# Citizen Science: Can Volunteers Do Real Research?

JEFFREY P. COHN

**Collaborations between scientists and volunteers have the potential to broaden the scope of research and enhance the ability to collect scientific data. Interested members of the public may contribute valuable information as they learn about wildlife in their local communities.**

David Helms was hiking along the Appalachian Trail in Virginia one lovely day last summer. After trekking for several miles, Helms stopped at a preselected place, set his backpack down, and pulled out his global positioning system (GPS) receiver. First checking the GPS to make sure he was at the right spot, Helms left the well-traveled Appalachian Trail and bushwhacked through some dense brush and past tall oak and poplar trees to a narrow pathway in the woods. Plentiful deer tracks and scat told him this was the animal trail he was looking for.

Helms, president of the Natural Bridge Appalachian Trail Club in Lynchburg, walked first one way along the path, then the other, searching for the digital camera he had attached to a tree a month before. After looking for several minutes, he found it. Working quickly, Helms shut the camera off, detached it from the tree, replaced the camera's photo card with a new one, and changed its batteries. He then walked down the animal trail two-thirds of a mile and reattached the camera to another tree, carefully positioning the camera so that the lens pointed toward the trail. Next, he bent over awkwardly, smiled, and moved to trigger the camera's motion sensor. The camera took Helms' picture, thus ensuring that it still works properly.

*Volunteers Emily Helms and Melissa Johnson position a camera on a tree overlooking a game trail and prepare to deploy a foul-smelling mix of scent-gland extracts that attracts animals to the camera. Their efforts help scientists learn which animals live along the Appalachian Trail. To see images taken with motion-rigged cameras, visit* www.washingtonpost.com/wp-dyn/content/gallery/2007/11/12/GA2007111201621.html. *Photograph: David Helms, Natural Bridge Appalachian Trail Club.*

Helms is a citizen scientist participating in a scientific survey of mammals living along the 575 miles of the Appalachian Trail from southern Virginia to Pennsylvania. He is one of nearly a hundred volunteers who handle equipment, gather data, and record observations, says William McShea, a wildlife ecologist at the National Zoo's Conservation and Research Center in Front Royal, Virginia, and the survey's director. McShea's mammal survey is part of a larger research effort by government agencies, universities, conservation groups, and individual scientists to monitor environmental trends along the entire 2175 miles of the Appalachian Trail. Both the mammal survey and the larger Appalachian Trail MEGA-Transect (as in "MainE-to-GeorgiA") project depend on citizen

scientists like Helms, who is a retired accountant and chief financial officer.

The term "citizen scientists" refers to volunteers who participate as field assistants in scientific studies. Citizen scientists help monitor wild animals and plants or other environmental markers, but they are not paid for their assistance, nor are they necessarily even scientists. Most are amateurs who volunteer to assist ecological research because they love the outdoors or are concerned about environmental trends and problems and want to do something about them. Typically, volunteers do not analyze data or write scientific papers, but they are essential to gathering the information on which studies are based. Citizen scientists represent "a partnership between volunteers and scientists to answer real-world questions," states Rick Bonney, director of program development for Cornell University's Laboratory of Ornithology in Ithaca, New York.

## Science 2.0

Working with citizen scientists is hardly new. The practice goes back at least to the National Audubon Society's annual Christmas bird count, which began in 1900. About 60,000 to 80,000 volunteers now participate in that survey. What is new is the number of studies that use citizen scientists, the number of volunteers enlisted in the studies, and the scope of data they are asked to collect, says Jennifer Shirk, a graduate assistant and project leader at Cornell's Laboratory of Ornithology. Researchers now often ask their volunteers to use sophisticated equipment and techniques to monitor air and water quality; document when plants grow, bloom, and die; and observe when birds and other animals migrate through an area or how they behave when they are there.

For its part, Cornell—both the Laboratory of Ornithology and the university's academic departments—is one of the leading users and promoters of citizen science. Cornell's researchers have been using volunteers in studies to monitor birds, as well as in other research projects, since the 1960s, Shirk says. The name "citizen science," however, was not used by Cornell researchers until the 1990s. Current citizen-science projects at Cornell include studies of diseases in house finches, urban bird surveys, and Project Feeder Watch.

Nationwide, the National Science Foundation (NSF) is funding about a dozen projects involving citizen scientists, including many of Cornell's, says David Ucko, deputy director of the NSF's division for research in learning. Most take the form of grants for education rather than scientific research. "Our objective is to increase public awareness of and participation in science," Ucko states. "Actually, we are more interested in the educational values than the research results."

Cornell scientists who track citizen-science studies have so far found more than two hundred research projects being conducted by researchers in North America. Some observers think there may actually be thousands. Working with citizen scientists is "a growing worldwide phenomenon," Shirk adds. "We've just begun to scratch the surface."

"Citizen science is science 2.0," Bonney says of how ecological studies are often done today. "We can employ citizens to gather data that we cannot get any other way. It is my personal crusade."

But why citizen scientists? Why depend on amateurs who may make mistakes, may not fully understand the context of the study, or may produce data that might be unreliable? Why not hire scientists, graduate students, and field technicians? One obvious reason is money. "We can't afford them," states Donald Owen, an environmental protection specialist with the National Park Service (NPS) in Harper's Ferry, West Virginia, speaking of professionals. "We can't get enough research assistants to do what we can get volunteers to do. Not even close. The Appalachian Trail was built and is still maintained by volunteers. Using volunteers is the way the world works on the trail."

Using volunteers also allows scientists to gather data on a larger geographic scale and over a longer time period than is possible in more traditional scientific research, adds Karen Oberhauser, assistant professor of wildlife and conservation biology at the University of Minnesota in St. Paul. That helps researchers spot anomalies in the data, compare the results from one area or time with another, distinguish trends, and understand differences among subpopulations or geographic areas.

Moreover, working with citizen scientists gets more people out and into the natural world as well as involved in the scientific process. "We want to inspire the public to appreciate nature through hands-on research projects," says Marc Albert, an NPS ecologist with the Boston Harbor Islands National Recreation Area in Massachusetts. "We want to give everybody a chance to enjoy the Appalachian Trail and tell us about its health," adds Brian Mitchell, an NPS ecologist in Woodstock, Vermont. Mitchell is also program coordinator for the Northeast Temperate Network, a part of the MEGA-Transect project. "We want everybody from grade-schoolers to grandmas," he says.

*Volunteers Polly Stevens and Bob Kelly use a small landing craft to count the number of breeding cormorants, gulls, and other shorebirds nesting on the 34 islands that constitute the Boston Harbor Islands National Recreation Area. Photograph: Sherman Morss Jr.*

*Monitoring their site in New London, Minnesota, these Monarch Larva Monitoring Project (MLMP) volunteers are students of Laura Molenaar, a New London teacher and MLMP volunteer. Citizen scientists, who range from schoolchildren to retirees, help researchers collect data on longer timescales and larger geographic scales than the scientists and their students and field technicians could cover. Photograph: Sarah Kempke, University of Minnesota.*

*High-school students monitoring monarch butterfly larvae at Rio Bravo Park in Texas pause for a group photo. The monitoring project includes more than 600 sites from Minnesota to Texas and east to the Atlantic Coast. Photograph: Carol Cullar.*

## Reliability of data

But can citizen scientists learn to use equipment, read results, and collect data that are as accurate, reliable, and usable as those generated by professional researchers? Yes, says Mitchell, "if we explain to them what they should be doing and how to do it. Nothing we're doing is so difficult that volunteers can't do it if they are properly trained." Toward that end, the National Zoo's McShea, for example, spent the better part of a day with his volunteers. He explained the mammal survey and its goals, showed them how to set up and use digital cameras, told them when and how to remove the camera cards, and demonstrated how to upload the photos into their computers and e-mail them to a Smithsonian Institution (the parent organization of the National Zoo) Web site.

Furthermore, Mitchell says, the scientists who design research projects have to write study protocols that take citizen scientists into account. "You have to develop specific protocols [for citizen scientists] and then go out and measure to test the results [they get] for reliability," adds Geraldine Tierney, an ecologist and research scientist at the State University of New York in Syracuse. Tierney says protocols should limit what citizen scientists are asked to do. They may be asked to identify, document, and count 5 or 10 easily recognized plants that serve as indicator species rather than be expected to recognize all species in a given area. Good guide books and other printed materials can help volunteers do that.

In early studies, the data gathered by citizen scientists were often too vague to be used, says Matthew Stevens, monitoring coordinator for the Appalachian Trail Conservancy (ATC) in Lyme, New Hampshire. "The data were not precise enough," Stevens recalls. The problem was that the data generated by volunteers sometimes represented a range rather than specific numbers, which made it difficult to detect changes or to support conclusions. Now, citizen scientists are trained to read instruments and provide actual numbers. Be cautious, however, Shirk advises: study leaders can err on the other side by asking volun-

teers to collect data that are too complex or detailed.

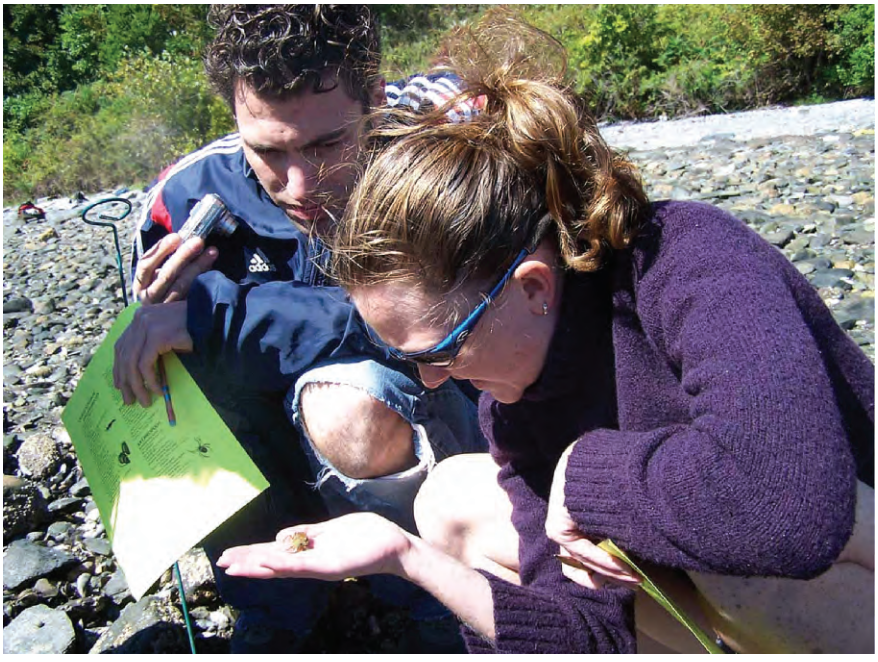
But not always. People who volunteer to participate in studies often are themselves scientists or science teachers and their students. Or they may be conservation group members or staffers, experienced bird-watchers, backpackers or hikers, or other outdoor enthusiasts. In other words, citizen scientists are typically people who care about the wild, feel at home in nature, and have at least some awareness of the scientific process.

"Some of the data will be of variable quality," Tierney admits. In such cases, Tierney and others say, the scientists who direct studies involving volunteers have to be prepared to scrutinize the data carefully and be willing to discard suspect or unreliable data.

To keep that to a minimum, researchers have developed ways to check the accuracy of the data volunteers submit. "We pair-trained staff with our citizen scientists so we can compare data and determine its reliability," says Georgia Murray, an Appalachian Mountain Club staff scientist in Gorham, New Hampshire. Murray adds, "We have to balance [the need to] collect good data [with the goal of] educating the public on nature and the scientific process."

For their part, many citizen scientists take pride in helping advance scientific knowledge and protecting the wild. "What's intriguing and exciting is knowing that the scientists will use the data," says Trudy Phillips, a retired chemical engineer and another volunteer from Lynchburg on McShea's mammal study. "We need to know how things are going."

Overall, the data generated by citizen scientists are pretty good, according to David Delaney, a graduate student in evolutionary biology at McGill University in Montreal. And he would know. While studying introduced and native crabs along the Atlantic Coast from New Jersey to Maine, Delaney compared the identifications that a thousand volunteers made of crabs caught at 50 sites with those he made himself. The overwhelming majority of citizen scientists nearly always identified the crabs correctly. Even seventh graders got them right 95 percent of the time. Perhaps more surprising, third graders were right 80 percent of the time, an acceptable accuracy rate for most ecological studies. Such information is important to wildlife biologists and land managers who track the expansion of exotic species and develop programs to control them. "The only thing worse than not having data is inaccurate data," he says.



*Volunteers count the number of native and exotic crab species found on the Atlantic Coast from New Jersey to Maine, and in the process they learn about crabs and other creatures inhabiting the intertidal zone, as well as about the scientific process (top). Employees from Genzyme Corporation are among the volunteers who identify, size, and sex crabs for David Delaney's invasive crab study (bottom). Photograph: Linda Hurt (top) and Island Alliance (bottom).*

## Monitoring montane taxa

The MEGA-Transect project charts the state of the environment along the Atlantic Coast by monitoring the effects of global warming and other ecological changes along the Appalachian Trail over time. To do so, the project uses ongoing research and monitoring studies as well as encourages new ones, says NPS's Owen.

The MEGA-Transect project was launched at a November 2006 meeting in Shepherdstown, West Virginia. Sponsored by the ATC, the NPS, and the US Geological Survey (USGS), the meeting brought together wildlife biologists, botanists, and land managers. As conceived at the meeting, the project uses the more than 36,000 members and 5000 active volunteers of the conservancy as citizen scientists. Indeed, ATC volunteers have been working as volunteers on research studies since 2003, says David Startzell, ATC's executive director.

For the MEGA-Transect project, ATC volunteers gather data on when trees and other plants produce buds, leaves, flowers, and seeds; record when butterflies and other pollinators appear; or note when migrating birds enter and leave their summer range. They also monitor the pH levels of lakes, ponds, marshes, streams, and springs, and they measure and photograph air and water pollution.

In designing the study, MEGA-Transect scientists looked for inspiration to surveys conducted by the All Taxa Biodiversity Inventory in the Great Smoky Mountains, the Northeast Temperate Network, and the Boston Harbor Islands National Recreation Area, Mitchell says. One project that served as a model for working with volunteers is Mountain BirdWatch. Begun in 2000 by the Vermont Center for Ecostudies (VCE), the survey monitors the abundance and distribution of songbirds living in the upper elevations of New England mountains. Study scientists work with about 175 volunteers who count the birds they see or hear at designated stations along transects in the woods. More experienced birders count all the birds they see or hear, whereas less experienced volunteers count individuals of five easily recognized species.

"Many research and monitoring programs would be unsustainable without citizen scientists," says Dan Lambert, northeast regional coordinator for the American Bird Conservancy. Lambert is also a research associate at the VCE in Norwich and director of the Mountain BirdWatch survey. "It would be very difficult to attract enough field technicians for what is only a three- or four-week job." Using volunteers to collect data allows VCE to run the survey on a shoestring, Lambert adds, saving about $30,000 a year. "To put paid technicians in the field would cost us that much." Citizen scientists spend one 24-hour period in the woods in June each year gathering data. VCE researchers and collaborators analyze the data and write the scientific articles.

The mountain bird survey has also tracked the distribution of Bicknell's thrush. Once thought to be a subspecies of the common gray-cheeked thrush, Bicknell's thrush is now listed as a species of special concern in several states because its numbers are thought to be declining. Using data gathered by citizen scientists, researchers at VCE and Antioch University have developed a computer model that predicts where the thrush breeds, which lets planners know where to permit development or how climate change may affect the birds, Lambert says.

McShea conceived the idea for surveying mammals, especially predators, along the Appalachian Trail after attending the November 2006 meeting that launched the MEGA-Transect project. The six-month survey done in 2007, which he hopes to repeat in 2008, used some 50 cameras to take pictures of all animals that pass in front of the lenses. Helms's cameras captured shots of deer, raccoons, rabbits, squirrels, mice, and a bobcat. Phillips caught those animals plus a coyote.

## A new way to get involved

The list of projects that rely on volunteers is long and getting longer, and some focus on less showy creatures. Under the North American Amphibious Monitoring Program, USGS scientists facilitate and coordinate state projects using volunteers to monitor frog populations. Each participant listens for calling frogs at 10 to 15 sites four times a year, and some have been doing so since the mid-1990s. "That lets us see trends and set conservation priorities," says Sam Droege, a USGS wildlife biologist in Laurel, Maryland. More recently, Droege enlisted about 20 volunteers to catch, bag, and tag native bees in a pilot study designed to begin gathering data on bee numbers and status.

In another study, the NPS recruited nine volunteers, all experienced birders, to help park staff and scientists monitor coastal waterbirds one summer on the 34 islands that make up the Boston Harbor Islands National Recreation Area. The citizen scientists identified up to a dozen species (depending on their level of expertise) of birds and then counted the number of breeding birds, nests, and chicks. They also observed and recorded the birds' breeding behavior. Before the surveys began, Albert and other NPS scientists had to spend more time developing protocols and training citizen scientists than their field research usually requires. "We had to accommodate our volunteers in ways you usually don't have to with paid staff or consultants," he says. That included special training sessions and scheduling boat trips to the Boston Harbor Islands when the weather and water conditions made it safe for volunteers to go.

Elsewhere, the University of Minnesota's Karen Oberhauser has enlisted more than a thousand volunteers to monitor monarch butterflies at some 600 sites from the Upper Midwest to Texas and

*On shore, citizen scientists use mirrors attached to poles to see inside the nests and count the number of eggs and chicks of shorebirds on islands in the Boston Harbor. Photograph: Sherman Morss Jr.*

east to the Atlantic Coast. Once a week, citizen scientists travel preselected transects that take them into backyards, farms, parks, and preserves or along railroad tracks to look for milkweed plants, the female monarch's preferred place to lay eggs. Each time citizen scientists visit a study site, they record the number of milkweed plants as well as the number of monarch eggs and larvae they find. By checking each site weekly throughout the summer, the volunteers obtain data on survival rates as the caterpillars grow and advance from one stage to another. Some volunteers also record data on the status of the milkweed plants and the number of other insects found on each, and a few are trained to collect monarch larvae to check for tachinid flies, parasites of monarch caterpillars.

"Instead of looking for environmental problems, this study aims to develop data on a large geographic scale and time period," Oberhauser says. "Recording the ups and downs of monarch numbers over time requires the help of volunteers living throughout their range. Our volunteers are often more dedicated than many of our undergrads." Beyond gathering data for the scientific study, Oberhauser is also helping citizen scientists learn about monarch butterflies and how science is done.

In the end, what have citizen scientists achieved? Has their labor actually helped advance scientific knowledge? Yes, says Bonney, pointing, for example, to complete and accurate maps of the breeding ranges of every North American bird. And with the help of volunteers in gathering data, researchers have been able to track the progress of conjunctivitis in house finches, the first time scientists have ever followed a disease in a wild animal. Citizen scientists have also collected data that helped scientists develop guidelines for land managers to preserve habitat.

Nevertheless, despite years of practice, the use of citizen science is still an evolving art. "We're playing it by ear," says NPS's Mitchell. "We are designing studies and involving citizen scientists as we go along." Stevens anticipates that the ATC's volunteers and other citizen scientists will help provide information that policymakers need to understand ecological changes on the public lands they manage. "The environment belongs to all of us," Stevens says, adding: "We want to give people a chance to get involved in its preservation in a whole new way."

For more information, visit these sites:

*www.birds.cornell.edu/LabPrograms/CitSci/*

*www.appalachiantrail.org*

*www.dlia.org/atbi/*

*www.birds.cornell.edu/citscitoolkit*

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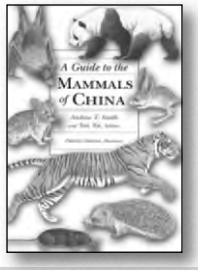


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