

ISSUES : DATA SET

Data Management using National Ecological Observatory Network's (NEON) Small Mammal Data with Accompanying Lesson on Mark Recapture Analysis

Jim McNeil¹ and Megan A. Jones^{2*}

¹Smithsonian-Mason School of Conservation, George Mason University, Smithsonian Conservation Biology Institute, Front Royal, VA, 22630

²National Ecological Observatory Network – Battelle, Boulder, CO 80301

*Corresponding author: Megan A. Jones (mjones01@battelleecology.org)



Field technicians at NEON small mammal field site (Source: National Ecological Observatory Network – Battelle)

THE ECOLOGICAL QUESTION:

How are ecological data collected? How can good data management practices be incorporated into scientific practice (including field collection, data sheets, spreadsheets, and metadata)? How can the number of organisms in an area be estimated?

ECOLOGICAL CONTENT:

Ecological Data Management, Species Abundance Estimates

TIEE

Teaching Issues and Experiments in Ecology - Volume 13, April 2018

WHAT STUDENTS DO:

Students learn fundamentals of data organizing, create and evaluation their own data sheets, evaluate NEON's approach to data, manipulate data in a spreadsheet, and estimate abundance of small mammals using the Lincoln-Peterson model.

STUDENT-ACTIVE APPROACHES:

[Pairs/Share](#), [Informal Groupwork](#), [Turn-to-Your-Neighbor](#)

SKILLS:

In this lesson, students gain skills in identifying and organizing ecological data, using spreadsheets to prepare data for analysis, and in interpreting preliminary results.

ASSESSABLE OUTCOMES:

In this lesson, students can be assessed on the learning objectives (see Overview) through several artifacts. The lesson includes several discussion questions. Faculty can opt to assess student knowledge based on participation in the discussion or have these be a written assessment. Upon completing this activity, students will be able to:

- explain the importance of data management in the scientific process. Assessment through oral/written responses to Discussion Questions.
- identify elements of a useful, organized data sheet. Assessment through data sheet artifact produced in Field Collection & Data Sheets section.
- create a spreadsheet data table for transcription of field collected data. Assessment by artifact created during the Data Sheets and Data Files section and response to Discussion Question 4 in Data Analysis.
- explain how NEON small mammal data are collected and understand the format that the data are provided. Assessed through Discussion Questions in Public Data and Data Analysis questions.
- manipulate data in a spreadsheet program. Assessment by Excel worksheet produced in the Data Analysis section.
- calculate plot-level species population abundance using the Lincoln-Peterson Mark-Recapture model. Assessment by Excel worksheet produced in the Data Analysis section.
- interpret results. Assessment through Discussion Questions in the Data Analysis section.

SOURCE:

National Ecological Observatory Network. 2016. Data Product DP1.10072.00. Available online <http://data.neonscience.org/> from Battelle, Boulder, CO, USA.

ACKNOWLEDGEMENTS:

The authors would like to thank Leah Card, Field Technician II - Mammologist, Domain 2 Field Operations, for providing the original data to Jim McNeil used to create this activity (this activity now uses data downloaded in September 2017). We also want to thank two anonymous reviewers and all members of the 2017 Spring Faculty Mentoring Network Dig Into Data for providing feedback on the concept and scope of the activity for publication.

OVERVIEW OF THE MODULE

Undergraduate STEM students are graduating into professions that require them to manage and work with data at many points of a data management life cycle. Within ecology, students are presented not only with many opportunities to collect data themselves, but increasingly to access and use public data collected by others. This activity introduces the basic concept of data management from the field through to data analysis. The accompanying presentation materials mention the importance of considering long-term data storage and data analysis using public data.

This data set is a subset of small mammal trapping data from the National Ecological Observatory Network (NEON). The accompanying activity introduces students to proper data management practices including how data moves from collection to analysis. Students perform basic spreadsheet tasks to complete a Lincoln-Peterson mark-recapture calculation to estimate population size for a species of small mammal. Pairs of students will work on different sections of the datasets allowing for comparison between seasons or, if instructors download additional data, between sites and years. Data from six months at NEON's Smithsonian Conservation Biology Institute (SCBI) field site are included in the materials download. Data from other years or locations can be downloaded directly from the NEON data portal to tailor the activity to a specific location or ecological topic.

Learning objectives are achieved through a variety of tactics. By the end of this activity, students will be able to:

- explain the importance of data management in the scientific process. This is accomplished through discussion with faculty/class. Presentation slides are provided to guide this discussion.
- identify elements of a useful, organized data sheet. This is accomplished through inspection of the provided NEON data sheet and how the different data collected are entered into the data collection sheet.
- create a spreadsheet data table for transcription of field collected data. Students will accomplish this by creating and revising a spreadsheet data table and by comparing their version to the provided standardized spreadsheet data table. Faculty are provided with the example Excel workbook and presentation slides to facilitate this learning.
- explain how NEON small mammal data are collected and understand the format that the data are provided. To accomplish this students will read through the provided data collection protocol, view the .csv file containing NEON small mammal data, and view the variables data file

to understand what data are contained in the data files. The NEON small mammal data set, protocols, and metadata are included.

- manipulate data in a spreadsheet program (example provided is Microsoft Excel). An example workbook and student handout are provided to show the steps.
- calculate plot-level species population abundance using the Lincoln-Peterson Mark-Recapture model. Presentation slides are provided to introduce the model, and an example workbook and student instructions are provided to show the analysis steps.
- interpret results in plot level species abundance based on temporal variation, geographic locations, or by species. Faculty are provided with notes to help guide this discussion.

Please note that this activity was developed while the NEON project was still in construction. There may be future changes to the format of collected and downloaded data. If using data directly from the NEON Data Portal instead of using the data sets accompanying this activity, we recommend testing out the data each year prior to implementing this activity in the classroom.

This module was originally taught starting with a field component where students accompanied NEON technicians during the small mammal trapping. The rest of the activity was implemented in a classroom with students using personal computers. As a field component is not a possibility for most courses, the initial part of the activity has been modified to include optional videos that instructors can use to show how small mammal trapping is conducted. Instructors are also encouraged to bring small mammal traps and small mammal specimens into the classroom when available. Students will need access to computer to complete this activity, however, we recommend they complete the activity in pairs. This could be presented in a computer lab or in a classroom where student have access to personal computers.

DATA SETS

The National Ecological Observatory Network is a program sponsored by the National Science Foundation and operated under cooperative agreement by Battelle Memorial Institute. This material is based in part upon work supported by the National Science Foundation through the NEON Program.

The following datasets are posted for educational purposes only. Data for research purposes should be obtained directly from the National Ecological Observatory Network (www.neonscience.org).

TIEE

Teaching Issues and Experiments in Ecology - Volume 13, April 2018

Data Citation: National Ecological Observatory Network. 2017. Data Product: NEON.DP1.10072.001. Provisional data downloaded from <http://data.neonscience.org>. Battelle, Boulder, CO, USA

Activity Data Sets

[NEON.D02.SCBI.DP1.10072.001.mam_pertrapnight.072014to052015.csv](#) – Small mammal trapping data from NEON’s Smithsonian Conservation Biology Institute (SCBI) field site for July 2014 to May 2015 (seven months total as no trapping was conducted November to March). This .csv contains combined months from the combined small mammal trapping data from September and October 2014. This data are a combined table based on the individual site-month tables available from the NEON Data Portal. This file should be used with a group of student to implement their skills and allow different partners to estimate abundance for different plots and seasons to allow for larger patterns to be examined in the classroom.

[NEONSmallMammalDataAbundanceWorkbook.xlsx](#) – This workbook contains only the September and October data from the NEON.D02.SCBI.DP1.10072.001.mam_pertrapnight.072014to052015.csv file. Each worksheet lays out one step needed to conduct that Lincoln-Peterson species population abundance analysis.

[NEON.D02.SCBI.DP1.10072.001_variables.csv](#) – Metadata file for NEON small mammal data (DP1.10072.001) describing the variable names.

[NEON.DP1.10072.001_readme.txt](#) – Metadata file for the NEON small mammal data (DP1.10072.001) providing more information on the data product.

[NEON.D02.SCBI.DP1.10072.001.20140917-20140924.xml](#) – Example XML file for the September 2014 data that is provided with this activity.

STUDENT INSTRUCTIONS

Before class:

Review the following resources to prepare for the data management activity:

- Watch the NEON overview video: <https://youtu.be/39YrzpxVRF8>
- Read and be ready to discuss: [Abbreviated NEON Small Mammal Trapping Protocols](#)
- Read and be ready to discuss: Sutter, R.D., S.B. Wainscott, J.R. Boetsch, C.J. Palmer, and D.J. Rugg. 2015. Practical guidance for integrating data management into long-term ecological monitoring projects. *Wildlife Society Bulletin* 39:451–463.
- Read and be ready to discuss: Borer, E.T., E.W. Seabloom, M.B. Jones,

and M. Schildhauer. 2009. Some simple guidelines for data management. *Bulletin of the Ecological Society of America* 90:205–214.

Make sure to bring your laptop to class/meet in the computer lab on [insert date of class session] and make sure Microsoft Excel is installed. You'll be working in partners to enter and analyze data that day.

Why Data Management:

Data are the backbone of scientific research and exploration, so learning how to collect and process data efficiently is a critical skill for scientific professionals. Most people are not born understanding how to collect, record, enter, and analyze data, but with guidance and practice you can learn how to handle information and create world-class datasets.

Scientific organizations, especially large ones, spend a lot of time and effort determining the best ways to process data. The National Ecological Observatory Network (NEON) is one such organization that has made efficient data collection and processing a priority. NEON was designed to collect long-term ecological data on a continental-scale to help researchers address questions related to climate change, land-use, and invasive species. Data are collected at field sites called domains using standardized protocols, which allow for comparisons across large geographic ranges. Data on dozens of different variables and species will be collected every year for 30 years, yielding a comprehensive look at ecological processes across the entire United States. Regardless of the variables being measured, the general flow for data in these projects progresses from data collection to data files and metadata files as shown in Figure 1.

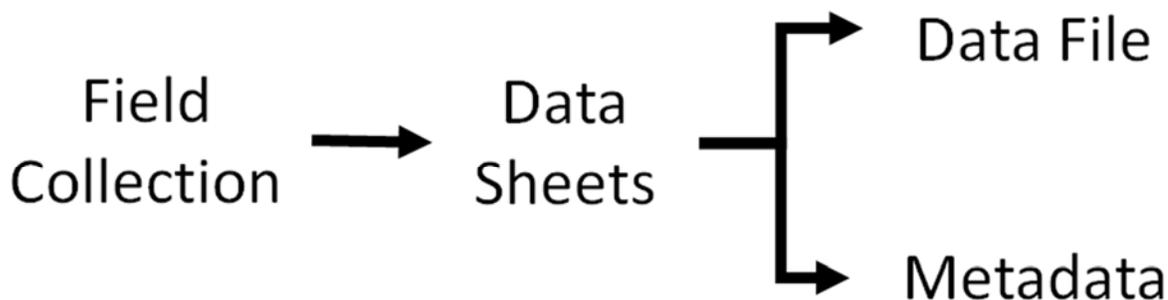


Figure 1. A workflow from data collection (can be in the field, lab, or other venue) to data collection sheets (paper, app, or entry form) to data files and metadata files.

Given the scale and scope of the project, they will create literally terabytes of data every year, so the information needs to be very well organized to be useful. In this activity, you'll get practice translating field data into a usable format for long-term archiving and then explore how real NEON data can be used to detect ecological patterns, in this case the change in small mammal abundance over a year.

Field Collection & Data Sheets:

Small mammals were chosen by NEON to be bioindicators because they are present across the country in a wide variety of habitats. Their small size and short lifespan makes them sensitive to environmental changes, and they are responsible for spreading or maintaining a wide diversity of zoonotic diseases in an environment. They are also easy to safely collect as live specimens using arrays of traps like those described in the *Abbreviated NEON Small Mammal Trapping Protocol*. Live trapping has the advantage of being able to return the animal to their habitat without having to destructively sample. As you learned in the readings and the YouTube videos, in just a few minutes you can collect a lot of information from an individual animal. Because researchers want to reduce the stress on the animal while it is captured, it's important to have an efficient framework for recording that data.

Take a few minutes now and review the NEON Small Mammal sampling data sheet. See if you can identify what variable is being recorded in each of the column categories. Make sure you know what codes refer to what type of animal being collected

Now look at the example data sheet. On the data sheet, circle the column headings for the following variables:

- Plot ID
- Date of capture
- Species
- Individual ID
- Sex
- Weight
- Whether individual is a recapture?

Data Sheets & Data Files:

Processing raw data sheets into a data table is only easy if the data table is well designed. Thinking about the presentation and the principles described in Borer

TIEE

Teaching Issues and Experiments in Ecology - Volume 13, April 2018

et al. 2010 and Sutter et al. 2015, work in pairs to create an Excel data file that displays the information from your example data sheet for the variables you identified above. Make sure that your data table adheres to the best practices for data file construction that we talked about.

Discussion questions:

1. Why might field (or lab) data collection sheets look different from the digital data files?
2. Do you think the NEON data sheets are well designed to transfer the information to a data file? What makes the process easier and what makes it challenging?
3. Imagine you were responsible for entering data from hundreds of data sheets. How would you make sure you were not making mistakes? What types of checks could you do to make sure you were correctly transferring the data?

Public Data & NEON:

Another hallmark of NEON is that the data are all publically available. NEON has created an online data portal (<http://data.neonscience.org>) that allows access to all of the NEON data from any Domain across the country. This portal will serve as the long-term repository and clearinghouse for all of the NEON data in perpetuity.

We will use a series of data files downloaded from this portal to estimate the abundance of several small mammal species in different seasons (spring, summer, and fall) at NEON's Smithsonian Conservation Biological Station field site during 2014 and 2015.

Metadata:

As we talked about during the presentation, metadata are another important component of collecting good data. A good metadata file can help someone unfamiliar with a data file interpret the codes and variables presented – and will help you remember what you did when you come back to the data later. It also provides an opportunity to discuss any irregularities in the data set.

Discussion Questions:

4. Examine the metadata file for the NEON data file. Briefly discuss with your partner how this file could have helped you interpret the data sheet and create your own data file or perform data analysis. Be prepared to share your observations with the class.

TIEE

Teaching Issues and Experiments in Ecology - Volume 13, April 2018

- Now that you better understand the kinds of data collected in the NEON data file, think about what types of questions could be answered using this data. Discuss with your partner and draft 2-3 questions that could be asked with this data.

Data Analysis:

Once you have a well-designed data file, you can use that information to determine interesting patterns. One of the simplest ways that the NEON small mammal datasets can be used is to calculate abundance estimates for individual species within the plots. There are many ways to estimate abundance. One of the simplest is the Lincoln-Peterson method. This calculation uses data about the recapture of marked individuals of a species to estimate how many individuals of that species are present in a particular habitat. Because NEON small mammal protocols include marking individual animals with unique numerical identifiers, we can easily use NEON datasets to calculate small mammal abundance using Lincoln-Peterson according the following equation.

$$\frac{n_1}{N} = \frac{n_2}{m_2}$$

N = total population size estimate

n_1 = Number of individuals captured and marked in first sampling bout

n_2 = Number of individuals captured in second sampling bout

m_2 = Number of marked individuals in second sampling bout

It's important to note that there are several assumptions that should be met for this calculation to generate an accurate estimate of population size:

- Individuals are randomly distributed between captures
- There is no change in the population (i.e. births, deaths, immigration, emigration) between sampling bouts
- Marking individuals does not impact their likelihood of being captured again in the future

Discussion question:

- Lincoln-Peterson estimation depends on several assumptions about the population. Knowing what you do based on the sampling methods outlined

TIEE

Teaching Issues and Experiments in Ecology - Volume 13, April 2018

in the *Abbreviated NEON Small Mammal Trapping Protocols* document, do you think any of those assumptions have been violated in this data set? Why and what could be done to address those issues?

Step-by-step directions for Lincoln-Peterson model

Working in pairs, use the workbook – [NEONSmallMammalDataAbundanceWorkbook.xlsx](#) – as a guide to calculate the Lincoln-Peterson estimation of population abundance using the following protocol. Please note that the workbook is laid with each worksheet showing each step, you do not need to create new worksheets for each step. You can perform most of the steps in a single worksheet:

1. Open the data file ([NEON.D02.SCBI.DP1.10072.001.mam_pertrapnight.072014to052015.csv](#)) using Excel. Resave the file as an Excel workbook with you and your partners' names starting the file name.
2. You and your partner will perform the analysis for sampling bouts either in the spring (April to May 2015), the summer (July to August 2014), or the fall (September to October 2014) for samples collected in your assigned plot. Record your time frame and plotID below:

Timeframe: _____

Plot ID: _____

3. Copy all the data to a second worksheet and name that worksheet. Remember, keep raw data raw!
4. Sort the data by plotID and then by collectDate. Now you can see when trapping occurred at each plot.
5. To start, you will perform the Lincoln-Peterson calculation for white-footed mice (*Peromyscus leucopus*, PELE) a common species in this area. Therefore, filter your data for the specified taxonID and plotID. Now you see only the data of interest for you Lincoln-Peterson calculation.
6. Identify unique individuals collected throughout your time frame. Record the following:

Number of individuals captured during the first month of the time frame

TIEE

Teaching Issues and Experiments in Ecology - Volume 13, April 2018

(n_1): _____

Number of individuals captured during the second month of the time frame

(n_2): _____

Number of individuals from the first month recaptured during the second month (m_2): _____

Remember this is the number from the first month that were recaptured in the second month. Not the total recaptured in the second month.

7. Use these numbers to calculate the population abundance of PELE for your site and time frame: _____
8. Share your results with the class.

Discussion questions:

7. Why is it important that the m_2 value is the number of individuals captured in the first month that were captured in the second month and not the total number of marked individuals captured?
8. Based on everyone's data, how does the population abundance change for white-footed mice between plots? What are some hypotheses for why this pattern may exist?
9. Based on everyone's data, how does the population abundance change for white-footed mice over the year at this site? What are some hypotheses for why this pattern may exist?
10. Looking back at the spreadsheet data table you created in section on Data Sheets and Data Files, how does this compare to format of the data from NEON? In what ways, if any, would you revise your spreadsheet?

NOTES TO FACULTY

Related Documents

[DataManagementSlides.pptx](#) – This presentation accompanies the student activity and provides visuals to support the steps of the activity.

[Abbreviated NEON Small Mammal Trapping Protocols.docx](#) – This document is adapted from NEON Document NEON.DOC.000481 in May 2017. It describes the layout of NEON small mammal sampling grids and is only intended for use with the educational teaching module outlined in this article.

[NEONSmallMammal_SCBI_BlankDataSheet.pdf](#) – This document shows how a NEON field data sheet is formatted and is provided to show a potential format for

TIEE

Teaching Issues and Experiments in Ecology - Volume 13, April 2018

recording this type of data. This document is limited to D02 data sheets, all NEON Small Mammal trapping data sheet can be found in document *NEON.DOC.001585 Datasheets for TOS Protocol and Procedure: Small Mammal Sampling*.

Challenges to address:

1. Students do not have laptops to work with the files on their own equipment.
Solution: Prepare a computer lab with the required files before the class session or use course management software to upload the activity files so they can be downloaded in a computer lab during the exercise.
2. Students are unfamiliar with how to use spreadsheets, especially the sort and filter functions. Note that the activity is written referring to Excel, however, it can easily be adapted to Google Sheets.
Solution:
Option 1: Provide a pre-lab on the use of spreadsheets (Excel or Google Sheets). The HHMI Biointeractive Spreadsheet Data Analysis Tutorials (<http://www.hhmi.org/biointeractive/spreadsheet-data-analysis-tutorials>) may be useful for this.
Option 2: Pair students based on their experience such that students with Excel experience are matched with those who do not have it. If there are not enough students with experience, faculty can walk the class through the sorting and filtering steps as a demonstration or prepare pre-sorted and filtered versions of the data set for students to use.
Option 3: Use the *NEON Small Mammal Data Abundance Workbook* to demonstrate sorting and filtering functions to the class prior to the pairs working with the larger dataset to calculate their species abundances.
3. Students are uncomfortable with the concept of trapping small mammals.
Solution: Use the activity as a way to discuss Animal Care and Use standards and emphasize that all protocols are designed to minimize the impact and stress on the animals. Reinforce that responsible scientific sampling goes through review and is approved before being implemented. Also emphasize that there are not alternative methodologies for collecting this information; if we are to understand the biology and ecology of small animals like small mammals, they must be captured and handled.

Comments on the Activity

The Student Instructions section above provides most of the details on how to go through the activity materials. The information is broken out by the activity

TIEE

Teaching Issues and Experiments in Ecology - Volume 13, April 2018

sections listed in the Student Instructions and the slides numbers in the presentation are noted. Also provided are some key points that students should consider for each discussion question.

The presentation slides included with the activity ([DataManagementSlides.pptx](#)) can be used to highlight key points as the students work through each step of the activity. Below we've indicated which slides correspond to which portion of the activity below. They are meant as starting point and framework for faculty to tailor the activity to their own classroom. The slides are designed to be presented before the students start on the activity, but could also be used concurrently with it.

Comments on *Before class*

In addition to the resources listed for the students you may consider exploring or assigning any of these resources.

- Explore the NEON website: <http://www.neonscience.org/>
- Thibault, K. NEON breeding bird and small mammal abundance and diversity sampling. NEON: http://data.neonscience.org/api/v0/documents/FSUHandout_Vertebrates.pdf
- Select a video to show in class or have students watch prior to class starting
 - National Park Service. From Field to Lab: Small Mammal Monitoring in Denali National Park: <https://youtu.be/KvGvS8pApFE> (1:32 - 2:30 highlights small mammal trapping/handling techniques)
 - University of Oxford. The Laboratory with Leaves (Part 10): Small Mammals: <https://youtu.be/bljva3pa2YA> (This video provides context for why small mammal monitoring is important to ecology in general).

Comments on *Why Data Management*

This section is primarily covered through the pre-course student readings and through the slides. This needs to set up the imperative of why scientists need to think about data management. If your students are not motivated by field ecology examples, there are many situations and other lines of work where data management is still essential. If you feel this might be the case with your students, have them brainstorm situations where they've encountered or can imagine good and bad data management strategies in their preferred line of work.

TIEE

Teaching Issues and Experiments in Ecology - Volume 13, April 2018

Key files:

- Papers/materials from *Before Class* section to prompt discussion.
- Presentation slides: 2-7

Comments on *Field Data Collection & Data Sheets*:

If resources permit, this section could be enhanced by having students actively participate in small mammal sampling. At the Smithsonian-Mason School of Conservation, we are fortunate to be located adjacent to a core NEON field site (SCBI), so students are able to observe NEON field technicians gathering this data in the field. Alternatively, if there are natural history specimens available for the target species in your area, bringing those into the class as visuals would also be a great addition to this portion of the activity. Finally, to save paper, it could be possible to have the students examine an electronic copy of the blank data sheet.

Key files:

- Presentation slides: 9-10
- [NEONSmallMammal_SCBI_BlankDataSheet.pdf](#)

Comments on *Data Sheets to Data Files*:

As the students work on creating their data tables (spreadsheets), the faculty should move between pairs and assist, but students should be allowed to struggle a little with interpreting the data sheet and developing an efficient way of entering the data. Students most often ask for clarification on the meaning of codes on the data sheet and for advice on the details of best practices for data organization. Giving them the space to experiment will help lead to a better discussion. The discussion questions can be addressed in the classroom or used as part of a written evaluation of the activity.

Key files:

- Presentation slides: 9-18
- Student created spreadsheet data table based on the [NEONSmallMammal_SCBI_BlankDataSheet.pdf](#)

Key points for discussion questions:

1. Why might field (or lab) data collection sheets look different from the digital data files?
 - a. There are a variety of reasons including data sheets needing to be easily human readable while data files need to be human and machine readable, the order of data being collected (easy of enter

- is often related correct transcription), the inclusion of multiple types of data that may go into different data tables (relational data), physical constraints (horizontal vs vertical 8.5"x11" paper, notebooks, etc) and more.
2. Do you think the NEON data sheets are well designed to transfer the information to a data file? What makes the process easier and what makes it challenging?
 - a. This will primarily be a matter of opinion. The data are laid out in a logical manner but some students may think that some field are too small or other similar comments.
 3. Imagine you were responsible for entering data from hundreds of data sheets. How would you make sure you were not making mistakes? What types of checks could you do to make sure you were correctly transferring the data?
 - a. Be sure students consider both manual checks (two people enter data, proof data that are entered, standard ways of writing numbers, layout similar to data sheet to avoid jumping around) and automated checks (set bounds – min or max values – on entry possibilities in forms).

Comments on *Metadata*:

NEON uses the Ecological Metadata Language (EML) to provide metadata with all data downloads. In the example dataset (or in datasets downloaded by students), there is an accompanying .xml file. This is the metadata file. Instructors could choose to go into these files more, either as a demo, or if time and materials are available, the students could explore it.

The discussion on metadata can be expanded greatly to include many other NEON documents including the xml files and other documentation that can be downloaded with the data (see NEONDataDownloaded directory). These additional documents reflect many aspects of the site characteristics, sampling effort, and data processing. While most undergraduates are not involved in data collection at a scale where metadata are essential, being familiar with the concept can put them a step above the competition when they are applying to jobs or internships. Several students in the Smithsonian-Mason programs have commented that data management, including work with metadata, was expected of them in government and NGO internships they worked with after graduating.

TIEE

Teaching Issues and Experiments in Ecology - Volume 13, April 2018

Key files:

- Presentation slides: 19-20
- [NEON.D02.SCBI.DP1.10072.001_variables.csv](#)
- [NEON.DP1.10072.001_readme.txt](#)
- [NEON.D02.SCBI.DP1.10072.001.20140917-20140924.xml](#) – may opt to exclude if not discussing XML and machine readable metadata

Key points for Discussion Questions:

4. Examine the metadata file for the NEON data file. Briefly discuss with your partner how this file could have helped you interpret the data sheet and create your own data file or perform data analysis. Be prepared to share your observations with the class.
 - a. The XML metadata file provides information that might be important for interpreting the results such as geographic location or elevation. It also provides information about who produced the data, how the data can be used, and how the data should be cited when used. This file is in a machine readable format that can be used with a scripted analysis.
 - b. Also provided are the *readme* and *variables* files. These metadata files also provide some or all of the above information but are more human readable (but not machine readable).
 - c. The *Abbreviated NEON Small Mammal Trapping Protocols* could also be considered a metadata file as it provides more information on how the data were collected.
5. Now that you better understand the kinds of data collected in the NEON data file, think about what types of questions could be answered using this data. Discuss with your partner and draft 2-3 questions that could be asked with this data.
 - a. Lots of options. If students get stuck could suggest anything to do with: sex ratio, age structure, life history, population size, trends in populations size, small mammal community structure.
 - b. If they add other data to the small mammal data, then even more options.

Comments on *Public Data & NEON*:

This version of the activity is built around a pre-downloaded data set from NEON's SCBI site, but if time and experience permits, students (or instructors)

TIEE

Teaching Issues and Experiments in Ecology - Volume 13, April 2018

could download separate data sets directly from the NEON data portal from sites that are closer to their location. Accessing this information does require a good internet connection and not all field sites have all of their data available yet. Faculty interested in doing this should download data sets before class to make sure they are amenable to the analysis portion of the activity.

Key files:

- Presentation slide 21- 24
- [NEON.D02.SCBI.DP1.10072.001.mam_pertrapnight.072014to052015.csv](#)

Comments on *Data Analysis*:

If faculty member is provided this directions in printed or PDF version, they may want to consider adding page breaks around the *Step-by-step directions for Lincoln-Peterson model* section so as to avoid any confusion between Discussion Question numbering and numbering for the steps to use for the worksheet.

Faculty should take the time to clearly explain the formula and assumptions of the Lincoln-Peterson model before having the students engage with the data file. Having a clear idea of the type of data they are looking for will make it easier for them to perform the data analysis. Also faculty should assign partner groups for each section of the activity. As with the creation of the data file, faculty should circulate among pairs and provide advice and answer questions, but it is best if the students are able to explore the issues surrounding the data analysis themselves. As above, the discussion questions can be addressed in the classroom or used as a written evaluation.

One important assumption is made in the calculation of the Lincoln-Peterson method using this data set. NEON small mammal trapping data includes both pathogen plots (three night bouts) and diversity plots (one night bouts). For simplicity in this activity, all nights of trapping in pathogen plots are lumped into a single bout for quantifying the variables in the Lincoln-Peterson method of population analysis.

Because there is so much concurrent data collected at NEON sites, this activity is also an excellent jumping off point for more sophisticated or alternative analyses. We've outlined a basic example of how these data could be used for analysis, but there are many ways the activity could be extended. For example, students could investigate community composition at different sites, or even the same plot. Pairs of students could work on data from different field sites to do a multi-site comparison. NEON terrestrial observation plots are laid out in a stratified random layout based on National Land Cover Database (NLCD) classes present at a field site. By incorporating NLCD data with the small mammal data, students can ask questions like how does the species composition

TIEE

Teaching Issues and Experiments in Ecology - Volume 13, April 2018

in different NLCD classes vary or how does the abundance of a given species vary? Pairs of students could calculate abundance and determine the NLCD class(es) for each plot. As background for this extension, faculty should introduce the concept of NLCD classes.

Key files:

- Presentation slides 25-26
- [NEONSmallMammalDataAbundanceWorkbook.xlsx](#)
- [NEON.D02.SCBI.DP1.10072.001.mam_pertrapnight.072014to052015.csv](#)

Key points for discussion questions:

6. Lincoln-Peterson estimation depends on several assumptions about the population. Knowing what you do based on the sampling methods outlined in the [Abbreviated NEON Small Mammal Trapping Protocols](#) document, do you think any of those assumptions have been violated in this data set? Why and what could be done to address those issues?
 - a. As mentioned above, we are using data from the first month as bout 1 (n_1) and from the second month as bout 2 (n_2 and m_2). It is likely some animals die or leave the plot between these two data points violating the assumption that there is no change in the population between sampling bouts.
 - b. Some individuals are known to be “trap happy” or “trap shy” after being captured, and therefore, they may violate the assumption that marking individuals does not impact their likelihood of being captured again in the future.
7. Why is it important that the m_2 value is the number of individuals captured in the first month that were captured in the second month and not the total number of marked individuals captured?
 - a. In some ways this is an extension of thinking about the Lincoln-Peterson assumptions from the previous set of questions in combination with understanding the NEON collection methods. As NEON is marking individuals in the same plot over time the total number of marked individuals is increasing. The Lincoln-Peterson method is based on the assumption that the marked individuals were all marked in the first bout. Therefore, we must only include individuals marked in the first bout. If m_2 is based on **all** marked individuals instead of only those captured in the previous bout, this will lead to an underestimate of the population.
8. Based on everyone’s data, how does the population abundance change for white-footed mice between plots? What are some hypotheses for why

- this pattern may exist?
- a. Responses may depend on what time frames and plots are used. Hypotheses should include the difference in habitat between plots. The nlcdClass variable does provide some broad categories of different habitat that the plots are within. NEON terrestrial plots have a stratified random sampling scheme to match the NLCD classes at a field site.
9. Based on everyone's data, how does the population abundance change for white-footed mice over the year at this site? What are some hypotheses for why this pattern may exist?
- a. Responses may depend on what time frames and plots are used. Hypotheses should include how the reproductive cycle may influence population size.
10. Looking back at the spreadsheet data table you created in section on Data Sheets and Data Files, how does this compare to format of the data from NEON? In what ways, if any, would you revise your spreadsheet?
- a. Answers will vary greatly depending on what they did. Possible answers could include row vs column layout, multiple vs single data table, use of spaces or special characters in column names, etc.

COPYRIGHT STATEMENT

The Ecological Society of America (ESA) holds the copyright for TIEE Volume 13, and the authors retain the copyright for the content of individual contributions (although some text, figures, and data sets may bear further copyright notice). No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the copyright owner. Use solely at one's own institution with **no intent for profit** is excluded from the preceding copyright restriction, unless otherwise noted. Proper credit to this publication must be included in your lecture or laboratory course materials (print, electronic, or other means of reproduction) for each use.

To reiterate, you are welcome to download some or all of the material posted at this site for your use in your course(s), which does not include commercial uses for profit. Also, please be aware of the legal restrictions on copyright use for published materials

TIEE

Teaching Issues and Experiments in Ecology - Volume 13, April 2018

posted at this site. We have obtained permission to use all copyrighted materials, data, figures, tables, images, etc. posted at this site solely for the uses described at TIEE site.

GENERIC DISCLAIMER

Adult supervision is recommended when performing this lab activity. We also recommend that common sense and proper safety precautions be followed by all participants. No responsibility is implied or taken by the contributing author, the editors of this Volume, nor anyone associated with maintaining the TIEE web site, nor by their academic employers, nor by the Ecological Society of America for anyone who sustains injuries as a result of using the materials or ideas, or performing the procedures put forth at the TIEE web site, or in any printed materials that derive therefrom.