Detecting foliar nutrient status from the sky

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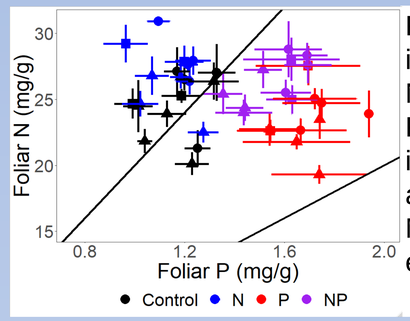
Background

It can be expensive, difficult, and destructive to collect representative foliage samples. Recent advances in remote sensing technology have made it possible to quantify individual tree crowns across entire landscapes from the sky. However, empirical data from field studies may be useful for guiding the interpretation of remotely sensed data. Here we use airborne imaging spectroscopy and LiDAR data to further explore nutrient limitation by N and/or P in the White Mountains National Forest of New Hampshire, USA.



Foliar N increased with N addition. Foliar P increased with P addition in the MELNHE experiment.

Objective:

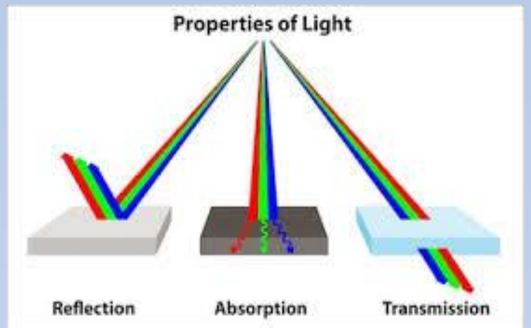
Can we use spectral and LiDAR data to detect differences in canopy reflectance related to increased N and P availability?

LiDAR data

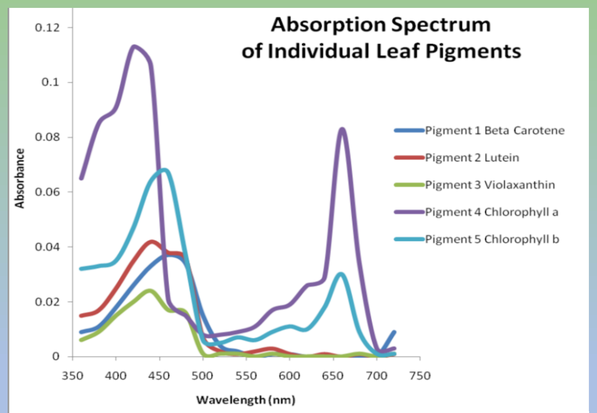
- Tree top detection using 'ForestTools'

Methods

The Multiple Element Limitation in Northern Hardwood Ecosystems (MELNHE) experiment has been adding 30 kg/ha/yr of N (NH_4NO_3) and 10 kg/ha/yr P (NaH_2PO_4) in a factorial combination by hand each spring since 2011. In August of 2017, the National Ecological Observatory Network Airborne Observatory Platform flew over 9 forest stands in the MELNHE experiment, collecting hyperspectral canopy reflectance at 400+ bands per 1 m^2, high-resolution RGB images, and LiDAR data.



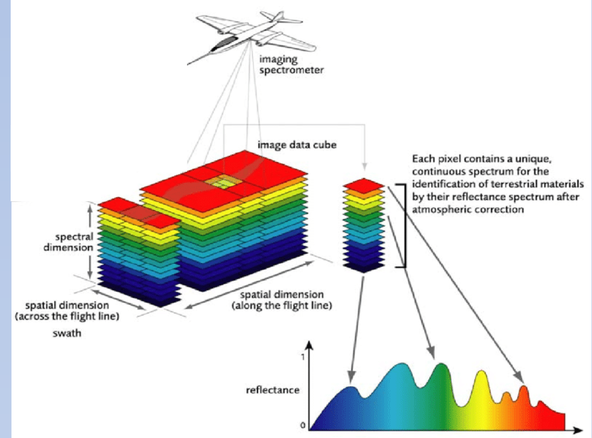
Leaves absorb wavelengths of light for photosynthesis, but also reflect light to mitigate photoinhibition.



Even though chlorophyll a absorbs the most light, accessory pigments are also important for optimal photosynthetic rate.

Spectral data

- mask by NDVI > 0.9, normalize reflectance

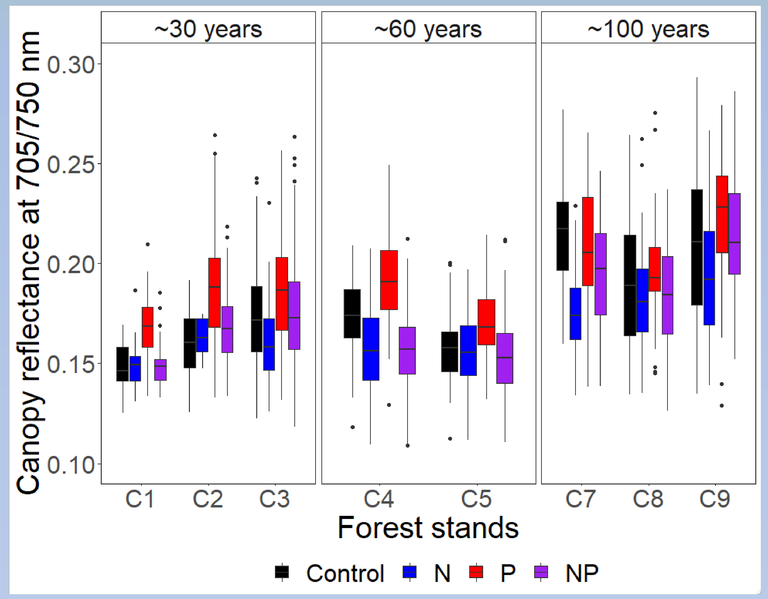


Data analysis

Reflectance was extracted for each tree crown. The ratio of reflectance at 705 nm and 750 nm was averaged by treatment plot and compared using a N*P factorial ANOVA blocked by stand.

Results:

-Canopy reflectance was lowest in young stands ($p < 0.01$).
-Trees that received P reflected more light at 705 nm compared to trees that did not receive P ($p < 0.01$).
-Trees that received N reflected less light at 705 nm compared to trees that did not receive N ($p = 0.01$).



Discussion:

- Treatment effect was detected at the plot level without accounting for species-level differences.
- Trees that received N may reflect less because they have more chlorophyll.
- Young forests reflected less light than old forests.
- After decades of anthropogenic N deposition, P availability likely decreased relative to that of N.