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eBird Community Science Project: Engaging Non-Major Biology Students in Authentic and Meaningful Research

Samantha Herrmann[1], Erica Szeyller[2], and Kellen Calinger-Yoak[3]

[1]The Ohio State University, Evolution, Ecology, and Organismal Biology and the Center for Life Sciences Education, 1735 Neil Ave., Columbus, OH, 43210, USA
[2]The Ohio State University, Center for the Study of Student Life, 1800 Cannon Drive, Columbus, OH 43210, USA
[3]The Ohio State University, Evolution, Ecology, and Organismal Biology, 318 West 12th Ave., Columbus, OH, 43210, USA

Abstract

The goal of many non-major biology labs is to provide inquiry-based exercises that reinforce the course content within a single lab period. While that lab format supports student learning of biology content and some science skills, students are missing out on the opportunity to hone their scientific literacy by engaging in the scientific process in a more authentic way and seeing themselves as a part of the scientific community. The eBird Community Science Project is a seven-week long research project spread out over a semester in the style of a Course-Based Undergraduate Research Experience. The project uses a well-known app and database for crowdsourced bird data, allowing students to practice science by developing and answering a valid research question and contribute data to global research efforts. At the end of the semester, students create a unique communication artifact that presents their research to a non-scientific audience of their choosing. Since 2020, the eBird Community Science project has been implemented in all sections of our Introductory Biology course at The Ohio State University in both face-to-face and remote classrooms.

Keywords: CURE, Avian Ecology, Non-major, Introductory biology, Science communication, Information literacy, Inquire-based learning

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Correspondence to: Samantha Herrmann, herrmann.74@osu.edu

INTRODUCTION

Course-based Undergraduate Research Experiences (CUREs) provide undergraduate students with an authentic scientific experience that they might not receive in traditional life-science labs. In a CURE course, students work together as a class to help address a genuine research question under the guidance of a Faculty member (Auchincloss et al. 2014). At many institutions undergraduate research positions in active labs are limited, so students at these institutions may have a hard time gaining real research experience. CUREs provide a way to engage students in the process of science with the result of providing students with research experience, breaking down barriers between Faculty members and students, and creating a more inclusive learning environment, particularly for minoritized students (Bangara and Brownell 2014). In addition, students who take CURE courses tend to have more positive attitudes towards science (Brownell et al. 2012), increased persistence in their STEM major (Rodenbusch et al. 2016), and greater gains in their scientific thinking and conceptual knowledge (Brownell et al. 2015).

Because CUREs are typically implemented with the intent to provide students with invaluable experience to prepare them for STEM careers, they are more frequently used in courses for STEM majors. However, non-major STEM students may receive benefits from participating in CUREs in their introductory courses including scientific research literacy skills, pro-science attitudes, and evidence-based decision making (Ballen et al. 2017). At Ohio State University, the Center for Life Sciences Education utilizes various CUREs for the biology major courses and a pre-nursing course, but the introductory biology for non-majors course (Biology 1101) uses a lab manual with more traditional, inquiry-based labs. These labs are stand-alone exercises that are completed in a single lab period and tend to be guided with a structured procedure. While they give students practice using the scientific method and thinking critically, they primarily function as a hands-on opportunity for course content reinforcement.

The emergency shift to online learning in 2020 provided the opportunity to develop a 7-week CURE-style laboratory project for non-majors that complemented the traditional labs and could be done in-person or remotely. A CURE model was combined with community science (also known as citizen science) research so students could contribute to and use real scientific data in their project and see ways they may continue to interact with the scientific community even if they are not pursuing a career in the sciences. Using community science projects in biology courses has the potential to increase student engagement, particularly for underrepresented students, increase accessibility to all students, and help reinforce scientific literacy skills (Cardamone & Lobel 2016, Kridelbaugh 2016).

While there are many community science projects that would be suitable for a lab experience for non-majors, the Cornell University's Lab of Ornithology eBird project was chosen. The eBird app is user-friendly and available for anyone to use. Community members make submissions through the app that ends up in a crowd-sourced database that is also accessible to anyone. This database is widely used in the scientific community for research and conservation, so students know they are actively engaged in these efforts when they use the app. Because birds are abundant and easily observable, using the eBird app is accessible for most people regardless of location.

The "eBird Community Science Project" was first implemented in Autumn 2020 in remote Biology 1101 courses. From the instructor perspective and informal student feedback, it was a success in meeting the Center for Life Sciences Education's laboratory objectives and engaging students with the scientific process. Biology 1101 returned to a face-to-face format in Autumn of 2021 and the exercises have been adjusted for an in-person laboratory experience. The "eBird Community Science Project" is now integrated into the lab manual and continues to be implemented each semester.

Implementing the Project

The "eBird Community Science Project" follows a typical CURE paradigm in that it is a multi-part research project where students in each lab section develop a research question as a class and work together to answer that question. There is flexibility for the course instructors in how they want to implement it in their schedule, but the project will consist of the following major components:

- Introduction to the eBird Community Science Project (Exercise 1) where students get a background on avian ecology and community science, work on critical thinking skills, and reflect on the transferrable skills they will gain.
- Observations and Hypotheses Part 1: Literature Review (Exercise 2) where students distinguish primary and secondary sources, evaluate sources for reliability, and find sources to make observations and write hypotheses.
- Observations and Hypotheses Part 2: Direct and Data Observations (Exercise 3) where students learn how to use the eBird app and database to make observations and write hypotheses.
- Experimental Design (Exercise 4) where students develop a study design that will allow them to test their hypothesis over the rest of the semester.
- Results and Data Analysis (Exercise 5) where students learn how to create figures and use basic statistics to analyze the data they have collected.
- Drawing Conclusions (Exercise 6) where students interpret their results and develop information literacy skills by evaluating scientific information presented in various formats to different audiences.
- A final project where students individually create a communication artifact that allows them to share their project and its implications to an audience of their choice.
- An optional independent assignment completed around the same time students do Exercise 4, where they will outline a research proposal grant.

Most of the exercises begin with a pre-laboratory assignment to be completed prior to the start of the lab section; with the goal of helping students prepare for the in-class portion of the lab. Students are not expected to know anything about the lab exercise when completing the pre-laboratory assignment. It is customary at our institution for all lab exercises to have a pre-laboratory assignment. Directions to complete those assignments are communicated to students at the start of the term , so no introduction or further instructions are required for these students. They are formally introduced to the lab exercises by the lab instructor in class. Within a single lab section, students work in small groups to complete this project except for the final communication artifact which may be done as a group or independently depending upon the wishes of the instructor. The hypothesis students test is one they come up with as a class and while each group works independently, they are all mentored by their lab instructors throughout this experience. During weeks when students are not doing a Community Science Project lab, they will do one of the traditional lab exercises. The spacing of the Community Science Project lab sessions is flexible. Timing is determined by the course instructor and can be interleaved with traditional labs that reinforce course content, that are aligned with their lecture schedule.

STUDENT OUTLINE

Community Science Project Exercise 1
Introduction to Community Science

Throughout this semester, several of your lab exercises are dedicated to the Community Science Project. Your lab instructor will provide more information in lab this week, but you can look at the syllabus to see which weeks are "Community Science Project" weeks. Although the exercises for the Community Science Project (CSP) weeks will look a little different than the non-CSP weeks, you will still have a pre-lab for most of these exercises that will be completed before class. This week's exercise will introduce you to Community Science and the value of non-scientists engaging in the research process.

Pre-Laboratory Questions (2 pts)

1. Take a moment to reflect on why birds are important. What do they mean to you? How have you interacted with birds in your life? **(1 pt)**

Now, review the reasons to care about birds presented on this website: https://www.3billionbirds.org/why-birds-matter

2. (a) Do any of your reasons about why birds matter align with reasons presented on the website above? **(.5 pts)**

   (b) What is one reason from the above website that birds are important was surprising or impacted you? Explain. **(.5 pts)**

Learning Objectives
Following this exercise, you will be able to:

- Explain the biological and sociological importance of birds
- Define community science
- Differentiate between community science and science
- Explain how community science can contribute to research and conservation
- Describe who scientists are and what they do
- Apply basic principles of bird identification
- Connect the community science project goals with your personal career skills

Part 1: Why are Birds Important? (5 pts)

The graphics in Figure 1.1 show data from Rosenberg et al. 2019. This research was published in Science which is one of the world's leading journals in science research and news. These data were used to produce many of the graphics and video seen on 3BillionBirds.org. 3BillionBirds is a partnership of conservation organizations and higher education institutions with the goal of raising awareness of current issues faced by birds and supporting greater protections for birds.

1. Pretend that you are talking to a friend or family member. With your group, review the graphics on the following page in Figure 1.1 and clearly articulate how bird populations have changed over time in a way that imparts the significance of the change to your audience. **(2 pts)**

2. Hypothesize **two** tentative explanations for the changes in bird populations over time. **(1 pt)**

Watch this video from 3BillionBirds.org: https://go.osu.edu/3billionbirdslost

3. (a) What are the main reasons for bird population decline as presented in the video?

   (b) Did the information presented in the video support your hypotheses? Explain. **(1 pt)**

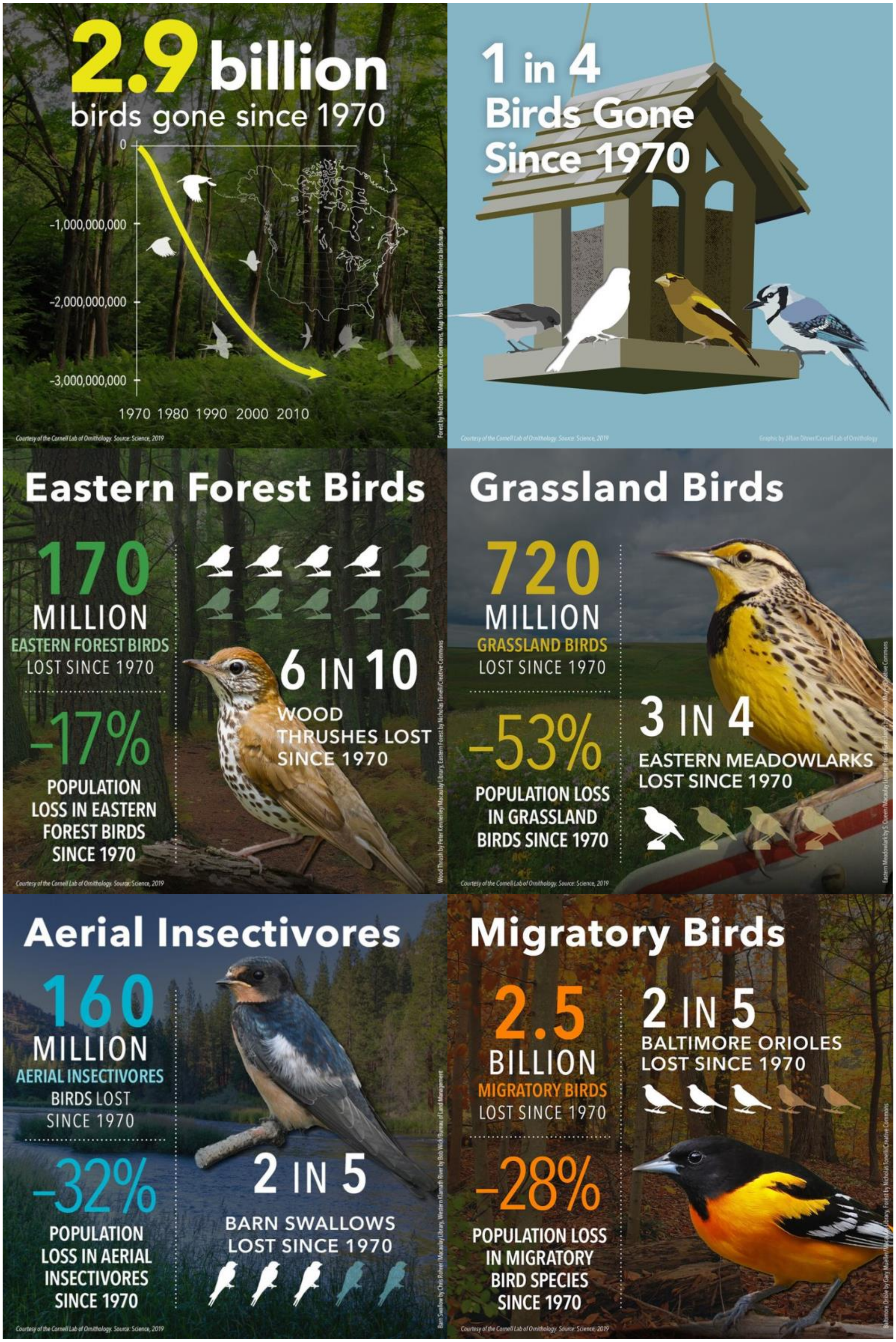

2.9 billion
birds gone since 1970
0
-1,000,000,000
-2,000,000,000
-3,000,000,000
1970 1980 1990 2000 2010
1 in 4
Birds Gone
Since 1970
Eastern Forest Birds
170
MILLION
EASTERN FOREST BIRDS
LOST SINCE 1970
6 IN 10
WOOD
THRUSHES LOST
SINCE 1970
-17%
POPULATION
LOSS IN EASTERN
FOREST BIRDS
SINCE 1970
Grassland Birds
720
MILLION
GRASSLAND BIRDS
LOST SINCE 1970
3 IN 4
EASTERN MEADOWLARKS
LOST SINCE 1970
-53%
POPULATION LOSS
IN GRASSLAND
BIRDS SINCE 1970
Aerial Insectivores
160
MILLION
AERIAL INSECTIVORES
BIRDS LOST
SINCE 1970
-32%
POPULATION
LOSS IN AERIAL
INSECTIVORES
SINCE 1970
2 IN 5
BARN SWALLOWS
LOST SINCE 1970
Migratory Birds
2.5
BILLION
MIGRATORY BIRDS
LOST SINCE 1970
2 IN 5
BALTIMORE ORIOLES
LOST SINCE 1970
-28%
POPULATION LOSS
IN MIGRATORY
BIRD SPECIES
SINCE 1970

Figure 1.1.

The following two figures both display data about bird mortality, but initially it might seem like they do not make sense together. Figure 1.2 from Rosenberg et al. (2019) shows the net loss of birds each year since 1970 while Figure 1.3 from Loss et al. (2015) shows the sources of bird mortality each year.

Figure 1.2.

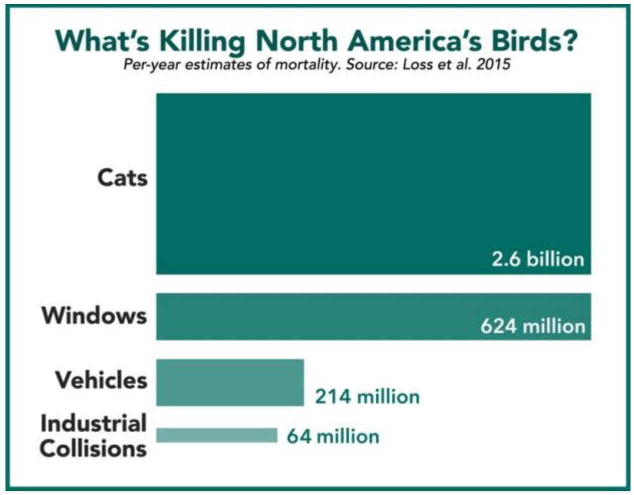


Figure 1.3.

4. Figure 1.2 indicates that a net nearly 3 billion birds have been lost since 1970 while data in Figure 1.3 show that an estimated 2.6 billion birds are killed each year by cats alone. How can both of these data be simultaneously accurate? **(1 pt)**

Part 2: Who are Professional Scientists and Who are Community Scientists? (6.5 pts)

As we have seen in Part 1, the bird populations in North America are struggling, and you have thought about reasons as to why that is a problem for society. You may think it is up to someone else to solve these problems, but we can ALL help to make a difference. Many types of people have teamed up for conservation initiatives that have had a real impact.

5. Read the section called Comebacks: Reasons for Hope on https://www.3billionbirds.org/findings. At the end of the section, it states "Saving birds must start with all of us working together." What do the authors mean by all of us? List all of the different groups of people that have an impact on bird conservation. Consider groups that are directly mentioned in this section as well as those that may have an indirect impact on bird conservation. **(1 pt)**

Review the 7 Simple Actions: https://www.3billionbirds.org/7-simple-actions to help birds website, pay particular attention to #7 on Do Citizen Science.

Oxford Dictionary defines **community science (i.e. citizen science)** as "the collection and analysis of data relating to the natural world by members of the general public, typically as part of a collaborative project with professional scientists."

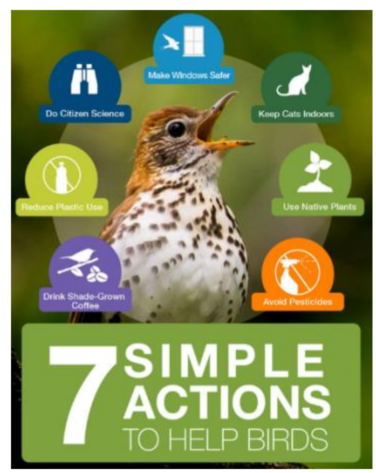


Figure 1.4.

Before we jump more into what community science is, we will consider the two primary groups that must collaborate in community science projects: professional scientists and community scientists.

Who are Professional Scientists?:
Individually, imagine a scientist in as much detail as possible. Note what image first comes to mind. Think about a scientist at work. What does the scientist look like? What are they wearing? Where are they working? What sort of equipment and tools does the scientist have to help in their work? Convene with your group and compare your different ideas of who scientists are.

6. Discuss your imagined scientist with your group/class, what were some common characteristics of professional scientists among your group or class? **(1 pt)**

Join a full class discussion with your Lab Instructor on who scientists are and what they do. You might also check out the following websites: Who's the Scientist?: https://go.osu.edu/whosthescientist And This Is What a Scientist Looks Like: https://go.osu.edu/iamascientist.

7. After discussing and/or reviewing the websites, do you think your group's original characteristics of scientists were accurate or oversimplified? Explain. **(1 pt)**

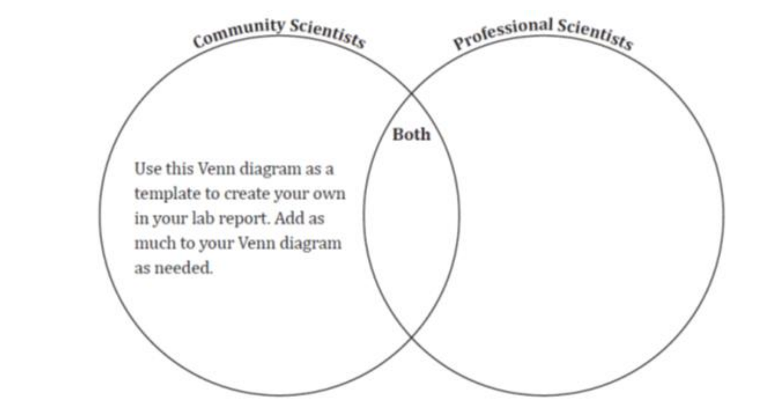
Who are Community Scientists (aka Citizen Scientists)?:

Visit Google with your group to explore question 8. Note that the term citizen science is much more widely used so you may have better luck finding clear definitions with that search term. As you are reviewing websites, try to find sources that you think are reputable.

8. Who are community scientists? What do they do? Remember to cite your sources. **(2 pt)**

Bringing Professional and Community Scientists Together:

9. Complete the Venn Diagram to compare and contrast the roles of community scientists and professional scientists in community science research projects. **(1.5 pts)**



Illustrated by © Van-Grienr, LLC

Part 3: Why do Community Science? (2.5 pts)

From Your Perspective:

In your community science project, you will get to have the experience of stepping into the shoes of both the community scientist and professional scientist. As a community scientist, you will learn to make observations, and collect and contribute data that may be used for science and conservation initiatives. As a scientist, you will learn how to develop unique hypotheses, gather data from a database, analyze data to 'test' your hypothesis, make conclusions, and communicate those results.

Through this project you will learn about how to conduct authentic science that tackles a novel question and contributes your personal observations to a national database. Hopefully you will:

- Improve scientific literacy skills
- Better understand the difference between science and pseudoscience
- Develop a greater appreciation or interest for the natural world

And maybe you might end up being a professional scientist yourself! Even if not, skills from this project will help you in any future career...

Below are the NACE Career Competencies from the OSU Career Readiness website: https://go.osu.edu/osucareerreadiness. Competencies marked with a hummingbird are expected to be supported with your Community Science Project.

NACE Career Competencies:

Oral and Written Communications

Teamwork and Collaboration

Leadership

Critical Thinking and Problem Solving

Professionalism and Productivity

Digital Technology
Global/Intercultural Fluency
Career Management

Active Citizenship and Community Engagement

10. Individually consider your future career choices and goals. What skills/knowledge will you be learning in this project that will transfer to your future career aspirations? **(1 pt)**
    - Make sure to include the responses from each group member in your final submitted report.

From a Broader Perspective:
Read the following abstract from the Sullivan et al. (2017):

"Ensuring that conservation decisions are informed by the best available data is a fundamental challenge in the face of rapid global environmental change. Too often, new science is not easily or quickly translated into conservation action. Traditional approaches to data collection and science delivery may be both inefficient and insufficient, as conservation practitioners need access to salient, credible, and legitimate data to take action. Open access data could serve as a tool to help bridge the gap between science and action, by providing conservation practitioners with access to relevant data in near real time. Broad-scale citizen-science data represent a fast-growing resource for open access databases, providing relevant and appropriately scaled data on organisms, much in the way autonomous sensors do so on the environment. Several such datasets are now broadly available, yet documentation of their application to conservation is rare. Here we use eBird, a project where individuals around the world submit data on bird distribution and abundance, as an example of how citizen-science data can be used to achieve tangible conservation science and action at local, regional, and global scales. Our examination illustrate show these data can be strategically applied to improve our understanding of spatial and temporal distributions of birds, the impacts of anthropogenic change on ecological systems, and creative conservation solutions to complex problems. We raise awareness of the types of conservation action now happening with citizen-science data, and discuss the benefits, limitations, and caveats of this approach."

11. Refer to the abstract above and back to the Do Citizen Science section on the 7 Simple Actions website: **(1.5 pts)**
    (a) How could community science improve bird populations?

    (b) What particular benefits does community science have over traditional science?

    (c) What potential costs does community science have over traditional science?

Part 4: Your Community Science Project (4 pts)

For your community science project, we will be contributing data to and using data from eBird.org. Watch this video (https://go.osu.edu/ebirdintro) that describes eBird.org. **Take notes.** Later in the project each student will submit a brief proposal outlining their research plan. Proposal writing is standard practice in the scientific community when seeking grant funds to conduct research. Your response to question 14 (below) will be the starting point for that individual proposal.

As mentioned previously the broad goal for this project is for you to engage in authentic scientific practices.
Following this project, students you will be able to…
- Apply the process of science to answer questions about the natural world

- Explain the definition of, importance of, and limitations of Community Science.
- Locate and summarize reliable sources.
- Develop a unique hypothesis based on observations.
- Develop a replicable study design.
- Collect data from a variety of sources.
- Analyze data in reference to a hypothesis.
- Create graphs to visually display data.
- Relate project findings and goals to content covered in lecture
- Relate data analysis to relevant (possibly to the local community) societal issues
- Communicate research findings to a particular audience

Refer to the lab schedule on your course syllabus to get a better idea of project flow for your class.

12. Synthesize information that you have learned during this lab. As a group take a few minutes to write a paragraph (no more than 5 sentences) that: **(4 pts)**
    a) describes what community science is and how it contributes to scientific knowledge
    b) includes a basic description of eBird,
    c) explains generally what you will be doing in this project, and
    d) explains the potential significance of your work on the project.

Once you have finished your paragraph, call your Lab Instructor over to read it to them.

Sources:
Cornell Lab of Ornithology. n.d. Digital Media. 3 Billion Birds. https://www.3billionbirds.org/additional-media

Loss SR, Will T, & Marra PP. (2015). Direct mortality of birds from anthropogenic causes. Annual Review of Ecology, Evolution, and Systematics, 46, 99-120. https://go.osu.edu/birdmortality

Rosenberg KV, Dokter AM, Blancher PJ, Sauer JR, Smith AC, Smith PA, Stanton JC, Panjabi A, Helft L, Parr M, & Marra, P. P. (2019). Decline of the North American avifauna. Science, 366(6461), 120-124.

Sullivan BL, Phillips T, Dayer AA, Wood CL, Farnsworth A, Iliff MJ, & Rodewald, AD. 2017. Using open access observational data for conservation action: A case study for birds. Biological Conservation, 208, 5-14.

Community Science Project Exercise 2
Observations and Hypotheses: Literature Review

The first steps of the scientific method are making observations to then form a hypothesis, or a tentative explanation for a natural phenomenon. Scientists form observations from a number of sources including reading scientific literature, direct observations of the natural world, and looking at patterns in data. We will practice each of these methods of observation to help formulate a hypothesis for our semester-long project.

We will begin with reading literature to form observations. BUT, before we can get into reading and using scientific information for observations, it is important to learn about what makes a source reliable and be aware of biases present in different types of communication about science.
In this pre-lab, we will learn how to distinguish different types of sources and why that matters. In lab this week, we will also have the chance to practice finding and interpreting primary literature so we can be confident in our abilities to find accurate information and critically evaluate sources in the future.
When considering the reliability of different resources, you will hear the terms "**primary**" and "**secondary**" source come up.

Pre-Laboratory Questions (2 pts)
1. Do a little research with your group and define both of these terms in the scientific context. Be sure to cite your sources. (1 pt)

Sometimes you will hear people refer to different sources as being "better." But, which source to use depends largely upon how you are using it.
2. Who is the target audience of a primary scientific source? Of a secondary source? (.5 pt)

3. Under which circumstances is a primary source the most beneficial to use? When would a secondary source be the most beneficial? (.5 pt)

Learning Objectives
Students will be able to

- Distinguish between primary and secondary resources and explain their value
- Evaluate sources for reliability and accuracy
- Analyze information provided by different sources on the same topic
- Demonstrate ability to make sound decisions using available information
- Demonstrate how scientific literature can be used as observations

The first step of the scientific method is making observations to then form a hypothesis, or a tentative explanation for a natural phenomenon. Scientists form observations from a number of sources including reading scientific literature, direct observations of the natural world, and looking at patterns in data. We will practice each of these methods of observation to help formulate a hypothesis for our semester-long project.
This lab is the first part of a two-week lab where we learn how to make observations and generate testable hypotheses with those observations. We will begin with reading literature to form observations. BUT, before we can get into reading and using scientific information for observations, it is important to learn about what makes a source reliable and be aware of biases present in different types of communication about science.
In lab we will practice finding and interpreting primary literature so we can be confident in our abilities to find accurate information and critically evaluate sources in the future. We will also use that primary literature to make observations and form a hypothesis. In the coming weeks, the second part of this lab will entail using direct observations from the natural world and data to make observations and formulate hypotheses.
Join your Lab Instructor and the rest of the class for a discussion on types of sources.

Part 1: Identifying Reliability (5.5 pts)

An important part of being a critical thinker is the ability to distinguish types of information sources and analyze these for reliability. There is not only a tremendous amount of misinformation available at our fingertips, but sometimes even those with the best of intentions can write misleading headlines or interpretations of scientific research.
Open and skim through the articles available on our course webpage. Your Lab Instructor may have given you advice on how to skim, but essentially it means reading through the article to get a general idea of what the article is about and the major findings.
1. Include the title of each article below (.5 pt)

Article 1 Title: ____
Article 2 Title: ____
Article 3 Title: ____

All three of these articles provided were obtained through googling “Cats kill birds.” You are probably seeing that even though they are found using the same search, they all look quite different and may communicate different information.
2. For each of the articles, compare the qualifications of the author(s). (1 pt)

3. Which of these articles can be considered primary literature? How can you tell? (.5 pt)

4. What are other differences you notice between the primary and secondary articles? (1 pt)

5. Which of the articles do you think the average (non-scientist) person is likely to read? Why? (.5 pt)

Scientific literature is not written in a manner to be easily digestible by the average person. Journalists that write about the research and report it are invaluable in making scientific information accessible to a wide audience. We call these “lay articles” or “pop science.” As you have discussed your Lab Instructor, when reading these articles, we need to use our critical thinking skills because they are a degree (or more) removed from the source of the information. We will work on these skills by evaluating different sources of information.

Focus on articles 2 and 3 when answering the following two questions.
6. What characteristics of article 2 might lead someone to think it is a reliable information source? What characteristics of article 2 that might make you skeptical? (1 pt)

7. What characteristics of article 3 might lead someone to think it is a reliable information source? What characteristics of article 3 that might make you skeptical? (1 pt)

Part 2: Information Communication (7.5 pts)

Even though the three sources are all about the same topic, the information that is communicated by each one varies. How does this impact the accuracy? How confident can we be that we are getting reliable information from our secondary sources?

Compare Article 1 with Article 2. Article 1 is the original study testing the hypothesis that **a large portion of bird and mammal mortality is caused by free-roaming cats**. Article 2 is the lay article that reports on that study.
8. Compare and contrast the original study and the lay article using the following points. Make note of specific major differences and similarities between the articles. (3 pts)

a) Stated hypothesis:

b) Clarity of methods:

c) Main findings or conclusions:

9. One a scale of 1-10, how accurately did the lay article depict the findings in the scientific article? Explain your answer. (.5 pt)

Revisit Article 3 and compare that to Article 1.
10. How does the message in Article 3 differ from that in Article 1? What might explain the discrepancies between the two? (1 pt)

11. If someone was to only see Article 3 and not Article 1, would they have an accurate understanding of the information in Article 1? Explain (1 pt)

These articles, and indeed the bird/free-roaming cat conflict, are great examples of how communication of scientific information matters. We see that when science is communicated for a scientific audience, the message can be misinterpreted or misunderstood when it is communicated to a lay audience. This is why scientific literacy is so important! This can prevent miscommunication of information or motivation. After you do your research project in this class, you will get a chance to communicate your findings in both an accurate and compelling way.
Next, summarize the major takeaways of critically analyzing secondary literature.

12. How might the conclusions you draw from comparing scientific and lay media articles inform the way you approach reading of articles touting 'new studies' in the future? (1 pt)

13. In your own words, summarize the pros and cons of using secondary literature. (1 pt)

Part 3: Finding Primary Literature (2.5 pts)

The ability to seek out and use primary literature is an important skill in being a scientifically literate citizen. Why is this? Think about your future after this class or after college. What circumstances might cause you to do a primary literature search?
We will practice doing a primary literature search. Being an Ohio State student, you have access to several databases that you can use to search and read primary literature. Your Lab Instructor will demonstrate how to access the library website to use these databases.

14. Individually, practice searching for primary literature by doing a search for a primary source that relates to this Community Science project. Each person should pick one of the following topics to do their search.

- Birds + citizen science
- Birds + wind turbines
- Birds + migration patterns
- Birds + urban lights
- Birds + urban noise
- Birds + window strikes
- Birds + nest site selection
- Birds + edge effect
- Birds + brood parasitism

15. Once each person has found an article, share your finds with each other and pick one article for the group to use going forward.

a) Provide a full citation for the article you found (0.5 pt):

b) Briefly (3 sentences or less) and in your own words, summarize the major findings from this article? Which section(s) of the article did you use to get this information? (1 pt)

16. How can you be confident that the authors in this article followed sound scientific practices and the data are appropriately interpreted? In other words, what parts of this article demonstrate that the data and conclusions are sound? (1 pt)

Part 4: Using Literature to Formulate Observations and Hypotheses (2.5 pts)

To develop questions and hypotheses, scientists will spend time doing literature reviews. Primary literature tells us what is known and therefore can be considered an observation about the world around us. Many people (including novice scientists) would probably be surprised to learn how much time researchers spend reading articles about their research interests. This is a critical step in helping researchers develop well thought-out hypotheses that contribute new information to a growing body of knowledge.

Example:

Observation from literature: Outdoor cats kill birds.
Question: Do outdoor house cats or feral cats kill more birds?
Hypothesis: Feral cats contribute to more bird deaths than outdoor house cats because house cats are fed by their owners causing them to hunt less.
Prediction: There will be more bird kills in areas with proportionally higher feral cat populations as compared to house cat populations.

Practice:

Observation from literature: Birds migrate from the southern to northern hemisphere in the spring.
Question: What signals birds to begin migrating?

17. Hypothesis: ____ (0.5 pt)

Prediction: More birds will arrive in the northern hemisphere when there are prevailing winds from the south in the spring.

Try it on your own:
Use the article you found and wrote about in Part 3. If for some reason this article does not work well for this section, you are welcome to use one of the other articles your group found. Just make sure you include a citation for the new article you are using for Part 4.

18. Provide at least 3 observations about bird biology that sparked your interest while reading the article. (1 pt)

-
-
-

19. Your responses to questions 17 and 18 are examples of how we use literature to make observations. Now, use those observations to develop your own hypothesis. Write a question that arises from your review of this article and provide a hypothesis for that question. This should be different from the hypothesis presented in the article your found. (1 pt)

a. Question:

i. Hypothesis:

Community Science Project Exercise 3
Observations and Hypotheses: Direct and Data Observations

This semester, we will be developing our own research project to learn about the scientific process in an authentic and meaningful way. Observations are the first step in this process. In Part 1, you learned about using scientific literature to make observations and hypotheses. This week we will learn how to make observations and develop hypotheses using direct observations of the natural world and data from those and other observations.

Although each lab section will have their own project, we will all use birds as our research subjects. Birds are a great species to study because observations can be made all over the world and in any type of environment. You can make observations by taking a walk through your neighborhood, going on a hike in a natural area, or simply from looking out your window. Christina Geer got into birding as a way to find calm in 2020 by watching birds from her father's terrace in Dover, Delaware (link to article: https://go.osu.edu/christinagreer).

Observations are collected and stored in the eBird database, and this provides an abundant amount of data for us to use for our research project this semester. So, while you will collect your data using what is available in the eBird database, it is important to know how those observations got there in the first place.

Pre-Laboratory Questions (4 pts)

In this Pre-lab, you will learn about and prepare for submitting observations to the eBird. In lab this week we will submit a checklist to the eBird database so you know what the experience is like making and submitting observations. This will provide important perspective when you go to analyze and interpret your data later this semester.

Pre-Lab Part 1: Accessing eBird (1 pt)
First, decide if you would like to enter eBird observations using an app on your phone or iPad, or by using the website on your computer. We will be making observations together in class, so **it is recommended that you use a mobile app** rather than a computer. The benefit of using the mobile app is that you can submit your data while you are observing the bird rather than needing to document your observations and input the information later. Regardless of what you choose, you will need to register for an eBird account.

Read the directions below in relation to the observation method you have chosen:

Enter Sightings with eBird Mobile: https://go.osu.edu/ebirdmobile
Enter Sightings with eBird Website: https://go.osu.edu/ebirdwebsite

1. Register for an eBird account, and explore the app/website briefly so you know where to go to submit an observation. Have the eBird app or website open and ready to show your Lab Instructor at the start of the lab session. **(1 pt)**

Pre-Lab Part 2: Identifying bird species (1.5 pts)
To make direct observations and to submit to eBird, you need to do your best to identify the bird species you have seen. This is a skill, and some birds are easier to ID than others.

2. Observe the following image (Figure 3.1). Assume it is January in Columbus, Ohio. How many bird species (or types) do you think are present in the image? Explain how you came up with this number. You will not be graded based on if you guess the right number of species. **(0.5 pt)**

Figure 3.1

Next, learn a couple of ways you can ID birds in order to get an accurate species count. Review the PDF poster on the Four Keys to Bird ID: https://go.osu.edu/fourkeysposter and shown here in Figure 3.2.

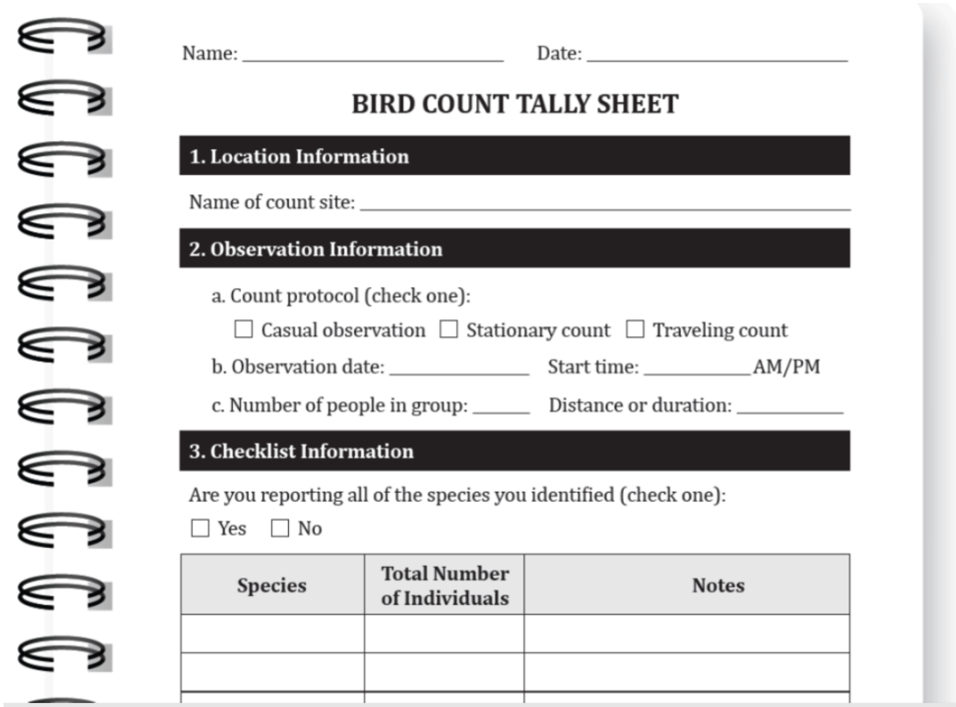
Figure 3.2 Courtesy of Cornell Lab of Ornithology

Of course, there is an app that can also help you with IDs! We would **highly suggest** downloading the Merlin App: merlin.allaboutbirds.org. In this app you can use the four keys to ID birds or you can take a picture of a bird and get suggested IDs. You can also use Merlin Bird ID on the main allaboutbirds.org website by clicking “Get Instant ID Help”.

3. Considering the Four Keys to Bird ID and/or the Merlin app, now how many species do you count in Figure 3.1? Explain your answer **(1 pt).**

Pre-Lab Part 3: Recording Observations (1.5 pts)

An important part of collecting data for research is keeping good records. When we do fieldwork, we use data sheets to collect all relevant information about the location and what we have seen. View the following data sheet in Figure 3.3. It will approximate the information you will need to collect to submit observations to eBird.org:


Name: ________________ Date: ________________

BIRD COUNT TALLY SHEET

1. Location Information

Name of count site: ________________

2. Observation Information

a. Count protocol (check one):

☐ Casual observation ☐ Stationary count ☐ Traveling count

b. Observation date: __________ Start time: ________ AM/PM

c. Number of people in group: ____ Distance or duration: ________

3. Checklist Information

Are you reporting all of the species you identified (check one):

☐ Yes ☐ No

Species	Total Number of Individuals	Notes

Figure 3.3. Illustrated by © Van-Grienr, LLC

4. Why do you think is important to include “Are you reporting all the species you identified?” in the data sheet in Figure 3.3? **(0.5 pt)**

5. After critically reviewing both the data sheet in Figure 3.3 and four keys to bird ID/Merlin app, imagine that you were going out to observe birds. What are important details to consider when making observations of birds. I.e. what do you want to make sure to include in your field notes? **(1 pt)**

Now that you have techniques for IDing birds and you have thought about the important pieces of information to include in a datasheet, you are ready to submit an observation to eBird in lab this week.

Learning Objectives

Following this exercise, you will be able to:

- Access and use the eBird app to submit observations
- Generate hypotheses about the natural world using direct observations, as well as observations from data and literature.
- Demonstrate how data and scientific literature can be used as observations.
- Interpret graphical data.
- Navigate data on eBird.
- Find scientific sources related to an observation.
- Evaluate the ability for eBird to help answer specific scientific questions.

Introduction

There are different ways to observe the natural world. You can go outside or look in a microscope to observe nature directly or you can look at observations generated by others in the form of data or scientific literature. In the last Community Science Project (CSP) lab, we learned how you can use scientific literature to make observations and hypotheses. In this lab, you will learn about how direct and data observations can lead to scientific questions and hypotheses. At the end of the lab, your group will make a hypothesis about birds that you would like your whole lab team to study for the community science project. Your group will have the opportunity to “pitch” your idea to the whole lab team.

Your hypothesis might shape the research that your whole lab group will be doing for the remainder of the term!

Part 1: Submitting Observations to eBird (2.5 pts)

In your pre-lab you prepared for making observations in eBird by downloading the app, learning techniques for IDing birds, and thinking about the important pieces of information to include in a datasheet. Now you will learn how to actually submit an observation to eBird. Remember, observations like yours can be used for data in scientific research projects, and you will be using other people's observations for your class research project this semester.

Pre-Field Trip Discussion: Why do you think it is important to include an answer to the question "Is this a complete checklist of the birds you were able to identify" in eBird submissions?

For this field trip, you will get to choose the location on campus to make your observations. To prepare for this, think about what birds need to survive and where you have observed them in the past.

1. What types of features in the habitat are important to birds? Considering those habitat features, where (specific locations) do you think you will be most likely to see birds when you go outside? (1 pt)

Now go try it out! Go outside with a partner for 30 minutes as instructed by your Lab Instructor.

- For this activity, only one of you will need to use the eBird app. The other can use their device to help with ID, including the Merlin App and the All About Birds Website (allaboutbirds.org).
- You should find a location that is not near other pairs in your class so as not to submit the same observation twice.
- Over the course of the total 30 minutes your pair should add **at least two** different bird species to your checklist.
- If you are unable to ID a bird in the field, write down notes about how the bird fits into the Four Keys to ID and see if you can ID it later. Do not be discouraged if you cannot figure it out – bird ID takes practice.
- DO NOT submit your checklist now! You will revisit it during your class discussion after you have had an opportunity to double check your IDs.

DISCLAIMER: You should only submit a checklist once you are confident in your sighting. Local eBird reviewers and birders will often 'chase' eBird sightings to confirm them and professionals use your eBird submissions for research and wildlife management, so it is mportant to take the time to ensure you have identified the right species to the best of your ability. If a species is marked as unreported, rare, or requires comments for submission, you should double check your ID. Submitting a bird that you did not see is grounds for academic misconduct and evidence that you submitted to eBird without making an observation is subject to being sent on to COAM. This is a learning process: as long as you are trying to ID the bird to the best of your ability and using available resources (like a field guide or Merlin) you should have no problem. If you are very unsure of your sighting and feel uncomfortable submitting it to eBird, you can show your unsubmitted report instead.

2. Call your Lab Instructor over to see your eBird data sheet or submission. Make sure your information clearly shows the birds you saw. (1.5 pts)

If you enjoyed doing bird observations today, you might also enjoy getting involved in the following local bird-related groups.

OSU Ornithology Club (https://go.osu.edu/osuornithologyclub)
Birding Central Ohio Facebook Group (https://go.osu.edu/birdingcentralohio)
Columbus Audubon (https://columbusaudubon.org/)

Figure 3.4. Photo used with permission from Cassidy Ficker, President of OSU Ornithology Club

Part 2: Using Direct Observations of the Natural World to Develop Hypotheses (1.5 pts)

We are going to be using our bird observations to develop hypotheses.

Post-Field Trip Discussion:

How might there be variability in eBird data between observers?

What are at least two strengths of eBird as an open source database?

Example:

Observation from Direct Observations of Birds: There seem to be more American Robins on campus in March than during the coldest part of the winter.
Question: Do American Robins leave Central Ohio for the coldest part of the winter?
Hypothesis: American Robins migrate out of Central Ohio during the coldest months because there is less food available.
Prediction: The frequency of American Robins will decrease during the coldest months in Central Ohio.

Practice:

Observation from Direct Observations of Birds: Red-tailed Hawks (like 'Xerxes' that you may have seen on social media) eat Eastern Grey Squirrels.
Question: Are there more Red-tailed Hawks in places where there are more Eastern Grey Squirrels?
3. **Hypothesis:** ____ (0.5 pt)
Prediction: The frequency of reported Red-tailed Hawks will be positively related to the Eastern Grey Squirrel population.

Try it on your own:

Review the eBird submissions made by your group members.

4. After comparing your observations, what is one scientific question that arises? Re-write the question as a clear hypothesis (a tentative explanation for a natural phenomenon). (1 pt)
    a. Question:

        i. Question re-written as a hypothesis:

Part 3: Using Data to Formulate Observations and Hypotheses (8 pts)

In this section we will learn how to interpret and observe different types of data found on eBird. From those observations we will get curious and develop questions and hypotheses. This section will also give us an idea of how to access data in eBird, something that will be important during the data collection portion of this project.

Log on to eBird.org and click on "Explore" in the top navigation.

Scroll to the "Species Maps" (as seen in Figure 3.5) and click on it.

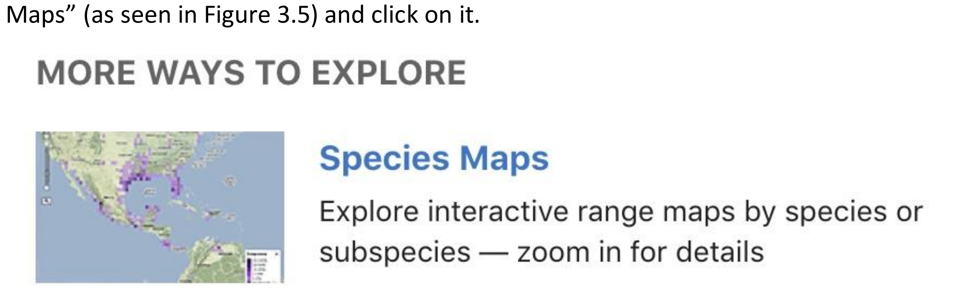


Figure 3.5.

Did you know you can see Snowy Owls (*Bubo scandiacus*) (Figure 3.6) in Ohio? It is true and the closer you get to Lake Erie in the winter the more likely you are to see them! We will use the species map to see how their frequency and distribution changes year

to year

Figure 3.6.

Within “Species” (as shown in Figure 3.7) type “Snowy Owl”.

Figure 3.7.

You will see a map similar to Figure 3.8. Once the data fills in play around a bit. Try zooming in. Switch settings around. Basically see what this mapping feature can do.

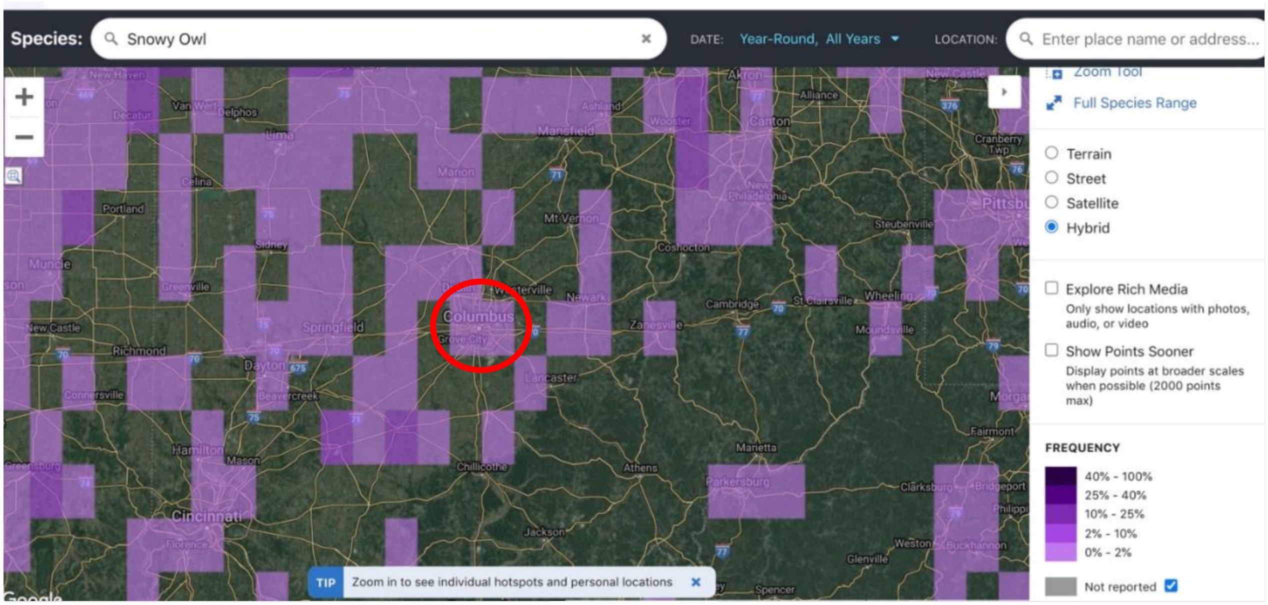


Figure 3.8.

5. After you are done exploring the map, explain what the circled area in Figure 3.8 (inside the Columbus 270 outerbelt) of the map above is showing you (FYI: frequency is the percentage of checklists reporting that species within a specified date range and region). (1 pt).

Reset your map to how it was when you started, you can do this quickly by re-clicking on “Explore” and then “Species Map” and typing in “Snowy Owl”.

See if the winter distribution of Snowy Owls is stable or changes from year to year.
Within the Date settings, set the Custom Date Range to Dec-Feb and the year to 2018-2019 as shown in Figure 3.9. This means that you are observing the frequency and distribution of Snowy Owls from Dec 2018-Feb 2019 (so just one winter). Now step backwards in time from 2017-2018, and 2016-2017 and observe how these data change from year to year.

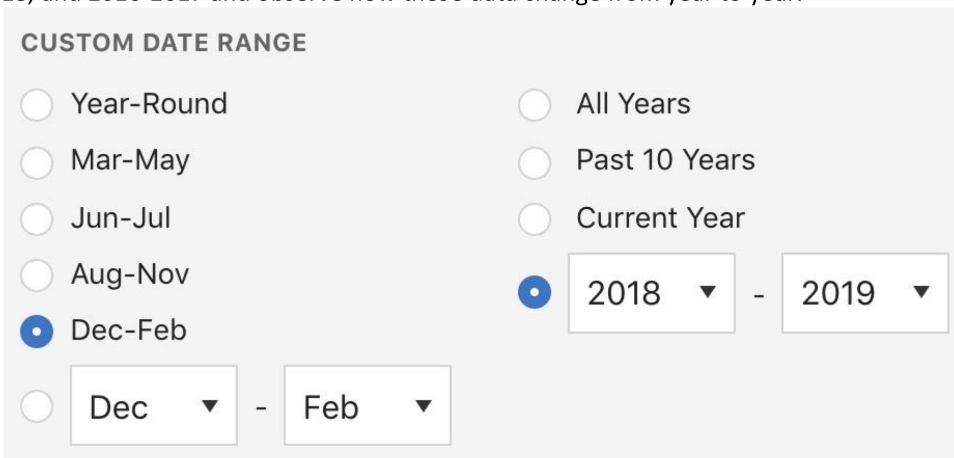


Figure 3.9.

6. How does the distribution of the Snowy Owl from Dec-Feb change from year to year? (1 pt)

7. What is a tentative explanation (hypothesis) for this phenomenon? (0.5 pt)

Switch from thinking about snowy owls to thinking about the geography in Ohio and how that may affect bird sightings. In Location, type “Ohio”. When you are a bit more zoomed in you can get a better idea of geography. According to the Oxford Dictionary Geography is “the study of the physical features of the earth and its atmosphere, and of human activity as it affects and is affected by these, including the distribution of populations and resources, land use, and industries.”

8. What are two **geographical** questions that you could ask about bird distribution/frequency using the Species Map? (1 pt)
   a.

   b.

Bar charts

Click on “Explore” in the top navigation, scroll to find the “Bar Charts” as shown in Figure 3.10. Click on “Bar Charts.”

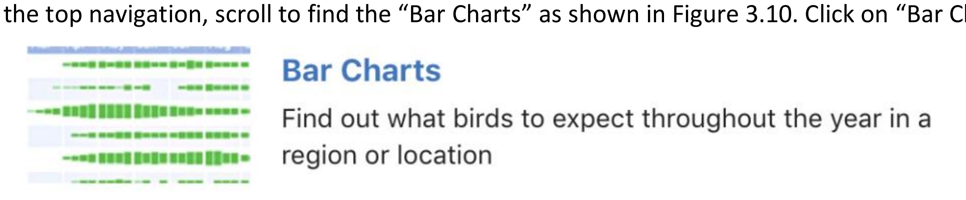


Figure 3.10.

For Choose a Location, select “Ohio”, and as a subregion “Counties in Ohio” as shown in Figure 3.11. Click “Continue” at the bottom. Choose just “Franklin” and click “Continue”. (Note that you can pick up to 15 counties at once).

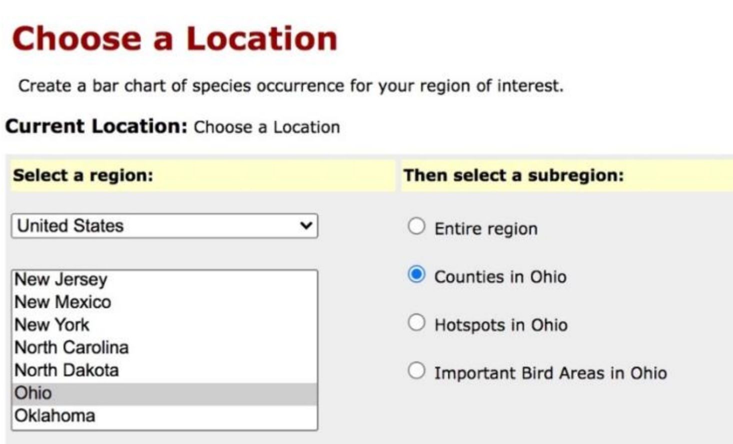


Figure 3.11.

9. What are 3 species that are common in Franklin County Year-Round? (0.75 pts)
   a
   b.
   c.

10. What is 1 species that is common in Franklin County for only part of the year? How do you know? (0.25 pt)

The Wood Thrush (*Hylocichla mustelina*) is an Eastern Forest bird. The Wood Thrush has a dapper cinnamon back, a speckled brown chest, and sings a lovely song that you can hear throughout Central Ohio all spring. As you learned in the Introduction to Community Science Lab, 6 in 10 Wood Thrush have been lost since 1970 (see Figure 3.12) making it a target species for many conservation efforts. We will jump into the data for the Wood Thrush.

Figure 3.12. Courtesy of Cornell Lab of Ornithology

Find the Wood Thrush Bar Chart, it should look like Figure 3.13:

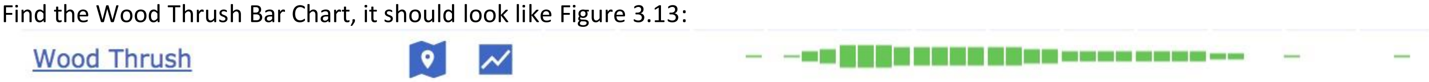


Figure 3.13.

Click on the icon that looks like a graph --> 

Within this view you can see a number of different graph tabs looking at the pattern of Wood Thrush in Franklin County, Ohio over the year (Figure 3.14).

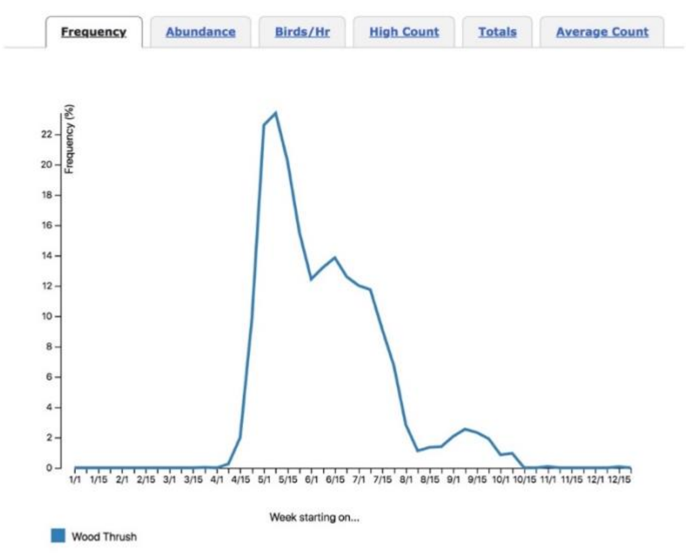


Figure 3.14.

If you scroll to the bottom of each graph you can see link to a definition of the Y axis (See "What is Frequency?" circled in figure 3.15 below).

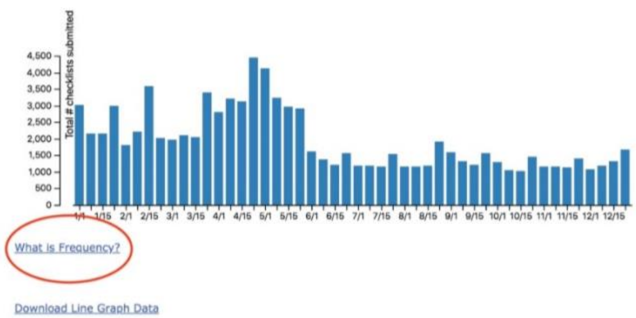


Figure 3.15.

11. In your own words, what is the difference between frequency and abundance? Do you think one measure is better than the other? Why or why not? (1 pt)

For the purposes of this activity we will look at frequency (this is also the value seen on the bar charts and species map).

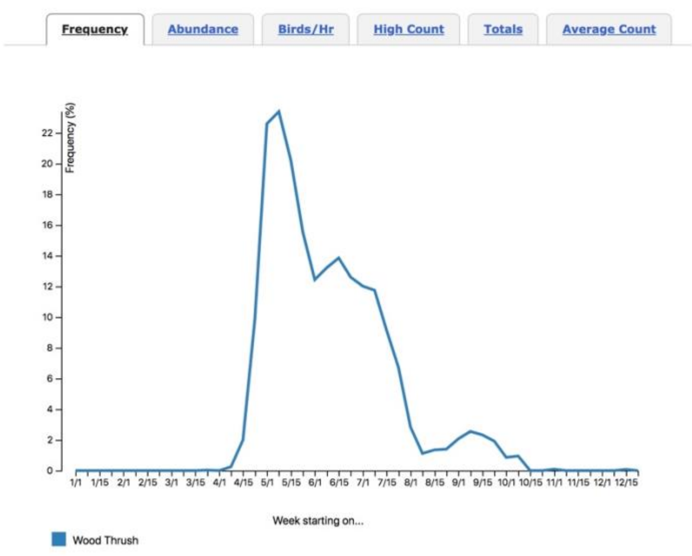


Figure 3.16.

12. Describe what you are seeing in the graph in Figure 3.16 **and** provide 1 hypothesis that tentatively explains this pattern. (Note, if you look at this graph in eBird, you can hover your cursor over the graph to reveal the exact value). (1 pt)

Now determine if this pattern changes from year to year. At the top in "Date Range" click "Change Date" as shown in Figure 3.17.

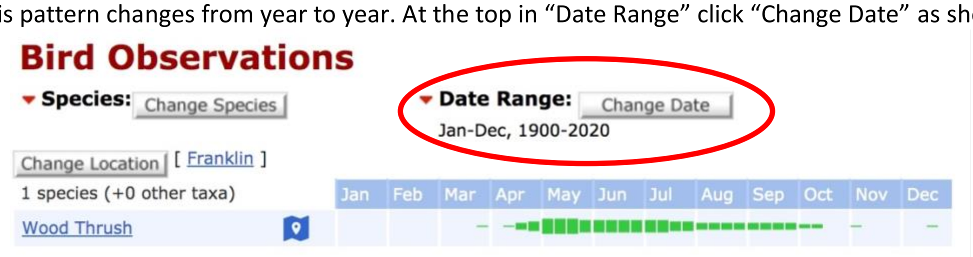


Figure 3.17.

In the Change Date section (Figure 3.18), for "Choose a range of years:" select Start in: 2017, End in: 2019. Select the box to Separate years. This will make it so that there is a separate line on each graph from 2017, 2018, and 2019. Click "Continue" and observe the Frequency line graph.

Figure 3.18.

13. Describe any patterns that you observe in the resulting graphs. (1 pt)

14. Provide 1 hypothesis that might explain part of the patterns seen in the graphs. (0.5 pt)

Part 4: Community Science Project Hypothesis Submission (4 pts)

By now you have spent some time observing birds yourself, looked at data as observations, and used literature for observations. From each of those observation types you have practiced making hypotheses. Now it is time to broaden our scope and think about what you would like to investigate as part of your eBird community science project. Only one hypothesis will be chosen to explore with the full lab team. This will allow your lab team to work together to collect data and hopefully come to a strong conclusion.

15. Brainstorming: Recall everything you know about birds up to this point. Think back to the Introduction to Community Science lab, Observations and Hypotheses Part 1: Science Communication lab, the pre-lab you turned in today, the lab today, and any other interactions you have had with birds. List at least four scientific questions that your group has about birds. (1 pt).

Over the course of this semester, your class will be testing a hypothesis using eBird data and, if necessary, other publicly available resources. Each group will pitch a hypothesis, and the Lab Instructor will pick one. So, your job is to come up with the best testable hypothesis!

16. From those ideas choose two that are particularly interesting and reframe them as hypotheses. (2 pt)
    a. Question 1:
        i. Hypothesis 1:
    b. Question 2:
        ii. Hypothesis 2:

17. Remember, you are coming up with hypotheses that can and will potentially be tested by the whole class. Can you investigate these hypotheses using eBird (either by the class collecting data or by using the data available in eBird)? Explain. Do you need access to additional resources (e.g. NOAA temperature data) to investigate those hypotheses? If so, what are they? (0.5 pt)

18. Based on the ease of answering using eBird and other resources, which hypothesis would you like to pitch? (0.5 pt)

Call your Lab Instructor over and give them a 2-minute or less “sales pitch” to explain the hypothesis and why you think it would be a good question to pursue with the lab team.

Image Sources:
Figures 3.1, 3.6: Purchased from BigStock by © Van-Grienr, LLC
Figure 3.2, 3.12: Cornell Lab of Ornithology. n.d. Digital Media. 3 Billion Birds. https://www.3billionbirds.org/additional-media
Figure 3.3: Illustrated by © Van-Grienr, LLC
Figure 3.4: Photo used with permission from Cassidy Ficker, President of OSU Ornithology Club
Figures 3.5, 3.7-3.11, 3.13-3.18: Screenshots retrieved from https://www.ebird.org. 2020.

Community Science Project Exercise 4
Experimental Design

No Pre-Laboratory Questions

Learning Objectives
Students will:
- Describe the different factors that can affect experimental design and, more specifically, its capability to accurately test the hypothesis.
- Identify the variables of their test
- Consider how to standardize variables not being tested
- Consider the details needed to make an experiment repeatable
- Create a protocol that provides appropriate data to test their hypothesis while limiting potential complications
- Analyze experimental designs for potential errors or missing details
- Articulate a plan for collecting data using the class timeframe

Part 1: Testing the Hypothesis (2 pts)

As a class, you have made observations and developed several hypotheses. Your Lab Instructor has picked one hypothesis that you will go forward with as a class. While the whole class will be testing the same hypothesis, each group will work on this independently.

1. Write the question and hypothesis that your class will be working on here: (.5 pts)
   Question:
   Hypothesis:

You have practiced submitting observations to eBird.org to see how the data in eBird are created. We will be using the database in eBird to collect the data for our class hypothesis. This means for your class research project, you will not be going out and observing birds yourself, but rather using data collected and submitted by community scientists, including Ohio State students. When you did the Observations and Hypotheses lab, you learned how to find data in eBird. Remember looking at the bar charts and comparing abundancy and frequency? That gave you an idea of what data are available and how you can use them. With that in mind, start thinking about how we can test our hypothesis using eBird.

2. The goal of this lab is to write a detailed study protocol. To do that, we must know what data we will need to test the hypothesis. What data can you use from eBird to test your class hypothesis? What data will you have to collect from other sources to test this hypothesis (e.g. NOAA)? Your answers should be specific. (1 pt)

3. Write a prediction for your hypothesis. Remember, a prediction can be formatted in an “If… then…” statement. (.5 pts)

Part 2: Preparing for a Research Study (2.5 pts)

Your hypothesis is your tentative explanation for observations that were made by members of your class. How do we know if this hypothesis is correct? We will need to develop an experiment that we have the resources and time to conduct. When writing out our study design, we need to think about all the factors that will impact our ability to complete the study. This is the same process followed by many professional scientists when designing a study.

4. What are all the different factors that you need to consider when designing your experiment? This is a brain dump! Write a list with at least four items here. (1 pt)

5. What are challenges or pitfalls that you can anticipate when it comes to testing this hypothesis? (.5 pt)

Stop here and join your Lab Instructor and the rest of the class to discuss the things we need to consider when it comes to designing our experiment.

6. In your discussion, you thought about the difference between an observational study and a controlled experiment. Which will you be conducting? Explain your response. (1 pt)

Part 3: The Parts of Our Study (9.5 pts)

<u>The Variables</u>

Now that we have considered the many factors that can impact our study or our ability to carry it out, we can get ready to design our study. We should develop a protocol for this study that ensures we can complete it and minimizes all potential challenges and pitfalls that you thought of above. The protocol should be repeatable, and we should be confident the data will either support or refute our hypothesis.

To start, clarify the specific data we will be collecting. To do this we will identify our independent and dependent variables, specify how we will measure them, and provide a website or location for where we will collect the data.

Example:

Say my hypothesis is that smaller birds have an advantage in wooded areas compared to larger birds because the trees are less of an obstacle when finding food or escaping predators.

Prediction: If smaller birds have an advantage over larger birds in wooded areas, then there should be more smaller birds found in wooded areas compared to larger birds.

Here are examples of how we would answer questions 7-11 for this hypothesis.

Q7. Is there any variation between groups in how you will test this hypothesis? If so, how will your group differ from other groups in your class?

Each group is able to choose their own hotspots as long as they are in different parts of Ohio.

Q8. Now fill out the table 4.1 below about how you will collect data for your independent and dependent variables.

	What is your variable?	Specifically, how will you measure this variable?	Where will this information come from?
Independent	*Size of the bird*	*We will look at the average wingspan as a proxy for size. As a class, we decided "large" is any wingspan greater than 80 cm.*	*Allaboutbirds.org Under the "ID Info" for each bird species*
Dependent	*Number found in wooded areas.*	*We will measure abundance of our species in hotspots that are mostly wooded areas.*	*eBird.org, using the barcharts for our species we will access the "abundance" data*

Table 4.1

We can provide more details on how we will collect our data for these variables. You may notice in Table 4.1, there are many ways a person could collect these data. We will narrow it down so that our study is consistent and repeatable.

Q9. What region(s) will you be using for this study? Explain your response.

Our group will look at 4 hotspots in Ohio that are mostly wooded areas. We will confirm this by looking up information about each hotspot.

Q10. What species will you be using for your study? Explain your response.

We will be randomly choosing 10 species from each hotspot. We will do this by using a random number generator online.

Q11. Describe the time range for your data collection.

We will collect data from the spring migration months as designated by eBird to ensure our data will account for migratory and non-migratory species. We will use data from 2017-2021.

Your Turn:

Now, use the example above to specify and describe your own variables. Refer back to your class hypothesis and any specifics your Lab Instructor has provided you with to answer these questions.

7. Is there any variation between groups in how you will test this hypothesis? If so, how will your group differ from other groups in

your class? (.5 pt)

8. Now fill out table 4.1 below about how you will collect data for your independent and dependent variables. (2 pts)

	What is your variable?	What will you measure?	Where will this information come from?
Independent			
Dependent			

Table 4.1

We can provide more details on how we will collect our data for these variables. You may notice in Table 4.1 that you completed, there are many ways a person could collect these data. We will narrow it down so that our study is consistent and repeatable.

9. What region(s) will you be using for this study? Explain your response. (.5 pt)

10. What species will you be using for your study? Explain your response (e.g., why did you choose these species or, if they will be randomly selected, how you will go about doing that?). (.5 pt)

11. Describe the time range for your data collection. (.5 pt)

Our Study Design

Now that we have clarified our specific variables and how we will collect data for those variables, we can consider the overall study design.

12. What are other variables (besides the independent variable) that can impact your dependent variable? Come up with at least 2. How can you standardize those? (1 pt)

13a. What are the replicates in your study? (e.g. are you collecting data for multiple species, over multiple months, multiple ears?) (.5 pt)

b. Why is it important to have those replicates? (.5 pt)

14. In what ways could your study have bias and how will you minimize this? Bias means that the researcher unconsciously affects the results because of expectation or subjective influences on how they collect the data. (.5 pt)

15. Each group member will be collecting a portion of the data from eBird and other locations as appropriate that your group will use to test the hypothesis. By the time you get to the results data analysis lab (see syllabus), your group should have a single Excel spreadsheet with all of the data each member has collected for the group to analyze. Come up with a plan for how your group can do this. How will you collect and store your data? How will you divide up data collection responsibility across the group? (.5 pts)

16. What is the timeframe for you to complete this study? Specifically, how much time do you have to collect your data? When will you analyze your data and draw conclusions? Look at the syllabus and consider how you will complete the work during this semester (.5 pts)

17. What are all the resources you will need to complete this study? (.5 pt)

18a. Generally, what will data that support your hypothesis look like? What data would cause you to reject your hypothesis? (1 pt)

b. Consider your response to Part 1 and the prediction you wrote for "Testing the Hypothesis", question 3. Draw a graph that visually represents your prediction. In other words, if your hypothesis is correct, what would a graph of the data look like? (.5 pts)

Part 4: The Study Protocol (4 pts)

19.Write out your study protocol. This should be detailed and written in a way that anybody could complete this experiment the same way. Use your responses from parts 2 and 3 to write this protocol. You can complete it step by step as listed below or organize this information in any way that you think is clear and provides all the necessary information to make it repeatable. (4 points)

Step 1: What is your hypothesis? State it clearly so anyone repeating this protocol knows what you are testing.
Step 2: What are the variables of this study? List both the dependent and independent variables.
Step 3: Where will you collect your data from? For each variable, clearly explain how you will collect your data. Include relevant websites.
Step 4: Describe the data you will collect. To do this, you should go on to the websites you listed in Step 3 describe how you will collect data in as much detail as you can. Revisit the instructions on using eBird from *Exercise 3: Observations and Hypotheses from Direct and Data Observations* to help guide you to your data. Document this process. A person who is repeating this experiment should know details such as what species they are studying, which hotspots to use, which years and months to collect data from, etc. At the end of your response, provide an example screenshot, as shown in Figure 4.1, of the data you will collect for each variable.
Example screenshots:
Independent variable: *Dependent Variable:*

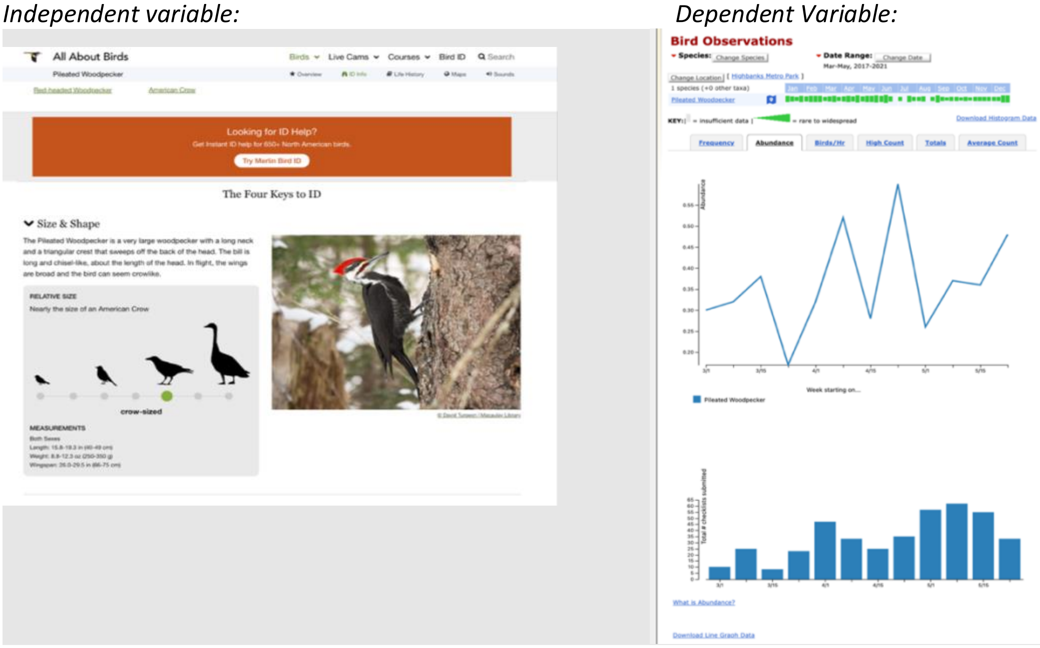


Figure 4.1. Courtesy of Cornell Lab of Ornithology

Step 5: How will you record your data? Clearly state the program you will use and how your group will work together to compile the data. Attach a sample data collection sheet. This should be an empty worksheet with the appropriate variables listed as your headers.
Step 6: Anticipate how you will analyze your data. Will you be comparing group means or looking for a correlation? Discuss with your group the difference between these two before answering.
Step 7: Include any information for the reader that might help them repeat this study with minimal issues. For example, what variables should they try to control and how? What are ways they can respond to specific anticipated challenges?
Step 8: Restate your prediction. If someone was repeating this experiment, what would the data look like that would enable them to support their hypothesis? What data would cause them to reject their hypothesis?

Part 5: Protocol Feedback (1 pt)

Join your classmates for a discussion on the class study design.
20. What came up either during a peer review or the group discussion that you had not considered in your protocol? (1 pt)

Update the design you wrote in Part 4 after receiving feedback from your Lab Instructor and peers so that it reflects any changes needed after your peer review and group discussion. Your Lab Instructor will be using this version when grading #19.

Part 6: Next steps (1 pt)

Your Lab Instructor will provide a single data collection protocol for your group to use over the coming weeks. They may have told you to hold off on collecting data temporarily if new ideas came up during the discussion, but for now you have a general plan so you should talk about how you will divide up the work among your group. Everyone should be a part of this process. Look ahead at your syllabus so you know when you will need to have the data ready for analysis.

21. What are the next steps for each group member? How will you hold each other accountable? As a group, you are committing to the work that you write down here. If anything changes, be sure to inform your Lab Instructor so they are aware what to expect from you. (1 pt)

Image Source

Figure 4.1: Cornell Lab of Ornithology. n.d. Digital Media. 3 Billion Birds. https://www.3billionbirds.org/additional-media

Community Science Project Exercise 5
Results and Data Analysis
Modified from Data Analysis activity written by Kellen Calinger-Yoak, Ph.D.

Pre-Laboratory Questions (5 pts)

Before your lab, you will submit an Excel sheet that displays your data. These are the individual data that you have collected to be compiled with your group data. Remember, these are the data you will use to test the class hypothesis for your community science project.

You need access to the program, Excel. Excel is one program that can be used to organize information. We like it because it is accessible, it can do basic statistics, and fundamental Excel skills are transferrable and can go on your resume. Through Office 365, Ohio State provides Excel to all students. If you have not used Excel before, start by going here:
https://microsoft365.osu.edu/
Log in using your OSU email. Once you are logged in, you will be able to see the different Office programs you can access. You can use them right there in your browser, which is a nice feature because you can share documents and spreadsheets with others. We find it very helpful to also install Excel on your device, especially when doing statistical tests. Click on the home button in the upper left corner, then in the upper right corner you should see an option to install Office. If this does not work for your device, or if you have any other issues, check out the FAQ page here: https://go.osu.edu/office365faq, which has helpful information for all types of potential concerns.
Upload an Excel sheet that includes your data. (-2 points if not in Excel sheet).

Learning Objectives
Students will:
- Use Excel to organize datasets
- Recognize categorical and continuous data sets
- Compare and contrast types of data sets and the appropriate figures/tests for each
- Create appropriate figures for a particular data set
- Perform appropriate statistical analyses for a particular data set
- Describe the information communicated in a graph or Figure
- Explain what a p-value means and when it would be considered significant
- Analyze figures and statistics to infer patterns or relationships in data

Introduction
Data analysis is an essential step in the process of science. This helps researchers understand if the patterns they are seeing are actual patterns or simply due to chance alone. You have been collecting data for your Community Science Project over the past few weeks. Now, you are ready to start looking at the results and think about what your data actually tell you. Through this activity, you will also gain insight into the process behind and meaning of scientific results you encounter in your daily life.

To do this, we will start by learning about appropriate figures and statistical tests with hypothetical data sets in an Excel workbook titled “Bird Island Datasets” available on the course webpage. Notice there are two sheets in this workbook, both with the same variables but different ways of collecting data. You will work with your lab group and follow this guide to analyze figures and a statistical test of both datasets. A little rusty on either Excel or data analysis? That is ok! This guide is detailed and will walk you through every part.

Use these bird island data sets as a guide for this activity. This exercise will show you how to read graphs and statistics using these datasets, and then you will apply what you have learned to your own. In a follow up lab, we will use our analysis to draw conclusions about our studies.

Part 1: Types of data (3.5 pts)

1. Do a little research with your group. What is the difference between continuous and categorical data? Cite your source(s). (1 pt)

Whether or not you collect continuous or categorical data depends entirely upon your question and your resources: one is not better than the other. For example, look at the provided Excel sheet to see two different datasets. Notice both of them compare bird species to island size, but the way they collected their information is slightly different.

2. What do you think the hypothesis is for the data collected in these Excel sheets? (1 pt)

3. What conditions may have led the researchers to collect categorical data in spreadsheet 1? What conditions would have led researchers to collect continuous data presented in spreadsheet 2? (1 pt)

You have already thought about the best way to collect data for your question, we just did not put a name on it.

4. Looking at the dataset that your group collected for your project, would it best be described as categorical or continuous data? (.5 pt)

Part 2: Types of Graphs (2 pts)

Once we collect our results, scientists will use graphs and tables to visually represent the data. Not every graph will work well for all types of data. A common way to represent categorical data is through a bar chart, while a scatterplot works well for continuous data.

Categorical Data
Toggle to the "Bird Island" spreadsheet that has the categorical graph and examine it. You will notice the bar graph compares the means of each group and includes error bars that represent the standard deviation. A mean is simply the sum of all numbers in a group divided by the total number of samples, while a standard deviation is an estimate of how representative the mean is of the individual data points in each group. For example, the average of 1, 1, 1, 100, 100, and 100 is 50.5. However, 50.5 is not a particularly accurate reflection of any of those individual data points. The standard deviation or spread for this example above is quite large (~ 50). On the other hand, the average of 40, 40, 40, 61, 61, 61 is also 50.5, but the standard deviation is much smaller (~12), telling us that the numbers we are comparing have a smaller spread around the mean.

5. Looking at the bar charts in the "Bird Island" datasheet, would you say the two groups being compared look similar or different? Explain your answer. (1 pt)

Continuous Data
Toggle to the "Bird Island" spreadsheet that has the continuous data graph and examine it. Scatterplots are a commonly used Excel graphing format when neither variable is categorical, that is, both variables are sets of continuous numbers.
In Figure 5.1, notice the trendline going through the individual datapoints. Scientists often use lines of best fit, or trendlines, to determine the relationship between two variables.

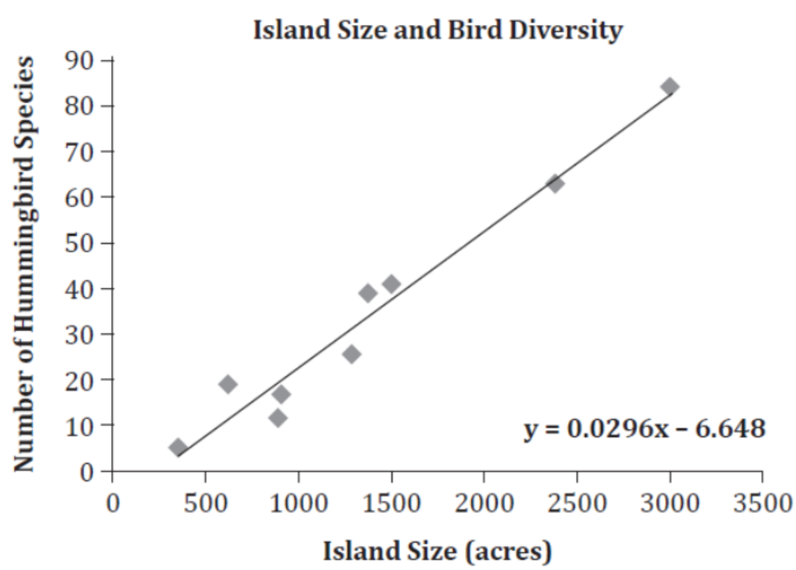


Figure 5.1.

The equation of the trendline is on the graph in Figure 5.1 because it provides us with important information about the relationship between the two variables. Of particular importance is the slope of the line. The slope tells you how much the dependent variable changes per unit increase of the independent variable (the rate of change).

6. Using our example in Figure 5.1, how many more hummingbird species are there per acre increase in size of the island? (.5 pt)

7. Why would a bar chart not work well for continuous data? Why would a scatterplot not work well for categorical data? (.5 pt)

Part 3: Types of Tests (4.5 pts)

Once scientists have collected all of their data, they will run statistical tests to determine if there are *meaningful differences* in the data. For example, in the bar charts in your Excel workbook, it looks like there is a difference in hummingbird species between large and small island, but how can we objectively tell if that difference is meaningful? What if the differences we see are due to chance? If the differences are just due to chance, then we would not expect the next group to test this to get the same results. Statistics will help us determine if any differences or relationships we see are meaningful OR if they are likely due to chance.
Just like making graphs, the choice of statistical test is determined by how you collected your data. There are numerous types of tests, and the more complicated the study or experiment, the more elaborate the statistical tests can become. For right now, just keep it simple and learn about some very fundamental statistical analyses. We will then apply what we have learned to our own data.

Statistics for Categorical Data

When using categorical data, we can look for differences by comparing group averages. Meet the t-test. T-tests are used to compare two means while integrating information about sample sizes and spread of the data about the mean of each group.
Look at the Bird Island categorical datasheet presented in Figure 5.2. On the right side, notice there is a table with some statistics:

A	B	C	D	E	F	G
Island class	Total number of bird species		Group	Mean # of bird species	Standard dev	Variance
Large	152		Large	116	25.25866188	=VAR(B2:B5)
Large	97		Small	51.75	21.21909517	
Large	115					
Large	100					
Small	33					
Small	79					
Small	58					
Small	37					

Comparison of Bird Species Count on Islands of Differing Size

Figure 5.2.

We commonly use the mean, the standard deviation, and the variance of our data for graphs and statistical tests. You already know what a mean and standard deviation are. The variance measures how far datapoints are from the mean, so it is another way of measuring the spread around the mean.
Now we will look at the t-test. Under the collected data in your Excel workbook, there are cells that contain the t-test as seen in Figure 5.3:

Island class	Total number of bird species
Large	152
Large	97
Large	115
Large	100
Small	33
Small	79
Small	58
Small	37
Comparison	Large vs. small
t-statistic	=(E2–E3)/SQRT(G2/4+G3/4)
df	
p-value	

Group	Mean # of bird species	Standard dev	Variance
Large	116	25.25866188	638
Small	51.75	21.21909517	450.25

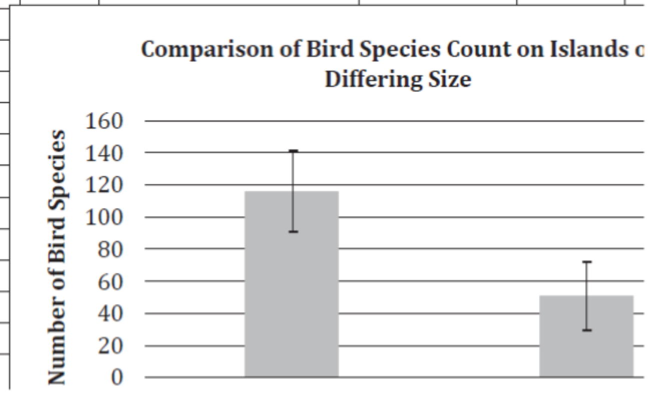


Figure 5.3.

The first number is the t-statistic. Essentially, the t-statistic answers the question, "How certain are we that these groups are truly different from each other based on how different the means are, how much the individual data points vary in each group, and how big the sample size is?" Fortunately, that can easily be calculated using a formula in Excel using the mean and variance.
We can then calculate the p-value of our data. P-values, or probability-values, provide an estimate of how confident we are that the difference observed between groups is real and not simply due to random chance. A very low p-value, for example 0.01, means that there is only a 1% chance that your results are due to random chance and that we are 99% confident that the difference between groups is due to some true difference between treatments. In contrast, a very high p-value like 0.5 means there's a 50% chance that our observed difference between groups is due to random chance. In this case, we say that there is no significant difference between groups. How do we know when the p-value is low enough to say there is a significant difference? Scientists tend to be rather cautious about saying that groups are significantly different from each other. Typically, scientists require that a p-value be 0.05 or *less* for two groups to be significantly different from each other. Everything above p = 0.05 typically is classified as *not* significantly different.

8. That is it! So, looking at the datasheet in your Excel workbook, what can you say about island size and number of hummingbird species with this p-value? (1 pt)

If there is no significant difference between groups, then typically we will reject the hypothesis. Sometimes, people assume that this means that something went wrong with the research or you should just give up, but that is not the case! Rejecting your hypothesis can actually be very interesting because there must be a reason why our expectations do not align with the data.

9. If a researcher rejects their hypothesis, what should they do next? (1 pt)

Statistics for Continuous Data
In our example of continuous data above, we examined the relationship between island size and hummingbird diversity and plotted a trendline to visualize that relationship (see Figure 5.1). While it certainly *looks* like there is a strong relationship between our two variables, we need to have a way to *objectively* assess whether the relationship is significant.

Yet again, statistics saves the day! Regression analyses provide a statistical test of the relationship between two continuous variables. Remember that we calculated the change in the number of bird species for every acre increase in island size using the slope from our trendline. Regressions provide us with several useful metrics that expand our understanding of this relationship. First, regression analyses produce an R^2 value. The R^2 value tells us how much of the variation in the dependent variable is explained by the independent variable. For example, if the $R^2 = 0.8$, that means that 80% of the variation in the dependent variable is explained by variation in the independent variable. If we apply this to the hummingbird example, then we could say that differences in island size explain 80% of the differences in number of hummingbird species.

Regression analyses also provide us with a *p-value,* or *probability value.* P-values in regression analyses also provide an estimate of how confident we are that the observed relationship between variables is real and not simply due to random chance, just like in the T-test. Fortunately, a regression analysis can also be done simply in Excel. Notice in the spreadsheet provided in Figure 5.3, there is a regression summary below the data:

23	Summary output					
24						
25	*Regression statistics*					
26	Multiple R	0.981787874				
27	R square	0.96390743				
28	Adjusted R square	0.958751348				
29	Standard error	5.236414911				
30	Observations	9				
31						
32	ANOVA					
33		*df*	*SS*	*MS*	*F*	*Significance F*
34	Regression	1	5126.06	5126.06	186.9457	2.63684E−06
35	Residual	7	191.9403	27.42004		
36	Total	8	5318			

Figure 5.3.

Use the information in Figure 5.3 to analyze the data. The R Square output is the R^2 value. The R^2 for this relationship is 0.96.

10. In your own words, what does this .96 tell us about the relationship between hummingbird species and island size? (1 pt)

The next value we are interested in is the *Significant F* value. This value is the p-value for the regression analysis. The p-value for this relationship is 2.64×10^{-6}.

11. With this p-value, what can we say about the relationship between hummingbird species and island size? Explain your answer. (1 pt)

And there you have it. Two tests for two different types of data. Remember, statistics can get quite a bit more complicated than this, but for our project, these tests will work well enough to help us understand what our data mean. Now, you can apply what you have learned to create a graph and run a statistical test on your group dataset.

12. Using your response in question 4, what type of graph and what type of test will you use? (.5 pt)

Before you go on, call your Lab Instructor over to be sure that you are heading in the right direction.

Part 4: Analyze Your data (5 pts)

On our course webpage, you will find two documents each with instructions for analyzing your data. After you have cleared it with your Lab Instructor, open the appropriate document for your data (either continuous or categorical). Use the instructions to create graphs and run a statistical test in Excel. You will upload this Excel sheet along with your responses to this exercise. If your Lab Instructor cannot see your tests and figure, you will not be able to earn points on the remaining questions.

13. Create a graph for your data. Your figure should be logical and have axis labels. Make sure all important graphical elements are included in your Excel sheet submission. (1 pt)

14. Perform a statistical test on your data. Make sure your Excel sheet submission has a complete statistical test that makes sense based on the data. (1 pt)

15. Describe the graph you created. What does it demonstrate to a reader who has not seen your dataset? (1 pt)

16. Describe your statistics and what they tell you about any relationships in your data (1 pt).

17. Consider the hypothesis you are testing as a class. Do these data support your hypothesis or not? Explain your answer. (1 pt)

Image Sources:
Figure 5.1: Illustrated by © Van-Grienr, LLC
Figures 5.2-5.4: Created in Microsoft Excel. 2023.

Community Science Project Exercise 6
Drawing Conclusions and Communicating Scientific Information

No Pre-Laboratory Questions

Learning Objectives
Students will:
- Interpret datasets to draw conclusions
- Describe the importance of their research to different audiences
- Use their conclusions to formulate new questions or hypotheses
- Evaluate conclusions and scientific claims from other sources
- Identify misleading claims
- Compare and contrast scientific and non-scientific audiences when communicating important information about a scientific study
- Formulate a plan on how they will make the results of their study appealing to different audiences

Part 1: Drawing Conclusions (8 pts)

Once researchers have collected their data, they can start to think about what they actually mean. At the end of a scientific publication, researchers will write a conclusions or discussion section where they communicate their interpretation of the results and what they think are the big takeaway messages from their research. In doing this, they will answer the following questions:
- What new knowledge do we have?
- What should other researchers do with this knowledge?
- Where should we, as researchers, go from here?

Generally, the questions we ask about the world around us cannot be answered with a single study, and so we usually test our hypothesis multiple times in multiple different ways in order to be confident in it.

1. Now that you have analyzed your data either as a group or as a class, what can you conclude?

A. Refer back the statistical analysis you did in the data analysis lab. Do your data support your hypothesis? Explain (.5 pt)

B. Is there anything that you feel like your raw data did not capture? Consider observations you made along the way or potential errors you encountered. (.5 pt)

C. Now, state your conclusions using the three bullet points above as a guide. Be careful not to overstate your conclusions. For example, you would not say you “proved” something to be true. (1 pt)

2. Do your data show what you expected? Why or why not? (1 pt)

3. What would you say is the big take-away message of your research? What do you think scientists who study similar questions would be interested in hearing from you? (1 pt)

4. What do you think non-scientists would be interested in learning from your community science project? Explain your response. (1 pt)

5. What did you think you would be able to say at the end of your study that you cannot say with confidence at this point? In other words, what can you not conclude? Explain. (1 pt)

6. Based on what you now know, what are scientific questions that you still have or scientific questions that arose from your project? Write two. (1 pt)

The scientific process is often treated as a linear process with a clear beginning and end. But as you are learning, it is a process that is also creative and free-flowing, perhaps sometimes requiring back-tracking or starting over. Ultimately, it is a cyclical process with no clear end. Instead of looking like a traditional stepwise process, the image presented in Figure6.1is a better representation:

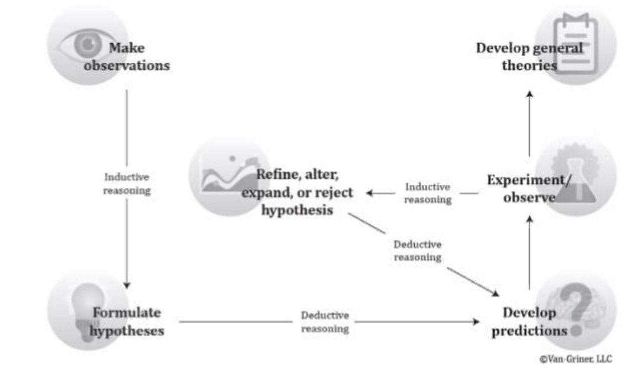


Figure 6.1.

Once we wrap one study, the next step is to revise and rewrite our hypothesis so that we can continue to work towards answers to our questions.

7. Pick one question that you wrote in #6 above and use that question to revise or rewrite your hypothesis. (1 pt)

Part 2: Debunk the Junk: Evaluating Claims and Misleading Information (6 pts)

As a scientifically literate citizen, knowing how to critique conclusions and claims is an important skill. This section will also help you to think critically about how to communicate your own results/conclusion in a compelling way while maintaining accuracy**.**
8. Now that you have learned about how we can draw conclusions, use your knowledge and the provided data to evaluate the accuracy of the conclusions below. Cite particular parts of the graph or the conclusions to support your evaluation (1 pt)

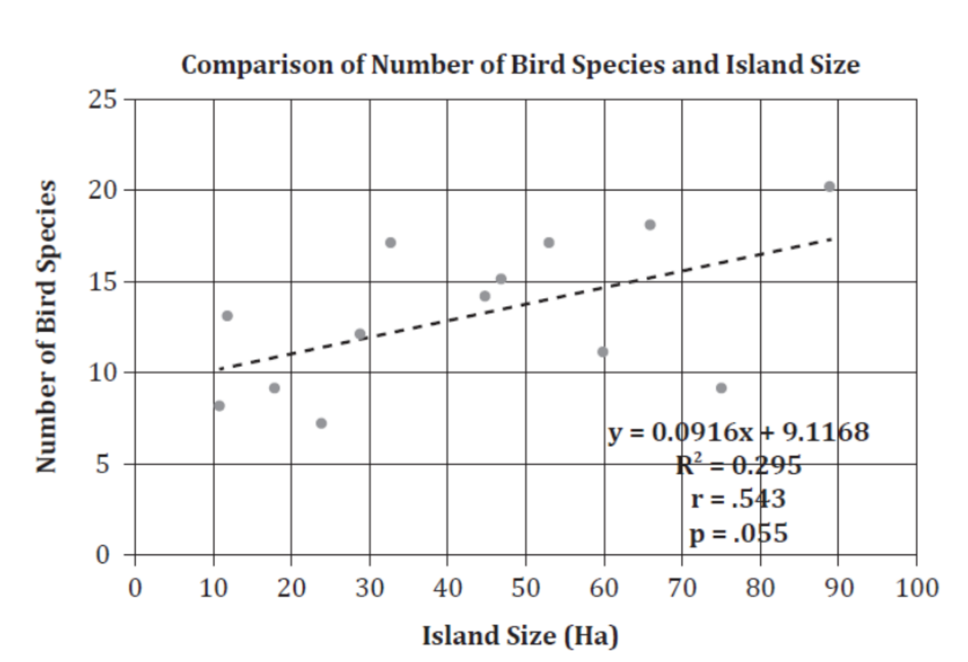


Figure 6.2.

Conclusions: We hypothesized that larger island would be capable of housing more species of birds. The results support our hypothesis as there is clearly a significant, positive correlation between number of birds and island size. Our analysis indicates that this correlation is strong, and island size explains 30% of the number of bird species found on the islands. Therefore, we can conclude that larger islands have better trees for nesting because they have more bird species.

9. The peer review process is an important part of ensuring that scientists do not publish claims or interpretations that do not make sense based on the data. However, that process stops at the primary literature. When scientific information is published in

secondary literature, there may or may not be the same level of critical analysis in reporting the findings. Sometimes, when non-scientists report about a recent scientific study in secondary sources, they want to make broad, sweeping conclusions that may not always be appropriate based on the data. Why do you think this is? Why not just report the data without any exaggeration? (1 pt)

In the above example, you evaluated conclusions drawn from data analysis. In the future, you will likely have to evaluate scientific claims, which are statements about how the world works that can be tested using the scientific method. We can practice this by looking at a 2014 Gallup Poll that asked about people's beliefs in climate change. Visit the following website and scroll to the first image which so you can see the trend in beliefs over several years: https://go.osu.edu/galluppollglobalwarming.

10a. According to this poll, how many people in 2014 are fully convinced climate change is caused by humans? (.5 pt)

b. Does the information from this poll make climate change caused by humans any less real? (.5 pt)

Now, watch this video https://go.osu.edu/johnoliver to see how these claims were evaluated by John Oliver on his show "Last Week Tonight".

11. What is John Oliver's critique about this poll? How does he evaluate the claims made by the people polled? (.5 pt)

12. Using this poll and the John Oliver video as examples, consider why so many people are skeptical of global warming and explain why science communication to a non-scientific audience is important. (1 pt)

Unfortunately, we encounter many misleading claims, polls, or data interpretation on a regular basis. We will have a look at an example from an area that commonly uses misleading claims for marketing: nutrition. Say you are someone that likes a warm drink at night, but you do not want caffeine in that drink because it will keep you awake. It is getting chilly, so a nice cup of hot cocoa will hit the spot. You might initially be pleased about coming across the food label shown in Figure 6.3.

Figure 6.3.

13. While reading the label, you realize it is actually very misleading. Analyze the information on the label and evaluate why it is misleading. (.5 pt)

It would be great if this example was rare as far as misleading advertising goes, but it is very common, especially on food labels. Your job as an informed individual is to make sure when you describe scientific information you do it in a way that is appealing but not misleading. Practice by writing titles for our project.

14. Write a title for your research project that could go on a research poster for a scientific audience (.5 pt):

15. Write a title for your research project that could go on a popular science article for a non-scientific audience (.5 pt):

Part 3: Communicating to Different Audiences (3 pts)

In Part 1, you thought about the actual scientific claims you can make from your data, and in Part 2, you thought about how information is presented in a way to grab people's attention. You have probably realized that communicating the same information to different audiences requires different approaches. For your final project in this class, you will be asked to communicate your project to a non-science audience. The idea will be to demonstrate the value of your research to a chosen audience in a way that is compelling but not misleading. The way you describe the value of your project to a non-scientific audience will be different than if you were appealing to a scientific audience.

16. Knowing what you have learned about scientific research AND what you already know about people from your own major or experience, create a Venn diagram that identifies at least 5 characteristics of what you would communicate to a scientific

audience, a non-scientific audience, and to both groups. You should use examples from your own project and you can be more general in describing how to convey information between these two groups. If you create it on a separate page, be sure to submit that with this assignment (1.5 pts)

For example, this Venn diagram (in table format) shows what you might communicate about the methods to each audience:

Scientific Audience	Both	Non-Scientific Audience
e.g. enough details from the methods so the project could be replicated		e.g. briefly describe the methods so audience members understand generally what was done and what data were sampled.

17. We will practice what you thought about in Part 1 of this lab and in generating your Venn Diagram. Give an example sentence from your project conclusion that is written for each audience. The example sentence should help the audience understand and value your work without being misleading. (1 pt)

18. Summarize the information in your Venn diagram. What should be different in your communication between a scientific and a non-scientific audience? What will be the same? (.5 pt)

Part 4: Project Work Time (3 pts)
You will have some time to work with your final project for the Community Science Project. Your Lab Instructor may provide you with more instructions, but you should brainstorm ideas for your project and have a plan on the content that you will cover. You can find the instructions for the final project on our course webpage to get a better idea of what you will do over the coming weeks. If you did the Research Proposal assignment, you should consider that when deciding how to communicate your research in your final project.
Before you leave today, fill out the following Work Statement:

19. You will be communicating your research project to a non-scientific audience of your choice. This requires you to be both knowledgeable and creative. In the space below, brainstorm different audiences that you may choose to work with and the type of artifact(s) you would use to communicate your research to them. (.5 pt)

20. Choose an audience and explain why they should know more about your research. In other words, why is it important for this particular non-scientific audience to know what you learned from your project? (1 pt)

21. Which type of communication artifact will you use to communicate to this audience? Justify your decision. (1 pt)

22. Review the course schedule and determine how you will break up the work for the final project over that time period. Explain your plan here. (.5 pt)

DO NOT MOVE ON WITHOUT DISCUSSING 19-22 WITH YOUR LAB INSTRUCTOR

If there is time left in lab, you should get started on the project in class. Your Lab Instructor will expect to see an outline of the information that you will include in your artifact before you are excused.

Image Sources
Figures 6.1, 6.2, and 6.3: Illustrated by © Van-Grienr, LLC

Sample Group Final Assignment (25 Pts)

Introduction
Part of the process of science is communicating your results. Typically, scientists write up their project and submit it to a primary literature source to go through the peer review process. Peer reviews of scientific work are typically very rigorous; often, research papers are rejected outright or must undergo multiple revisions prior to publishing. Once published, the research is then disseminated to a wider audience.

As someone who is not majoring in biology, you probably will not spend much time in the future explaining scientific research to a scientific audience. You will be communicating with different types of audiences, and for that reason, you probably have a unique perspective on how to talk about research to different groups of people. For this activity, we are going to skip ahead to communicating our research to a wider audience. This is your opportunity to communicate your research in a way that is accessible, relatable, and meaningful to an audience of your choosing. While your whole research team worked with the same hypothesis and data, you get to customize your final message in a way that is personally or professionally relevant to you.

All components should be in your group's own words and of your group's own creation. Include in-text citations and literature cited as appropriate.

Learning objectives
Following this activity, you will be able to:

- Recall the different parts of your research project.
- Explain complex scientific information in a way that is understandable to a specific audience.
- Choose a format for communication that helps to effectively deliver the message.
- Connect the research project to other course components
- Describe the value of this research project, both personally and on a larger societal scale.

Part 1: Research Summary (7 pts)

Part 1 will help you recall and think about how to simply explain different parts of your research project. This will help you to focus your ideas and will lay the foundation for creating a communication artifact for Part 2.

Recalling your project:
1. Fill in each of these sections with a sentence or two including only the most critical information needed to understand the project. Try to be simple and clear in your explanations while still being accurate. (4 pts)

Initial Observations:

Hypothesis:

Methods:

Results:

Conclusions:

Broader Impacts:
To effectively communicate to a broader audience, it is important to consider how your project connects to the lives of others. Answer each question below with only a sentence or two that includes the most critical information.

2. Explain how your research project helped you understand other biological concepts in Bio1101 this semester. Include 1 specific example. (1 pt)

3. Explain your own personal connection to the project. What did you gain from this experience? It might help to think back to the Intro to CSP lab, where you considered your future career choices and goals (1 pt)

4. Explain how the project connects to the lives of other people. (1 pt)

Part 2: Communication Artifact (18 pts)

Now that you have explained the overview of the project and the broader connections, you are ready to think about how to communicate your research to others. The goal of communicating with your chosen audience is simple: accurately represent your research findings so that they are accessible, relatable, and meaningful to your audience. Basically, answer the question of why your audience should care about your research. You do not need to completely reexplain your research project; only include the information necessary to communicate your message effectively.

Pick an audience you would like to address. You might consider an audience that is relevant for you considering your future career goals. You can choose from:

- Future coworkers
- Family member or friend
- Social media followers
- An art consumer
- A business owner
- Magazine editors (e.g. submitting a Scientific American Blog post)
- Kids (e.g. kids at summer camp)
- Popular news consumers
- Politicians
- Your choice (please reach out to your lab instuctor for approval)

Pick a format for communication. You might consider a format that is relevant for you considering your future career goals or most relevant to your chosen audience. Your options include:

- Written non-artistic (e.g. letter, blog post, lesson plan)
- Written artistic (e.g. story or poem)
- Infographic
- Social Media Post
- Poster
- Art
- Video
- Podcast
- Presentation (e.g. presenting an idea to a business owner)
- Conversation (you can do this as a written transcript, audio, or video)
- Your choice (please reach out to your TA for approval)

Part 2 should include…
A written statement (about 1 paragraph in length) that includes: (4 pts)

- Your chosen audience.
- The format of your communication and why you chose this format.
- The message that you want to communicate. (i.e. the goal of your communication).
- A description of how you plan to frame your message. Basically, how is your message accessible, relatable, and meaningful for your audience in your chosen format? How does your communication answer your audience's question of "Why should I care?".
- A copy of your communication artifact. (12 pts)

The communication artifact will vary greatly in "length" based on format but generally it should be brief, *i.e.* 1-2 paragraphs written, or no more than 5 minutes audio/video.

References to outside work (2 points)

If you use any photographs or images that you did not create yourself, you must include a photo credit in the artifact.
Any other sources used to write your statement or create your artifact should include in-text citations and full references.

Automatic ½ credit on whole assignment if missing photo credits OR in-text citations OR references cited. Automatic 0 if missing photo credits, in-text citations AND references cited.

Rubric

Criteria	Full Credit	Partial Credit	No Credit
Part 1: Recalling your Project (4 points)	In student's own words. Accurately and succinctly recalls all parts of the research project (observations, hypothesis, methods, results, conclusions).	In student's own words. Recalls all parts of the research project but might have some inaccuracies or be slightly wordy. Accurately and succinctly recalls most parts of the research project.	Not in student's own words. Recalls all parts of the research project but descriptions are inaccurate or overly wordy. Accurately and succinctly recalls less than half of the research project.
Part 1: Broader Impacts (3 points)	In student's own words. Explains how the research project helped the student understand biological concepts. Includes one clear example of how the research project links to biological course concepts. Explains how the research project relates to the student's and others' lives. Broader impacts are reasonable and demonstrate depth of thought.	In student's own words. Completes more than half of the broader impacts with clear explanations. Completes all of broader impacts but there may be some clarity missing in explanations. Broader impacts lack some depth of thought.	Not in student's own words. Completes less than half of the broader impacts with clear explanations. Completes all of broader impacts but answers do not allow reader to assess student understanding of the questions provided.
Part 2: Statement (4 points)	In student's own words. Includes a chosen audience, and a format. Presents the message that they would like to communicate their audience. Explains how student's message is accessible, relatable, and meaningful for their audience in their chosen format. The reader is clear on the student's goals with their chosen audience	In student's own words. Includes more than half of the requested information in this section. There might be some lack of clarity in explanation. The reader is clear on the student's goals with their chosen audience	Not in student's own words. Includes less than half of the requested information. Explanations are unclear.
Part 2: Communication Artifact (12 points)	Of student's own creation. Includes the necessary information about the research project to achieve the goal of the communication.	Of student's own creation. Includes a bit more information than necessary about the research project to achieve the goal of the communication.	Not of student's own creation. Includes a lot more information than necessary about the research project to

	Research project information is accurate and demonstrates student understands the major findings and purpose of their project. Communication is completely understandable, relatable, and meaningful to the chosen audience. There is a clear connection between the communication artifact and the statement of explanation (i.e. the artifact clearly achieves the goal of communication in the way the student intends).	Research project information is accurate but students may have missed out on an important point. Communication is moderately to mostly understandable, relatable, and meaningful to the chosen audience. There is a moderate connection between the communication artifact and the statement of explanation (i.e. the artifact clearly achieves the goal of communication in the way the student intends).	achieve the goal of the communication. Information from the research project is inaccurate or does not reflect the data and conclusions Communication is not understandable, relatable, and meaningful to the chosen audience. There is very little to no connection between the communication artifact and the statement of explanation (i.e. the artifact does not achieve the goal of communication in the way the student intends).
References Cited (2 points)	Student uses in-text citations after all sourced information and provides a complete "References Cited" section. In-text citations are formatted appropriately so that the reader can easily find the articles in the references cited section. Format of the references cited allows for the reader to easily find the sources. Student provides photo credits in a manner that the viewer can find the original source or creator.	Student uses in-text citations after most sourced information and provides a complete "References Cited" section. In-text citations are not formatted in a way that the reader can easily find the articles in the references cited section. Format of the references cited provides some difficulty for the reader to easily find the sources. Student provides photo credits in a manner that the viewer can find the original source or creator.	Student uses in-text citations after sourced information sparingly or does not provide a complete "References Cited" section. Format of in-text citations makes it difficult to impossible for the reader to find the articles in the references cited section. Format of the references cited makes it difficult to impossible for the reader to easily find the sources. Photo credits are difficult or impossible to find the creator or original source.

MATERIALS

Exercise 1: Students will need to watch a video online. They can do this on their own electronic devices or as a class.

Exercise 2: Students will need to have electronic devices that they can use to search literary databases. Lab Instructors will need to be able to project their lesson on how to do a literary search.

Exercise 3: Students will need to have a mobile device with the eBird app downloaded so they can submit their observations. They may find it helpful to use the Merlin app to ID birds. Afterwards, students will explore the eBird database in a browser using a tablet or laptop.

Exercise 4: Lab Instructors will want to write out or project the different steps of the experiment in the last section during a group discussion. It will be helpful for students to have a laptop or tablet so they can revisit previous labs and eBird.

Exercise 5: Students will need to have a laptop with Excel to do this. Neither the pre-lab data collection nor the in-lab analysis work well on tablets or other mobile devices. Only one laptop per group is needed, but this lab moves a little faster if two or more students in each group have a laptop. We provide students with an Excel workbook and instructions with images. We do not include that in the printed manual because it gives us freedom to make quick updates if anything with Excel changes.

Exercise 6: Students will need an electronic device to watch a brief video during lab.

NOTES FOR THE INSTRUCTOR

General notes:

The eBird Community Science Project (or the CSP) entails a lot of active learning and open-ended questions. Students often resist lessons of this nature and it can be daunting for lab instructors, especially if they are not used to mentoring a research project. Therefore, buy-in is important in this project. It is important to let students and lab instructors know at multiple points during the research process that it is ok to “fail” and a big part of scientific research is problem-solving and course-correcting. Encourage them to have fun and be curious, and let students know that you are excited about their projects and seeing their results. We also hold an orientation for all lab instructors at the beginning of the semester to go over the project. We take about two hours to talk about the CSP goals and how those goals fit into the course, what the different parts of the project will look like, and how the lab instructors can make the most out of this project with their students.

There are six lab exercises in this project and a final communication artifact. Each lab exercise takes a whole lab period, and they tend to run 1.5-2 hours. During weeks when students are not doing a CSP exercise, they are doing one of the traditional labs. The schedule and spacing depends on the lecturer’s schedule and which traditional labs they like to use. We do recommend that there is at least two weeks between Experimental Design (Exercise 4) and Data Analysis (Exercise 5). Oftentimes lecturers will also keep at least two weeks between Observations and Hypotheses Part 2 (Exercise 3) and Experimental Design (Exercise 4) so that lab instructors have plenty of time to choose a hypothesis and prepare a plan for testing that hypothesis. The final project is a communication artifact. This may be done as a group or independently. In addition to the six CSP lab exercises, instructors often dedicate the final lab to having students present their final artifact.

To help students understand the connection/flow of the project, we recommend showing a scientific method flow chart at the beginning of each exercise. Show students where this lab fits in with the scientific method so they see how this exercise connects with the previous exercises and gives an idea of what to expect in the remaining exercises.

Lab-specific notes:

Exercise 1: This lab component is meant to lay the groundwork for starting this project. It introduces the idea of community science (citizen science) and gives the opportunity to talk to students about the fact that they will be conducting their own research project on birds over the semester. By thinking about why birds matter to society, students are preparing for their final project which entails communicating the value of their research to a non-scientific audience. This lab also provides students with sources they may find helpful in future parts of the project. This lab is full of opportunities for discussion, and lab instructors have discretion over when they want to engage the students. It is ok if students initially do not have any reason as to why birds are important to them; we encourage them to be open about their thoughts. It is important to communicate with students that this project was designed to create an authentic learning experience that provides them with skills they will find helpful in their future endeavors. Depending on their year or rank, some students have a hard time envisioning the skills they will need in their future careers, so this is a good time for lab instructors to act as mentors.

Exercise 2 and 3 Overview: These exercises are part of a two-part lab experience that gives students the opportunity to develop their own hypotheses from observations. In the first week, they will learn about using literature for observations, in the next week they will be using eBird to make observations of the natural world and using data. In both lab sessions, students will be making observations and then developing hypotheses. After the second observation and hypotheses lab (Exercise 3), each group will have the opportunity to pitch one of their hypotheses from Exercise 2 or Exercise 3 to potentially be chosen for the lab section-wide eBird project. The final project entails students thinking about how to communicate their own research project, so this is an opportunity to see how that communication varies by audience.

Exercise 2: In this lab students will learn about different types of sources, and how to use literature to make scientific observations. Part of this lab also entails students learning how to do a primary literature search, so lab instructors should have a presentation or lesson planned to walk students through a database search.

Exercise 3: Students have already started generating hypotheses based on literature coming into this lab and will continue practicing generating hypotheses with field and data observations. This exercise will have them choose one hypothesis that they pitch as the hypothesis to be chosen for the whole class to test. Part of this lab will involve students making observations using the eBird app. Ensure that students do not submit observations unless they are confident in their data. This is a good opportunity to talk about data quality. Consider finding and reaching out to your local eBird reviewer to talk about this part of the lab – they may have tips and want to know the week when this lab will occur so they can pay special attention to the data. This lab also walks students through the eBird database, which is how they will be ultimately collecting their data (once a hypothesis is chosen and an experimental design is created). Be sure to go through eBird yourself so you know how to help guide students if they get lost. This is a good time to remind students that they will be doing a research study as a class using eBird. They may get confused and think after this lab they will have to make more observations using the app for their data, but they are done with the app after this lab. All their data comes from the online database. Push students to come up with a testable hypothesis, but you will almost certainly have to make modifications later, and that is ok! When you are choosing a hypothesis, we highly recommend erring on the side of simplicity. A common hypothesis students want to test is something along the lines of "Urban areas will have fewer birds than rural areas because of the pollution and lack of natural areas." We also recommend that when thinking about how much data each student should collect, consider that something that takes you about 10 minutes to collect may take students an hour. Say you were testing the above hypothesis, and decide each group is going to compare the number of a birds of a given species in 4 urban and 4 rural areas over 10 years, it is reasonable that each person in a group of four takes one urban and one rural area and collects the data for their species in those areas over 10 years.

Exercise 4: Students will develop their own experimental design to test the chosen hypothesis with very heavy guidance from you. This is an important part of them gaining a sense of ownership and authenticity over their project. The whole class will be working with the same overall experimental protocol however each group (and individual within the group) may be collecting a portion of the overall data needed to test the hypothesis. This lab will help prepare students so they understand the research question and experimental design as well as how to complete the research. In the next CSP lab, they will be analyzing the data they are collecting. You will need to choose and potentially modify a hypothesis before starting this exercise. Depending on your class, you may need to have a protocol written to release to your students by the end of the lab, or you may have time to look at their work and write it later. Either way, you should have a very good idea about how the students will be collecting their data. For parts 1-4, let them have the freedom to brainstorm as much as they can on their own. It may also be helpful to have a spreadsheet for them to look at, so they know how to organize the data they are collecting. After this lab, you should provide students with a set of instructions for how to collect their data. Much of this will be repeated from the instructions in Exercise 3, but we find that this extra step makes the student experience much smoother as they are working independently on collecting a portion of the dataset.

Exercise 5: Students will come into the lab having collected their data for their project. Sometimes it will already be compiled into a single spreadsheet, but you should plan on giving them time to do that in the beginning of the lab. In this exercise, they will learn how to create a graph for those data and how to analyze it. Although they will learn about bar charts, scatterplots, t-tests, and regression analyses, they will pick the most appropriate graph style and analysis tool and learn how to use them for presentation of their data. In the next CSP, they will draw conclusions and think about the bigger picture. We provide students with instructions for graphing and analyzing data in Excel, and we have the instructions separated by categorical and continuous data. The interface and functionality of Excel may vary across devices; computers work best for this and usually students can figure out any variation from the instructions. If students are trying to add the data analysis pack but cannot find it, they probably already have it installed. It would be a good idea for lab instructors to practice following the instructions with a fake dataset or using an instructor key prior to this lab session.

Exercise 6: Once they have analyzed their data, students need a little time to think about what that means and why it is important. This is the meat of what goes into their communication artifact, so they will think a lot about how they will communicate their own research to a particular audience. They will have time to start working on their final project here and will leave the lab knowing what is expected of them for that final project (varies by class). Students should come to lab with ideas on how to explain their results and revise their hypotheses for future research. If students reject their hypothesis, they often want to conclude they must have done something wrong or that they need to redo the test. Let students know rejecting a hypothesis is as interesting (if not moreso) than accepting it. Sometimes students will have statistics that should clearly lead them to reject the hypothesis, but they will still want to accept it. Help students get excited about the impact of their data, because they will find this whole project much more rewarding if they see that they have collected and analyzed meaningful data.

CITED REFERENCES

Auchincloss LC, Laursen SL, Branchaw JL, Eagan K, Graham M, Hanauer DI, Lawrie G, McLinn CM, Pelaez N, Rowland S, Towns M, Trautmann NM, Varma-Nelson P, Weston TJ, Dolan EL. 2014. Assessment of course-based undergraduate research experiences: a meeting report. CBE—Life Sciences Education, 13(1), 29-40.

Ballen CJ, Blum JE, Brownell S, Hebert S, Hewlett J, Klein JR, McDonald EA, Monti DL, Nold SC, Slemmons KE, Soneral PA. 2017. A call to develop course-based undergraduate research experiences (CUREs) for nonmajors courses. CBE—Life Sciences Education, 16(2),

Bangera G, Brownell, SE. 2014. Course-based undergraduate research experiences can make scientific research more inclusive. CBE—Life Sciences Education, 13(4), 602-606.

Brownell SE, Kloser MJ, Fukami T, Shavelson R. 2012. Undergraduate biology lab courses: comparing the impact of traditionally based "cookbook" and authentic research-based courses on student lab experiences. Journal of College Science Teaching, 41(4), 36-45.

Brownell SE, Hekmat-Scafe DS, Singla V, Chandler Seawell P, Conklin Imam JF, Eddy SL, Stearns T, Cyert MS. 2015. A high-enrollment course-based undergraduate research experience improves student conceptions of scientific thinking and ability to interpret data. CBE—Life Sciences Education, 14(2), ar21.c

Cardamone C, Lobel L. (2016). Using Citizen Science to Engage Introductory Students: From Streams to the Solar System. Journal of microbiology & biology education, 17(1), 117.

Kridelbaugh DM. (2016). The use of online citizen-science projects to provide experiential learning opportunities for nonmajor science students. Journal of microbiology & biology education, 17(1), 105.

Rodenbusch SE, Hernandez PR, Simmons SL, Dolan EL. 2016. Early engagement in course-based research increases graduation rates and completion of science, engineering, and mathematics degrees. CBE—Life Sciences Education, 15(2), ar20.

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About the Authors

Samantha Herrmann is an Assistant Professor of Teaching Practice for the department of Evolution, Ecology, and Organismal Biology and a course coordinator for the Center for Life Sciences Education at The Ohio State University. She earned her BA in Zoology and Environmental Science from Miami University and her Ph.D. in Evolution, Ecology, and Organismal Biology from the Ohio State University. Her teaching focus is on introductory courses for majors and non-majors and as a course coordinator, she provides instructional guidance and administrative support for the non-major courses and works with staff and faculty on course development. Her current scholarly and pedagogical research interests include CURE-specific teaching development, curriculum assessment, and student sense of community in online courses.

Erica Szeyller earned her BA in Psychology from West Chester University of Pennsylvania, and her MS in Evolution, Ecology and Organismal Biology from The Ohio State University. She spent a decade as a Course Coordinator in non-majors biology education and teaching professional development in the Center for Life Sciences Education at the Ohio State University. During her time as a course coordinator, she worked on research projects related to student motivation in online and face-to-face biology courses, and predictors of student-centered teaching practices in teaching associates. Erica is currently a Research Analyst in the Center for the Study of Student Life at the Ohio State University where she uses data to understand student experiences and inform best practices in student affairs.

Kellen Calinger earned her BS in Biology from West Virginia University and her PhD in Evolution, Ecology, and Organismal Biology at The Ohio State University. She has spent the past 8 years teaching majors and non-majors introductory Biology students at Ohio State in both lecture and lab while working to develop novel undergraduate research laboratory experiences. Her current research spans both biology and pedagogy. In biology, she investigates how flowering responses to warming vary across vast geographic ranges. Her pedagogical research focuses on how diversity aligned curriculum improves students' understanding of bias and fosters feelings of belonging among marginalized groups.

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