CITIZEN SCIENCE

15 LESSONS THAT BRING BIOLOGY TO LIFE, 6–12

Edited by
NANCY M. TRAUTMANN
JENNIFER FEE
TERRY M. TOMASEK
AND NANCYLEE R. BERGEY

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National Science Teachers Association

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LESSONS

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Acknowledgments

This book was inspired by conversations at an NSTA National Conference among educators involved in citizen science. It represents extensive collaboration between curriculum specialists, science teachers, and scientists, some of whom are named as lesson authors and others of whom contributed vital reviews of lesson strategies and scientific content. The lessons were selected through a competition that yielded more high-quality lessons than we were able to include, and we extend deep thanks to all who participated. Jennifer Goforth served as our indispensible research and writing intern, and Irka Elsevier as a key editorial advisor. Many of the citizen science and education efforts represented in this book have been supported by grants from the National Science Foundation.

About the Editors

Nancy M. Trautmann is Director of Education at the Cornell Lab of Ornithology, where she leads a team that creates educational resources and experiences aiming to spark curiosity, build science skills, and inspire conservation action (*www.birds.cornell.edu/education*). She is lead author in the Cornell Scientific Inquiry Series published by NSTA Press, with titles including *Assessing Toxic Risk, Decay and Renewal, Invasion Ecology*, and *Watershed Dynamics*. She holds a doctorate in computer supported collaborative learning, and her academic interests center on engaging students in scientific research and citizen science, supporting effective teacher professional development, and exploring the potential of educational technology in supporting student collaboration and project-based learning.

Jennifer Fee is the Manager of K–12 Programs at the Cornell Lab of Ornithology. She is the lead author of the BirdSleuth curriculum (*www.birdsleuth.org*), with modules including Most Wanted Birds, Afterschool Investigators: Nature Detectives, and Investigating Evidence. She is interested in sharing citizen science and inquiry-based teaching with educators, particularly through curricula and online and in-person professional development workshops. She is a graduate from Truman State University (BS in Biology) and Illinois State University (MS in Behavior, Ecology, Evolution, and Systematics).

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NancyLee Rodenberg Bergey teaches science in elementary and middle schools as Associate Director of Teacher Education at the Graduate School of Education at the University of Pennsylvania. Before coming to Penn full-time, NancyLee taught, primarily science, for 29 years in schools that spanned the public/independent, urban/suburban, and elementary/middle school range. She also served as an adjunct professor at several colleges as well as writing for and teaching in a number of museums. Her current work focuses on improving science teaching in urban schools through the involvement of undergraduate science students and a focus on urban environmental issues.

Preface

Why Citizen Science?

Observing the life cycle of monarch butterflies and following their remarkable migratory journeys between Canada, the United States, and Mexico…

Tracking climate change by recording the dates of first leaf, flower, and fruit of local trees, shrubs, flowers, and grasses...

Discovering which bird species migrate, where they go, and when…

Exploring life cycles and population dynamics of frogs, toads, and other animals in nearby ponds…

Citizen science projects such as those listed above gather data through public collaboration in scientific research. Who are the "citizens" who take part in such efforts? Some are students and others are interested or concerned individuals from all walks of life. Together, professional and volunteer scientists collaborate to investigate biological and environmental trends over regions and timelines far broader than anyone could tackle individually.

For teachers, citizen science offers a way to motivate and inspire students through participation in research that is relevant both locally and globally. Students build meaningful connections to the natural world as they make observations, collect data, and view their findings within the broader scope of the project. When students design and conduct their own investigations, they also build science practice understandings and analytical reasoning skills through their involvement in citizen science.

In this book, we profile several scenarios of middle school classes engaging in citizen science and provide 15 lessons that present specific ways to build citizen science data collection and analysis into your science teaching. The lessons are organized around the 5E Instructional Model to progress from engagement and exploration through explanation, elaboration, and evaluation, and they engage students in the full range of science practices delineated in the *Next Generation Science Standards (NGSS)*.

We invite you to dig in and become part of the exciting and rapidly growing citizen science movement. Your students will not only learn science, they will be scientists, and their projects will bring biological and environmental science to life in your classes. What better way to fulfill the *NGSS* mandate to couple science practice with content and give students a real-world context in which to apply what they are learning?

L E S S O N 6

Bird Migration Patterns in My Area*

by Jennifer Fee, Cornell Lab of Ornithology

Overview

Students consider indicators of climate change, interpret various representations of eBird citizen science data, and reflect on how their actions as citizen scientists can assist in better understanding bird migration as a local indicator of climate change.

Learning Objectives

Students will be able to:

- Define *migration* and relate it to habitat preferences of individual bird species
- Use citizen science data outputs to interpret trends in bird migration occurrence and timing
- Name at least two factors that impact changes in animal populations over time

Big Idea

Trends in citizen science data collected over time can indicate the influence of changes in habitat, including those caused by climate change.

Citizen Science Connection

eBird (*http://ebird.org*)

Time Required/Location

90–120 minutes, indoors

* Modified from Bird Migration: A Local Indicator of Climate Change, by Julia Skolnik and Jessica Jones, The Franklin Institute

Resources Needed

- Computers with internet access
- Projector and screen
- Speakers
- Handout
- Additional resources on bird migration patterns (optional)

Background Information

Although migrating birds use photoperiod (length of daylight) as their major guide during migration, they will use local favorable weather conditions to their advantage as well. eBird is a citizen science project in which anyone, anywhere in the world, can submit their bird sightings online. The massive database housing these results is proving valuable to scientists conducting research on a variety of topics including adaptations of bird species to changes in climate or other aspects of the environment. A recent study using eBird data found that many migratory species, including the red-eyed vireo and scarlet tanager, tend to arrive at their nesting grounds earlier in warm years and later in cold years. However, other species such as the barn swallow and eastern wood-pewee do not seem to be adapting in this way to climate variation, and their populations may be suffering as a result (Hurlbert and Liang 2012).

See Chapter 4, "Case Study: Connecting With Students Through Birds," for further information and stories about teachers integrating eBird and animated maps into their science teaching.

Conducting the Activity

Engage

1. Ask students about the birds they have observed in their yards, at school, or at a local park:
    a. What kinds of birds have you seen? If you don't know the names, what do they look like?
    b. Which species do you notice year-round? Are there others that you see only in the summer or only in some other season? What is migration?

c. Where do you typically see birds?

d. Are the birds you see usually alone or in groups? What are they doing?

2. Watch video about changes in timing of bird behavior at *www.fi.edu/birds* (Bird Behavior). Engage students in a discussion about observed changes in bird behavior.

   a. Ask: What evidence of changes in migration timing were noted in the video? What is changing about birds' behavior patterns? What have scientists noticed? What did the scientists say this could mean?

   b. Why do you think this is happening? Do you think it is a problem? Why or why not?

   In a warmer than usual spring, insects emerge and plants bloom earlier than usual. Migratory birds may not arrive in time to sync with these food sources because they cannot perceive and respond to cues when they are in their wintering ground hundreds or perhaps even thousands of miles away.

3. Ask students, "What is citizen science?"

   Citizen science *refers to efforts in which volunteers partner with professional scientists to collect or analyze data. In the eBird citizen science project, any person anywhere in the world can submit information about the birds they have observed. This is creating a massive database with over one million new bird observations entered each month! The data are useful for exploring bird population dynamics and relationships to habitat. For example, we will use eBird data to find out what bird species live in our area, and which of them migrate. The data also are useful in tracking responses to global climate change such as changes in location of individual species or the timing of their migratory flights. See Chapter 1, "What Is Citizen Science?" for more information.*

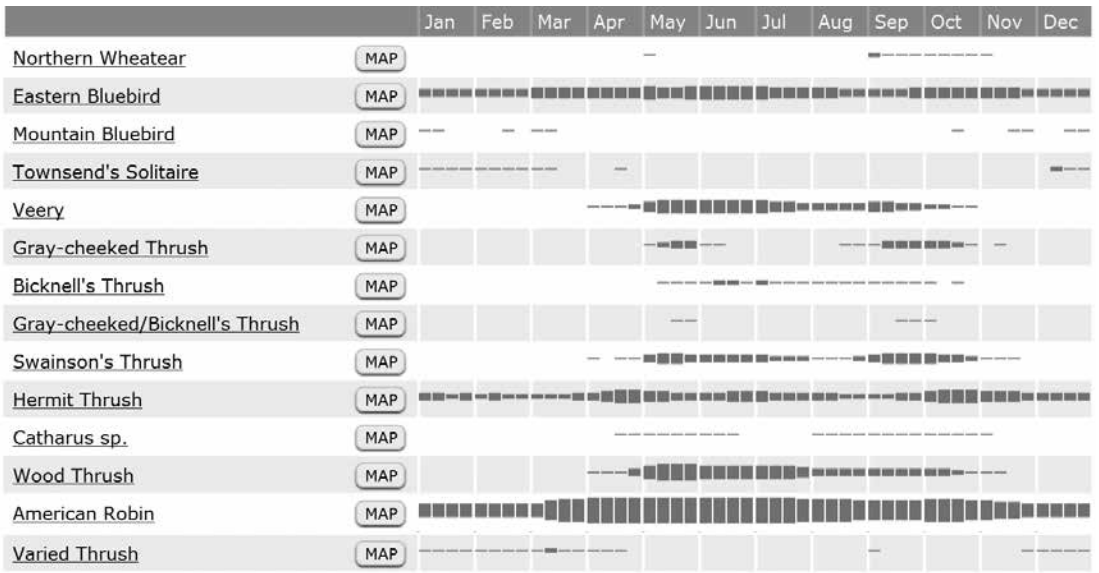
Explore

1. Using eBird's "Explore Data" function, select "Bar Charts" and select your state or other region of interest. Figure 6.1 shows an example chart for New York State. Take a look at the bar charts for your area. Do you see any species with thick green bars stretching across the entire year? (These species

FIGURE 6.1.

Bar chart showing monthly occurrence of bird species in New York State

(Only a portion of the full list is shown here.)



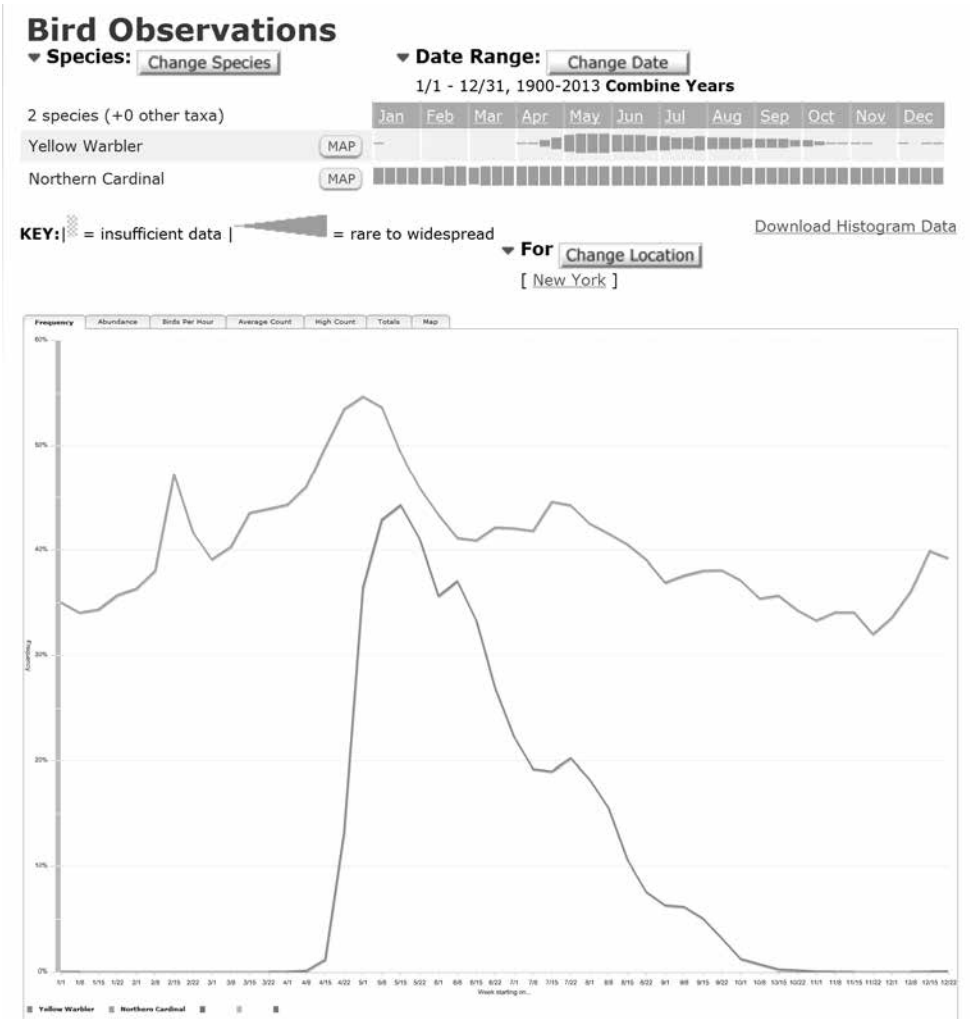
are present year-round.) And other species for which the green bars get much shorter or disappear entirely in certain seasons? (These species are migratory.) Looking at the bar chart for your area, what are some species that remain year-round? Are there others that migrate to your area for the summer breeding season? Are others present only in winter months, or pass through and are seen only during the spring and fall migratory periods?

In Figure 6.1, for example, you can see that eastern bluebirds and American robins are seen in New York year-round, whereas veeries and wood thrushes are seen there only in summer months. The gray-cheeked thrush migrates through New York in spring and fall, but isn't present in summer or winter.

2. Using eBird's "Line Graphs" function, create a graph comparing frequency of sightings of two bird species—one that is migratory and another that is resident year-round. For example, in Figure 6.2 you can see that yellow warbler sightings drop almost to zero in winter months in New York, whereas northern cardinals are commonly seen year-round.

FIGURE 6.2.

Frequency of sighting of northern cardinals and yellow warblers in New York State



3. Discuss the meaning of *frequency* as used in these graphs.

   In eBird, "Frequency" refers to the percentage of birding checklists within a defined region and range of dates that include that particular species. A simpler way to think about this is that it represents the chance you would see this species if you were to go birding in that region at that time of year.

4. Ask students why they think one species stays through the winter and another migrates to a different wintering ground?

   In this case, the yellow warbler eats insects, which are not present in New York in the winter. In contrast, the northern cardinal eats seeds that are available all winter long. The beaks of these two species are quite different and adapted for eating these specific types of foods.

Explain

As a group, investigate whether migratory species in your area have changed their migratory habits over the years.

1. List up to five species that are found in your area only during the summer. These are migratory species that breed in your state. For example, using Figure 6.1, the Veery and Wood Thrush would be excellent choices.
2. Again navigate to the "Explore Data" tab and click on the "Line Graph" option. Select up to five species of interest that migrate. Set Location to your state and Date Range to "1900–1965." Grab a screen capture of the resultant graph (see Figure 6.3 as an example, p. 108). Then run again with the date set to "2010" ending with the current date (see Figure 6.4, p. 109). Again grab a screen capture so you will be able to compare to the historic query.

Note differences in the two graphs (and look up explanations if possible). In this example, it is evident that the turkey vulture overwinters in New York in recent years, but didn't arrive until March in the historic query. What are some explanations?

Climate change is one possible explanation. However, other habitat changes also could be responsible. For example, a student could suggest that more automobile traffic is leading to more road kill. More dead animals means more food for scavenging turkey vultures, an explanation that has nothing to do with climate change. Also note that the differences in sample size could also account for some differences—with more checklists entered in recent years, there is a greater chance that someone will detect a species.

The wood Thrush arrives around the same date historically and today (around April 15), but it is reported less frequently today than in the past. What are some explanations?

> *According to the All About Birds website, wood thrush is a forest species that has declined 43% since 1966, with threats to both its North American breeding grounds and Central American wintering grounds. Forest fragmentation in North American forests has resulted in both increased nest predation and increased cowbird parasitism, significantly reducing their reproductive success. Another factor is acid precipitation. A study by the Cornell Laboratory of Ornithology was the first large-scale analysis that linked acid rain to this thrush's decline, attributed to loss of carbon needed to create the birds' eggs. For further information, see Chu and Hames (2002).*

Elaborate

1. Invite students to think about migratory birds they know in their area. Ask: "What birds live here, and when do they come and go?" Have students select a migratory species of interest. Using sources such as the All About Birds website, the "Range and Point Maps" feature in eBird, or a printed field guide, ask students to identify the summer (breeding) and winter (non-breeding) regions for their species. Where do birds of that species go when not in your region?
2. Draw students' attention to bird migration patterns as a possible local indicator of climate change. Highlight the parts of the video (shown in the Engage portion of this lesson) that noted bird migration patterns. Ask students why they think studying bird migration can help us understand more about changes in our global climate. Summarize other possible explanations for changes in arrival and departure dates and frequency of sightings.

Evaluate

1. Encourage students to work in pairs or groups with the eBird database and the "Bird Migration in My Area: eBird Data Collection Table" to determine the recent arrival and departure dates of five species of migratory birds in your county or state and to organize these species according to the timing of their migratory flights. Tell them to be prepared to share these trends with the class.

FIGURE 6.3.

Frequency of sightings of four migratory species in New York State, 1900–1965

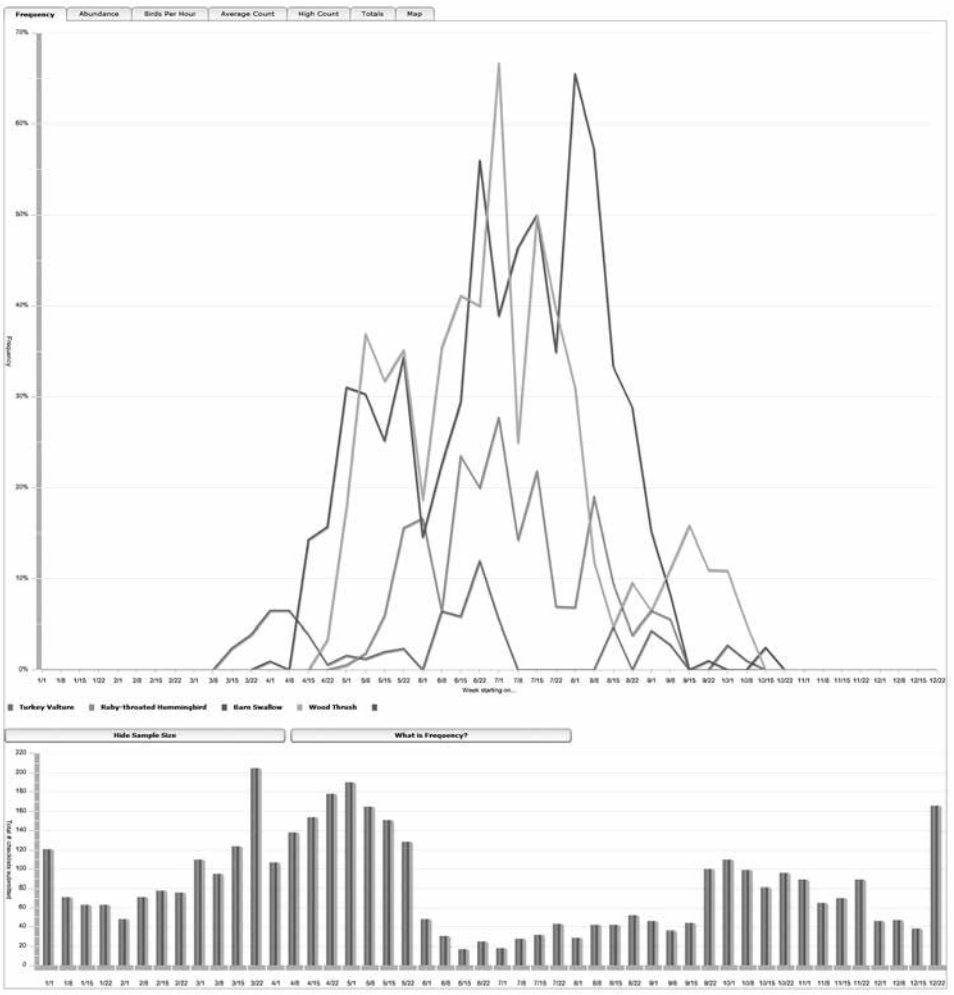
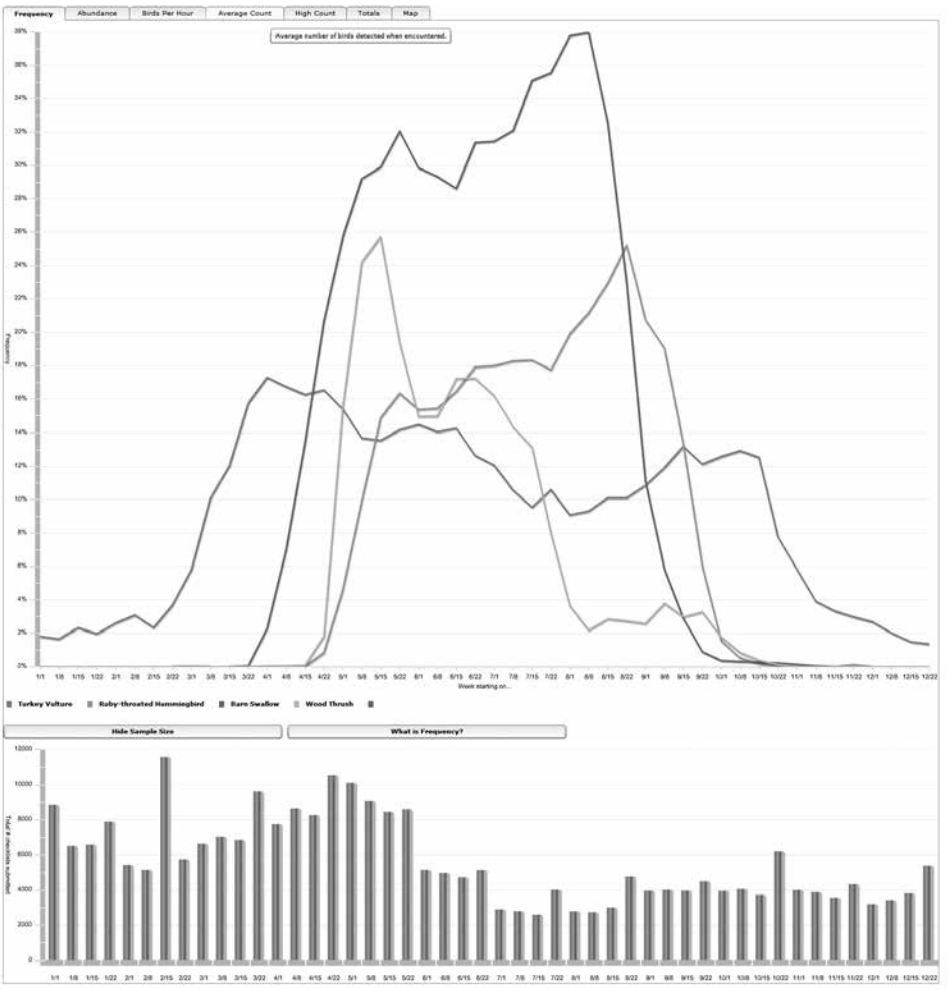


FIGURE 6.4.

Frequency of sightings of the same four species in New York State, 2010 to present

Note the difference in scales between Figures 3 and 4 (In the frequency graph, the historic scale ranges up to 70%, whereas the modern scale is only 40%; the sample size scale is only 160 historically but goes up to 7,000 sightings in the modern graph).



- Ask students to describe at least two factors that might impact changes in animal populations over time.
- After students have documented trends, encourage them to share preliminary findings they have made based on the eBird database.
- Note if any students found conflicting trends, and encourage them to use sufficient evidence to support their explanations.

Extend

Consider implementing additional lessons from the Franklin Institute's Communicating Climate Change curriculum (Skolnik and Jones 2011). One option is to take students outside to observe birds. You could invite a local bird expert to accompany your class on a field trip to a local birding hotspot. After registering your class with an eBird account, your students can record bird sightings and submit a collated class list to eBird. For a longer-term study, they could go birding once a week (or other interval of your choice), and submit each collated class list to eBird. The Cornell Lab of Ornithology offers a curriculum kit that supports learning about bird diversity and identification and supports teachers and students participating in eBird and querying the eBird database (Fee, Rosenberg, DeRado, and Trautmann 2011).

Lesson Resource

- Bird Migration in My Area: eBird Data Collection Table

On the Web

- All About Birds (*www.allaboutbirds.org*): Photos and information about behavior, habitat preferences, and range maps of bird species
- eBird (*http://ebird.org*): A citizen science project that collects and displays data about birds from around the world
- NASA, Global Climate Change (*http://climate.nasa.gov*): A website that documents the evidence, causes, and effects of climate change

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Additional Resources

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Summary: A scientific article about evidence of the ecological impacts of recent climate change on flora and fauna from polar to tropical environments

Wood, C., B. Sullivan, M. Iliff, D. Fink, and S. Kelling. 2011. eBird: Engaging birders in science and conservation. *PLoS Biology* 9 (12): e1001220. *www.plosbiology.org/article/ info%3Adoi%2F10.1371%2Fjournal.pbio.1001220*
Summary: In-depth explanation of eBird and scientific models produced with its data

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— from the preface

The editors of this book have a straightforward goal: to inspire you to engage your students through public collaboration in scientific research—also known as citizen science. The book is specifically designed to get you comfortable using citizen science to support independent inquiry through which your students can learn both content and process skills. *Citizen Science* offers you the following:

- Real-life case studies of classes that engaged in citizen science and learned authentic scientific processes and the habits of mind associated with scientific reasoning.
- 15 stimulating lessons you can use to build data collection and analysis into your teaching.
- Plenty of flexibility. You can use the lessons with or without access to field or lab facilities; whether or not your students can collect and submit data of their own; and inside your classroom or outside through fieldwork in school yards, parks, or other natural areas in urban or rural settings.

You do not need an advanced degree in science to guide your students in productive participation in a variety of citizen science projects. As the editors note, "Such involvement can scaffold teachers' entry into facilitating student investigation while connecting students with relevant, meaningful, and real experiences with science."

Grades 6–12

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