The role of wildfire in structuring avian communities using NEON data from Great Smoky Mountains National Park

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Description: Students build on fundamental concepts of disturbance ecology and its role in structuring wildlife communities. This module specifically assesses the role of wildfire in the eastern US and its impact on bird communities using NEON bird survey data from pre- and post- a major wildfire in the Great Smoky Mountains National Park (GRSM) in November 2016. Over two class/lab periods, students learn about natural disturbances in the eastern US and develop hypotheses about the GRSM case study, and then carry out data analysis using NEON data to test their hypotheses. Bird survey data from summer 2016 are used as pre-burn data and bird surveys from summer 2017 and 2018 are used as post-burn data, where some survey plots were affected by the burn and others were not. A Before-After-Control-Impact (BACI) design is used to determine whether bird species richness and diversity was affected by the fire. Students are challenged to think about how to 'wrangle' data from NEON downloads so that they can be used to (1) calculate diversity indices and (2) test hypotheses about changes in those indices pre- and post-wildfire.

Learning objectives (LO) are to:

1) Develop hypotheses about the role of natural disturbance (specifically wildfire) on the distribution and abundance of birds in GRSM
2) Use a Before-After-Control-Impact (BACI) design to test hypotheses using NEON bird data collected before and after a wildfire.
3) Wrangle and analyze data in R to carry out above objectives
4) Hypothesize alternative factors that may influence changes in avian communities following natural disturbance.

Data used: This module uses freely available NEON bird survey data from June 2016 and those that were replicated in May and June 2017. Overlapping plots in all three years (N=10) are 1-4, 6, 7, 10, 13, 15, & 20. These data are provided in the QUBES module as three separate .csv files from June 2016, May 2017, June 2017, and May 2018. The addition of a second post-burn year of surveys can see if there is a lag effect and also helps to demonstrate annual variation.

What to expect: This activity will take two labs/class periods to conduct, each lasting ~3 hours, and are tailored for upper level biology/environmental science majors. Alternatively, it can be spread across three 50/75 minute class periods. Instructors may be able to reduce this time if students already have an understanding of natural disturbances and their role in structuring communities.

The first lab/class focuses on preparing students with the necessary background information by discussing the role of natural disturbance and specifically wildfire in eastern US, getting a quick introduction to NEON, and learning the basics of point counts as a method for collecting data on bird communities. This lab period will end with students generating hypotheses about how wildfire may influence bird communities and how we can test these hypotheses using the NEON data at GRSM. This should take a significant portion of the class with students considering potential response variables and predictors. If students are not familiar with Before-After-Control-Impact (BACI) study design, this can be a perfect time to have them see the challenges of studies that just consider one of these (pre- versus post- impact studies do not account for changes over time not due to the impact, and impact versus

control studies do not account for the spatial heterogeneity not due to the impact. Instructors can then introduce BACI designs and how they are well suited to discern treatment effects versus natural variation.

The second lab/class period will focus on data manipulation and analysis. This activity will be guided by the instructor, but students will work through the steps in small groups to figure out what data are needed to calculate community metrics for each NEON plot and then to run the ANOVA tests for the BACI design. If students have little to no R experience, the instructor may prefer to provide 'code chunks' to students and have them cut and paste to see what each line of code does. Alternatively, the students can simply follow along as the instructor demonstrates "what code can do" for students with less experience.

Assessment:

1) After class/lab 1, students can be asked to turn in expected hypotheses and graphs of potential results supporting their hypothesis. Graphs and hypotheses should demonstrate they understand the appropriate predictors and responses, and can justify their expectations. This can be turned in at the end of class and thereby provide the instructor a chance to see if there is any confusion that needs clarification next class, or they can turn them in at the beginning of next class providing students more time to do the assignment.

2) After class/lab 2, students can be asked to turn in the final figures showing they were able to use code to wrangle and analyze the data as well as create appropriate figures showing results. They should also be expected to interpret the figures and explain factors that led to an insignificant finding when they expected there to be differences.

3) Responses to the following questions can be given to further assess student learning:
    a. What are some potential explanations for why we did not find a significant differences in bird species richness and diversity between fire-impacted and control plots?
    b. Describe and justify a potential next step to further analyze the data to look for impacts of the wildfire on the bird community in GRSM.
    c. What natural disturbances historically existed where you live? Do they exist today? If not, what types of management might mimic those natural disturbances? Why is that an important conservation goal?

What's included in this module?: 1) Suggested readings and background presentation materials (including slides) to prepare students for the lab exercise; 2) Faculty Instructions and a Power point presentation that provides the structure for the two class periods, 3) The NEON bird data from GRSM to carry out the module, 4) a PDF R-markdown file with step by step instructions and code for data wrangling and analysis. This is intended for instructors only, but can optionally be given to students to use during the lab activity as a guide, depending on the student's familiarity/experience in R.

Student preparation prior to class:

Students will be expected to read about the historical role of fire in the Southern Appalachian region and what we know about how vegetation and avian community structure responds to natural disturbances, especially wildfire. Specific readings can be found below. Students need to come to class with excel (or Google Sheets) and R/R-Studio loaded on their computer prior to class. They will not use it until the second class period. They will also need to do a tutorial on the basics of R and how to import data into R prior to the second lab.

Students are expected to have some understanding of how data go from the field to the spreadsheet. Having students do the online lesson *Data Carpentry: Data Organization in Spreadsheets for Ecologists* (Bahlai and Teal 2017) or the *More In-Depth Spreadsheet Management Adaptation Module* (Hernández-Pacheco 2018) earlier in the semester is a good idea to establish this understanding.

Students are also expected to have some background in basic statistics including developing testable hypotheses, response and predictor variables, categorical versus continuous data and how that dictates whether they would use linear regression versus t-test/ANOVA.

Readings and Tutorials:
Instructors should pick and choose some of the following that will best prepare their students for the module, depending on their previous exposure to the material.

Lab/class 1:

1. Primary literature about fire and natural disturbance in Eastern US (optional – this can be covered in the presentation if preferred)
    a. King, D. and S. Schlossberg. 2014. Synthesis of the conservation value of early successional state in forests of eastern North America. Forest Ecology and Management 324: 186-195. **This is a long paper, and depending on the goals of your course, you may prefer they not read this, rather you can cover the main points in a presentation.
    b. Rose and Simons. 2016. Avian Response to fire in pine-oak forests of Great Smoky Mountains National Park following decades of fire suppression. The Condor 118: 179-193.
2. Have students conduct a Google search for "Smoky Mountains Fire 2016".
3. Have students visit the Neon About page () and read the protocols and standardized methods page (). You can encourage them with the following questions that can be turned in.
    a. What is different (new, exciting, powerful) about the NEON effort? Why is that important now?
    b. What does it mean to have "open data" and why is this such a novel idea?
    c. What are the challenges associated with this type of effort being implemented by NEON? How are they attempting to overcome them?
4. Portions of the avian point count protocol (NEON_bird_userGuide_vA.pdf) can be assigned if students are not aware of how researchers conduct bird surveys.

Lab/class 2:

1. Data Carpentry: Data Analysis and Visualization in R for Ecologists by Fracois Michonneau and Auriel Fournier. Provides an introduction to R designed for participants with no programming experience and can be taken in ~6 hours. Instructors may want to request that students take this prior to the course
    - https://datacarpentry.org/R-ecology-lesson/
2. Look at the NEON bird data and familiarize yourself with it. Consider what data we will need to answer the hypotheses generated in the last class. Providing at least one of the csv files would be sufficient:
    NEON.D07.GRSM.DP1.10003.001.brd_countdata.2016-06.expanded.20180418T200555Z.csv