Integrating hyperspectral reflectance and wavelength analysis to estimate tree responses under abiotic and biotic stress

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Abstract

Forest ecosystems are the largest terrestrial carbon sink and monitoring them effectively, particularly in the context of global change, requires rapid and accurate determination of tree functional traits that indicate forest health. Hyperspectral reflectance has the capacity to predict leaf traits non-destructively using multivariate statistical approaches. The ability of hyperspectral data to estimate tree physiochemical responses is affected by wavelength range selection and the influence of wavelength on accuracy of trait estimation is not well known, especially for more complex physiological processes. To bridge this knowledge gap, this study examined chemical and physiological responses of one-year-old black walnut (*Juglans nigra* L.) and northern red oak (*Quercus rubra* L.) to a combination of biotic and abiotic stress events, including pathogen inoculation, water stress, nutrient deficiency, and salt deposition. Leaf photosynthetic-related, water-related, and chemical traits were paired with hyperspectral measurements spanning 350-2500 nm. A total of 100 different wavelength ranges were evaluated using PLSR to determine the variation prediction accuracy. Key findings indicated that incorporating short infrared wavelength ranges (1300-2500 nm) significantly enhanced trait prediction accuracy. In addition, this study also demonstrated that hyperspectral data can detect tree stress responses at fine-scale chemical and physiological levels that are in agreement with reference measurement responses to the different stressors. We suggest that hyperspectral reflectance can potentially offer a solution for monitoring forest health in multi-stress environments with an increase in the accuracy of trait estimations and an expansion of the classes of traits estimated.

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