Eastern White Pine Health Monitoring through Remote Sensing Assessment of Foliar Traits

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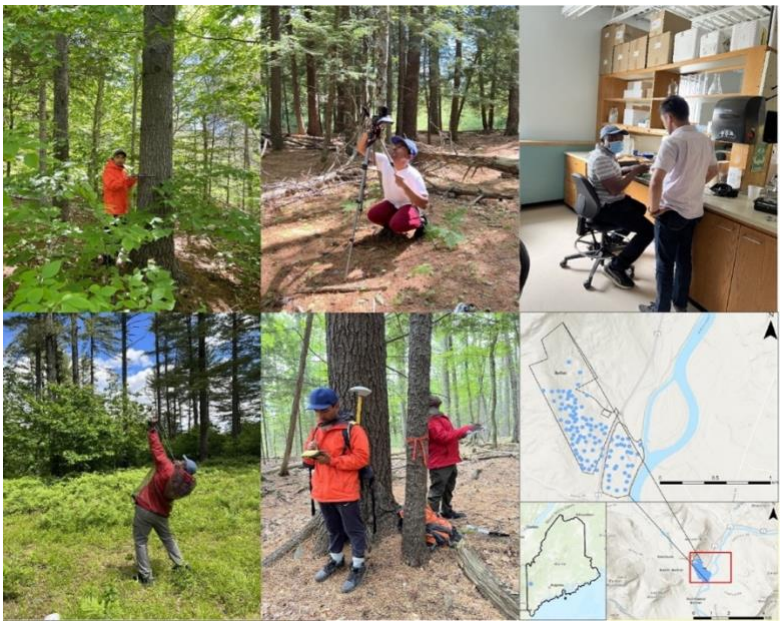
Project Abstract

Eastern white pine, an economically and ecologically important tree species in Northeastern forests, has been impacted by shifts in habitat and disturbances over the past two centuries and has become prone to several pests, pathogens, and dieback. In recent years, white pine needle damage has been a significant threat and is expected to become more severe. Remote sensing tools using aerial and satellite imagery assist field and aerial monitoring efforts by providing observations across large regions over time. Recent findings show that severe needle damage is successfully detected using fine-resolution satellite imagery, but detection of light and moderate defoliation faces challenges. Leaf traits such as nitrogen, chlorophyll, leaf mass per area, and leaf area index are essential indicators of the health of vegetation communities. Researchers will characterize white pine foliar traits by using models at leaf scale from remote sensing data. They will estimate key trait indicators for white pine susceptibility to needle damage and upscale and map damage using satellite imagery. They will produce a foliar traits databank and thresholds for discriminating infested and healthy white pines, a remote sensing-based workflow for mapping needle damage susceptibility using leaf traits as a proxy, and damage maps generated from satellite imagery. In addition to characterizing biochemical and biophysical traits of healthy and infected white pines in the Northeast, this project complements aerial detection survey and traditional remote sensing change detection techniques, benefitting stakeholders. The Maine Forest Service and USDA Forest Service can use the tools as part of short- and long-term efforts to monitor and mitigate negative impacts of the damage to eastern white pine.



Field campaign activities in Bethel and Demeritt Forest, Maine, in spring and summer 2022. The map shows the extent of the study area and location of the sample plots in Bethel.

Progress in 2022

As this project is time-sensitive and data on white pine needle damage (WPND) should be collected between May-July each year, fieldwork was designed in early May 2022 to collect data in predominantly white pine stands in Bethel and Demeritt Forest in Maine between June 1 and mid-July 2022. See data collection in figure below. After the fieldwork season, the team made additional visits between mid-July and mid-August for reevaluation and verification. A total of 200 samples were collected from both sites. The health of sample plots was assessed and grouped into three classes (Healthy, Light, and Moderate/Severe) based on the

severity of WPND symptoms. Diameter at breast height (DBH), leaf area index (LAI), live crown ratio and stand height were recorded. In Bethel, the measurements were taken at tree and leaf level and after site visit, and fresh foliage samples were also collected to analyze their chemical properties. In the lab, fresh weight, chlorophyll content, chlorophyll fluorescence, leaf mass per area (LMA), equivalent water thickness (EWT) and spectral information (using hyperspectral data at 400-2500 nm) were measured. Then all collected samples were oven dried and sent to UMaine Soil Lab for biochemistry measurement. For Bethel and Demeritt forest sites, very high resolution PNEO satellite imagery (with 6 spectral bands and 1.2 m spatial resolution) was ordered and purchased. All the collected field data and leaf spectral data are now being analyzed by the hired MS student and the PI.

Plans for 2023

Moving forward, the plan is to use the differences observed in the spectral profile of the needle samples, measured traits in the field, and remote sensing techniques to identify key foliar traits and significant differences (if present) between the different levels of infestation. We will finalize the estimation of field foliar traits using area-based expression and explore if there are significant differences among the traits between the healthy and infested classes. Then spectral vegetation indices (SVIs) and variables will be selected and used to evaluate the observed differences in the spectral profiles. The SVIs that we will calculate and the hyperspectral data (spectral bands) that we measured will be used to predict foliar chlorophyll, nitrogen, EWT for the healthy and infested needles with the help of partial least squares regression (PLSR) and Random Forest (RF) algorithms. Next steps will be designed based on the outcomes of the activities above.

Collaboration

We actively collaborate with Dr. Isabel Munck from the US Forest Service (USFS) and Mr. Aaron Bergdahl from the Maine Forest Service (MFS), Forest Health Division. Both have been instrumental in helping us with the study area selection for the project and have provided expert opinion on measurements and data collection. The WPND experimental plots at the Bethel site are managed collaboratively by USFS and MFS and were selected and permitted to use for this project after discussions with these organizations. Dr. Jose Meireles from the School of Biology and Ecology at UMaine has been collaborating with the team by providing the Spectra Vista HR 1024 instrument required for collecting the spectral data of the needle samples and helping with the measurements. Dr. Shawn Fraver (UMaine) provided us with the High Resolution Winseedle scanner that allowed us to calculate the conversion factor for the white pine needles that we used in the study.