

Mapping Potential Carbon Emissions from Soils and Sediments in the Yukon-Kuskokwim Delta

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Introduction

Permafrost regions store ~1300-1600 Pg of carbon, which is estimated to be half of the global belowground organic carbon pool and about two times the global atmospheric carbon level. (Zhang et al. 2003, Hugelius et al. 2014). As the climate warms, microbes become more active and more organic compounds become available, resulting in increased decomposition and carbon gas emission (Jansson & Tas, 2014). Understanding the amount and composition of organic carbon stored in permafrost regions is crucial for quantifying feedbacks from permafrost carbon on global climate change.

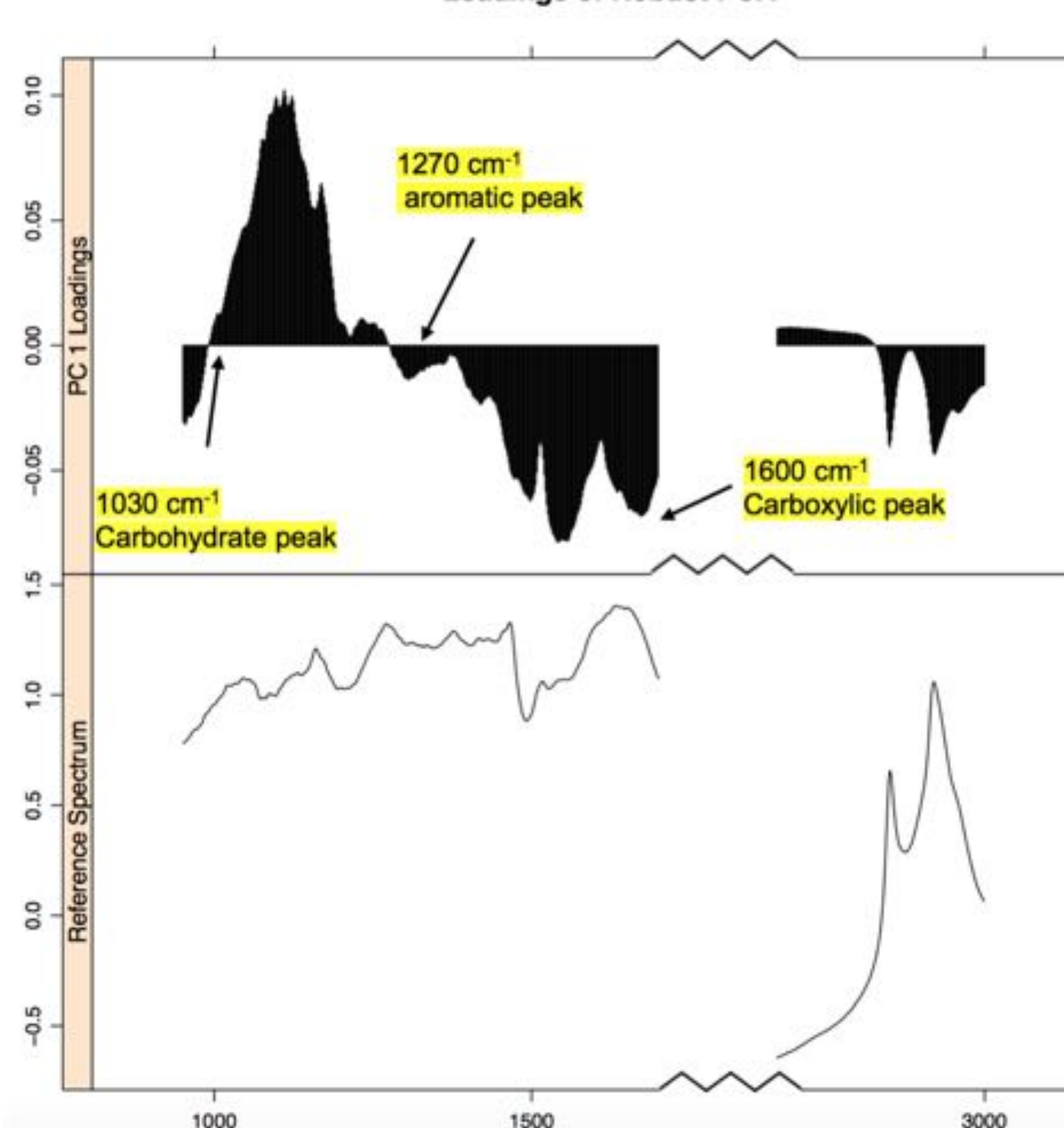
To address this uncertainty, we investigated carbon pools and composition across different landcover classes in burned (2015, 1972) and unburned areas of the Yukon-Kuskokwim Delta (YKD) in Alaska to determine the vulnerability of carbon across the landscape.

Methods

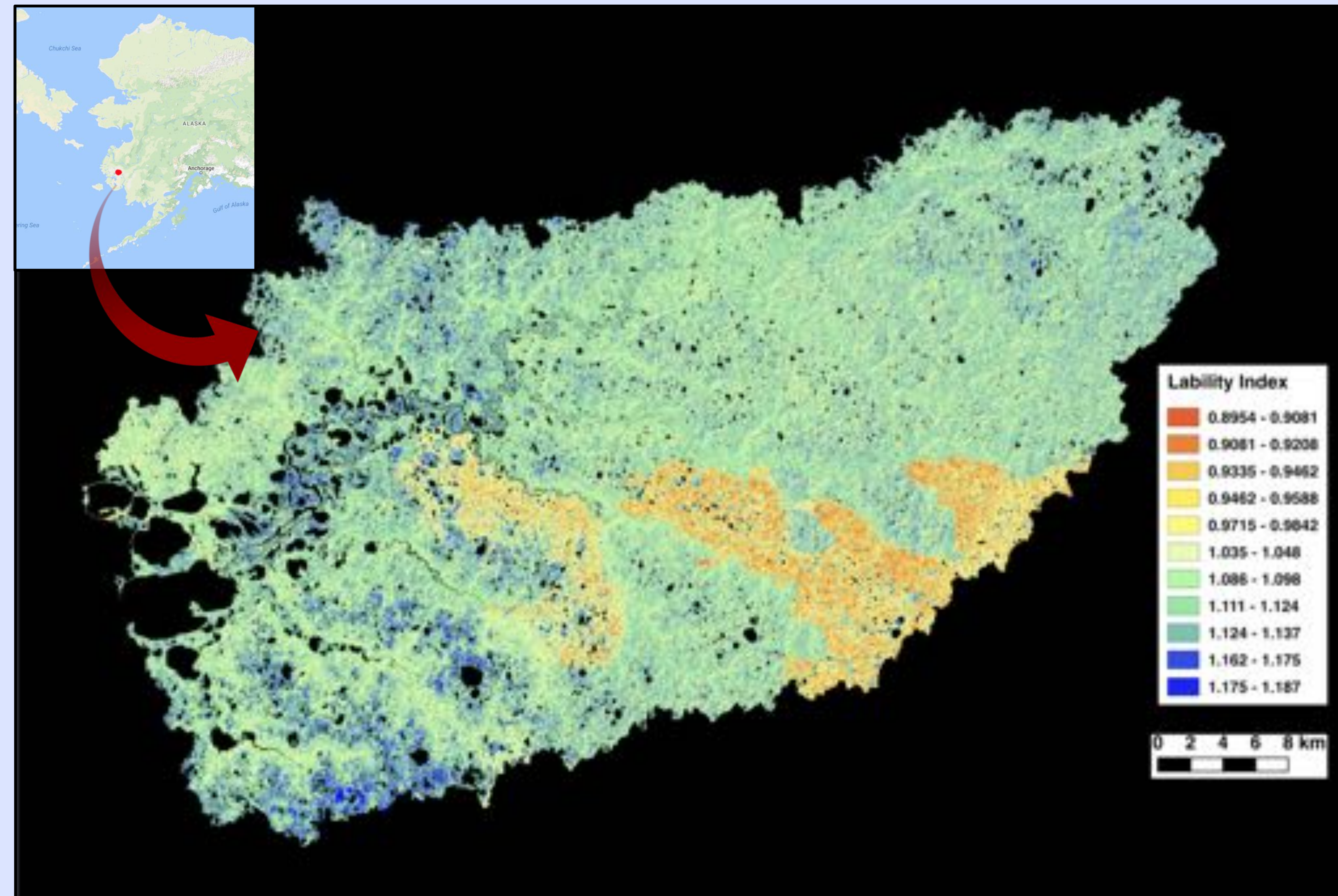
- Landcover was classified using an unsupervised classification algorithm in Google Earth Engine.
- 3 - 6 soil or sediment samples collected at 3-6 sites per class.
- Dried, ground samples were analyzed for compositional analysis using Fourier-transform infrared spectroscopy (FTIR) and for percent carbon using a LECO elemental analyzer.
- Carbon pools from each classification calculated as the product of %C, bulk density, and sample depth.
- Carbon lability calculated using a FTIR ratio of carbohydrate peaks to carboxylic peaks (1030/1600) (Ernakovich et al. 2015).
- PCA conducted to visualize differences in composition of soil organic matter among landcover classes.
- Map products are the result of a random forest predictive model implemented using Google Earth Engine. Inputs to the classification were Sentinel 2 multispectral imagery and Arctic DEM (5m). 194 sample points were used in the modeling process, with 30% withheld for model validation. Satellite imagery was filtered to 2016-2017, summer, cloud free days. Derived products included as covariates were NDVI, NDWI, and slope.

Carbon Vulnerability

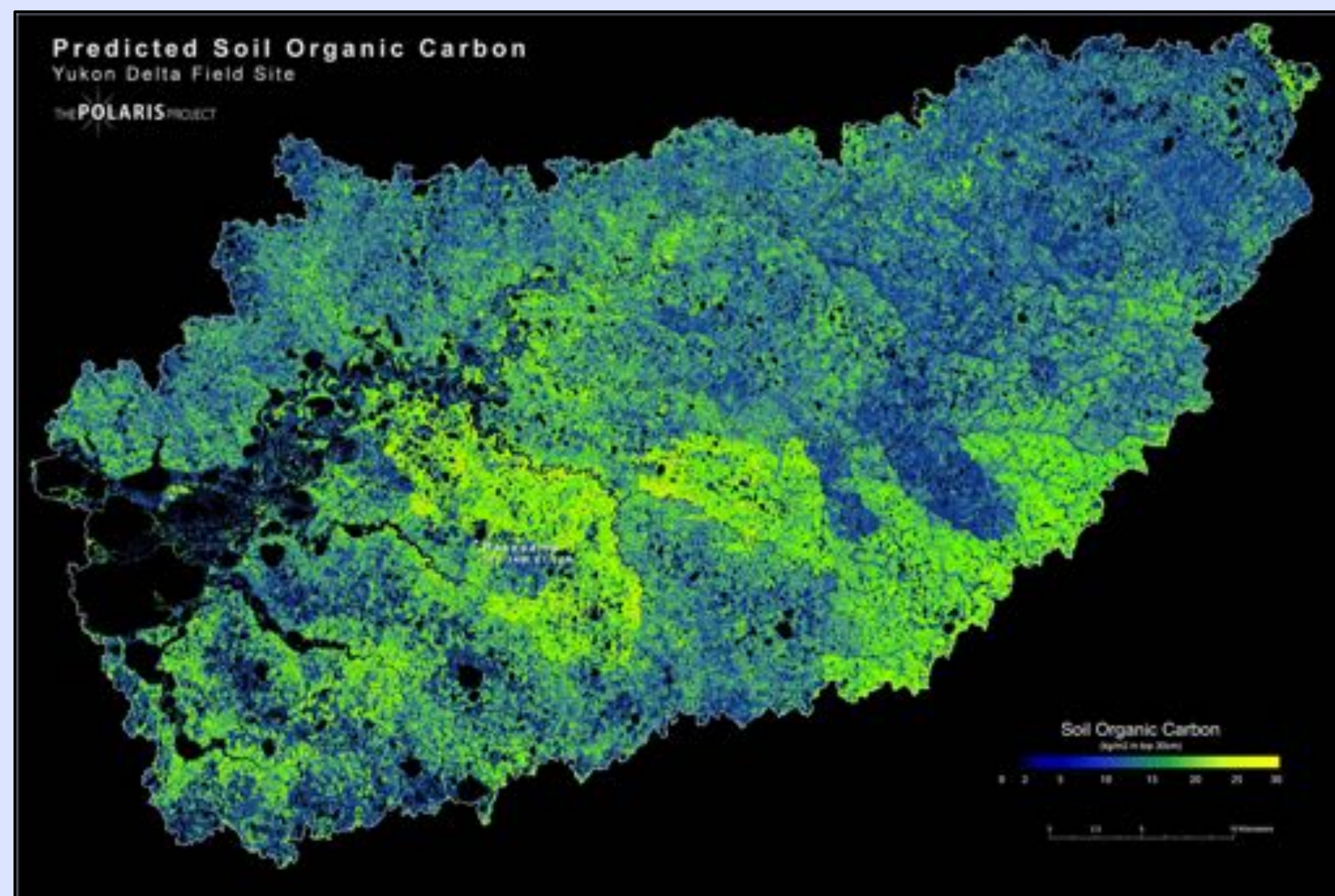
Loadings of Robust PCA



We assessed carbon vulnerability using the ratio of carbohydrates (peak 1030) to carboxylates (1600), following Ernakovich et al., 2015. This ratio can be used as a proxy for the degree of decomposition in soils and therefore carbon vulnerability.

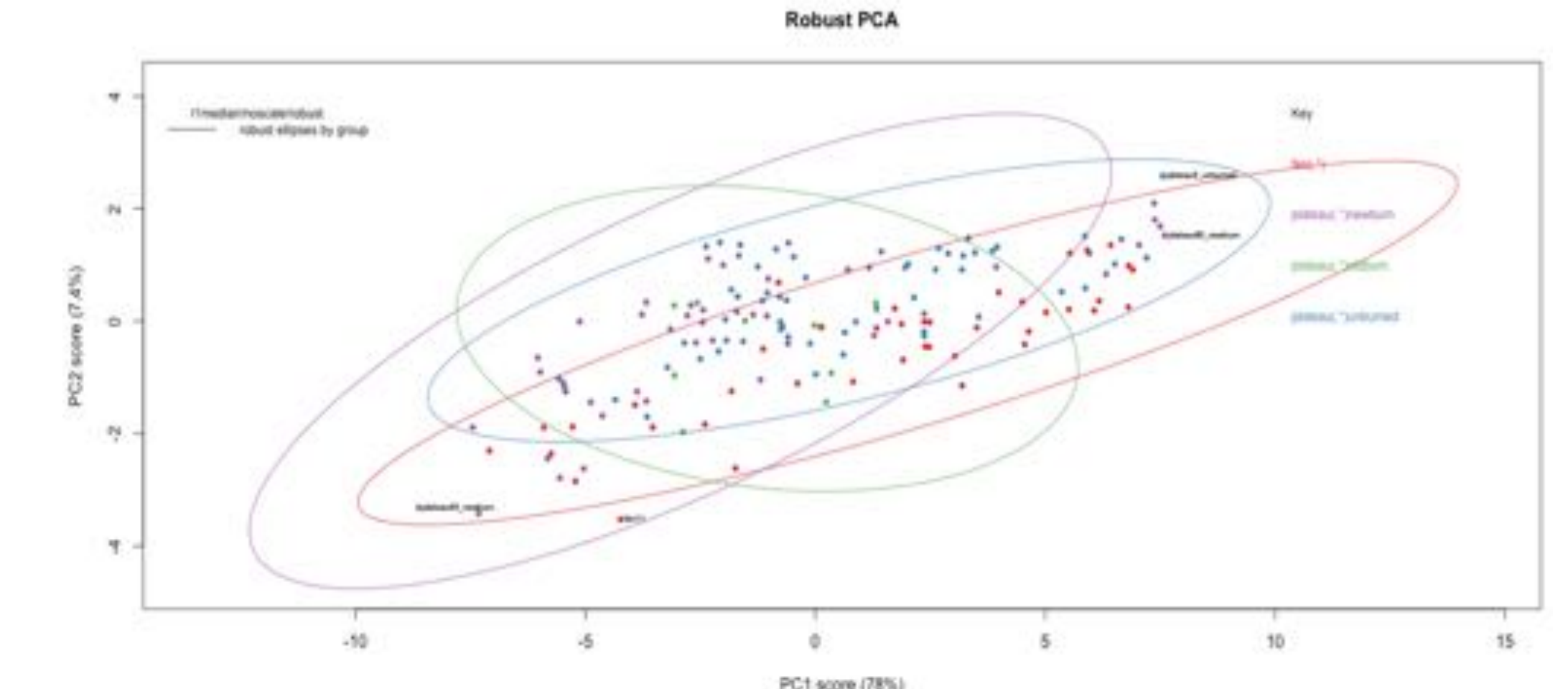


Map of soil carbon lability across the watershed where this work was conducted. Lability defined as carbohydrates/carboxylic in the soil or sediments.



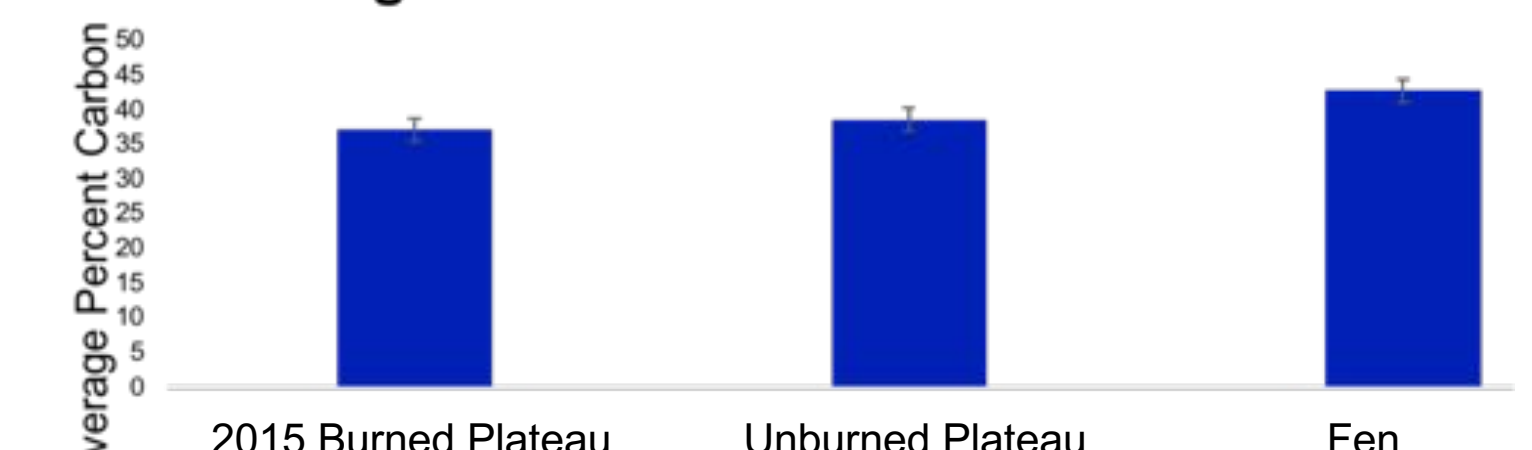
Carbon pool map made from 2016, 2017, and 2018 carbon pool data.

Robust PCA



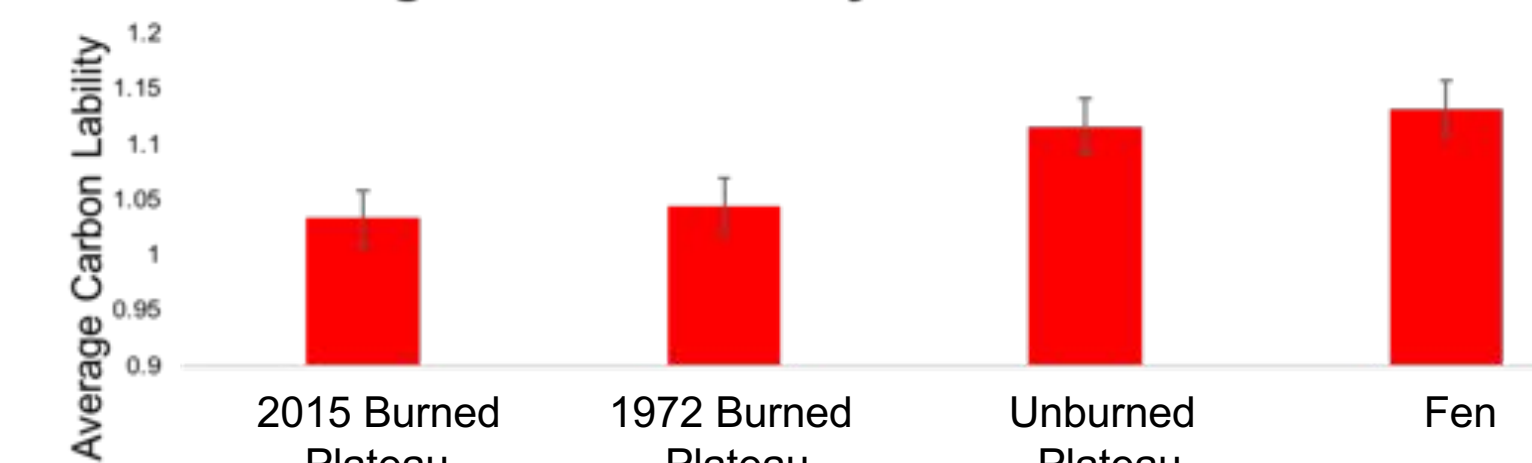
The first two components in a principal components analysis (PCA) captured 85.4% of the variation in the soil data. Clustering in each category indicates differences in composition of soil organic matter among landcover classes.

Average Percent Carbon Per Landcover Class



Differences in % soil organic carbon (top panel) and carbon lability (bottom panel) by landcover class.

Average Carbon Lability Per Landcover Class



Top panel analysis was conducted on samples from 2018, bottom panel was on samples from 2016, 2017, and 2018.

Results & Conclusions

- The first three components in the PCA captured 96% of variation in the data, and the first component alone captured 78%.
- Wildfire presence corresponds to a decrease in carbon lability (lower values/red shading in top map).
- Wetland presence corresponds to an increase in carbon lability (blue values on top map).
- As the permafrost continues to thaw, ground collapse may increase wetland formation, leading to more labile organic matter in these soils. However, environmental conditions interact with organic matter composition to drive decomposition rates. Saturated anoxic conditions may reduce aerobic decomposition, despite potential changes in lability, but would increase anaerobic carbon processing.

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