Linking canopy structure and function in a temperate deciduous ecosystem

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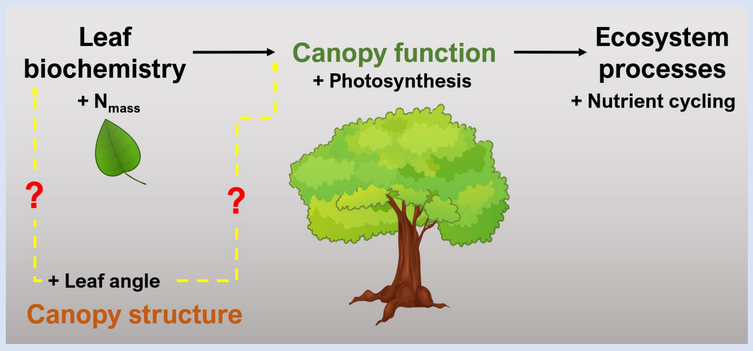
Integrating canopy structure and function – why does it matter?

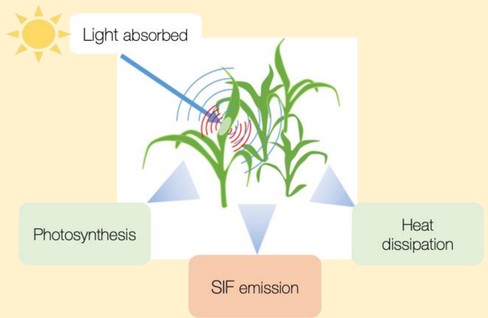


Plant canopy function affects large-scale ecosystem processes, including carbon cycling, surface energy balances, nutrient cycling, and trophic flows.

While we know how leaf biochemistry and functional traits affect canopy function, we know less about how canopy structure affects canopy function. My research is inspired by understanding how canopy structure coordinates with biochemistry and function at the leaf level to affect canopy function.

Connecting canopy structure to canopy function with remote sensing

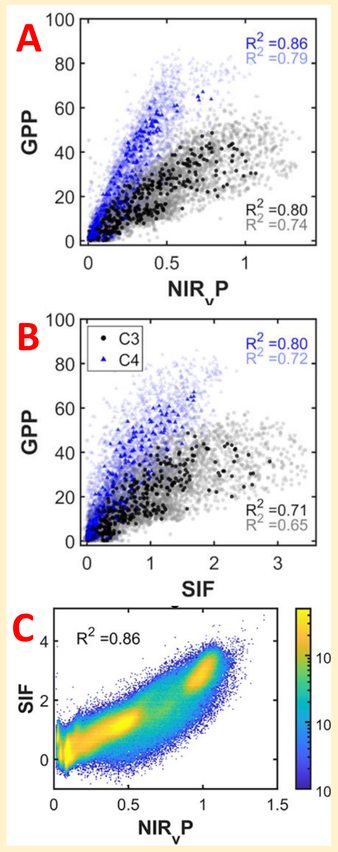
Remote sensing of canopy function



Mohammed *et al.*, 2019

1. Solar-induced chlorophyll fluorescence (SIF) is a novel method for monitoring gross primary productivity (GPP) and physiological dynamics (canopy function, panel A).

2. Near-infrared vegetation radiance (NIR_V) can also be used for monitoring GPP (panel B).



Dechant *et al.*, 2022

3. NIR_V and SIF are correlated (panel C), but the mechanism isn't understood.

4. The relationship should be affected by:
   1. Leaf biochemistry (canopy function).
   2. Properties of canopy structure, including the leaf angle distribution.

Research Question

How does variability in the NIR_V – SIF relationship correspond to variation in leaf angle distribution (canopy structure) and leaf biochemistry (canopy function)?

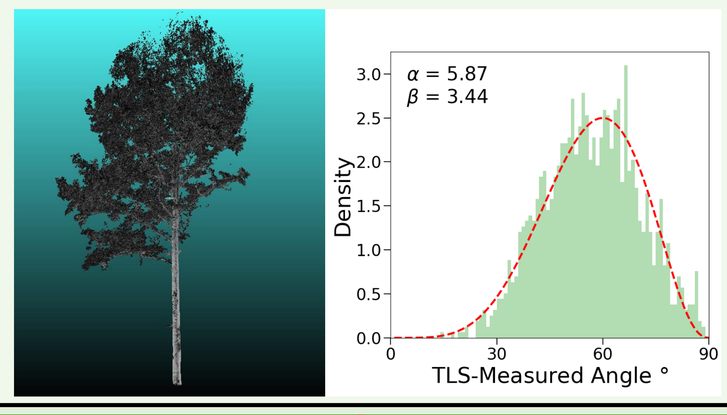
Measuring canopy structure

Terrestrial LIDAR scanning (TLS) permits the rapid and accurate measurement of 3-dimensional canopy structure. 3D models are used to calculate the leaf angle distribution (Stovall *et al.,* 2021).

Leaf angle distribution (LAD)

A beta function (parameters α and β) is used to model LAD.

- α and β are inversely related to standard deviation (SD). **Lower values = higher SD.**

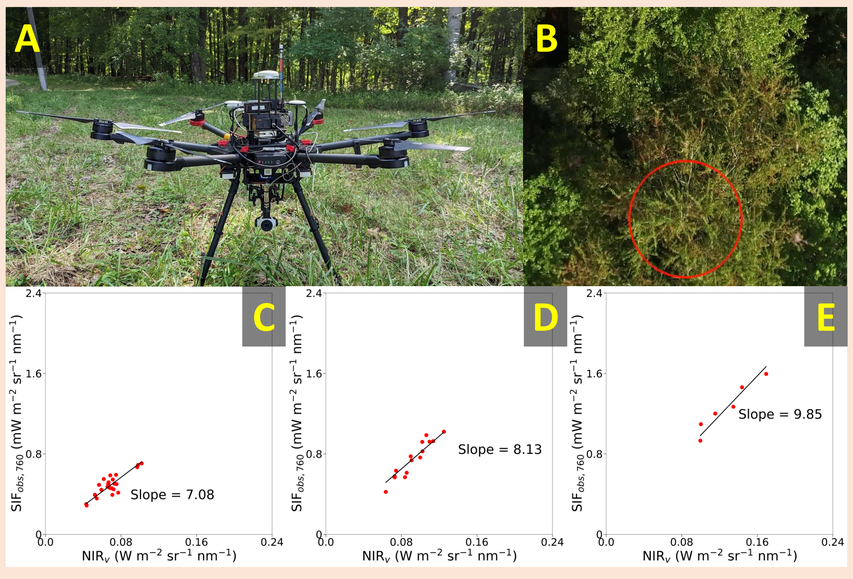


TLS and UAS observations

Using an unmanned aerial system (UAS, panel A):

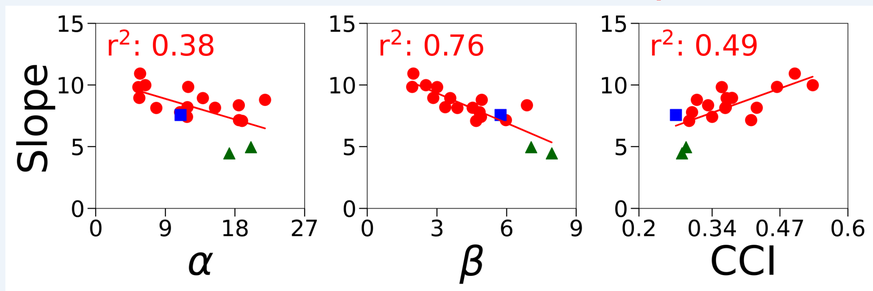
- NIR_V, SIF, and CCI, for individual canopies (panel B) was measured.
- Hourly observations from 8:00 – 17:00 across the 2021 growing season.

The diurnal NIR_V – SIF slope was calculated for each canopy (examples C – E). I examined how LAD parameters and the chlorophyll-carotenoid index (CCI), a proxy of canopy chlorophyll content, related to the slopes.



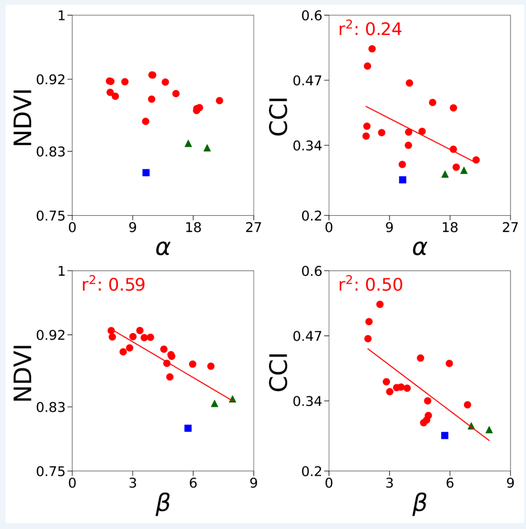
How are canopy structure and function linked?

1. LAD and canopy pigments control the covariation between NIR_V and SIF



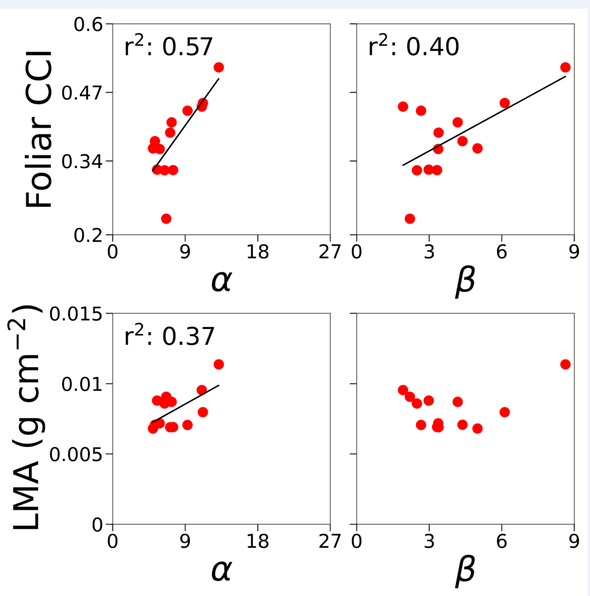
- Sensitivity of the diurnal slope **decreases** with increasing α and β (leaf angle SD declining).
- Sensitivity of the diurnal slope **increases** with increasing canopy chlorophyll content.

2. LAD is a control on CCI, NDVI



- Canopy chlorophyll content and NDVI **decrease** with increasing α and β (leaf angle SD declining).

3. Foliar traits show coordination with LAD



- Foliar CCI and LMA **increases** increasing α and β (leaf angle SD declining).
- LAD – CCI relationship at the leaf level is opposite of what was observed at the canopy level.

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