

Early identification of white pine blister rust disease symptoms in Whitebark Pine using a Hyperrail motion control system and hyperspectral sensor

Interactions of climate change and invasive pathogens will affect the health and adaptability of host species. *Cronartium ribicola*, the invasive non-native fungal pathogen responsible for the disease white pine blister rust (WPBR), has caused both economic and ecological loss in white pine forests since its introduction in North America. The white pines are often keystone species and provide many important ecosystem functions and services, and often have an economic role. All North American white pines are susceptible to the pathogen. Despite the susceptibility of white pines to WPBR, many of the species have a low frequency of natural genetic resistance. This resistance manifests itself via a single dominant major gene (MGR) conveying complete resistance, incomplete quantitative genetic resistance, with more complex patterns of inheritance, or both types. Managers traditionally rely on common garden approaches to screen trees for genetic resistance by artificially inoculating seedlings grown in progeny arrays with WPBR which takes approximately 3-5 years. The progression of the disease is manually scored by recording the presence of different disease symptoms, such as the presence of needle spots or stem cankers. Though these methods have yielded elite trees that are being used in reforestation, manually phenotyping thousands of trees for resistance or susceptibility is laborious and expensive. Emerging remote sensing (RS) techniques provide a powerful tool to aid in the rapid early detection of diseases, in some cases pre-visual detection, and can provide a more thorough picture of disease progression through time. Early detection in field settings can aid managers in setting priorities and strategies for management action. The utility of hyperspectral remote sensing has been demonstrated in early detection of forest pathogens in some cases, including Olive, Ohia, and recently white pines but to date has not been deployed in forest disease resistance breeding programs. Our goal here is to field validate a high throughput phenotyping platform based on hyperspectral remote sensing on the whitebark pine restoration site at rim village of Crater Lake NP.

Whitebark pine at Rim Village which have the potential to be infected with *Cronartium ribicola* have been planted as part of restoration project at Crater Lake NP. The trees are intermediately assessed as to their status as being infected or not. We propose to use a Nano VNIR (400-1000 nm) from Headwall Photonics mounted on a portable automated hyperrail, constructed in collaboration with the NSF funded OPEnS lab at Oregon State University. The hyperrail is a motion control system for the HS camera. Because the camera is a push broom sensor it needs to move to cover the target scene. The duration of the measurement depends on the ambient light, and the exposure time and speed of the camera are adjusted accordingly. The reflectance is determined using a spectralon 99% reflectance panel placed in the scene. The ground resolution from a height of 1.8 m is 1.6 mm and it covers a width of about 1 m with the FOV of 30.4°. Scanning will be conducted along with manual assessments of the trees by USDA Dorena Genetic Resource Center technicians for validation. Once the scene is imaged, the data are radiometrically corrected and pixels that are white pine (as opposed to background) are extracted and classified using the Classification Learner toolbox in Matlab. A SVM classifier, a machine learning method that works well with high-dimensionality data, will be trained by selecting 10,000 pixels per class randomly from imaged seedlings. Once the pixels are classified the difference in spectra between infected and uninfected trees will be compared to identify (and confirmed from preliminary results) which HS wavelengths are the most useful for disease detection in different white pine species. The accuracy of the classification result will be determined using an error matrix and kappa coefficient. Once the appropriate wavelengths or indices are identified monthly scanning of foliar tissue in the trials will track the disease progression and will be compared to visual scoring and disease severity to validate the success of the phenotyping.

The Hyperrail that we will use is a lightweight 3 meter extruded rail on tripods. The motion control system is mounted on the rail and moves the hyperspectral camera across the target scene. This is a useful approach in areas where UAVs are not allowed. The hyperrail has no impact on the surface area where it is set up. We will sanitize all equipment that will come into contact with the ground including

tripods and our boots. Because of Covid-19 we will also practice social distancing as well as wear cloth masks.

Data and Publications

No publications yet submitted.

Collected hyperspectral data is in the pre-processing stage and will be provided to the park once available.

