Remote Sensing to Scale Plant, Soil and Microbial Traits and to Infer Watershed Temporal Responses to Disturbance such as Forest Decline

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Abstract:

Ecological interactions between plants, microbes and geologic substrates are key to the retention of loss of elements across watersheds. Spatial, temporal, and phylogenetic scales affect interpretation of these interactions. An open question is how to best assess ecological interactions occurring across these scales, and to determine when and where do processes occurring at fine spatial scales affect aggregate watershed function? We are developing strategies to scale plant and microbial traits from point-scale measurements to watershed scales using remote sensing of plant traits and landscape features. By classifying and mapping functionally distinct soil, plant and landscape units our goal is to identify generalizable patterns in plant and microbial traits at the watershed-scale. In this presentation, we will present the following findings:

Characterizing Representative Soil Biogeochemical Units:

More than 400 soils were collected in 2018 across elevations over four catchments which varied in hydrologic, geologic, and vegetation properties. We classified soils into 5 functional categories based on similarity in microbial biogeochemical properties.

Scaling Soil Biogeochemical Properties and Microbial Traits at the Watershed Scale:

We developed machine learning- (ML) approaches that use airborne hyperspectral imaging and LiDAR data to estimate plant functional type and species cover, plant leaf traits such as leaf nitrogen and carbon, and leaf mass per area at both fine spatial scale and at watershed scales.

Remotely-sensed predictions of plant traits were then used to quantify the co-variability between soil microbiomes, soil properties and landscape features. ML approaches have identified predictive plant leaf traits (e.g. leaf water content) and landscape properties (e.g. topographic wetness) that were used to scale soil microbial traits at watershed scale. Using this approach, we identified that soil microbial biomass and nitrogen (N) accumulation follow landscape features related to water availability.

Synthesizing Data and Scaling Frameworks to Infer Temporal Watershed Dynamics:

We have also identified watershed areas of forest decline and biomass loss by analyzing time-series satellite imagery. Strong relationships were found with topographic properties and total potential solar radiation. Such ecosystem relationships and dynamics have implications for watershed N export, and may help explain significant variability in river N exports over the past several decades.

Abundant multi-omic data collected at East River is being used to build an interoperable and dynamic resource to directly parameterize HPC reactive transport models using genome-informed microbial traits. A goal is to improve predictions of the scale at which nitrogen retention and loss is regulated in a watershed.