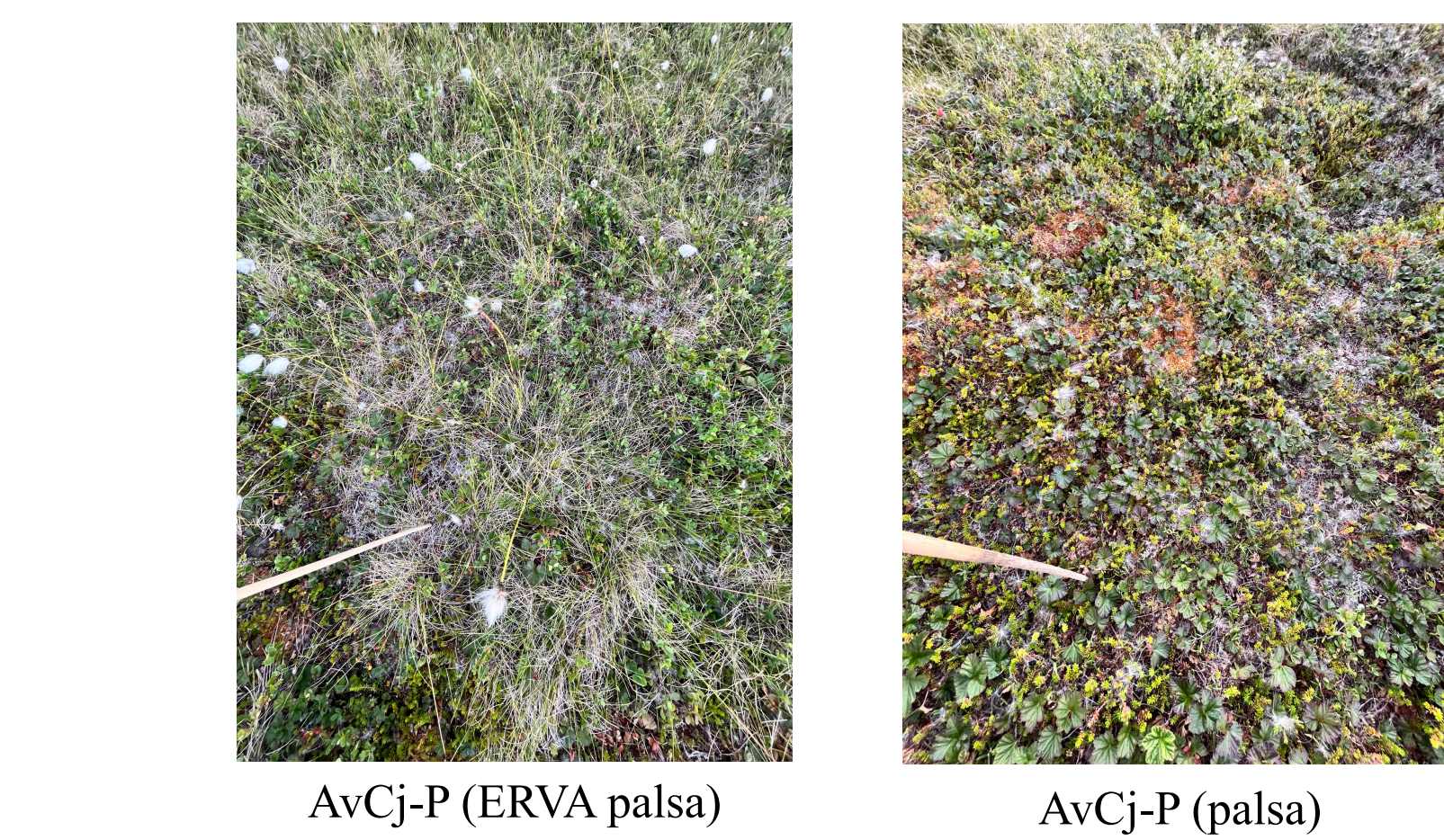
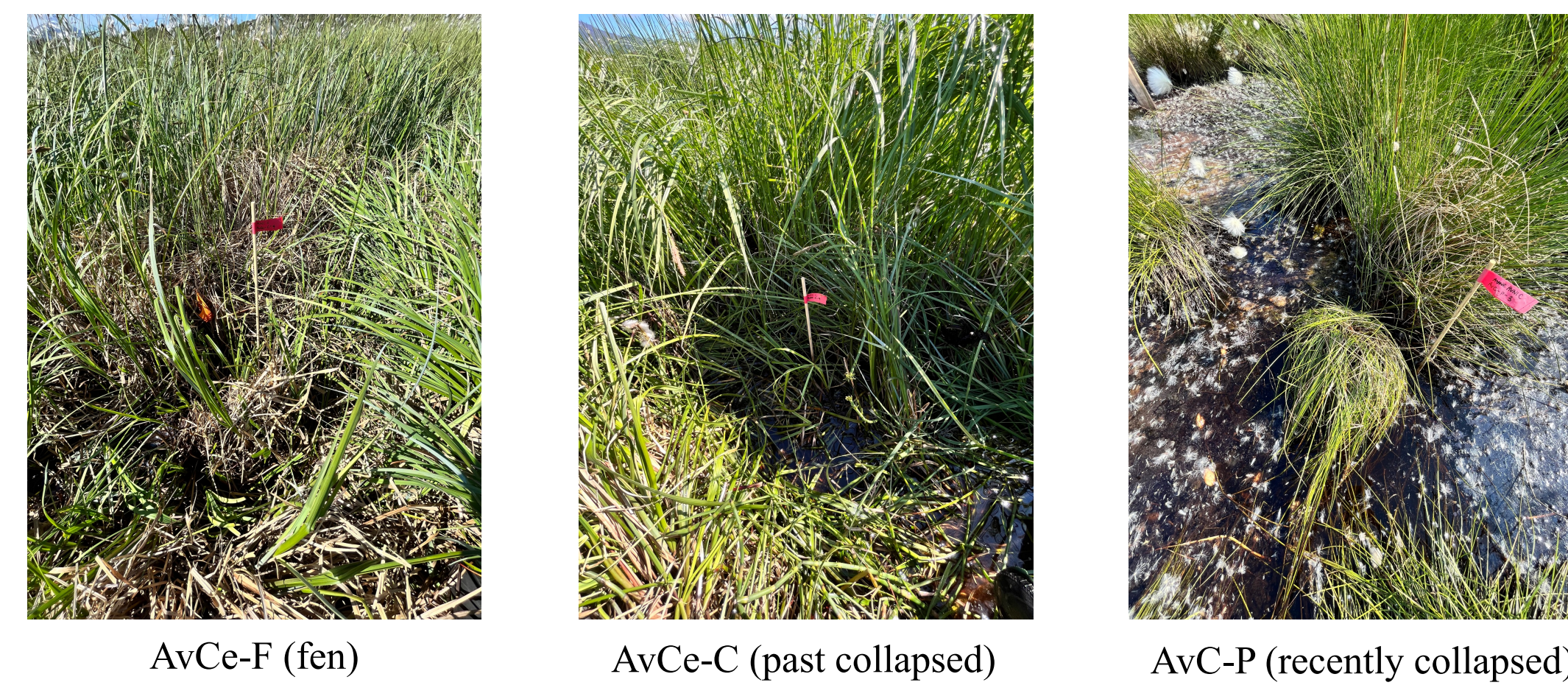


Figure 1. (left) Study Region located within the Arctic Circle of Northern Sweden | Stordalen Mire  
 Figure 2. (above) Avni C study design & collar locations

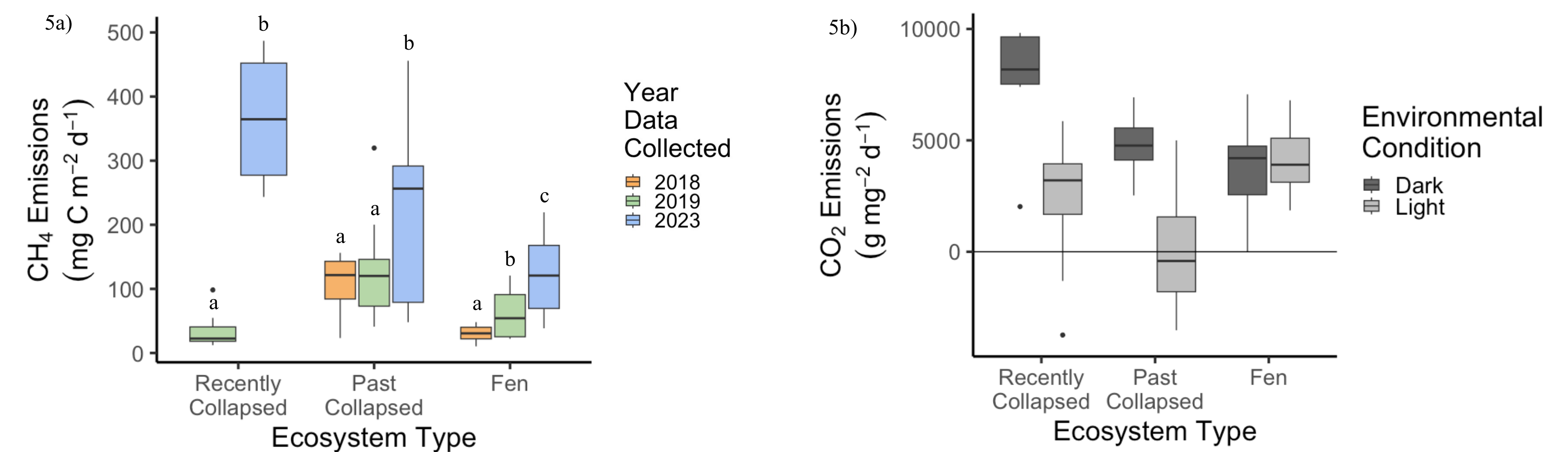
## Methods



- Using a LICOR gas analyzer (pictured right), LI-7810, we measured in situ CH<sub>4</sub> and CO<sub>2</sub> at pre-installed collars.
- Environmental variables were measured at each collar, including soil/air temp, PAR, active layer depth, water table depth, and vegetation cover/type.
- Light and dark measurements were taken at each subsite to account for both photosynthesis and soil respiration and its respective effects on gas uptake and production.

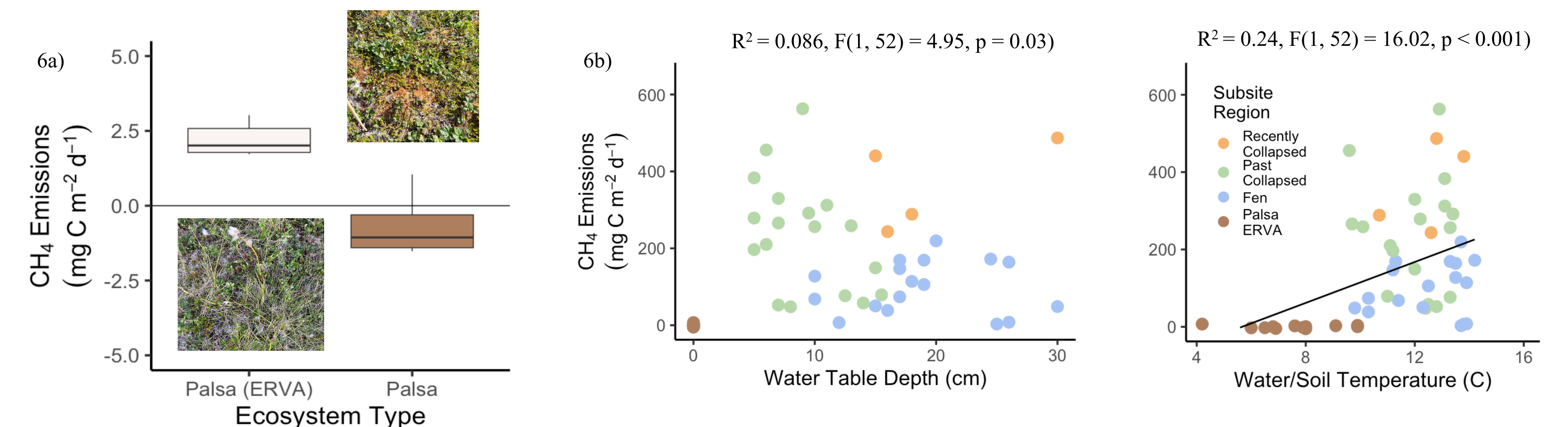


## Results: High CH<sub>4</sub> emissions from recently collapsed palsas decrease over time



Figures 5a-b. (a) CH<sub>4</sub> emissions are higher than 2018 and 2019 emissions ( $p < 0.001$ ) and decrease with time, since collapse. (b) ecosystem respiration was highest at the recently collapsed side ( $p > 0.05$ )

- CH<sub>4</sub> emissions have increased across all sites since 2018, with the highest emissions from the recently collapsed palsas
- CO<sub>2</sub> fluxes are more variable than CH<sub>4</sub>, with recently collapsed palsa sites producing the most CO<sub>2</sub>



Figures 6a-b. (a) CH<sub>4</sub> emissions across palsa sites, letters above the boxplots signify significant statistical differences ( $p < 0.001$ ). (b) CH<sub>4</sub> emissions across all sites regarding water table depth, positive values indicating a water table above the ground surface, and temperature

- Palsa sites dominated by *Eriophorum vaginatum* had net positive CH<sub>4</sub> emissions while **shrub dominated** palsa sites had net CH<sub>4</sub> uptake likely due to dryer soil conditions
- Shrub and peat dominated palsas had CH<sub>4</sub> uptake due to drier soil conditions and availability of labile carbon
- Increased water table depth and water temperature correlate to higher CH<sub>4</sub> emissions, with CH<sub>4</sub> emissions being highest in the recently collapsed palsas that have a bigger water table and warmer temperatures.

## Conclusions

- Within the last 5 years, CH<sub>4</sub> emissions at our sampling transect has increased due to palsa collapse, leading to high water tables and dominant sedge vegetation
- However, over time CH<sub>4</sub> begins to decrease in these collapsed features, potentially signifying microbial communities and vegetation are adjusting or labile carbon is used up over time
- Soil CO<sub>2</sub> respiration followed a similar pattern as CH<sub>4</sub> emissions, with the highest emissions from the recently thawed site
- Higher CH<sub>4</sub> emissions in *Eriophorum* dominated palsas, suggest influence of microhabitat variation on differences in source or sink emissions

### Acknowledgements

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### References

<sup>1</sup> Malmer et al. (2005), <sup>2</sup> Malhotra and Roulet (2015), <sup>3</sup> Perryman et al. (2019)



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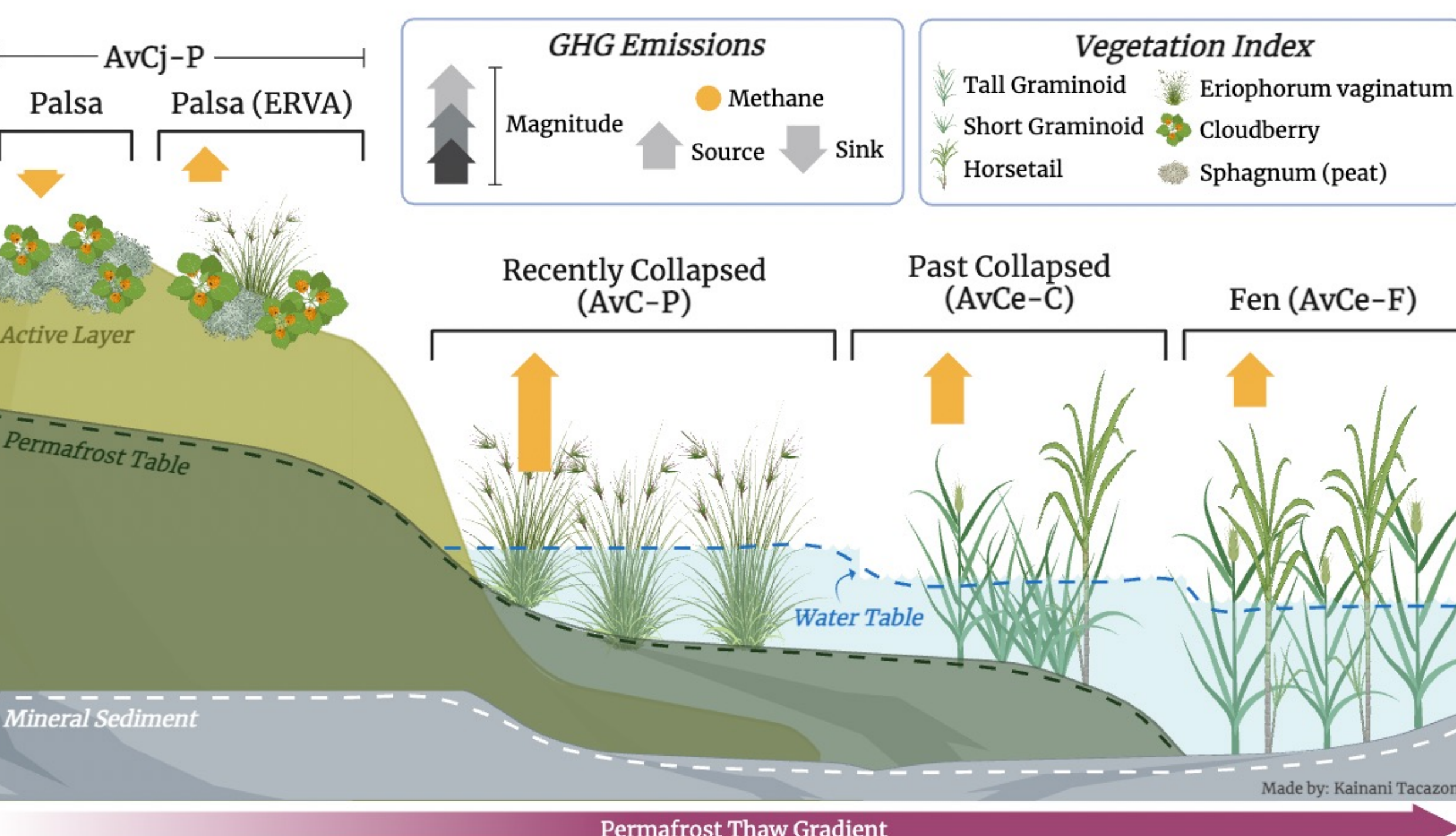


Figure 3. Avni C microclimate characteristics with predicted CH<sub>4</sub> emissions. Collars located in the collapsed and fen sites were installed in 2018.