Implementing Flexible Learning Projects to support authentic research experiences in Ecology (BIO 3317) at McDaniel College

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In this document, I outline my approach to teaching the lab section of my Ecology course, how the EREN-NEON-FLPs (Ecological Research as Education Network – National Ecological Observatory Network – Flexible Learning Projects) supported student learning outcomes regarding research and quantitative skills, and provide specific implementation notes for the Lichens in Diverse Landscapes projects. This work builds from the EREN-NEON-FLPs overall and my specific work with the Faculty Mentoring Network from both Fall 2020 and Spring 2021.

McDaniel College is a small, liberal arts college in central Maryland. Ecology (BIO 3317) is an upper-level biology elective that serves both Biology and Environmental Studies students, has a 3-hour lab section each week, and fills part of a Writing in the Discipline requirement for the Biology Major. As such, the course focuses not only on core ecological concepts but also on research methods and oral and written communication skills. Relevant student learning outcomes for the lab are to

(1) interpret, describe, and apply quantitative methods, and

(2) engage in the process of science by participating in, designing, implementing, and communicating about authentic research projects.

To support these learning goals, I use the first part of the semester in lab to teach field and analytical skills through structured projects; I then facilitate student-developed independent projects during the second half of the semester.

Throughout the COVID-19 pandemic, I have implemented several EREN-NEON-FLPs, which have helped me to provide high-value, authentic research experiences for undergraduates during their course work. Students have been able to complete lab activities either on campus together or on their own (outside of lab or at home, as needed). During the first part of the Spring 2021 semester, I implemented parts of the PHAE, Lichens, and Backyard beetles + Pollinators projects, while also providing instruction on data management and data analysis. Instruction was in person for field-based labs and online (synchronous) for data management and data analysis labs. These activities together allowed students to develop field and analytical skills, including random plot selection, land cover characterization, tree identification and measurements, timed observation, point counts, tidy data, and the use of correlations, t-tests, and ANOVAs.

To support our writing and analysis goals, students analyzed data and wrote individual papers based on the Lichens project. The Lichens in YOUR Local Landscape field module was straight-forward and fun to implement and required simple, inexpensive equipment. Prior to field work, students completed a pre-lab assignment that involved reading the lab materials, watching videos describing sampling and lichen identification, making an iNaturalist account, and submitting hypotheses regarding lichen abundance and morphotype diversity at several spatial scales. We

structured our data collection on campus to test student-generated hypotheses regarding the influence of habitat type (main academic portion of campus vs less managed region of campus) on lichen abundance. Students reported that they enjoyed seeing their submissions go immediately into the iNaturalist interface, where the data could be used by others; students additionally submitted data to a shared class spreadsheet, submitted their iNaturalist usernames to allow easy tracing of submitted data, and submitted scans of field data sheets to the class Learning Management System.

We used Excel for data management and analysis for the Lichens project, as this program is available to all our students and required minimal set-up for remote learning; students installed the Analysis ToolPak prior to lab and read a short stats review from our textbook, *Ecology*, by Bowman & Hacker. I structed the data analysis to address factors influencing lichen abundance at several spatial scales:

- Local scale: Habitat & Tree size
    - I reviewed the t-test, how to set up the data for a t-test in Excel, and how to interpret the results. We used a tree-level average across cardinal directions for the analysis
    - I introduced correlation & regression and how to use Excel to find the required statistics for correlation
- Regional scale: Tree genera
    - I downloaded the iNaturalist data for the region around central Maryland, using geographic coordinates to subset the data. A student who could not attend the field lab session completed data cleaning steps for a lab replacement activity (we had conducted a tidy data exercise earlier in the semester). In our downloaded data, I had the student delete records with entries that fell outside the allowed range (negative values or values greater than 100% for cover, non-standard entries for morphotype richness, etc.)
    - I then used information from the common and scientific names of the trees in the downloaded data to derive a clean, standardized Tree Genus variable which we could use for analysis. By using the genus, we avoided some potential problems with accuracy of species-level tree identities, and by using only the data from our region, I could make reasonable inferences about genus identifications (for example, based on common names or misspelled versions of scientific names)
    - I introduced ANOVA, how to set up the data in Excel, and how to interpret the results.
- National scale: Tree size & Cardinal direction
    - We were able to use records from the full iNaturalist project for this analysis (again, with some cleaning)

- We focused on tree size and cardinal direction, because these variables required minimal cleaning but were available for most records and did not require additional interpretation
- Students were required to correctly identify and apply the most appropriate statistical tests to analyze the national-level data

Students then wrote individual research papers based on this project, in advance of developing, conducting, writing, and presenting independent projects in the second half of the semester.