Remote Sensing of Plant Functional Traits for Modeling Arctic Tundra Carbon Dynamics

Jennifer Fraterrigo[1*], Mark Lara[2], Shawn Serbin[3], Eugénie Euskirchen[4]

[1] Department of Natural Resources and Environmental Sciences, University of Illinois, Urbana, IL
[2] Department of Plant Biology, University of Illinois, Urbana, IL
[3] Brookhaven National Laboratory;
[4] Institute of Arctic Biology, University of Alaska, Fairbanks, AK

Contact: (jmf@illinois.edu)
Project Lead Principal Investigator (PI): Jennifer Fraterrigo
BER Program: ESS
Project: University-Led Research
Project Website: N/A

Project Abstract:

Rapid warming in the Arctic is driving changes in the structure and composition of tundra vegetation communities. These changes are expected to alter key biogeochemical and physical processes that feedback to climate. However, the magnitude of this feedback is highly uncertain due to limited understanding of spatial variation in plant functional traits and the over-simplification of traits in current Earth system models. To facilitate improved representation of aboveground and belowground traits in models, we will characterize directly observable plant functional traits from remotely sensed data, and predict non-observable (e.g., belowground) traits by leveraging trait-environment relationships and trait covariation. Additionally, we will integrate trait information into the Terrestrial Ecosystem Model (TEM) to quantify and predict regional C balance in the Alaskan tundra. We will test four hypotheses: (1) Plant functional traits are predominantly shaped by climate, with local soil moisture and active layer depth moderating trait response to climate, but optimal trait values for a given environment depend on community type because plant functional types (PFTs) have different sensitivities to altered resources associated with climate warming. (2) Trait dispersion depends on environmental stress; where environmental conditions are more favorable for growth, there is greater variation in traits and greater trait diversity; (3) Root traits are predictable from leaf and size traits, climate and soil factors; and (4) Variation in traits affect Arctic C balance. Leaf traits as they relate to photosynthetic parameters will have the strongest effects on C uptake. Root traits will exhibit fewer direct effects on C uptake but will be important in supporting nutrient uptake that then influences C uptake. To test these hypotheses, we will study the variation in plant traits across the major tundra vegetation communities present along local soil gradients nested within a macroclimate gradient in northern Alaska, quantifying trait-environment relationships and trait covariation at the community- and PFT-levels. Using machine-learning approaches, we will integrate ground-based measurements with information derived from multi-scale remote sensing platforms from drone, hypertemporal, LiDAR, and hyperspectral imagery to produce maps of leaf, size and root traits, greatly expanding the trait information available for modelers. We will use Bayesian data-model fusion methods to improve the parameterization and formulation of TEM, which is widely used in Arctic carbon studies, and perform simulation experiments to evaluate how differences in plant functional traits affect C dynamics.