

# Can linking leaf traits to crown structure help us understand tree photosynthetic strategies?

Jack Hastings, Andrew Ouimette, Kaitlyn Baillargeon, Franklin Sullivan, Michael Palace and Scott Ollinger  
Earth Systems Research Center, University of New Hampshire, Durham, NH, USA



## Background:

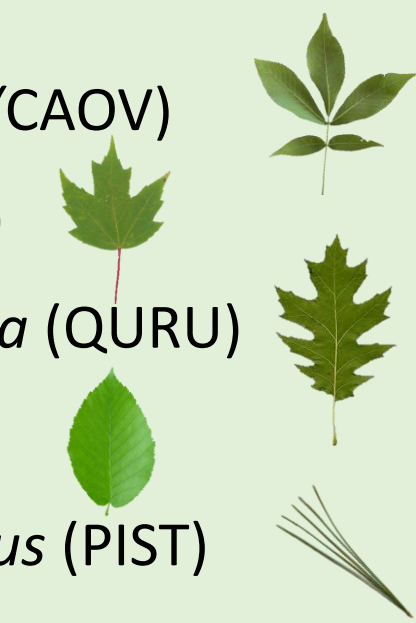
- Trees invest in aboveground architecture primarily to support the display of foliage for photosynthesis. The enormous variety of crown architecture observed across tree species is an indication of many different strategies to disperse foliage for light harvesting.
- Differences in tree species leaf nitrogen and photosynthetic capacity have been hypothesized to lead to different strategies for optimizing light interception and maximizing canopy carbon assimilation. These strategies influence patterns of carbon allocation that determines the geometry of stems and branches, which, in turn, control the display of foliage throughout whole crowns. Although intriguing, our understanding of how leaf-level traits drive canopy structure remains far from complete.
- Here, we provide an overview of our work to better understand links between leaf traits and canopy structure and how these relationships may help us better understand how photosynthetic strategies manifest at the crown-scale.

## Fieldwork:

- During the 2022 growing season, we used a 92 ft. mobile canopy lift (Figure 1) to make measurements along vertically gradients in the crowns of five of the most dominant species of a mixed hardwood – pine forest at the Thompson Farm Earth Systems Observatory in Durham, New Hampshire, USA.

### Our study species include:

- shagbark hickory, *Carya Ovata* (CAOV)
- red maple, *Acer rubrum* (ACRU)
- northern red oak, *Quercus rubra* (QRU)
- black birch, *Betula lenta* (BELE)
- eastern white pine, *Pinus strobus* (PIST)



- We characterized how numerous leaf- and branch-level traits changed along light gradients from sunlit upper canopy to shaded lower canopy. We measured leaf physiology (Amax, dark respiration, etc.), chemistry (%N), and structure (LMA, EWT, size), as well as leaf transmittance and reflectance. We also measured foliage display characteristics including leaf angle distribution and metrics of foliage clumping.

- Data processing and analysis is ongoing. This poster focuses on just a few canopy structural parameters that we think are important for understanding links between leaf traits and canopy structure.



Figure 1: (A) We used a 92 ft. mobile canopy lift to sample leaf and branch traits along vertical canopy gradients in five common trees species. (B, C) View from top of the canopy.

## Leaf angle distribution and foliage clumping:

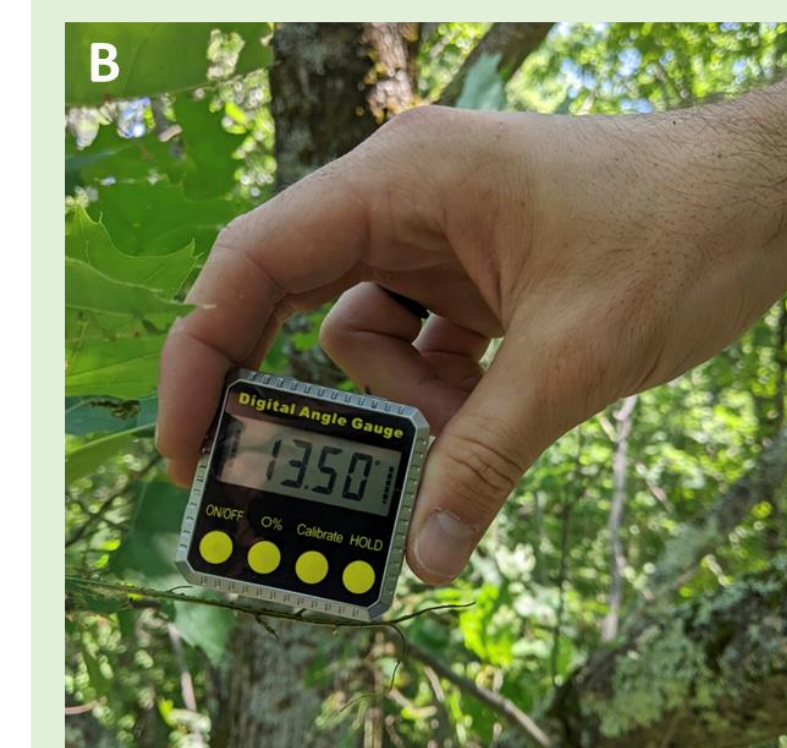
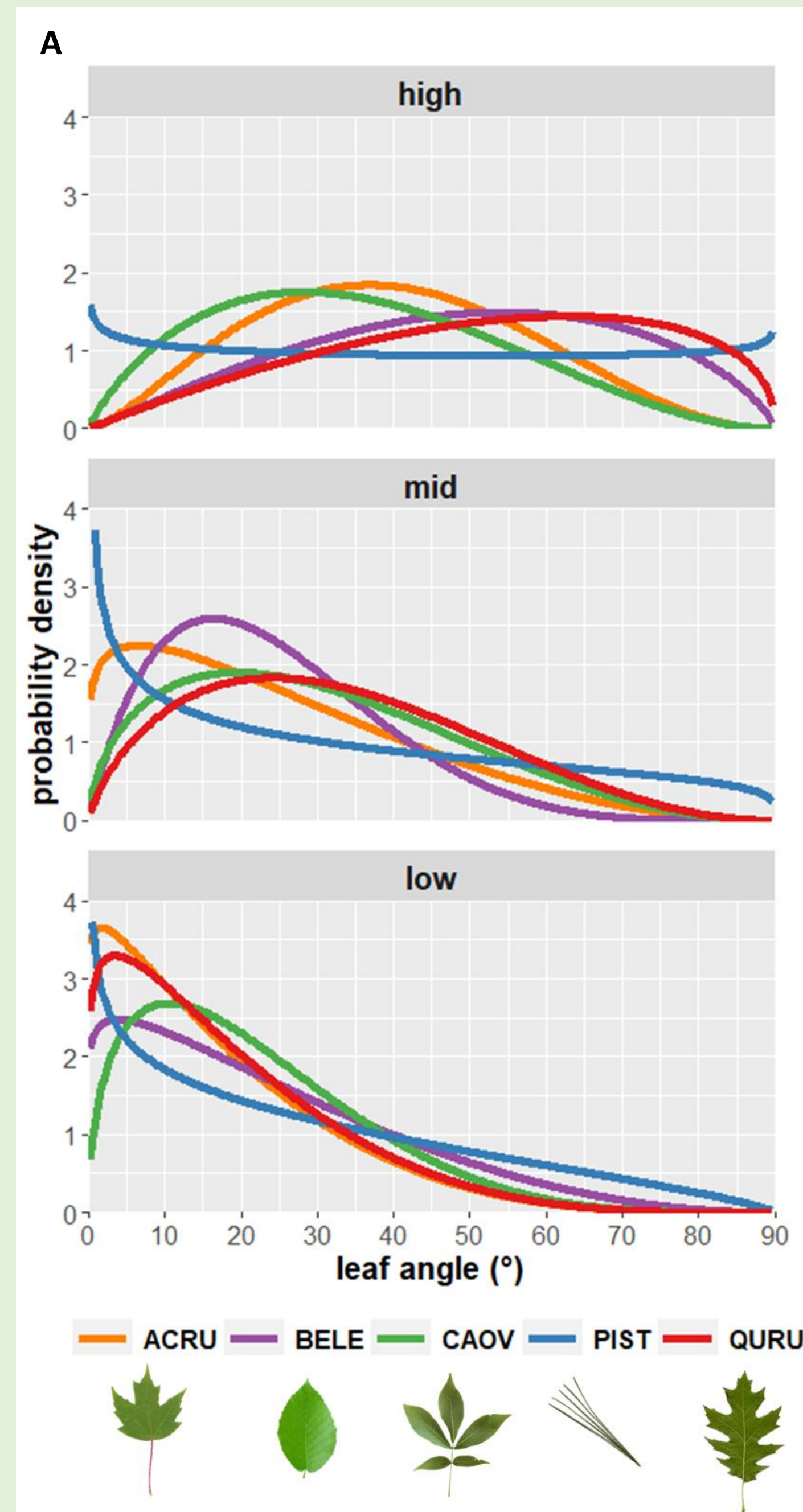


Figure 2: (A, left) Leaf angle distributions of high, middle, and low canopy foliage. (B, above) We made more than 2000 leaf angle measurements across the five species using a digital angle tool.

- Leaf angle distribution (LAD) and foliage clumping are two important structural parameters for understanding how tree canopies interact (e.g., absorb, reflect and transmit) with sunlight.
- We characterized LAD (Figure 2A) through the canopies of our target trees by measuring more than 2000 leaves in situ using a digital angle tool (Figure 2B).
- Clumping occurs at multiple scales (e.g., branches, crowns, stands) in forest, and can be described in numerous ways. Here we chose to characterize clumping (Figure 3A) at the branch-level using a ratio of branch silhouette area (Figure 3B) to total branch dry foliar mass, which we are calling specific branch area (SBA,  $\text{cm}^2 \text{g}^{-1}$ ).

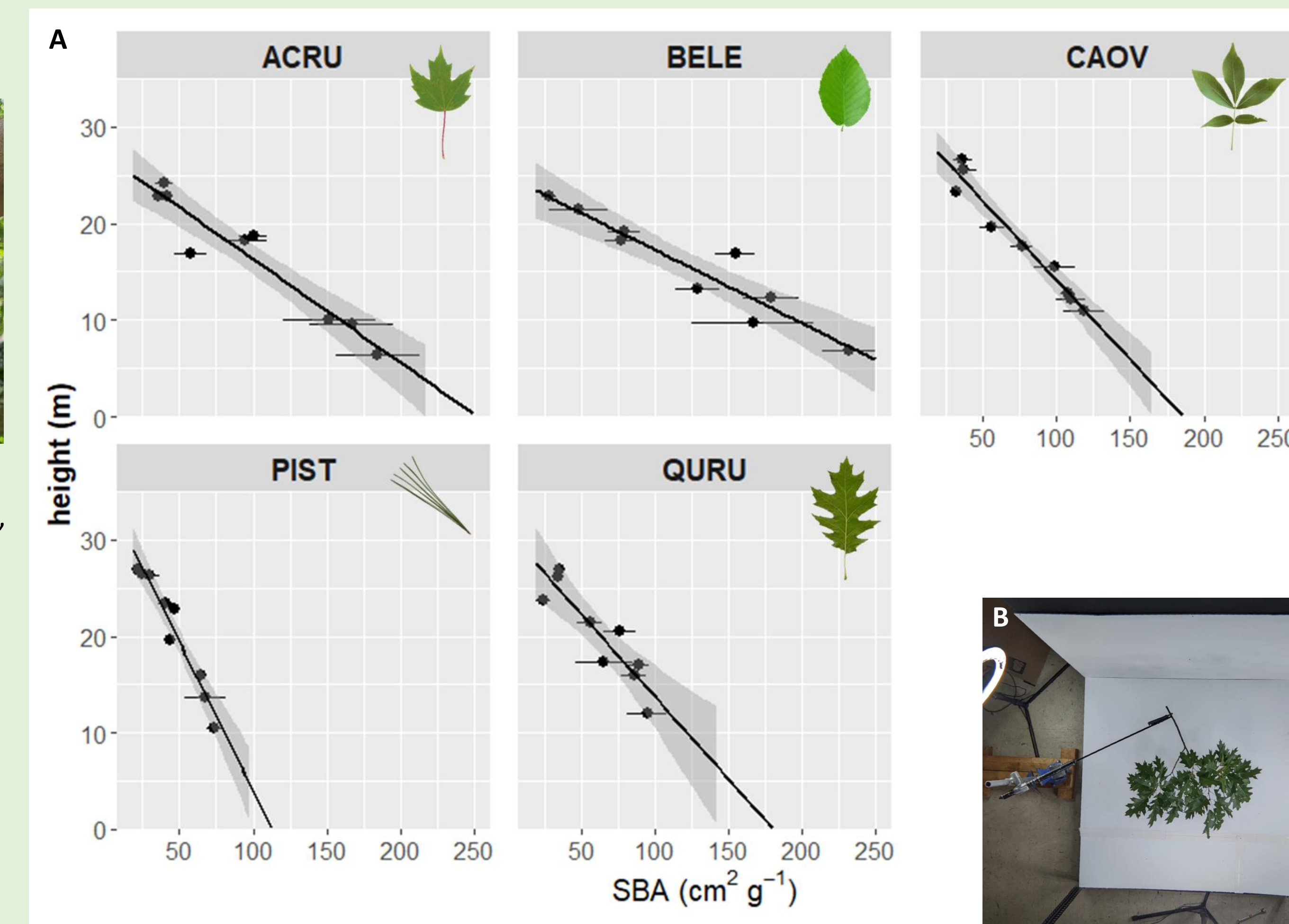


Figure 3: (A, left): Patterns of foliage clumping along canopy vertical gradients. Foliage clumping here is characterized using SBA, a ratio of branch silhouette area to total dry foliar mass. (B, below) Branch silhouette area was measured by taking photographs from above of collected branches set up in native orientation (i.e., matched branch angle and azimuth).

## Where are all the leaves?

- Characterizing leaf and branch traits is informative, but a key measurement for contextualizing these traits is understanding the species-specific distribution of foliage through their crowns. For example, species with higher leaf nitrogen and photosynthetic capacity should hypothetically prioritize displaying more foliage in the high-light upper canopy (Figure 4).
- To understand species-specific foliage distribution, we collected high-density UAS LiDAR over our study area (Figure 5). We are processing the LiDAR for measurements of individual tree crown leaf area density and other canopy traits.

Figure 4: Hypothetical (A) leaf and (B) canopy light environment for low %N and high %N canopies.

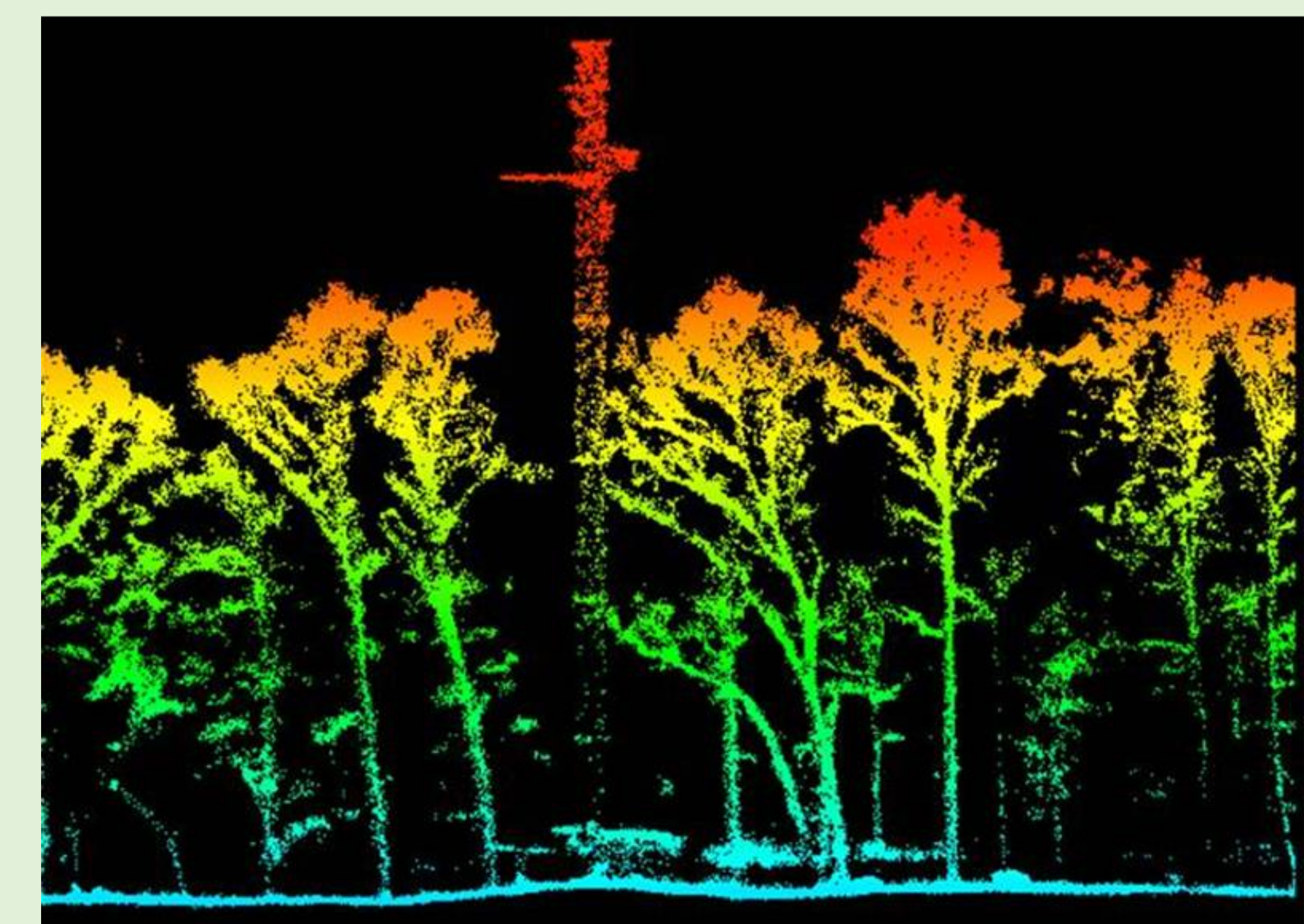
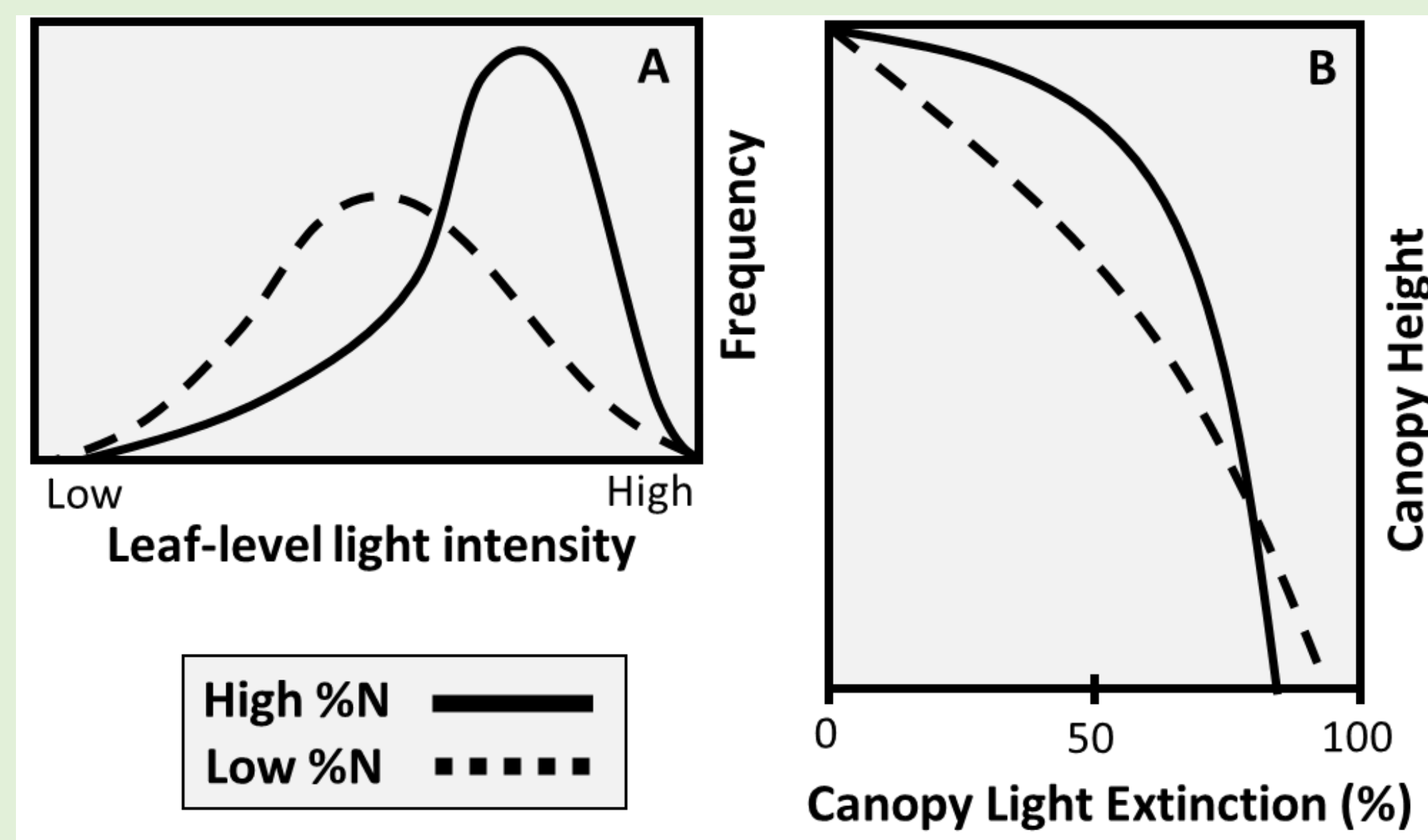
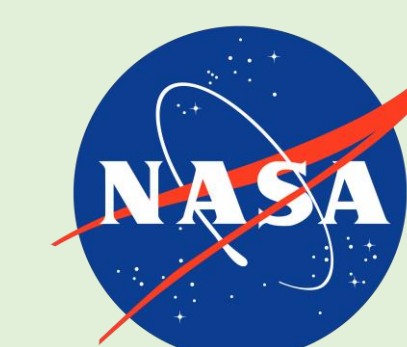


Figure 5: We collected high-density LiDAR over our study area, which will be processed to understand leaf area density in our study species. This slice of the LiDAR point cloud shows profiles of tree crown architecture as well as the Eddy Covariance tower at Thompson Farm.

## Acknowledgements:

Thank you to Casey Mills, Emily Landry, and Zaixing Zhou for your valuable help during the busy field season! This work was supported by the NSF (NSF-OIA-1920908, NSF-EF-1638688), NASA (NASA 80NSSC20K1730) and USDA NHAES (Hatch NH00671), and is a product of the Harvard Forest LTER program (NSF-LTER 1832210).



## Questions, comments?

Jack.Hastings@unh.edu  
\_JackHastings\_