Improving Long-Term Modeling of Soil Carbon and Permafrost Response to Wildfire through Observational Evidence in the Southernmost Permafrost Region of Alaska

Megan Andersen[1], Nicolas Jelinski[1], Edward GreyBear[2], Michael Sousa[3], Andrea Williams[4], Mikhail Kanevskiy[5], Yuri Shur[5], Roser Matamala[6], Julie Jastrow[6]

[1]University of Minnesota, Twin Cities, MN
[2]Ahtna Intertribal Resource Commission, Glennallen, AK
[3]USDA Natural Resource Conservation Service, Wasilla, AK
[4]USDA Natural Resource Conservation Service, Duluth, MN
[5]University of Alaska Fairbanks, Fairbanks, AK
[6]Argonne National Laboratory, Lemont, IL

Contact: (and10027@umn.edu)
Project Lead Principal Investigator (PI): Julie Jastrow
BER Program: ESS
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Project Website: https://ess.science.energy.gov/anl-sfa/ and http://tessfa.evs.anl.gov/

Project Abstract: The permafrost-affected soils and ecosystems of the Copper River Basin (CRB) represent the southernmost area of extensive, discontinuous permafrost in Alaska. These soils are considered ecosystem-protected because prevailing ecological conditions, rather than climate alone, are the major influence on permafrost stability. In subarctic and boreal regions, soil carbon and permafrost depth are strongly dependent on the thickness of the surface organic layer, which stores large amounts of carbon at a landscape scale and acts as an insulator to protect permafrost from degradation. Nevertheless, the surface organic layer is extremely sensitive to disturbances such as wildfire. Depending on severity, wildfires can remove or severely reduce the thickness of the organic layer, reduce insulation, and lead to soil carbon loss and permafrost degradation. Many observational and modeling efforts have examined fire-induced changes in organic layer thickness, soil carbon, and permafrost in Interior Alaska over decadal scales. However, the soils, permafrost, and landscapes of the CRB are dominated by clayey, fine-textured soils on flatter terrain with longer fire-return intervals compared to Interior Alaska. Preliminary work has shown that the fire responses of permafrost-affected soils and their carbon stocks in the CRB differ in critical ways from those observed for the generally silty textured, better drained soils of Interior Alaska. Unlike many sites in other permafrost-affected landscapes where soils can become drier following permafrost degradation due to increased drainage, our work has shown that soils in the CRB are more likely to become wetter post-fire. The restrictive permeability of CRB soils, fire-induced loss of transpiration, and low gradient landscapes combine to profoundly influence the long-term trajectory of CRB soils and ecosystems. These factors may lead to dramatically different outcomes with respect to soil carbon balance compared to Interior Alaska, with potentially increased rates of post-fire carbon accumulation due to wetter conditions. Yet, because of relatively warm ambient and permafrost temperatures in the CRB, it is unlikely that permafrost aggradation occurs post-fire by upward freezing from the permafrost table. Rather, the formation of new near-surface permafrost following the recovery of the organic layer may occur simultaneously with the development of taliks. These interacting factors could make CRB soil carbon stocks and permafrost either more or less susceptible to disturbances caused by wildfires and rising annual temperatures.