

Research Outreach: Leveraging NEON Data to Investigate Remote Sensing of Biodiversity Variables

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Introduction

Global biodiversity trends can be collected from satellites but finer scale processes cannot be studied without an expanded network of repeat ground and airborne observations over short-term intervals (every 1 to 5 years). Measurements from the National Ecological Observatory Network (NEON) are well suited to complete this knowledge gap.

This work is part of a larger effort to demonstrate a method for measuring biodiversity from integrated field and AOP data across a latitudinal gradient (7 sites) in eastern US forests (Fig. 1). Here we report the first steps toward testing the *spectral variation hypothesis* (spatial patterns of reflectance correlate with species diversity).

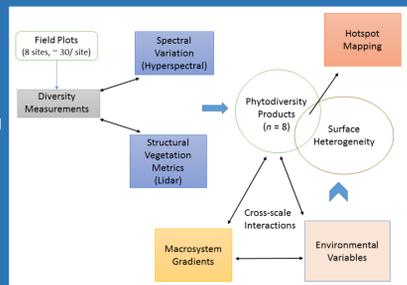


Figure 1. Calculating diversity metrics from NEON field data is the first step toward mapping biodiversity using integrated field and Airborne Observatory Platform (AOP) datasets.

If we can directly measure biodiversity across local landscapes, it provides an upscaling tool to explore areas in the local landscape where fine scale patterns of species diversity are mechanistically related to broad scale dynamics (environmental variables).

Objectives

- Determine the spatial and spectral detection limits for species diversity mapping with AOP

1. Calculate diversity metrics from NEON field data
2. Synthesize field data calculations to infer biodiversity gradients

- Workshop I: Coordinate with Ecological Research as Education Network (EREN) to accomplish the first two objectives of Research Question 1 (above) and develop instructional material and an assessment tool to offset time constraints on primarily undergraduate faculty integrating big datasets into the classroom (Styers, 2018).

Methods

- We worked with **Plant Presence Percent Cover (PPPC)** and **Woody Vegetation Plant Structure (WVPS)** field data to generate diversity metrics that the sampling designs could support (e.g., species richness, beta diversity, Simpson's Index)
- Diversity calculation instructions were developed & each participant was assign a project site in Workshop I (Fig. 2)
- At the end of the workshop, we synthesized calculations and mapped spatial distributions within and across sites.



Figure 2. Workshop I: Calculating Biodiversity Metrics using NEON Field Data (July 11-13 2018), Appalachian State University, Boone, NC. <https://sites.google.com/view/msbworkshop/home>

- The demonstration activity and workshop presentation slides were translated into classroom exercises & materials
- Before/after multiple choice quizzes were administered to evaluate learning macroscale concepts, spatial analysis skills, and data management using NEON data.

Outcomes & Results

- **PPPC** follows an annual sampling protocol for native and non-native plant species using a nested plot design (Thorpe et al., 2016) and supported calculations such as habitat diversity (α); landscape or total diversity across all plots (γ , Fig. 3); and species turnover or habitat difference within and across plots (β).

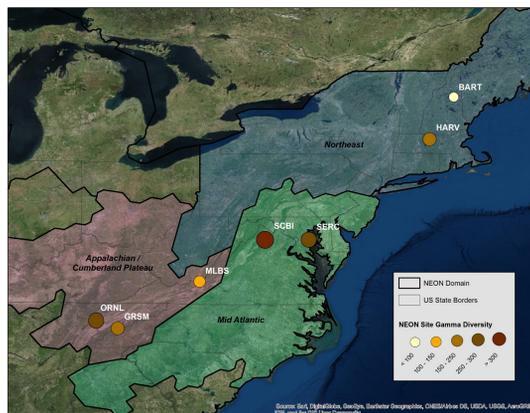


Figure 3. Gamma diversity calculations from Plant Presence Percent Cover NEON field data for seven sites in the Northeastern US

- **WVPS** sampling is every few years and includes species and abundance data from a sensor perspective (Thorpe et al., 2016). The design supported α diversity calculations such as species richness and Simpson's Index, γ -diversity (Fig. 4), and Whittaker's β -diversity.

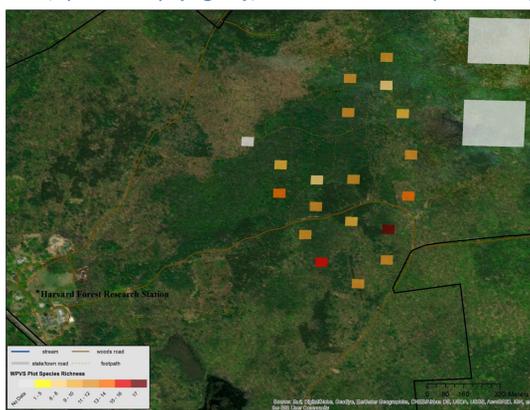


Figure 4. Species richness calculated from Woody Vegetation Plant Structure plots within Harvard Forest (2016).

- Exercises and materials were developed along two tracks: an introductory track that teaches Excel spreadsheet skills, and an advanced track that expands to teaching R and GIS skills.
- A 10-question multiple-choice quiz was administered to over 100 undergraduates in a wide variety of courses taught by workshop faculty at 6 different PUIs.
- Greatest gains: NEON, nested plots, basic understanding of diversity metrics
- Lowest gains: critical thinking about spatial scale, mathematical understanding of diversity metrics

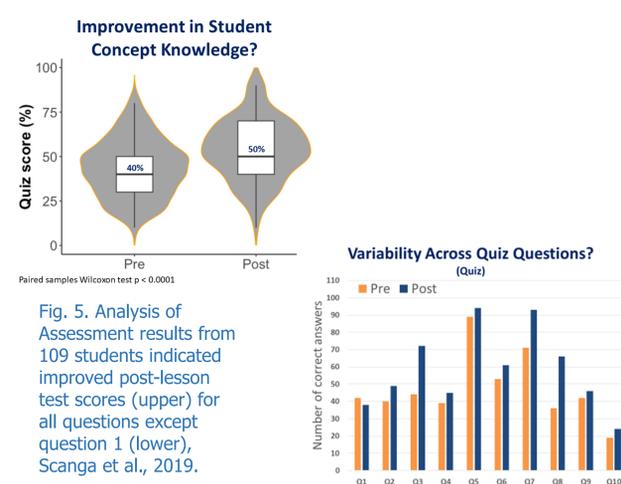


Fig. 5. Analysis of Assessment results from 109 students indicated improved post-lesson test scores (upper) for all questions except question 1 (lower), Scanga et al., 2019.

Conclusions

- Changes made to PPPC sampling through the Technical Working Group could have bearing on the types of biodiversity mapping efforts that NEON can support
- Locations where annual PPPC measurements intersect WVPS sampling should be flagged, as they are areas where coarse and fine scale diversity measurements overlap
- Diversity calculations can be automated and expanded by stacking files and creating indices at both the site and plot scales. Code has already been generated for PPPC (Barnett) and should be extended to include WVPC.
- Coordinate with NEON to make all instructor materials and code available to a broad group of NEON end users

Next Steps

- Make a final postdoc selection & offer!
- Develop a preprocessing workflow that leverages NEON airborne spectrometer bands such as Illumination Factor and Cast Shadow to minimize the influence of noise on reflectance values, especially in areas of flightline overlap (Fig. 5)
- Develop a preprocessing workflow to generate vegetation variability products from lidar point cloud data
- Generate biodiversity metrics from spectral signatures (Fig. 6) and structural statistics (e.g., average coefficient of variation for wavelengths in an area, average Euclidean distance from spectral centroid)



Figure 5. Harvard Forest spectrometer flightlines

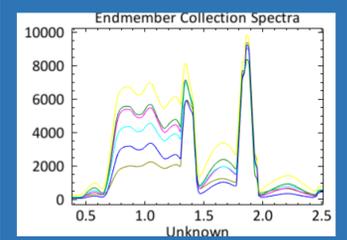


Figure 6. Average spectral signatures collected for 6 plots located in the Harvard Forest site

Workshop II: Swarthmore EREN participants will reconvene October 16-18 at to develop a second set of instructional materials focused on spatial analysis and remote sensing techniques for extracting biodiversity metrics from NEON Airborne Observatory Platform (AOP) data.

References

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