

# Phenology and Citizen Science

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Volunteers have documented seasonal events for more than a century, and scientific studies are benefiting from the data.

The first lilac bloom is considered a harbinger of spring. One person's observation of a backyard flower may be lovely, but thousands of people's observations in myriad locations, recorded in the same way and taken over the course of many years, become a data set that can be used to model potential changes in the arrival of spring and what those changes imply. Because these observations can be fairly simple to make, and because large data sets are necessary to design meaningful scientific studies, phenology—the relationship between annual events such as flowering, breeding, and migration and climatic or seasonal changes—lends itself to the participation of citizen scientists.

“That’s the cool thing about phenology,” says Jake Weltzin, executive director of the USA National Phenology Network (NPN). “We can work with the lay public. With only minor training, they can help us collect quality data through space and time in ways we cannot get [ourselves].” Weltzin says the training strives to ensure everyone is using the same methods, because without consistency so many streams of data would be useless. “But once you get the standardization down, a scientist or a homemaker can contribute equally.” Along the way, people who aren’t professional scientists learn

about field research and feel connected with the scientific process.

## Legacy data sets

The modern term “citizen science” most likely dates back to the 1970s, says David Bonter, project leader for Project FeederWatch at the Cornell Lab of Ornithology and assistant director for citizen science there. Current technology makes participation faster and easier and has also greatly improved the process of converting citizen observations into usable data. But lay involvement in data gathering dates back at least to the late 19th century. Simple Web sites make it relatively easy to aggregate data, mine it for improbable or impossible anomalies, and collate it into raw data sets. And the data can come from new observations made in real time or from the transcription of so-called legacy data sets, such as the North American Bird Phenology Program’s handwritten bird migration cards that document observations made from 1890 to 1970.

While the Cornell Lab has a long history of citizen science, it and other organizations that have sponsored phenological observations largely functioned as separate and unconnected data gatherers. That’s just the sort of isolation Mark Schwartz tired of as he conducted phenological research,

beginning with his dissertation in the 1980s. The US Department of Agriculture (USDA) had funded field stations to provide a network of observers with cloned lilacs and instructions for



North American Bird Phenology Program volunteer transcriber Ken Pauley, shown here birding at Kikoti Rocks in Tarangire National Park, Tanzania, says entering data from the historical observation records gives him a connection to birders from a different era. Photograph: Courtesy of Ken Pauley.

documenting their seasonal changes, in some cases going back to 1950. Schwartz, now a professor of geography at the University of Wisconsin–Milwaukee, used this data on spring lilac blooms to develop a model that could simulate plant phenology over a continental scale based on climate data. When the USDA funding dried up, Schwartz personally maintained contact with about 50 observers because he appreciated the potential value of keeping the network functioning.

By keeping the lilac study going, Schwartz has been able to refine his model over several iterations, and now, factoring in daily maximum and minimum temperatures, he has simulated lilac phenological responses for sites where there aren't any historical data. He can also make projections into the future. The rescuing of the lilac program helped make it clear to Schwartz that a systematic and central way of archiving phenological data sets, especially those from citizen scientists that might not have permanent institutional homes, would be critical to ensuring that these valuable observations got into the hands of researchers.



*Spring lilac blooming data became the basis for the climate models Mark Schwartz developed. He poses here with lilacs in bloom on the University of Wisconsin–Milwaukee campus, where he is a professor of geography. Photograph: Alan Magayne-Roshak, University of Wisconsin–Milwaukee.*

By August 2004, Schwartz was talking with colleagues about what ultimately became the NPN. It's both an umbrella organization for information on phenological research and, increasingly, a clearinghouse for historical data sets. The NPN also administers a plant observation project of its own and plans to add an animal phenology citizen science project this year.

### **Do citizen scientists gather good data?**

This is the question that invariably arises. To address it, the NPN, jointly sponsored by the US Geological Survey and the University of Arizona, has developed standard protocols for gathering observations. It also uses some back-end strategies to ensure that the data it stores will be up to the quality standards researchers require.

Schwartz, who also chairs the NPN's board of directors, says while quality is obviously important, it's not hard to come by. "What we have discovered is that most of these people can do a very good job of collecting data if they're given clear instructions." They tend to be highly motivated to do the job well because the only reward they seek is the knowledge that their data are being used. That said, Weltzin says both preventative and corrective measures are being built into NPN's data reporting system. People won't be able to enter a date in the future or select a plant species not found in their area. Anomalous data will be flagged, and the person who entered it may be asked to verify it with a photograph.

Bonter says Project FeederWatch, too, flags questionable data. The program also increasingly relies on digital photos. When someone reports an unexpected species at a feeder, Bonter or a colleague in the FeederWatch office gets a note to check out the report. Bonter finds people are generally receptive when asked for confirmation, and many volunteers have been credited with the first sighting of a species in an unexpected or new territory. "There's an awful lot of research that goes on out there," Bonter says,



*The Eurasian collared dove is an invasive bird species whose colonization of North America has been documented in part thanks to observations by participants in the Cornell Lab of Ornithology's Project FeederWatch. Photograph: Patricia Jones-Mestas, Project FeederWatch volunteer.*

and much of the more formal observing is being done by undergraduates, field assistants, or technicians. "I don't think that there's any reason to believe that their information is of any higher quality than somebody who's been watching what's happening in their own back yard for the past 25 years."

Historically, even without formal standards and protocols, amateurs were considered fairly reliable. Jessica Zelt, coordinator of the North American Bird Phenology Program, is overseeing the transcription of 6 million data cards. They came from a network of naturalists, ornithologists, and backyard birders that peaked at 3000 participants. Ken Pauley, a volunteer, has found that transcribing the handwriting is often the biggest challenge. He's a retired educator from the Museum of Science in Boston and an avid birder. He's been transcribing the historical cards for a year and enjoys the fact that he's helping make those old observations useful today.

The Bird Phenology Program, which is making its database available through the NPN Web site, built into its



*Government biologist Wells Cooke launched a program to document bird migration habits that eventually swelled to 3000 volunteers across North America. The program ran from 1890 to 1970, and now efforts are under way to transcribe all of the handwritten records. Photograph: Courtesy of the North American Bird Phenology Program.*

transcription software a requirement for each card to be entered twice, by different transcribers, so inconsistencies can be weeded out. If the two entries don't match, the card is sent back into the pool to be transcribed again. Zelt says efforts are under way to collect similar data through contemporary observations, thereby strengthening the value of the historical information.

### **Budding bud watchers**

Another citizen science program that has achieved a level of comfort with the quality of data it receives is Project Budburst. Like the lilac program, Budburst grew from the idea that continental-scale plant phenology observations were needed, would require widespread participation, and could engage a broad public.

"We are first and foremost an education and outreach project," says Budburst director Sandra Henderson, "but at the same time we want

to provide information that's useful for science." Sponsored by the University Corporation for Atmospheric Research, the University of Montana, and the Chicago Botanic Garden, Project Budburst encourages participation "from school kids to backyard naturalists to day hikers," she says. Budburst participants choose a plant and then use the instructions provided in a two-page document to get started.

Mary Anstey, a fifth-grade teacher at Riverside Elementary School in Greenwich, Connecticut, has divided her 20 students into five groups. Each group monitors one tree on the school property. During the fall, they made observations of the foliage and fruit. That information drives the research they then do in the winter, while they wait to document the spring blooming. The project is expanding the way that students view their surroundings.

"What they have started doing is to be more precise observers of nature," Anstey says. The project has sparked interest in all of her students, not just those who were already excited about science or are outdoorsy. In addition to honing the scientific skills of observation and data gathering, the students are using Project Budburst as a launch pad for exercises in expository writing (they write about their trees and their observations), reading (they research the tree species, the seasonal cycles, and climate change), and technology (as a team they visit the Project Budburst Web site and enter their data). Anstey calls this approach "transdisciplinary," and says her school district has been very supportive of her use of Budburst in the classroom.

Henderson says plants are great for phenology volunteers, including young students, because they're stationary. You can return to the same one again and again. For Anstey, the trees become a stable part of her curriculum, and although the students will change year to year, she can continue to contribute the same types of data about the same trees to Project Budburst

with successive groups of kids. Henderson says the data, when aggregated with observations from many sources, will help contribute to climate change studies.

Weltzin, NPN's director, says giving the public positive ways to contribute to the science of climate change helps broaden their understanding and diminish what he calls the "doom and gloom" around the subject. "We can then empower the public to engage in global change activities," he says. Project Budburst, though a partner of the NPN, differs from the citizen science plant project NPN sponsors: Registration is not a requirement for submitting data. That means the data won't be incorporated into NPN's own databases because, Weltzin says, registration is something the NPN requires to help preserve the integrity of its data.

The managers of both Project Budburst and the NPN are watching as another potential boon for citizen science emerges: the National Ecological Observatory Network, or NEON. Pending final congressional approval, it will begin construction this year. When it's all up and running, NEON will have 60 sites—3 locations at each of 20 domains. Becky Kao, manager of NEON's fundamental sentinel unit, says phenological observations of birds, mosquitoes, and plants will be collected and might answer questions such as whether plant phenology can be used as an indicator of community- and population-level changes in an ecosystem, or how the timing of birds and mosquitoes might alter disease modeling.

Most NEON work will be done by staff, but the project includes a citizen science component. Wendy Gram, chief of public education and engagement, says phenology is a natural fit. She is looking at Project Budburst as a model. Although NEON's citizen science component is still evolving, she anticipates that technology such as cell phones with cameras and GPS (global positioning systems) will help confirm people are correctly identifying specimens.



*Researchers confirmed the decline of the evening grosbeak population, once one of the most common feeder birds, after analyzing data submitted by Project FeederWatch observers. Photograph: Tammie Hache, Project FeederWatch volunteer.*

Gram says another goal is to develop NEON's citizen science projects in such a way that scientists anticipate the data and are ready to use them when they're available. "Everyone, including NSF [National Science Foundation] and research scientists and educators and this whole broader community, recognizes that it's great to collect all this data, but if the data themselves aren't usable and accessible and actually being valued by a variety of communities...that is going to be a disservice to all of the effort and funds that are being put into it."

### The long haul

Ultimately the dual goals of citizen science are to educate the public and generate data that can be used in research. Some of the younger programs, like Project Budburst, haven't been around long enough to have data

become part of the scientific literature. But, Bonter says, "we publish scientific papers from FeederWatch and our other projects here all the time." Recent papers emerging from largely citizen-collected data include one about the invasive Eurasian collared dove's rapid colonization of North America, and another on the decline of the evening grosbeak, once one of the most common feeder birds.

Schwartz has been able to track seasonal changes from blooming data. "Over the last 30 years, the onset of spring as measured by the lilacs is earlier by about a week on average," he says, a fact that has been documented by the citizen lilac observations. It's a conclusion researchers couldn't have drawn on their own, and it's something volunteers actually experience, which underscores their connection to the science.

Weltzin lists papers about the physiological patterns of invasive species, the relationship between phenology and population abundance, and the relationship between phenology and species distribution all as relying on data collected by citizen volunteers. Some have even contributed unknowingly, such as Henry David Thoreau, an amateur naturalist whose legacy data from Walden Pond has been used by modern researchers.

When NPN has its legacy clearinghouse fully functional, data such as Thoreau's and the Bird Phenology Program's—and even phenological observations recorded by Meriwether Lewis and William Clark during their 1803–1806 expedition—will be

accessible to the public, and advocates hope they will help researchers design studies that incorporate historical and contemporary observations.

The nagging question, to which FeederWatch and NEON have found different answers, is how to sustain ongoing citizen observations for phenological research. To be useful, phenological data sets must be collected over long periods of time, and traditional funding sources, such as grants from the NSF or other government agencies and foundations, are given typically for no more than five years.

NEON is designed to be gathering data for the next three decades and its infrastructure will be in place, so Gram and others there plan to develop and maintain projects that continue to attract citizen participants. FeederWatch, on the other hand, enjoys such a dedicated following that people who participate must pay \$15. "They're paying us to work for us," Bonter says. "It's really a challenge to build an endowment or come up with novel ways to fund long-term research."

Perhaps as researchers use contemporary and legacy data sets to find answers to vexing questions, the importance of ongoing observations will become self-evident. But that, of course, will depend in large part on exactly what it is scientists find when they dig into the data.

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