Early Detection of Oak Wilt Disease in Quercus ssp.

A Hyperspectral Approach

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Research Objectives

- To develop and conduct an environmental investigation of the pathogenesis of oak wilt disease in the woodlands of central Texas using field-spectrometry, a controlled greenhouse experiment, and analysis of hyperspectral imagery.

- To build a species discriminatory spectral library of the common tree species of the Texas Hill Country taking into account species phenology.
What is Oak Wilt disease?

- A vascular disease commonly afflicting oak species
- Disease agent is the fungus *Ceratocystis fagacearum*
- Oak wilt ranges from central Texas to the upper midwest
- First described in the 1930’s
- Has killed millions of trees
- Texas has been hit particularly hard
National distribution of oak wilt
Texas occurrence of oak wilt

Disease centers in the Kerrville area
An oak wilt photo gallery
Commonly affected species in Texas

- Quercus fusiformis (Plateau live oak)
- Quercus virginiana (Coastal live oak)
- Quercus texana (Spanish red oak)
- Quercus stellata (Post oak)
- Quercus marilandica (Blackjack oak)
The Challenge

- To spectrally discriminate a disease-induced stress signal from a multitude of other stress signals as well as inherent spectral variability within and across species and variability across time
Research Considerations and Experimental Design

Data Collection

- Field spectrometry
  - Baseline spectra
    - leaf
    - branch
    - canopy
  - Greenhouse study
    - Controlled inoculation
      - Observe spectral change
- Hyperspectral imagery
  - Airborne and satellite
    - Species ID
    - Stress ID
Preliminary Research

- Collection and analysis of leaf spectra for:
  - Variance within species
  - Variance across species
  - Variance with time (phenology)
  - Effects of water loss (stress)
  - Effects of additive reflectance
  - Continuum removal analysis
  - Effects of on-branch analysis vs. in-lab analysis
Collected radiance data

- Solar radiance spectra at base of atmosphere
- H₂O absorption
- Oak canopy radiance spectra
Reflectance spectra

- Visible
- Near infrared
- Middle infrared

- Chlorophyll absorption
- Leaf H₂O absorption

The red edge
Variation within species

![Spectral variation of live oak plot](image)
Variation across species
Phenologic influences

A Spectral Comparison of Seasonal Live Oak Leaves

- New spring leaf
- Mature late season leaf
Response of leaf reflectance to decreased water content for the adaxial surface of *Magnolia grandiflora*
Effects of water loss
Effects of water loss cont.
Additive reflectance phenomena

Figure 2. The effect of multiple leaf layers on the effective reflectance from vegetation. $I$ = incoming energy, $T$ = transmitted energy, $R$ = reflected energy (Adapted from Hoffer, 1978).
Effects of additive reflectance
Chlorophyll absorption trough continuum removal

- **Width (FWHM)**
- **Depth**
- **Area**

![Graph showing continuum removal](image)
Continuum-removed comparison

Comparison of continuum-removed spectra

- Juniper
- Post Oak
- Red Oak
Future work

- Start controlled inoculation experiment with 20 live oak saplings
  - Analysis of spectral leaf reflectance
  - Detection of an infection stress signal
  - Crossed design with inoculant and water regimen treatments

- Acquire hyperspectral (Hyperion) data in June

- Begin spectral field sampling of an oak wilt disease center (summer)
Questions?