Generating Plant Foliar Trait Products Using High-Resolution NEON Remote Sensing Data

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neon
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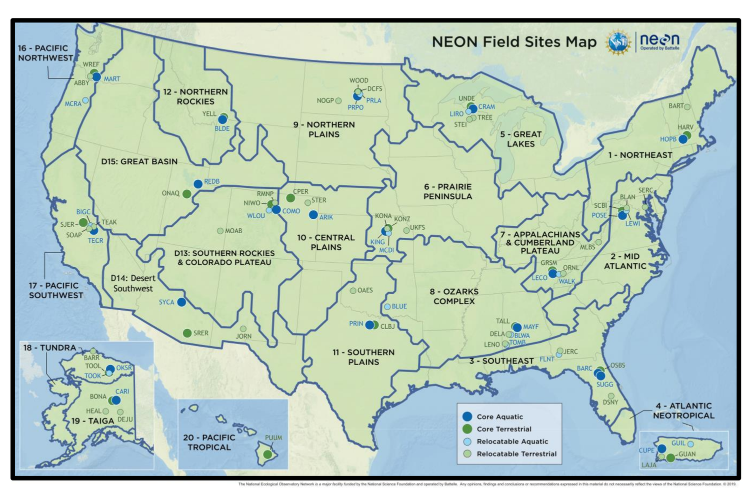
Abstract

Foliar structural and biochemical traits are important regulators of biogeochemical processes, such as primary productivity and nutrient cycling. They may also serve as key indicators of ecosystem response to anthropogenic and natural disturbances. Airborne imaging spectroscopy is a valuable tool for mapping ecologically important canopy foliar traits over large spatial scales. The Airborne Observation Platform (AOP) of the National Ecological Observatory Network (NEON) collects multiyear, high-resolution (1 m) hyperspectral imaging spectroscopy, lidar, and digital camera data for 81 field sites across the United States. By combining the high-resolution remote sensing data with ground-based measurements of sunlit foliar chemical and physical traits that overlap spatially and temporally with the imagery, this study aims to develop generalizable predictive models for leaf biophysical and biochemical properties for the 47 NEON terrestrial sites across the United States.



NEON field sites and ecoclimatic domains

Scan the QR code to explore NEON data

NEON Remote Sensing Data

Level-1 reflectance data, 426 bands (385 - 2500 nm) at 1m resolution

BRDF correction
Topographic correction
Wavelength resampling

Corrected reflectance

+

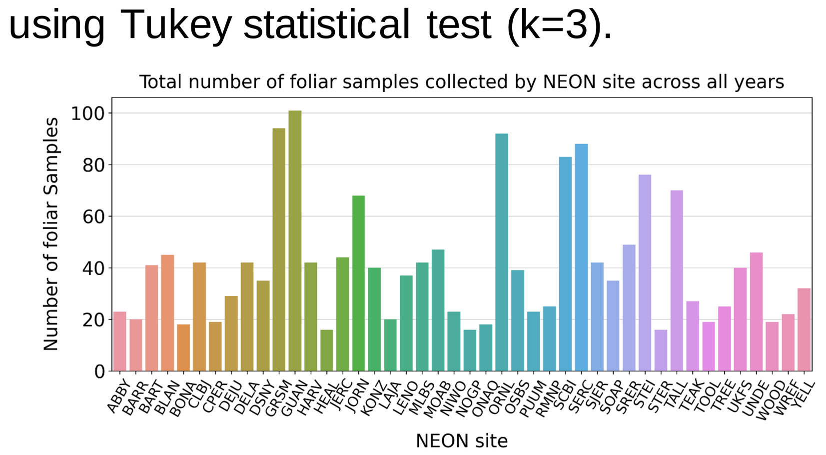
Level-3 lidar-derived rasters at 1m resolution

Canopy height model (CHM),
Elevation,
Slope,
Aspect

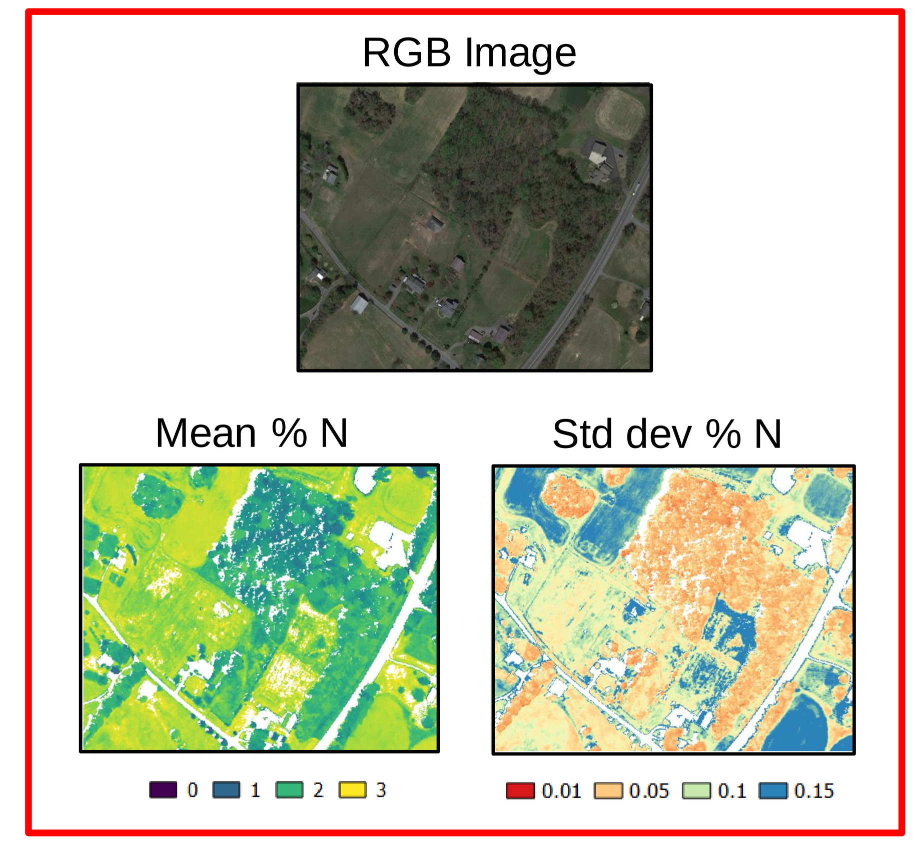
NEON Foliar Trait Sampling

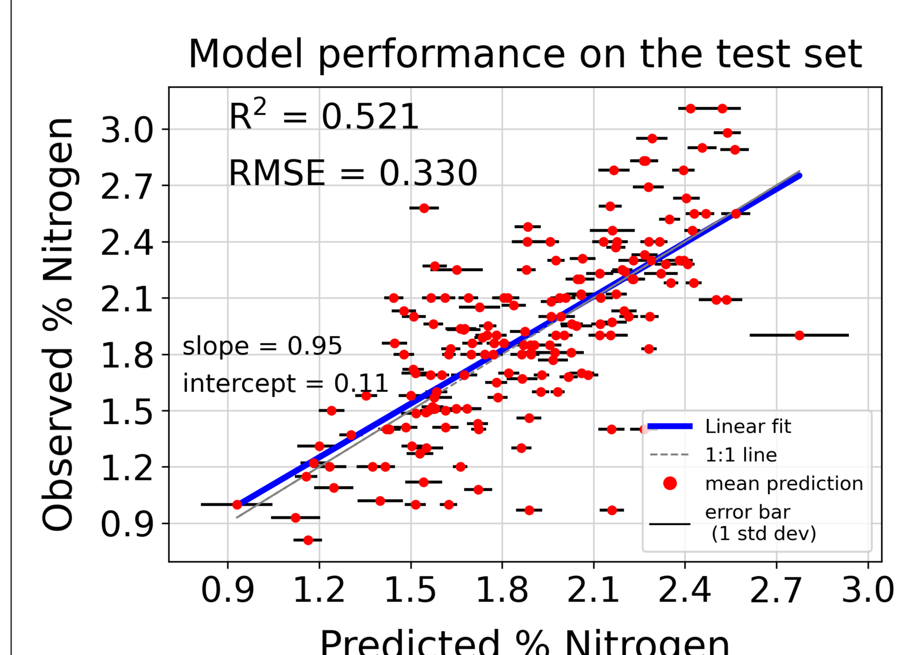
- Geolocated foliar sampling performed for woody individuals and herbaceous cover.
- Foliar traits sampled - biophysical (LMA, canopy water content), biochemical (C, N, lignin, chlorophyll, elements etc.), and stable isotopes (δ^{13}C, δ^{15}N).
- Drop outliers using Tukey statistical test (k=3).

Total number of foliar samples collected across all sites through 2022 = 1792

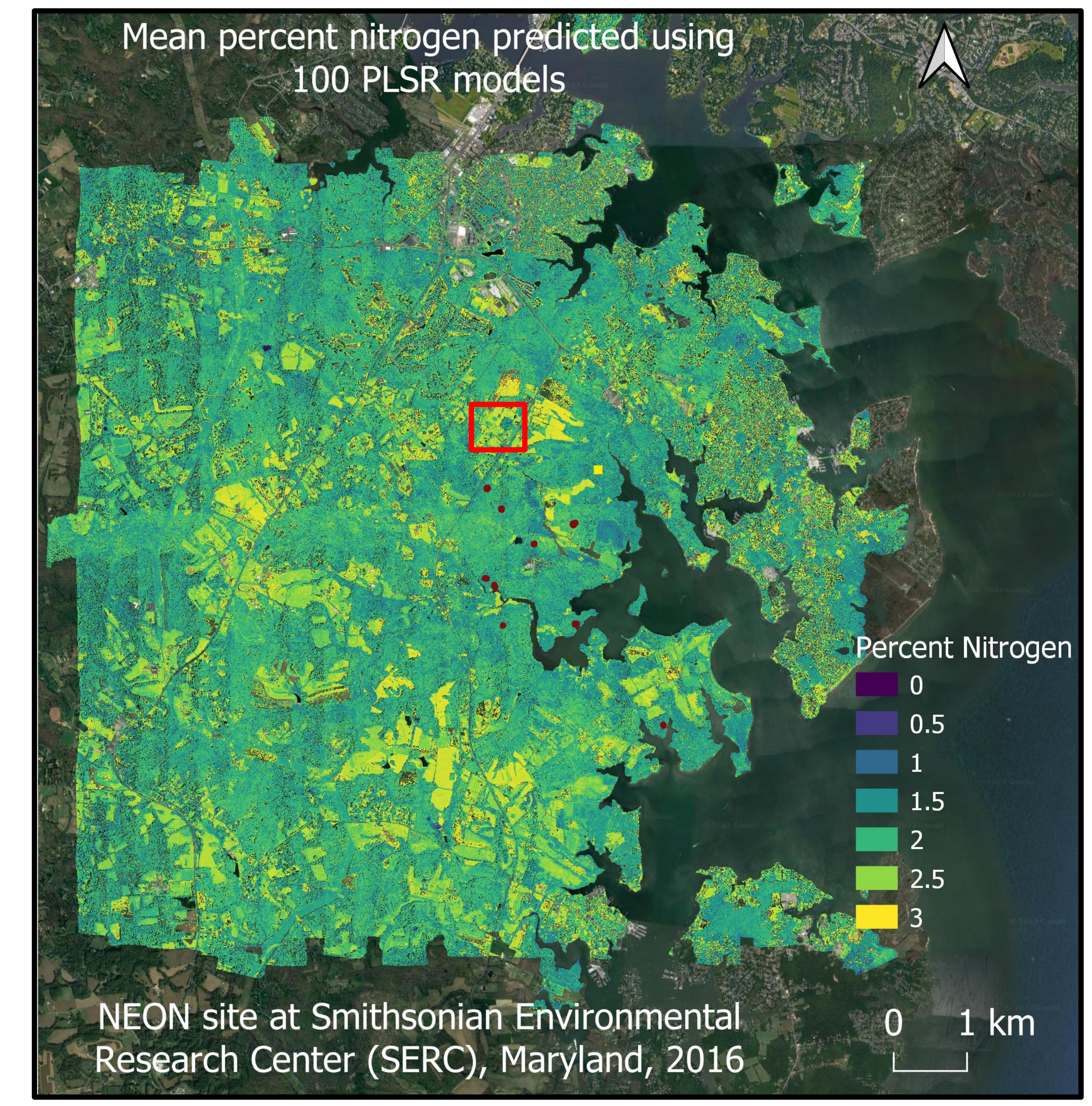


Results





PLSR models trained on percent nitrogen data collected from three NEON Domains (D01, D02 and D07). Number of foliar samples = 528

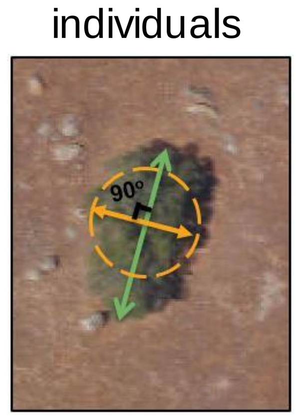


Methodology

Extract remote sensing data for foliar sampling locations

Woody individuals

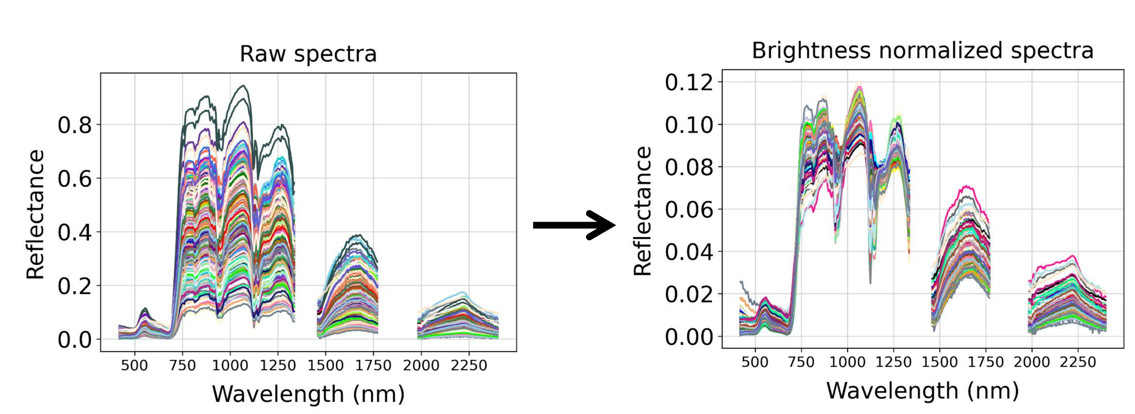
Herbaceous clip strip



Select only those 1m pixels within a crown which are
- Vegetated (NDVI > threshold)
- Not understory vegetation (CHM > threshold)
- Not affected by cloud shadows (NIR > threshold)

Drop reflectance bands affected by water vapor absorption

Perform brightness normalization on the spectra

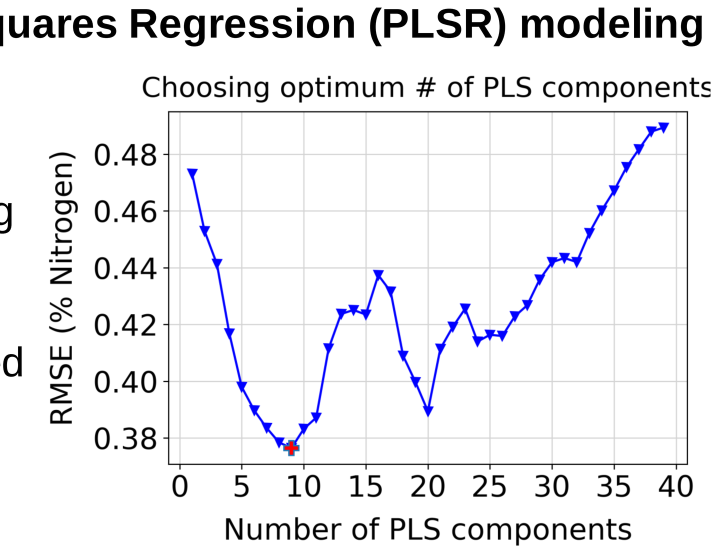


Calculate average value for spectra and lidar-derived values within each tree crown/ clip strip

Model inputs = 331 reflectance bands + 4 lidar variables

Partial Least Squares Regression (PLSR) modeling

- 80:20 data split for model training and testing.
- 9 PLS components used for regression using 10-fold cross validation.



- Fit an ensemble of 100 PLSR models by subsampling training data. Use outputs from 100 models to calculate pixelwise mean and std dev of predictions.

Future Work

- Test different values for thresholds (NDVI, SAVI, CHM, NIR etc.) for selecting pixels for model training. Vary the threshold values by site/domain.
- Improve PLSR model performance through selection of relevant reflectance bands.
- Include data from additional NEON domains. Test the performance of generalizable models (one model for all domains) v/s site-specific and domain-specific models.
- Test other regression models such as Random Forest.
- Develop models for additional foliar traits such as canopy lignin.
- Compare the range and distribution of predicted foliar traits with global trait databases such as TRY.
- Develop operational algorithm for generating trait maps

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