ML 2018 Project Abstract
For the Period Ending June 30, 2023

PROJECT TITLE: Detection and Treatment of Oak Wilt, Ph II
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APPROPRIATION AMOUNT: $301,941
AMOUNT SPENT: $301,941
AMOUNT REMAINING: $0

Sound bite of Project Outcomes and Results

We developed novel methods for accurate detection of trees infected with the deadly oak wilt fungal pathogen (*Bretziella fagacearum*) at the leaf and canopy level, landscape level and regional level using spectral biology. Using hand-held, drone-based, airborne and spaceborne sensors to capture reflected photons from trees, we detected spectral signatures of oak wilt disease by applying a series of modeling approaches. We also established a series of oak wilt sites for long-term monitoring of the efficacy of different management approaches and disseminated our findings broadly at local, regional and national level.

Overall Project Outcome and Results

Within two oak tree experiments--an indoor greenhouse experiment and an outdoor potted tree experiment--we used spectral reflectance fingerprints of leaves and canopies of oak trees infected with oak wilt to accurately differentiate them from trees stressed by drought and bur oak blight. We measured near-canopy full-range spectral reflectance (400-2400 nm) and multi-spectral reflectance above the canopy with a low-cost drone along with changing leaf water and photosynthetic status. Second, using airborne hyperspectral reflectance to detect tree canopies infected with oak wilt, we achieved high accuracy through a three-step phylogenetic process: we first distinguished oaks from other species (90% accuracy), then red oaks (*Quercus rubra* and *Quercus ellipsoidalis*) from white oaks (*Quercus macrocarpa*) (93% accuracy), and, lastly, infected from non-infected trees (80% accuracy). The step-wise phylogenetic approach increased model accuracy by ca. 20% over a single-step classification. Third, we developed a novel workflow for mapping oak wilt from spaceborne satellite observations by detecting temporal disease progression in trees using land surface phenology (LSP) metrics. We tracked phenological changes in pigments and photosynthetic activity of trees affected by oak wilt using metrics derived from the Chlorophyll/Carotenoid Index (CCI) from time-series observations from Sentinel-2. To develop models for mapping infected trees at large spatial extents from satellite imagery, we used high-resolution airborne imagery to detect and differentiate oak trees that were healthy, symptomatic for oak wilt, and dead to train machine-learning models. We discriminated among the three health conditions with overall accuracy between 80-82%. Our combined project results highlight the capabilities of spectral measurements from satellite, aircraft, drones and handheld devices to detect oak wilt at vastly different spatial scales, differentiate it from other kinds of stress, and map it at fairly high accuracy for the benefit of forest managers.

Project Results Use and Dissemination

We partnered with NASA, the US Forest Service, the Department of Natural Resources and the National Park Service to disseminate our project results for the purpose of managing the spread of oak wilt disease. We interacted with hundreds of citizens at the Minnesota State Fair about the oak wilt problem and how they can help. We presented our results locally, regionally and nationally to multiple departments and groups within the

University of Minnesota, the Upper Midwest Invasive Species Conference, the US Forest Service, the Ecological Society of America including through NASA's hyperwall, NASA's Biodiversity and Ecological Forecasting meetings, the International Workshop on Sapflow, and the American Geophysical Union. We have published two peer-reviewed articles, one is in review and one is in preparation.