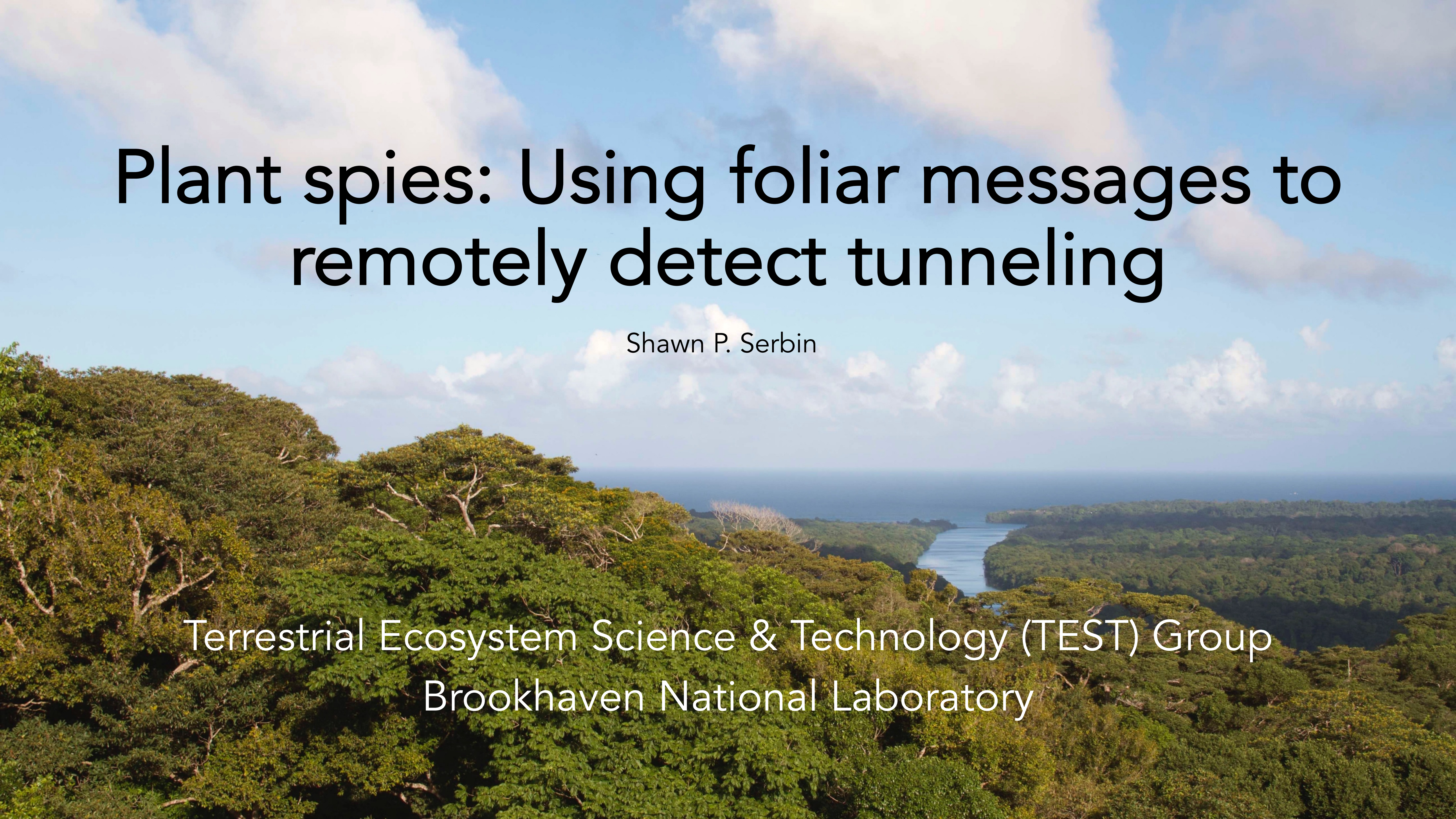

Plant spies: Using foliar messages to remotely detect tunneling

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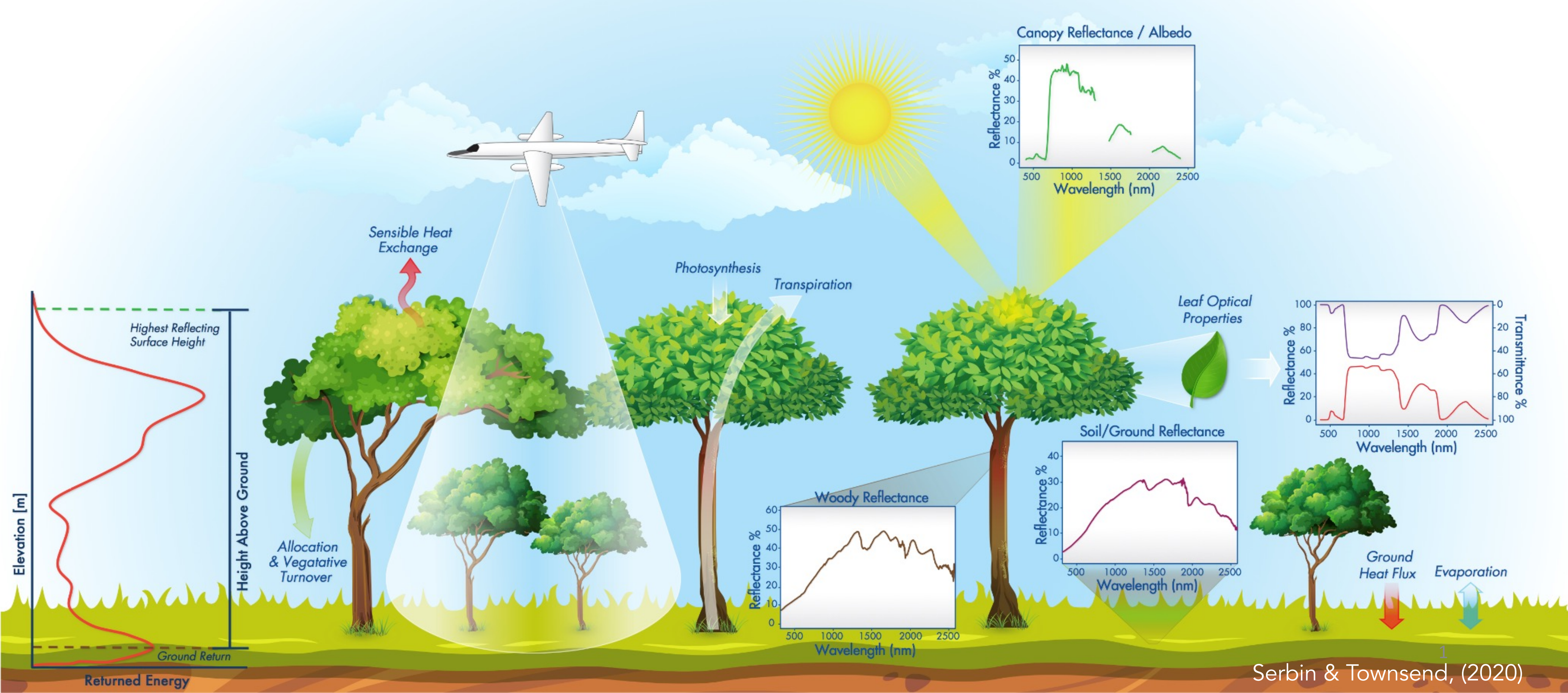
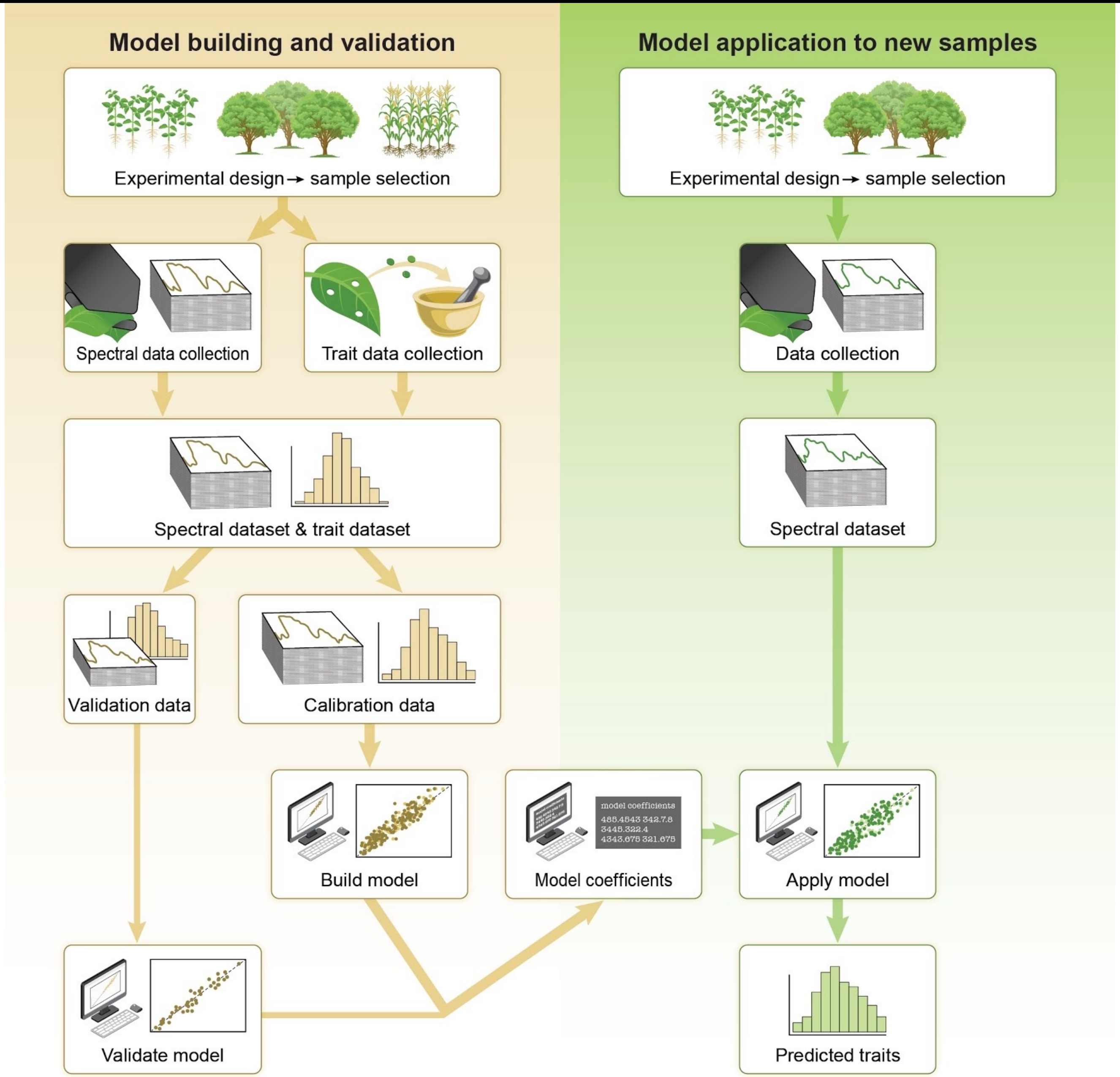
Enabling remote measurement of key vegetation properties

Motivation: Exploit the biophysical links between optical, thermal, and active sensing systems to quantify vegetation states, properties, dynamics, surface targets, and change from near-surface to regional scales



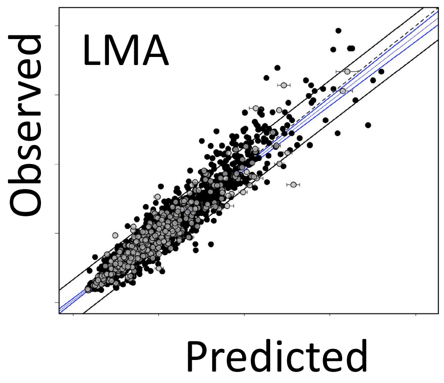
Serbin & Townsend, (2020)

Spectroscopic detection of plant traits

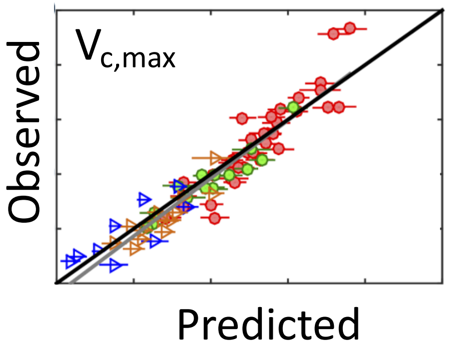


Burnett et al (in review). *A best-practice guide to predicting plant traits from leaf-level hyperspectral data using partial least squares regression*

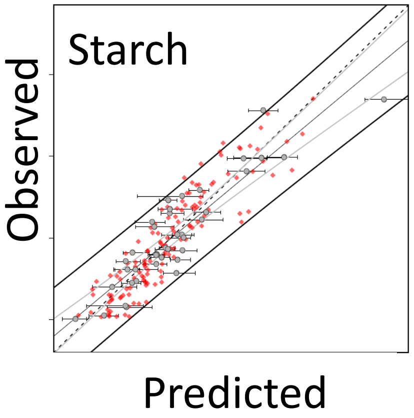
Inferring plant function through remote sensing



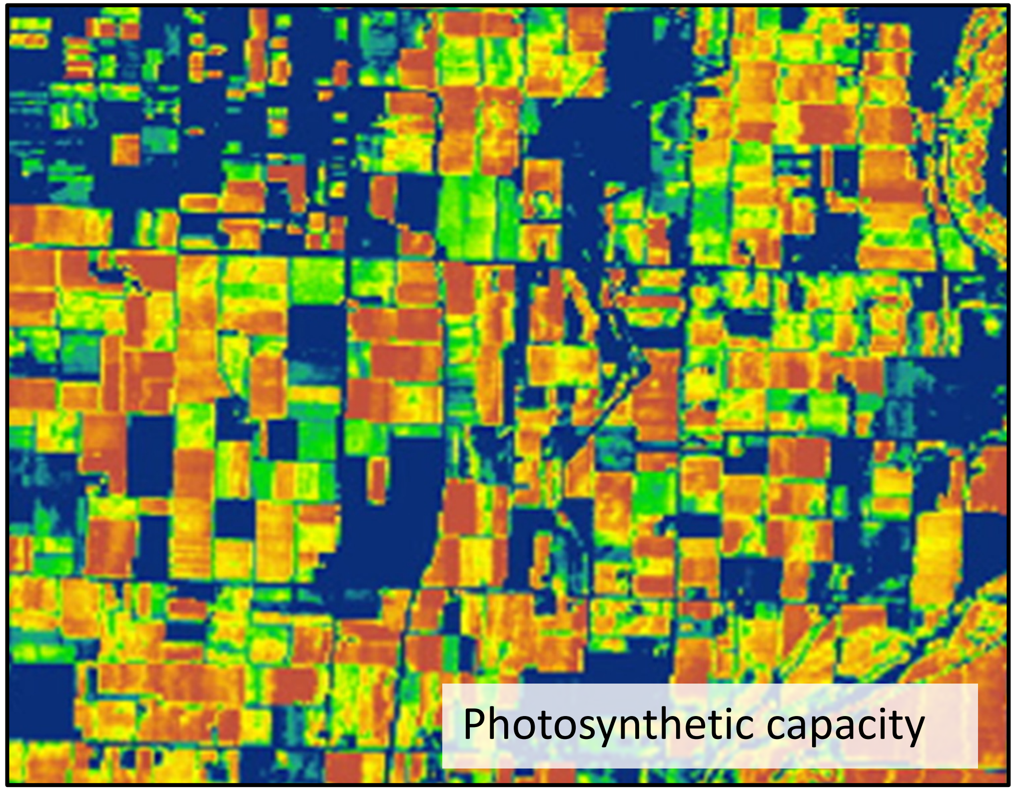
Structural traits
Banscota et al (2013), Singh et al (2015), Banscota et al. (2015), Yang et al (2016), Serbin et al 2019)

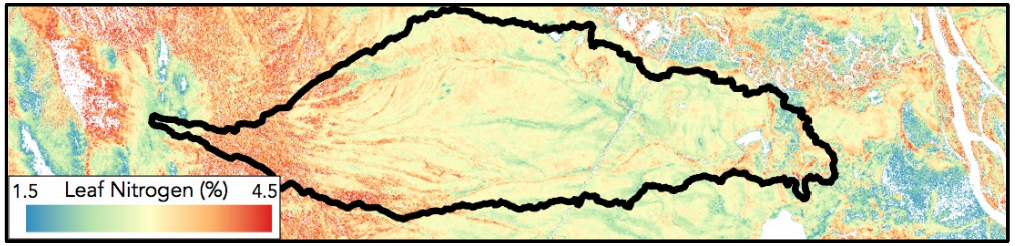


Physiological traits
Serbin et al (2012), Ainsworth et al (2014), Serbin et al (2015), Silva-Perez et al (2018), Wu et al (2019), Meacham-Hensold et al (2020)



Biochemical traits
(Couture et al 2013, Serbin et al. 2014, Couture et al. 2016, Shiklomanov et al 2016, Ely et al 2019)

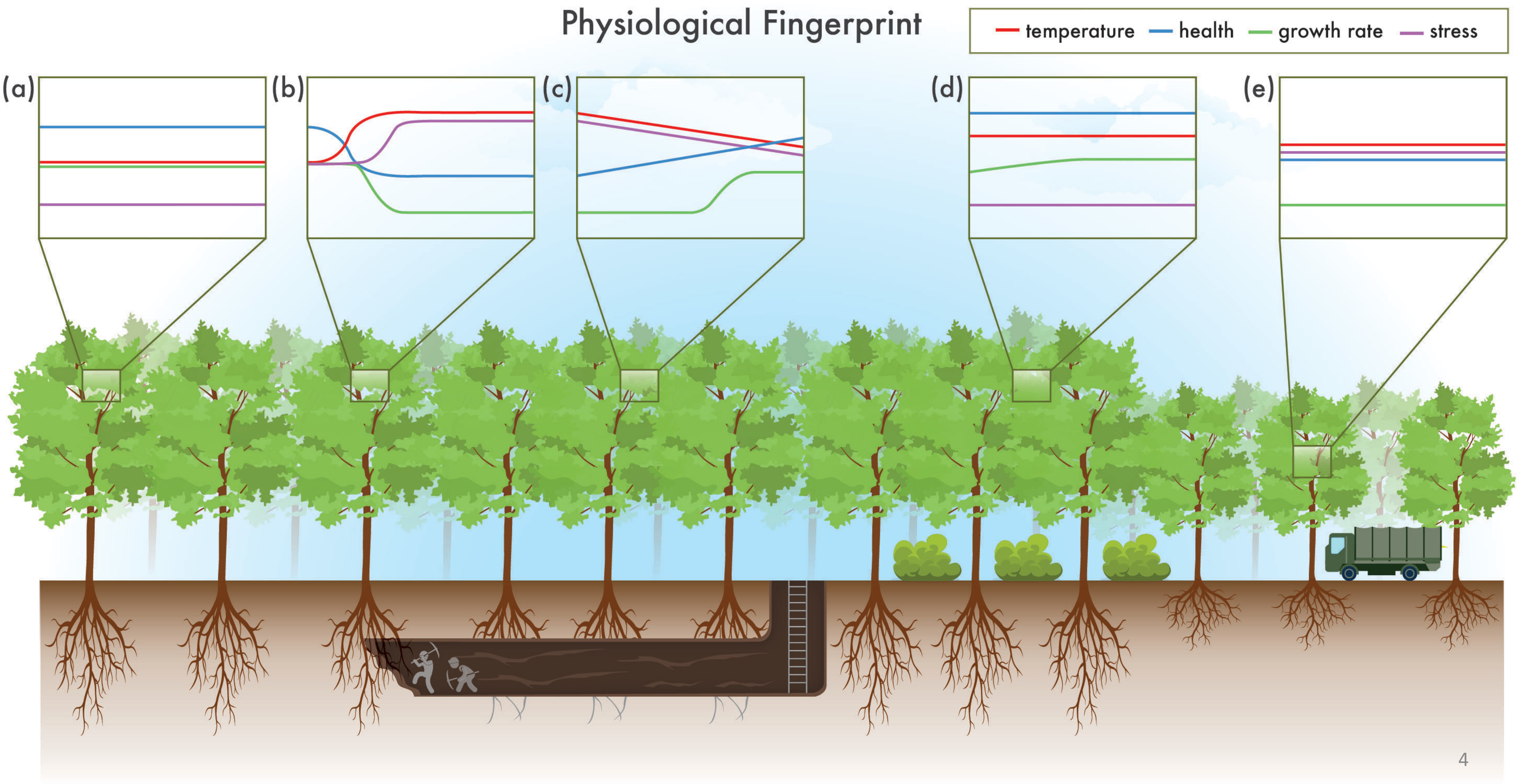




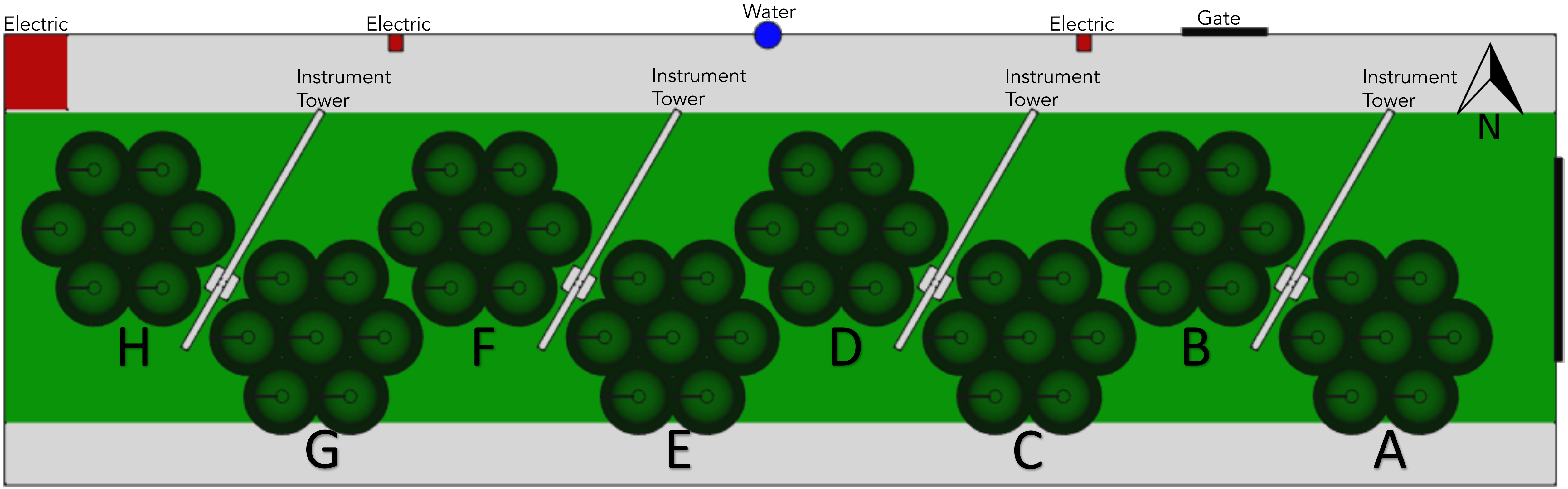
Leaf Nitrogen

Approach works across scales

Fingerprints of stress in vegetation



Tunneling experiment



Objectives:

- Grow plants and simulate tunneling
- Measure plant physiological, biochemical, and remote sensing properties
- Develop algorithms to link physiological responses with remote sensing signatures

Simulated tunneling by removing 50% of rooting volume

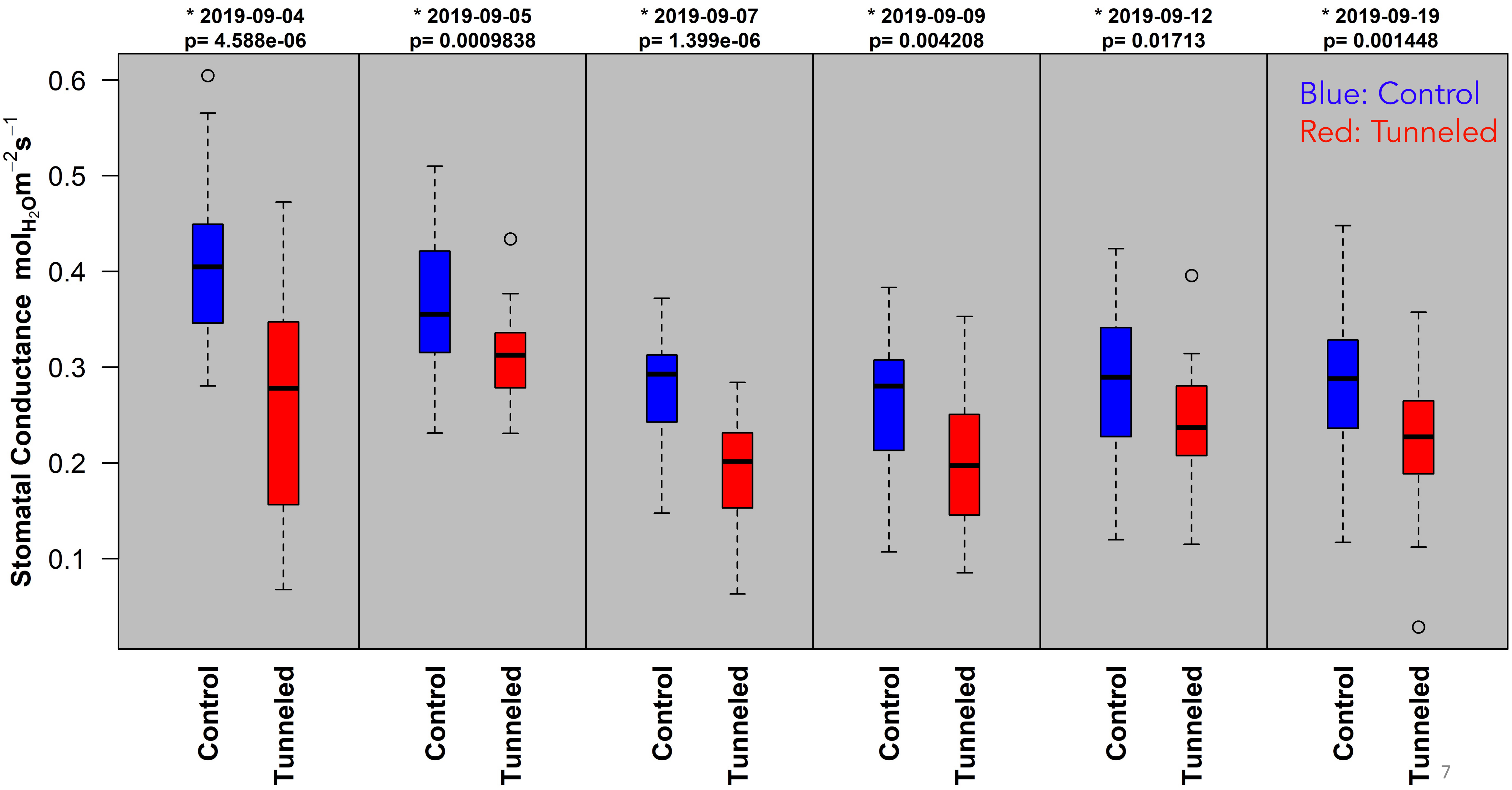




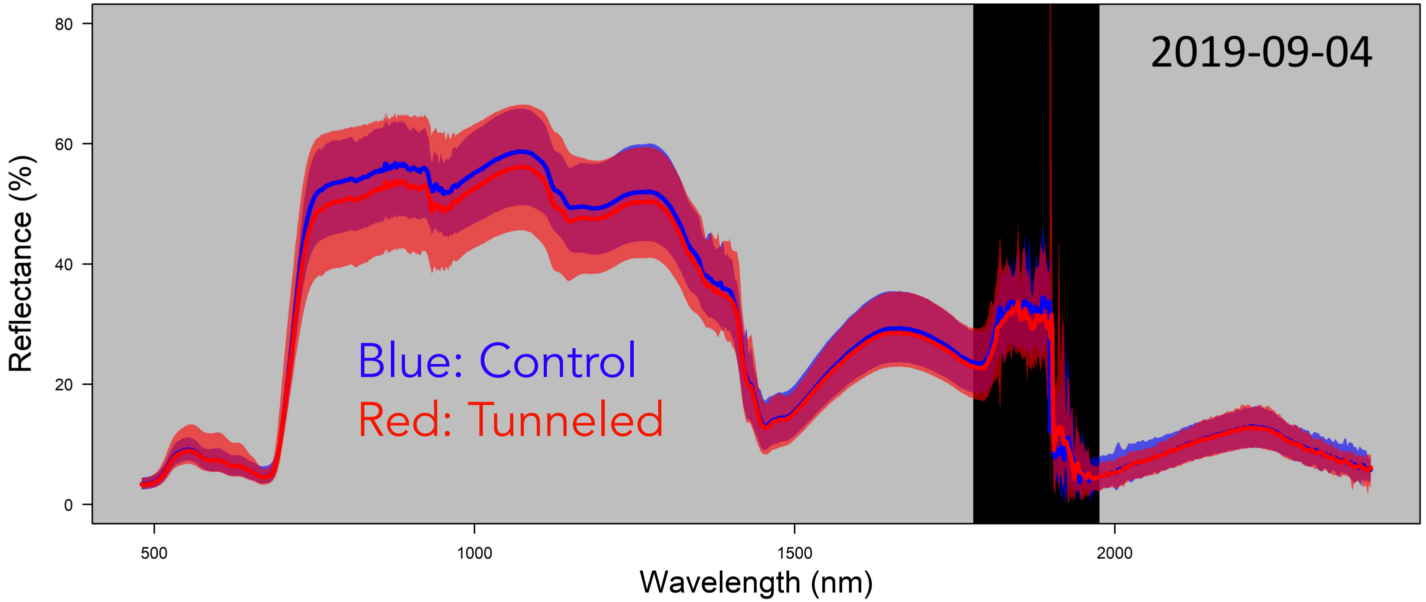


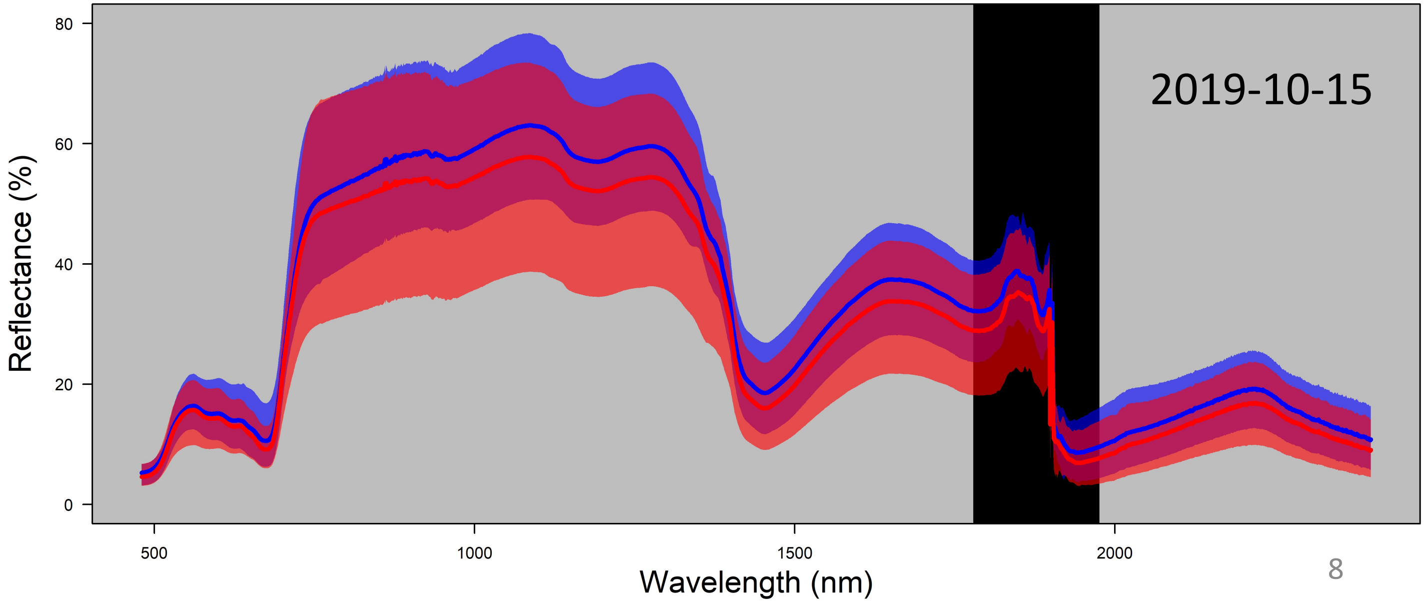



Lower stomatal conductance with tunneling

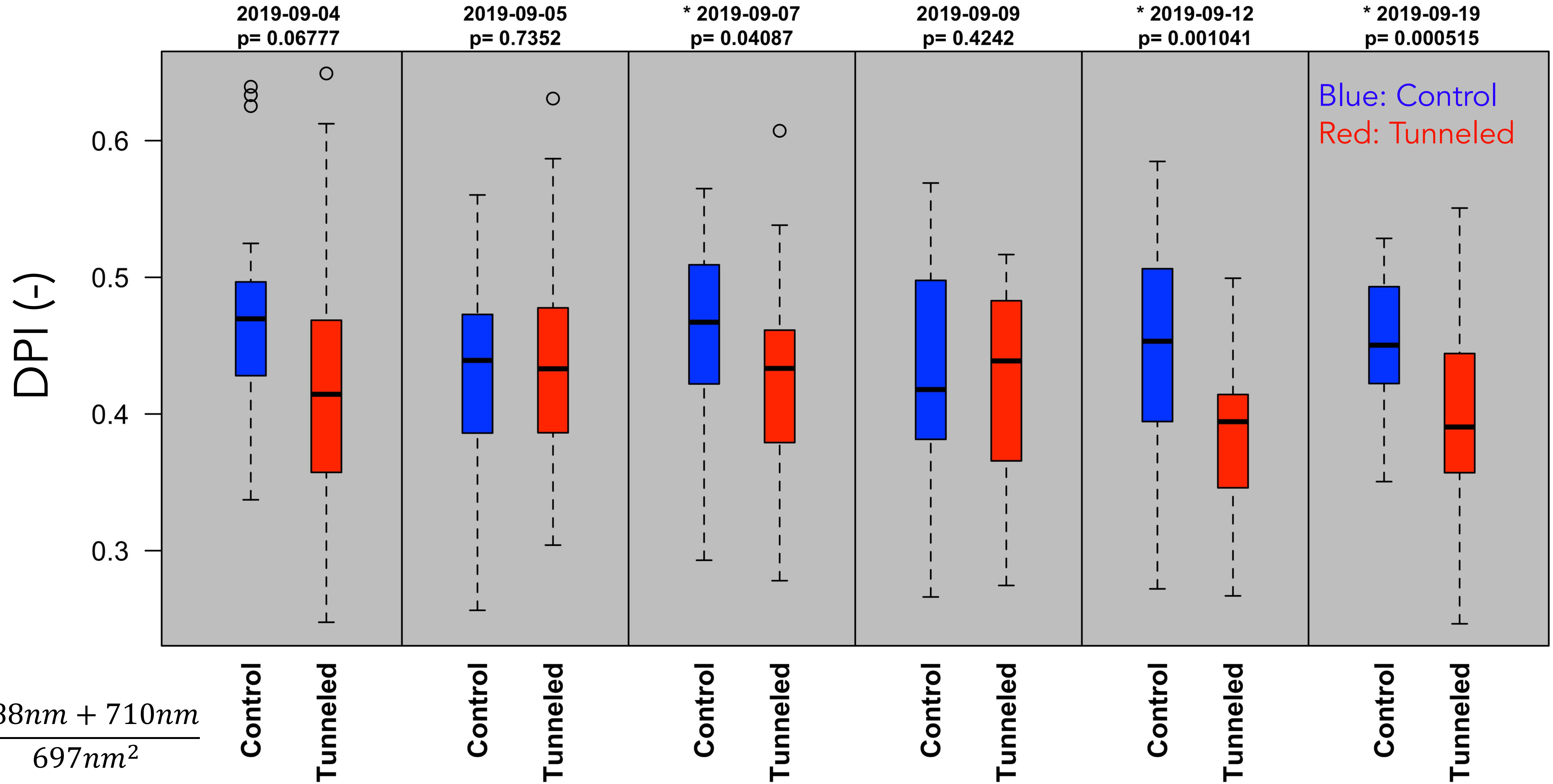


Response of canopy reflectance to tunneling



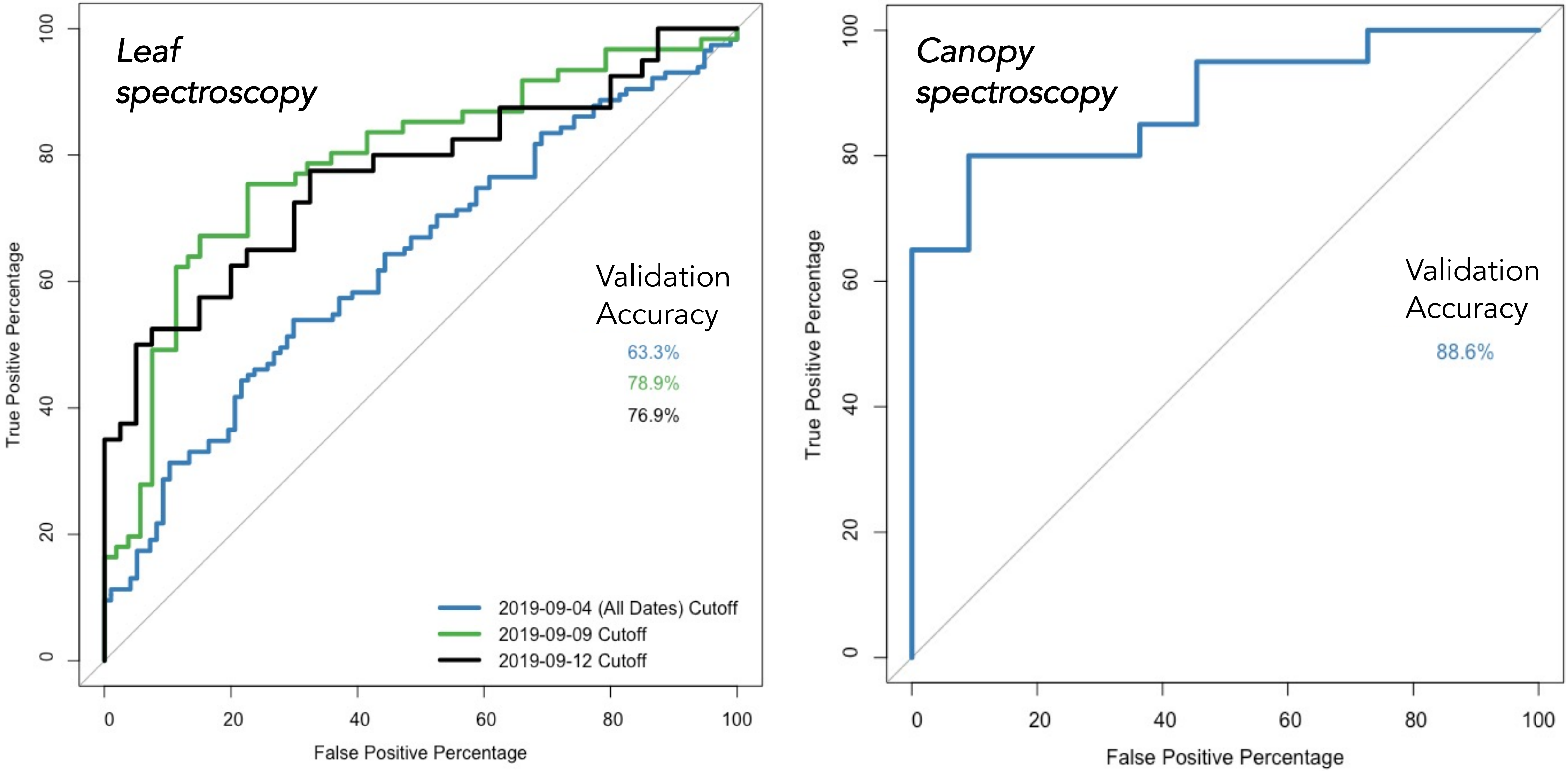


Tunneling significantly changed reflectance



$$\frac{688nm + 710nm}{697nm^2}$$

Machine-learning approach to detect tunneling

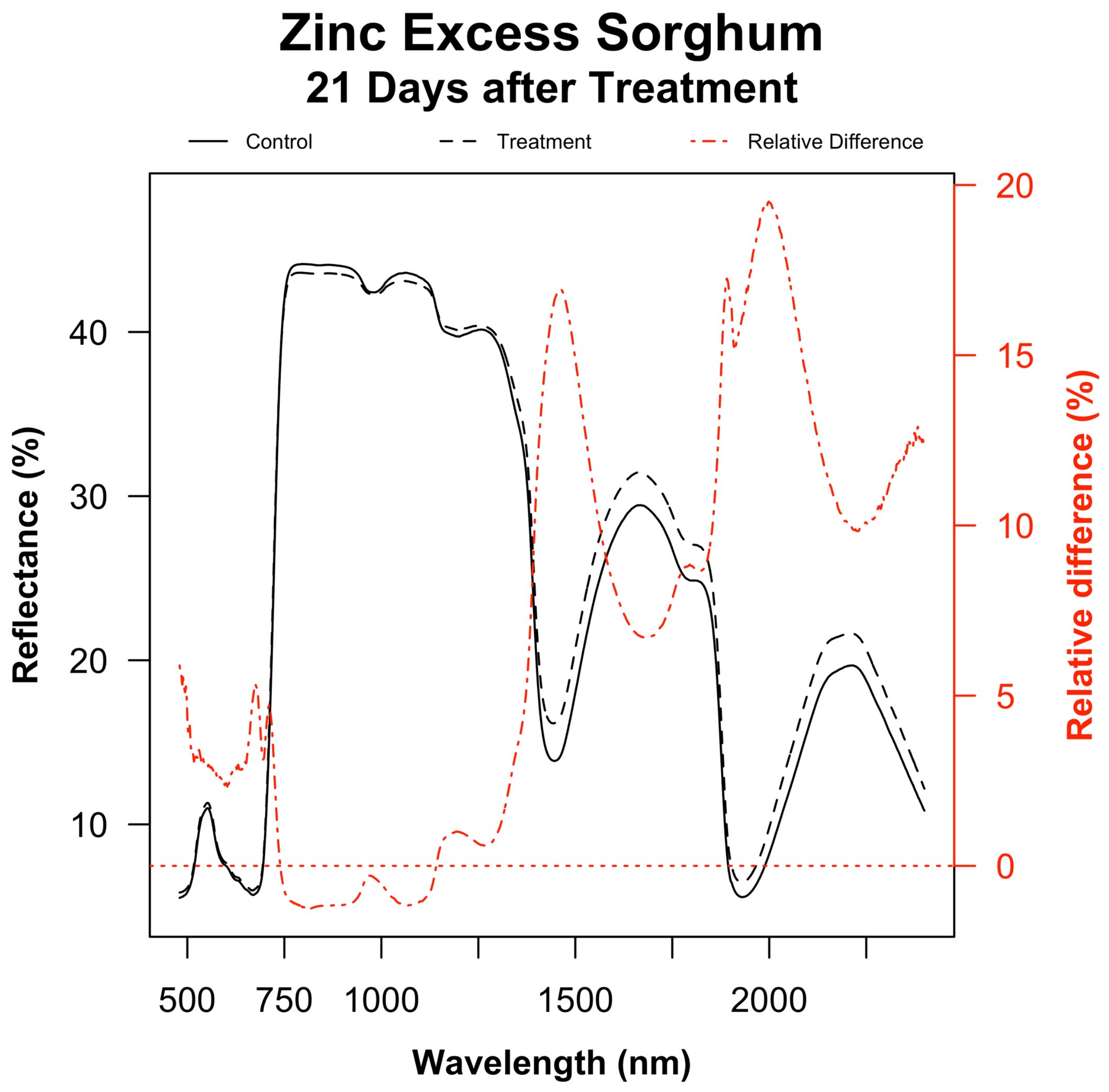


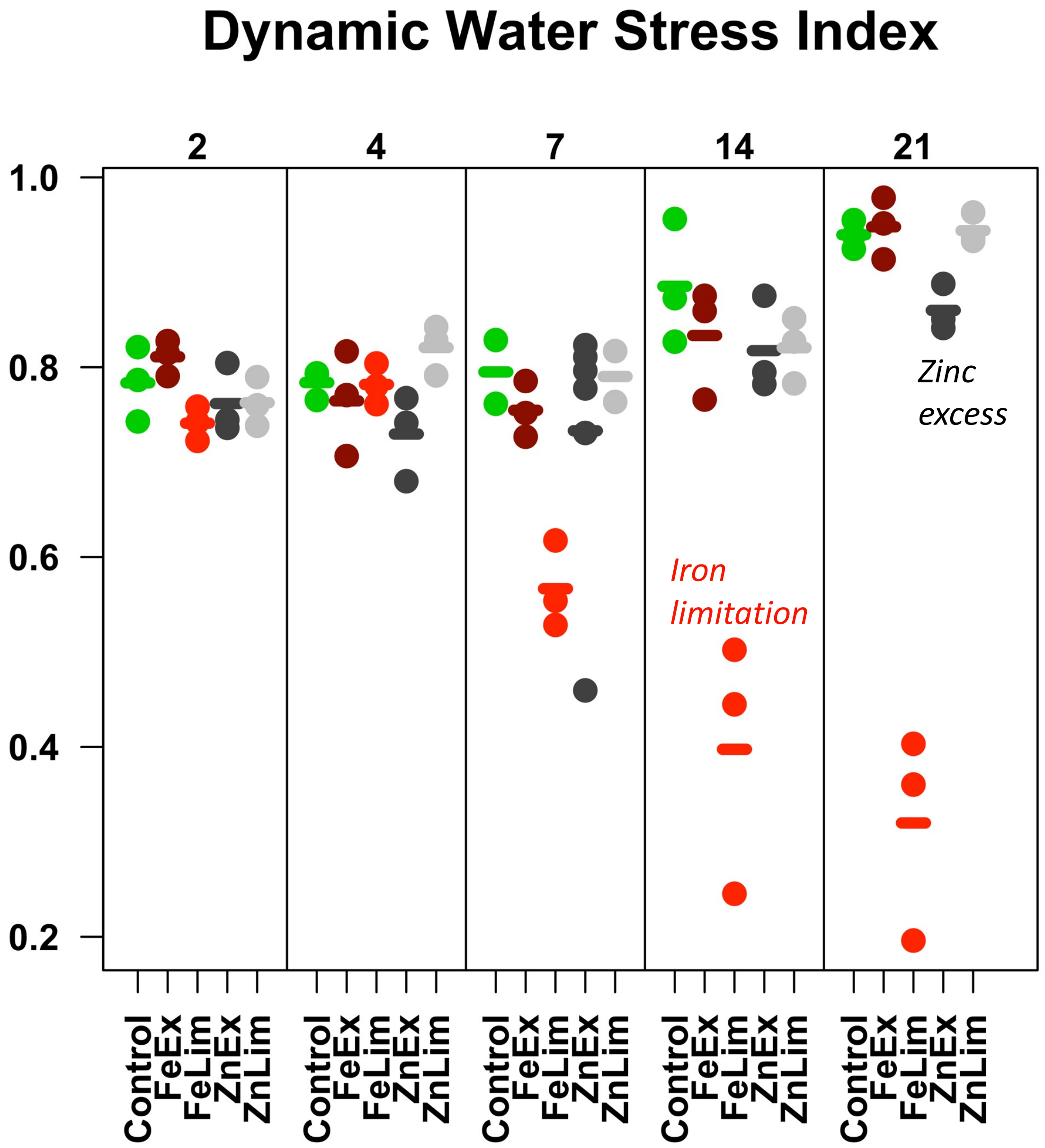
Out-of-sample Validation data

Project Summary

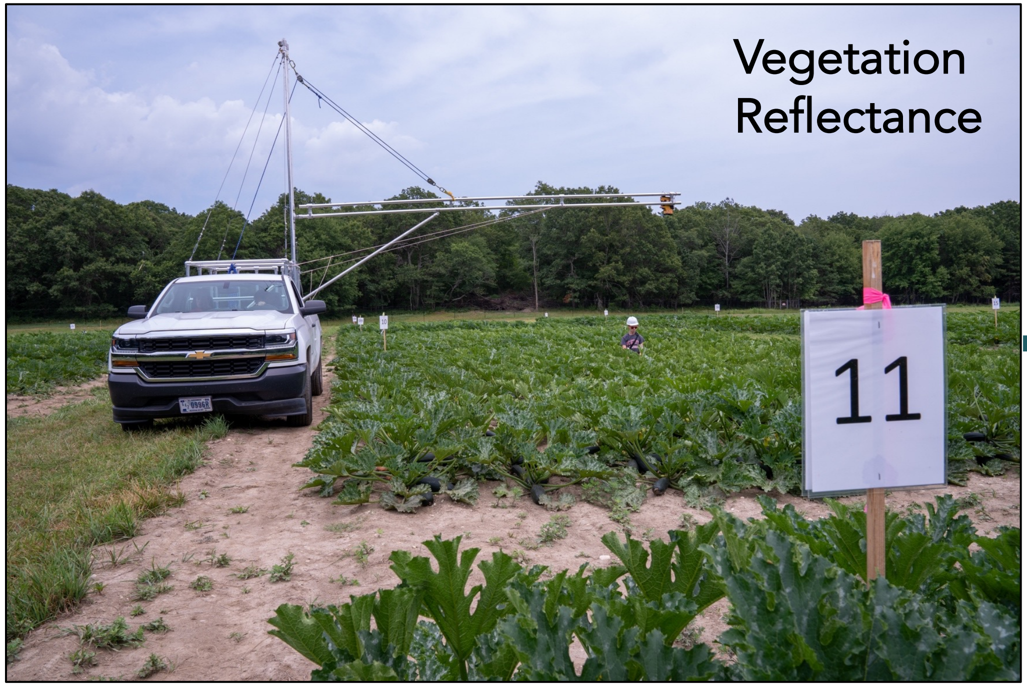
- The most robust physiological signal associated with tunneling was a reduction in stomatal conductance (plant water relations)
- Remote sensing data showed a range of responses, but strong links with changes in plant water status
- Even with a significant decline in leaf conductance, canopy transpiration was largely maintained, and we didn’t observe a strong thermal response (with TIR imagery)
- Despite large variation in functional properties across time and leaf age, spectroscopy showed strong predictive capacity for key physiological changes and an ability to directly detect tunneling stress signatures through reflectance alone

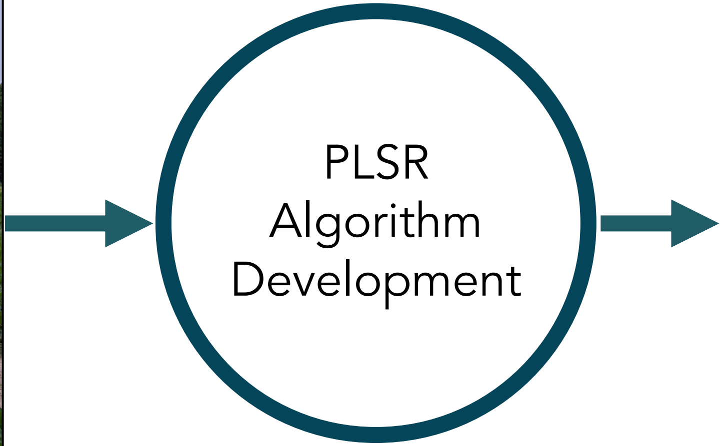
Impacts of iron limitation and zinc excess on spectra

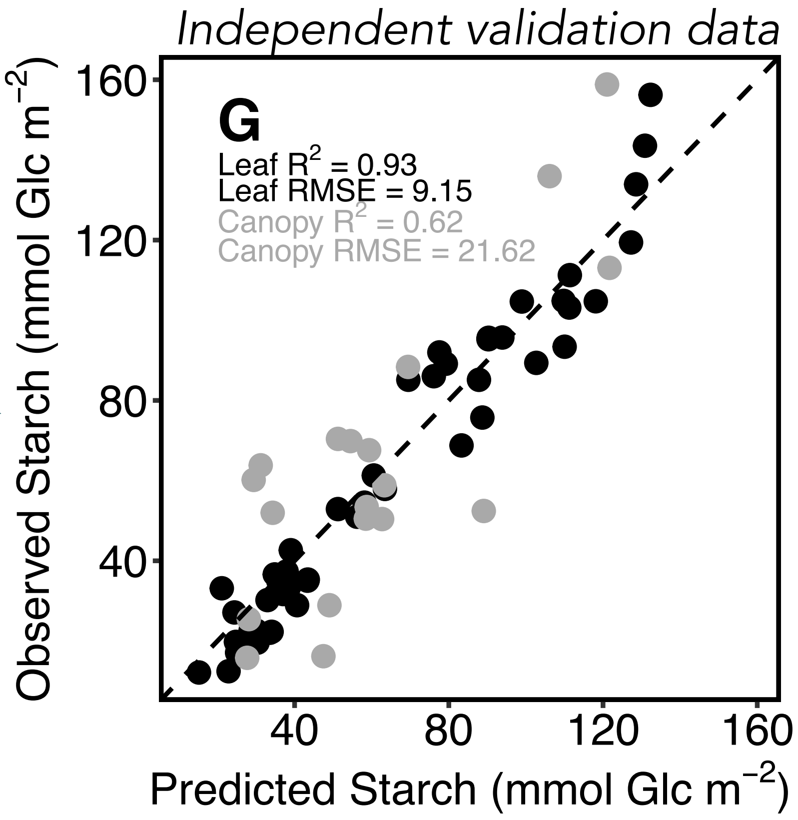




Physiological traits for drought detection can be predicted w/ reflectance spectroscopy



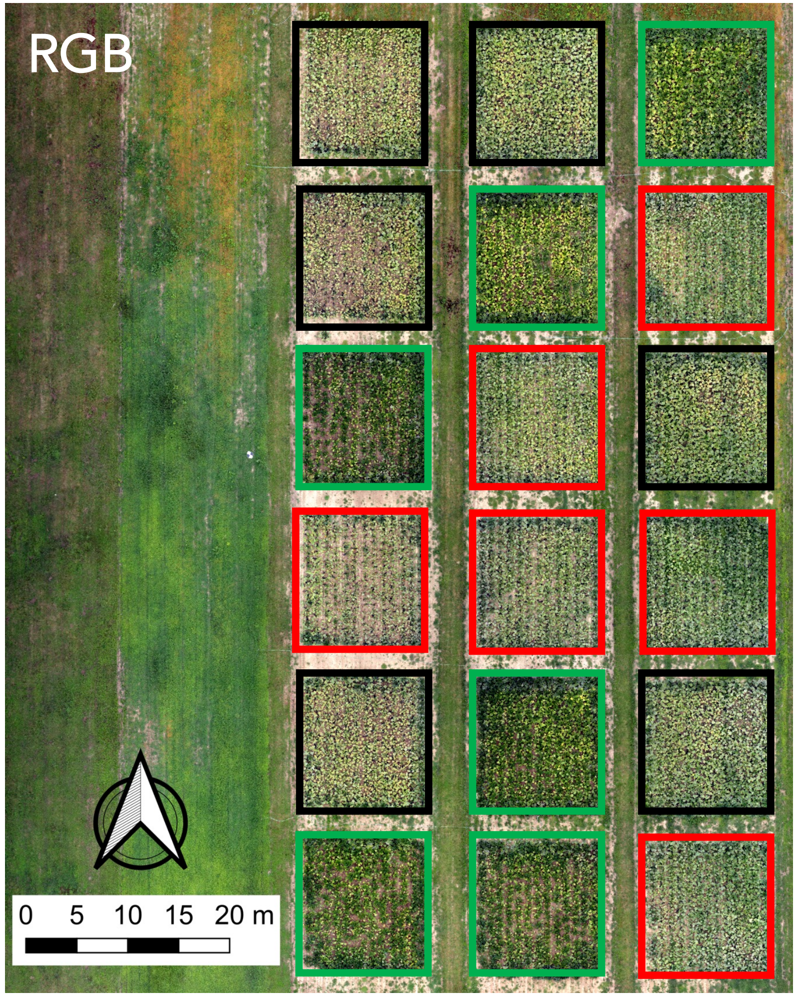




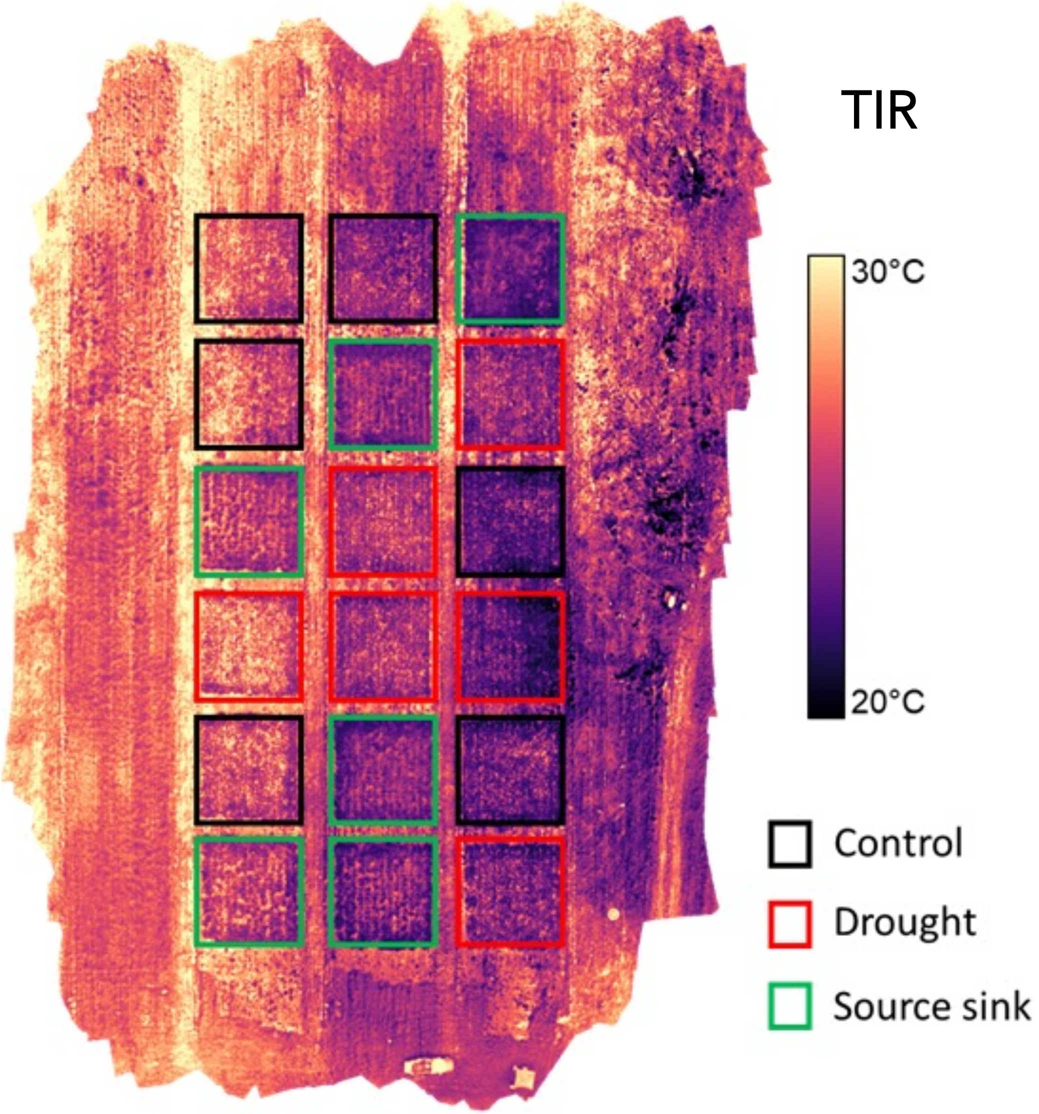
We have developed a series of models across a range of structural, physiological, and biochemical traits.

Burnett et al., Plant Cell & Environment (in press)

Sink manipulation increased plant vigor while drought stress increased canopy temperatures in zucchini plants



More vigorous plants w/ sink manipulation



"Warmer" plants w/ drought

Burnett et al., Plant Cell & Environment (in press)

BNL facilities for controlled plant manipulations