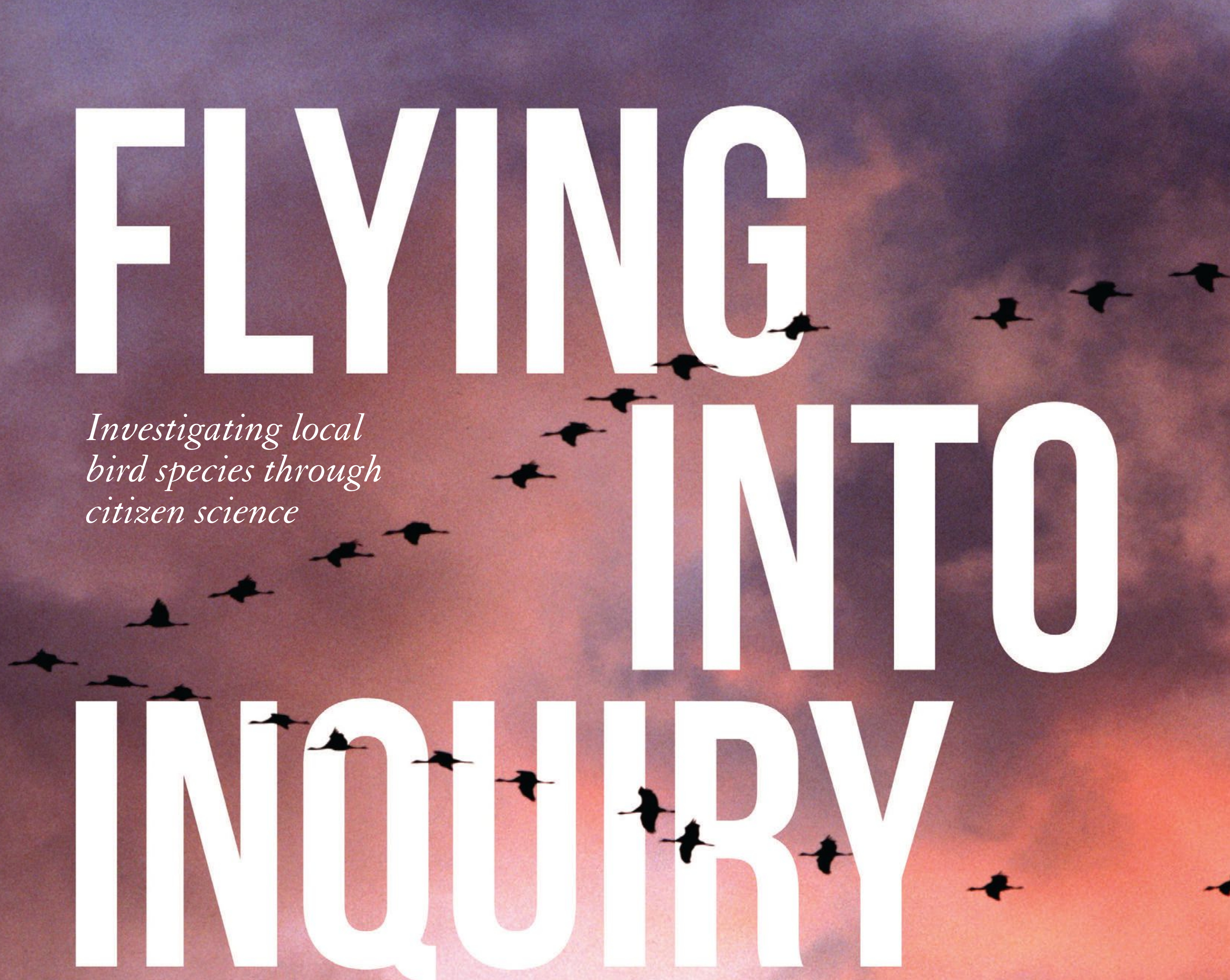


FLYING INTO INQUIRY

Investigating local bird species through citizen science

Nancy Trautmann, Jennifer Fee, and Phil Kahler

What bird species live in your area? Which migrate and which stay year-round? How do bird populations change over time? Citizen science provides the essential tools to address these questions and more. With ever-growing databases such as Project FeederWatch and eBird (see "On the web"), students can connect with people around the world as they make observations, pose questions, conduct investigations, and build deeper connections with the natural world.

This article describes several different citizen science investigations in which students learn about adaptation, interactions among species and their environments, and change over time—fundamental principles in biology (NRC 1996, 2012). Students see the real-world relevance of science as they experience authentic processes of science, from posing testable questions to analyzing data and reaching defensible conclusions.

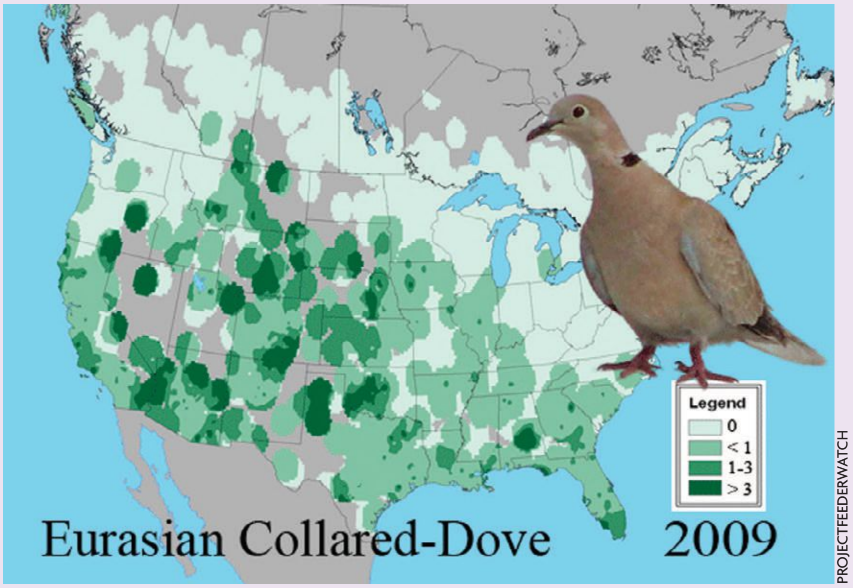
Citizen science

The wealth of data available in eBird, FeederWatch, and other citizen science databases (see "On the web") enables professional scientists to conduct research on previously unimaginable scales. They can produce more accurate range maps, identify species-specific habitat requirements, follow change over time, and make discoveries, such as the rapid advance of an invasive bird species—the Eurasian collared-dove. In the early 1980s, Eurasian collared-doves were first seen nesting in Florida. Scientists tracked the rapid spread of this non-native species across the United States through data entries by eBird and Project FeederWatch participants (Figure 1, p. 46). Findings such as this motivate students and highlight the relevance of citizen science.

Students can make discoveries using citizen science, as well. Frederick Atwood's students at Flint Hill School in Oakton, Virginia, used eBird graphs to compare birds' annual arrival and departure dates in their region (Barkett, Malawi, and Newberry 2012). Students can also use online data to view their bird observations within a broader context. Before or after observing local birds, they can use eBird or FeederWatch data outputs to determine what birds are common in their community, find trends, develop inferences, and discuss various interpretations of the data. If a school submits citizen science data over multiple years, students can view their own data within the context of site-specific trends.

FIGURE 1

Eurasian collared-doves conquering America.



This image is captured from an animated map sequence portraying spread of this invasive species across the United States (2000–2009). The full animation and explanation is available online (see "On the web").

Local bird study

In 1996, Phil Kahler (third author) wanted to engage his 10th-grade biology students in relevant schoolyard and community science, so he introduced them to local birds. He found that being outdoors and collecting data over time led students to develop curiosity and ask scientific questions, deepening their involvement in bird studies.

Now, Kahler's students at Tualatin Valley Academy in Oregon annually study local birds. Kahler uses a set of free downloadable "Investigating Evidence" lessons provided by the Cornell Lab of Ornithology (see "On the web") to help students observe, pose questions such as "Does temperature affect the number of birds observed at our feeders?" and "Does the presence of Steller's jays affect the presence of other species?" and conduct relevant investigations. They conduct weekly bird counts and submit their data to eBird (see "On the web"). Comparing checklists from year to year, students have noticed fluctuations in the number of species and the number of individuals per species. They've investigated factors ranging from weather variability to habitat change, learning both science content and process skills.

When Kahler's classes began observing birds in 1996, dark-eyed juncos were the most abundant species at Tualatin Valley Academy's feeding station. Three years later, students noticed a dramatic decline in dark-eyed juncos and a huge influx of house sparrows, a species scientists hadn't previously recorded in that location. Students wondered why—perhaps the juncos were driven off by nearby residential development or possibly by the invasion of sparrows. One student investigated whether eBird data showed similar junco declines elsewhere in Oregon. Seeing no widespread downward trend during this time period, she concluded that habitat loss was the likely cause (Kristina 2002). (See p. 50 for more on Kahler's experience.)

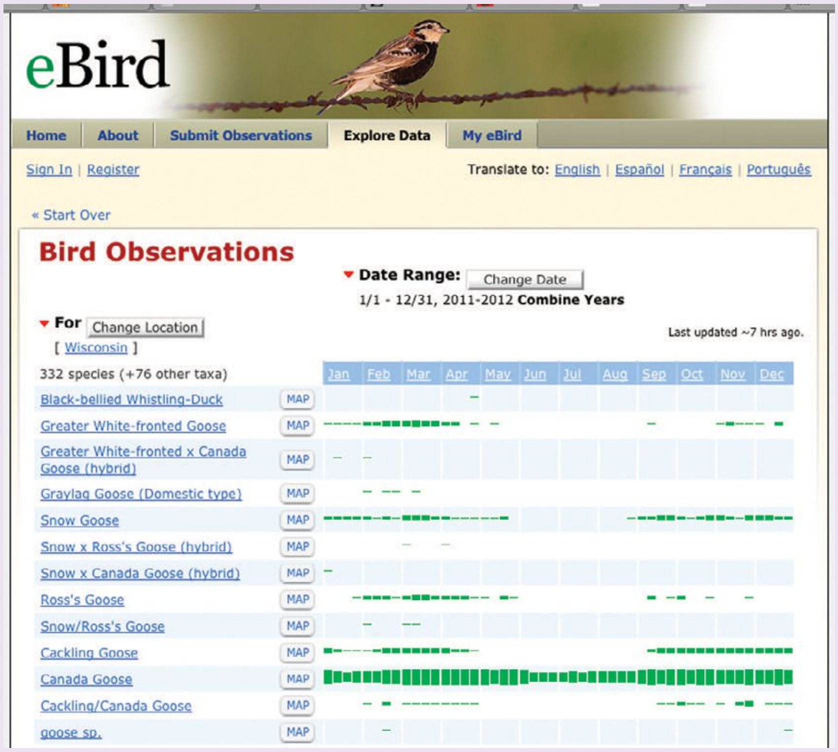
Online citizen science resources

Whether or not students collect and submit their own data, they can use citizen science data outputs to explore bird population trends over time and space. Each year, students in Taylor Abbott's ninth-grade biology classes at North Davis Preparatory Academy in Layton, Utah, track migrations of selected global bird species in eBird and investigate the reasons for these flights. Using eBird maps, students determine what types of ecosystem support selected species, consider the adaptations required for survival in these habitats, analyze potential uses of the various types of eBird graphs, and discuss the importance of tracking population trends and the role of "everyday civilians" in contributing to this key facet of science.

Students can also use Project FeederWatch's online maps and data to investigate distribution and abundance of North America's feeder species over the past 25 years. Students may not know that many species never visit a feeder, but they can discover this by comparing data from FeederWatcher and eBird. In the winter of 2011–2012, for example, FeederWatchers in Pennsylvania reported 95 species compared with 275 Pennsylvania species reported in eBird. What are these additional species, and what do they eat? Students could pick one or more species and investigate such questions using

FIGURE 2

Bird species in Wisconsin in 2011.



EBIRD.ORG

Example data output from *eBird* indicates 332 bird species were observed in Wisconsin in 2011. Canada Geese were seen year-round, whereas several other goose species were reported in the state during limited times of year.

sources such as All About Birds, an online compendium of information about North American bird species (see "On the web").

Students can also use eBird data and visualization tools to determine which bird species reside in their area year-round and which are migratory (Figure 2). Students can pose questions for investigation through further analysis of online data. For example, they might notice opposite patterns for two types of hawk in Wisconsin: The broad-winged hawk appears from April through October whereas the rough-legged hawk is common in the winter (Figure 3, p. 48).

eBird 's line graph functions make it possible to look into the two species' frequency and abundance. *Frequency* refers to the percentage of checklists within a defined region and range of dates that include the species of interest (i.e., the chance you would see this species if you went birding in that region at that time of year). Frequency graphs allow students to view in greater detail the opposite trends of Wisconsin's broad-winged and rough-legged hawks (Figure 3, p. 48).

"Average count" is a measure of *abundance,* referring to the average number of individuals seen within a given region and time period. Average count graphs show much higher peaks and more seasonal variation for broad-winged hawks compared with rough-legged hawks in Wisconsin (Figure 4, p. 49).

Digging into what these data say about the life cycles of the two hawk species, students can consult a source such as All About Birds to learn that broad-winged hawks breed in deciduous forests in the eastern United States, and huge numbers are seen during migration to and from wintering grounds in Central and South America (Figure 4, p. 49). In contrast, rough-legged hawks breed in the Arctic tundra and taiga regions and are absent in the lower 48 states until the winter months.

From data into models

The natural history databases being built through citizen science enable scientists to create complex, data-rich models useful in both research and education (Wood et al. 2011).

By combining eBird data with remotely sensed information on habitat, climate, human population, and demographics, scientists are modeling species' distribution, migration patterns, and habitat preferences (Marris 2010).

These models predict movement throughout the year and enable scientists to explore various scenarios, such as how migration timing might change with alteration of landscape or climate. Viewing animated maps that depict the model outputs, students can see the importance of habitats in supporting healthy bird populations. The chimney swift map, for example, depicts where this species prefers to nest during the summer and the reverse spatial pattern can be seen for the forest-dwelling indigo bunting (Figure 5, p. 49). Teachers can present these maps to students and ask students to describe what the maps might represent, explaining after initial speculation that the maps predict the probability of occurrence of specific bird species throughout the year. Without knowing what species are represented, students could discuss how the maps differ and speculate about what types of habitat and bird species they portray. Students are likely to conclude that dark areas in one map correspond with light areas in the other. Differences in the Figure 5 maps illustrate the chimney swift's tendency to nest in urban and suburban areas versus the indigo bunting's need for natural forest and shrub habitats.

From inquiry to action

Students monitoring local birds or conducting investigations with online citizen science data might be inspired to undertake habitat improvement or other conservation projects. Frederick Atwood's students at Flint Hill School in Virginia build nest boxes for eastern bluebirds or wood ducks. Both species are cavity nesters whose breeding success is limited by competition for available cavities. Bluebird populations fell in the early 20th century as introduced species such as European starlings and house sparrows took over available nest holes. Beginning in the 1960s, nest box campaigns alleviated much of this competition, and bluebird numbers have been recovering. When students create eBird graphs that depict the rise in native bluebird populations with the decline in numbers of invasive sparrows, they see why removing sparrow nests from their bluebird boxes is important.

FIGURE 3

Frequency of sightings of broad-winged and rough-legged hawks in Wisconsin.

EBIRD.ORG

Frequency graphs for Wisconsin broad-winged and rough-legged hawks show opposite patterns for these two species.

Conclusion

Citizen science creates opportunities for students to connect with nature, develop their own research questions, conduct indoor investigations using data visualization tools and models, and explain and predict distribution of selected species over time and space. Whether students contribute their own data or use online data, citizen science allows them to work with real data, participate in a community with professional scientists, and make authentic discoveries. What better way to make science relevant, enticing, and fun? ■

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On the web

All About Birds: *www.allaboutbirds.org*
BirdSleuth: *www.birds.cornell.edu/birdsleuth*
eBird: *http://ebird.org*
Project FeederWatch: *www.feederwatch.org*
Rubric: *www.nsta.org/highschool/connections.aspx*

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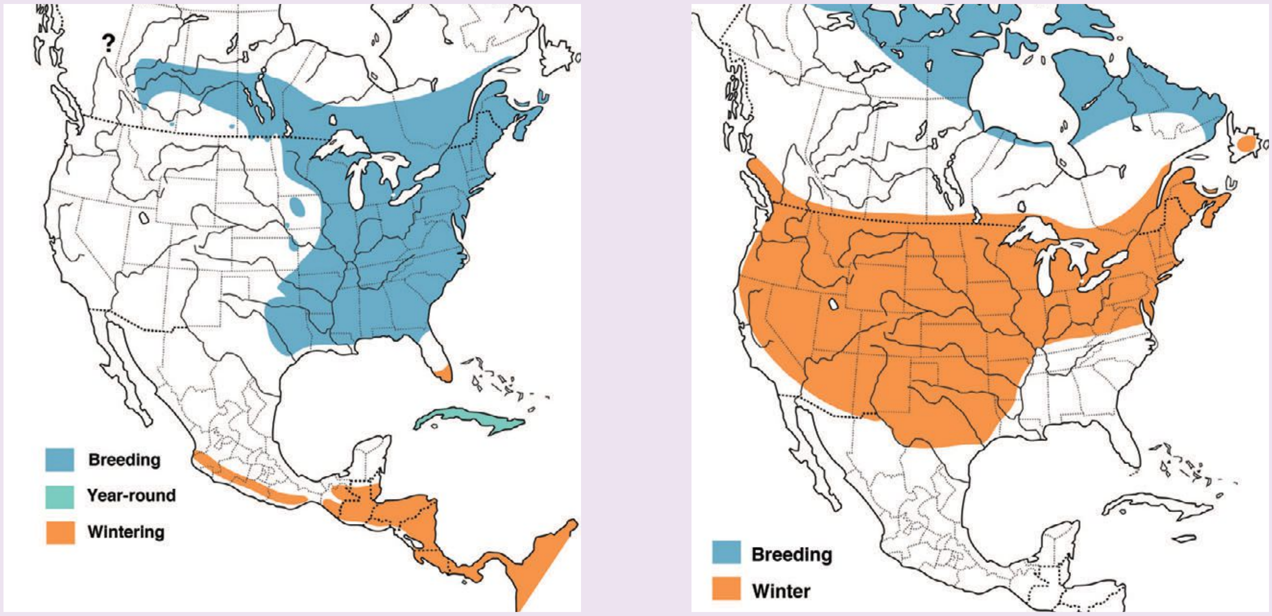
Wood, C., B. Sullivan, M. Iliff, D. Fink, and S. Kelling. 2011. eBird: Engaging birders in science and conservation. *PLoS Biology* 9 (12).

FIGURE 4

Range maps for the broad-winged hawk and rough-legged hawk.

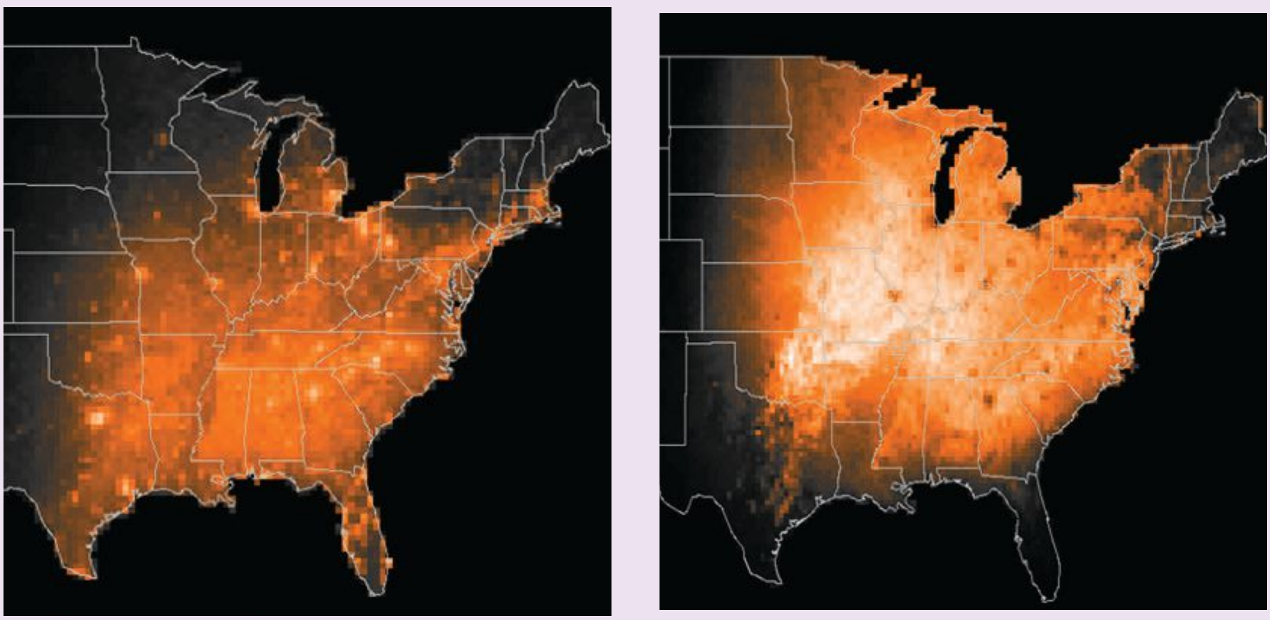


ALLABOUTBIRDS.ORG

The broad-winged hawk (left) and rough-legged hawk (right) spend different parts of their life cycles in the lower 48 states.

FIGURE 5

Breeding season occurrence for chimney swifts and indigo buntings.



EBIRD.ORG

Predicted probability of occurrence at the height of the breeding season for chimney swifts (left) and indigo buntings (right) indicate opposite influence of human population density on nesting habitat for these two bird species. Darker areas indicate those with lower probability of occurrence of that species at this particular time.

Implementation case study

Phil Kahler

Each fall, my biology class at Tualatin Valley Academy in Hillsboro, Oregon, makes weekly visits to our bird-feeding station in the woods behind the school to count birds for the Cornell Lab of Ornithology's *eBird* citizen science project. Before leaving the classroom, we record data from our WeatherBug station. Outdoors, we immerse ourselves in learning to identify the birds, observing their behavior, and asking questions. Afterward, one student enters the class data into *eBird* and shares with classmates using the "share list" feature. Students track data relevant to their particular study question.

More advanced students can develop behavior ethograms before selecting a study question. Recently, one group of three students wanted to know if spotted towhees always eat on the ground or if they would feed from an elevated feeder. Each student had a specific job during data collection. Over the span of 5 minutes, the *timekeeper* called out the time every 20 seconds, the *observer* counted how many towhees students observed on the ground and on the feeders, and the *recorder* kept track of the data on a tally sheet.

See "On the web" for my grading rubric. Peer review has always been important in my classroom. Students critique each other's papers before submitting their final drafts to BirdSleuth (see "On the web"). Students carefully check each other's reports to ensure they include all the important components of a scientific report (Figure 6).

FIGURE 6

Scientific report components.

Scientific Report Components	
Section of Report	**What might be found in this section?**
Introduction	Background information, including natural history information Statement of the hypothesis Why the question was chosen or is important to study
Materials and Methods	Materials used to conduct the study Data details: when and where data were collected, who collected them and how Any other methods used
Results and Analysis	Results, including tables and graphs What the data or any patterns mean How the data were analyzed (if they were analyzed)
Discussion and Conclusions	Conclusions Alternate explanations for the results Suggestions for improvements to the study design
References	Any citations: websites, magazines, science reports, or *Classroom Birdscope* articles

Peer review

Each year since 2009, my students have joined forces with Elizabeth Eubanks' class in St. Mark Catholic School in Boynton Beach, Florida, to create an online peer review system using a free wiki. Students from both schools create their own wiki pages and post their research question, hypothesis, methods, analysis, and conclusions. They read each other's work and leave helpful comments. Elizabeth Eubanks and I have full control to moderate the wiki site as we teach our students to practice professionalism. The highlight of the experience is when students talk with their peer review partners via Skype.

It is especially exciting to see how citizen science motivates my students. They know their bird observation data can answer real-world questions, and they are contributing to the global scientific community. The opportunity to publish their results in Classroom BirdScope, the Cornell Lab of Ornithology's annual student journal, strengthens this tie to real science for my students.