Exploring biodiversity through optical diversity

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Dimensions of Biodiversity Team
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  - Jeannine Cavender-Bares (PI), Keren Bitan
  - Rebecca Montgomery (phenology)
  - Sarah Hobbie
  - Peter Reich
  - David Tilman

- **University of Wisconsin**
  - Phil Townsend, John Couture, Clayton Kingdon
  - Rick Lindroth

- **University of Nebraska**
  - Art Zygielbaum, Abby Stilwell, Rick Perk

- **Appalachian State University**
  - Mike Madritch

- **University of Alberta**
  - John Gamon, Ran Wang
Project Overview

Optical Diversity Hypothesis

Surrogacy Hypothesis

J. Cavender-Bares
Optical Diversity Detects Species Richness – but why & how?

Chaparral (Santa Monica Mountains, CA)

Boreal Forests (Alberta, Canada)

Zutta 2004

DeLancey 2014
Remote sensing questions:

• *Why* does this work?
• What are we really detecting?
  – *leaf traits*?
  – *canopy structure*?
  – *phenology*?
• Can we detect underlying *functional* and *genetic* diversity?
• What is the *scale-dependence* of these topics?
Multi-scale Sampling Scheme

Airborne image

Plot image cubes – 9x9m (airborne and proximal)

Headwall image cube – 1x1 m

RGB true-color image

Spectral variability plot

Spectral variability plot
Phil Townsend and AVIRIS NG

← Cedar Creek LTER
Airborne Sampling

- AISA Eagle &
- Headwall E-Series
Cedar Creek Biodiversity Plots

AISA Eagle Image Courtesy: A. Stilwell, R. Perk, A. Zygielbaum (U. Nebraska)
Field Spectrometer Mounted on the Tram
Plot Grid Sampling Design

(sampled from tram)
Plot Grid Sampling Design

(sampled from tram)
Plot Grid Sampling Design

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(sampled from tram)
Plot Grid Sampling Design

(sampled from tram)
Synthetic Plot Image

(sampled from tram)

R. Wang & J. Gamon
Plot 68 (SR = 16)

Top figures - Abby Stilwell, Bottom figures – Ran Wang & J. Gamon
Imaging Spectrometer on Tram

Ran Wang operating the Headwall E-Series
Spectral Detection of Photosynthetic Activity

True-color image
(Plot 30, SR = 16)

False-color image:
Red = Fluorescence
Green = Chlorophyll
Blue = PRI
Leaf Trait Analysis

Principle coordinates analysis (PCO) of leaf spectra and other leaf traits (N, C, C:N, LMA, fiber, lignin, cellulose, NDWI, Chl, PRI) distinguish diversity levels.

(Courtesy J. Couture and P. Townsend)
Sampling leaf traits
Initial Conclusions:

• *Optical Diversity* detects species richness
  – Scale dependence not yet clear.

• *Surrogacy* – diversity affects productivity
  – Diversity linked to ecosystem function.
  – This relationship evolves over the season

• *Leaf traits, canopy structure, and phenology* are all important!
  – Relative effect not yet clear.