

Device-ive Science

***How Electronic
Devices
Encourage
Citizen
Involvement With
Environmental
Research***



Photo courtesy of Ian Callow.

Meet the Scientists

► **Dr. Duncan McKinley**, Policy Analyst (ə nə ləst): My favorite science experience was finding a new species of cricket. I found the cricket when I was a high school student volunteering with the Student **Conservation** Association and the Forest Service.



Photo courtesy of Duncan McKinley.



Photo courtesy of Russell Briggs.

◄ **Dr. Russell Briggs**, Soil Scientist: My favorite science experience is teaching students and professionals how to describe the range of soil characteristics that can be observed in the field.

► **Dr. Ann Bartuska**, Ecosystem Ecologist: My favorite science experience was the quiet of the maple forest in West Virginia as I collected leaf litter samples in **decomposition** bags to return to the laboratory for weighing. A fun science experience was standing in a West Virginia wetland in early spring with a thermometer to test whether the internal temperature of skunk cabbage before the buds expanded really DID hit 85° Fahrenheit...as reported in the journal *Scientific American*. It only hit 82°F!



Photo courtesy of Ann Bartuska.

Glossary words are **bold** and are defined on page 17.

What Kinds of Scientists Did This Research?

ecosystem ecologist: This scientist studies the interactions of organisms with each other and with nonliving parts of their environment.

policy analyst: Policy analysts review, evaluate, and **monitor** policies and legislation. They also write reports that **synthesize** various types of information.

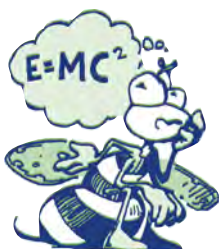
soil scientist: This scientist studies soils as one of Earth's natural resources.



Figure 1. Mobile and electronic devices are an important part of most people's lives. Photo courtesy of Ian Callow.

Thinking About Science

Like everything else, science changes over the years. Many scientific changes are happening because technology is rapidly advancing. Twenty years ago, few people imagined that hand-held mobile devices would be at the center of our lives (**figure 1**). Few people thought that phone calling, emailing, texting, playing video games, and watching videos would be possible by reaching into their pocket. As computer chips got smaller, these technological advances became possible.



At the same time, users access large computers (known as the “cloud”) through the Internet. Exchanging information among these large computers enables scientists to **analyze** larger and larger amounts of information. Scientists can combine large **datasets** to answer questions that no one had imagined just a few years ago. People with mobile devices can now also access a range of information because of these networked computers. Computers have made science more accessible to almost everyone.

Thinking About Environment

Scientific topics related to the natural environment may change because of what people have learned from past scientific studies. In forest science, for example, scientific priorities have changed over the years. In the 1940s and 1950s, scientists studied ways to increase the amount of wood that could be cut from national forests (**figure 2**). They studied how to put wood to the best use.

In the 1960s and 1970s, environmental protection became an important scientific topic. Since 1993, much forest science has focused on ecosystem services and how natural resources can be managed **sustainably**. Ecosystem services are environmental health benefits and human benefits provided by a community of plant and animal species. Examples of ecosystem benefits include clean air, clean water, outdoor recreation, beautiful scenery, and wildlife habitat (**figure 3**).



Society may also influence natural resource science topics. For example, people might be asked to reduce their water use because of a period of time when little to no rain has fallen. These people might become more concerned about having enough clean water. This concern will influence scientists, who will then study ways to better conserve water supplies. You can see that society and science are closely related. Both past scientific findings and social needs influence the topics that scientists study.



Figure 2. Manti-La Sal National Forest, Utah. National forests are large areas of forest that the Forest Service manages on behalf of all Americans. For more information about national forests, visit <http://www.fs.fed.us/managing-land/national-forests-grasslands>. Photo courtesy of Babs McDonald.

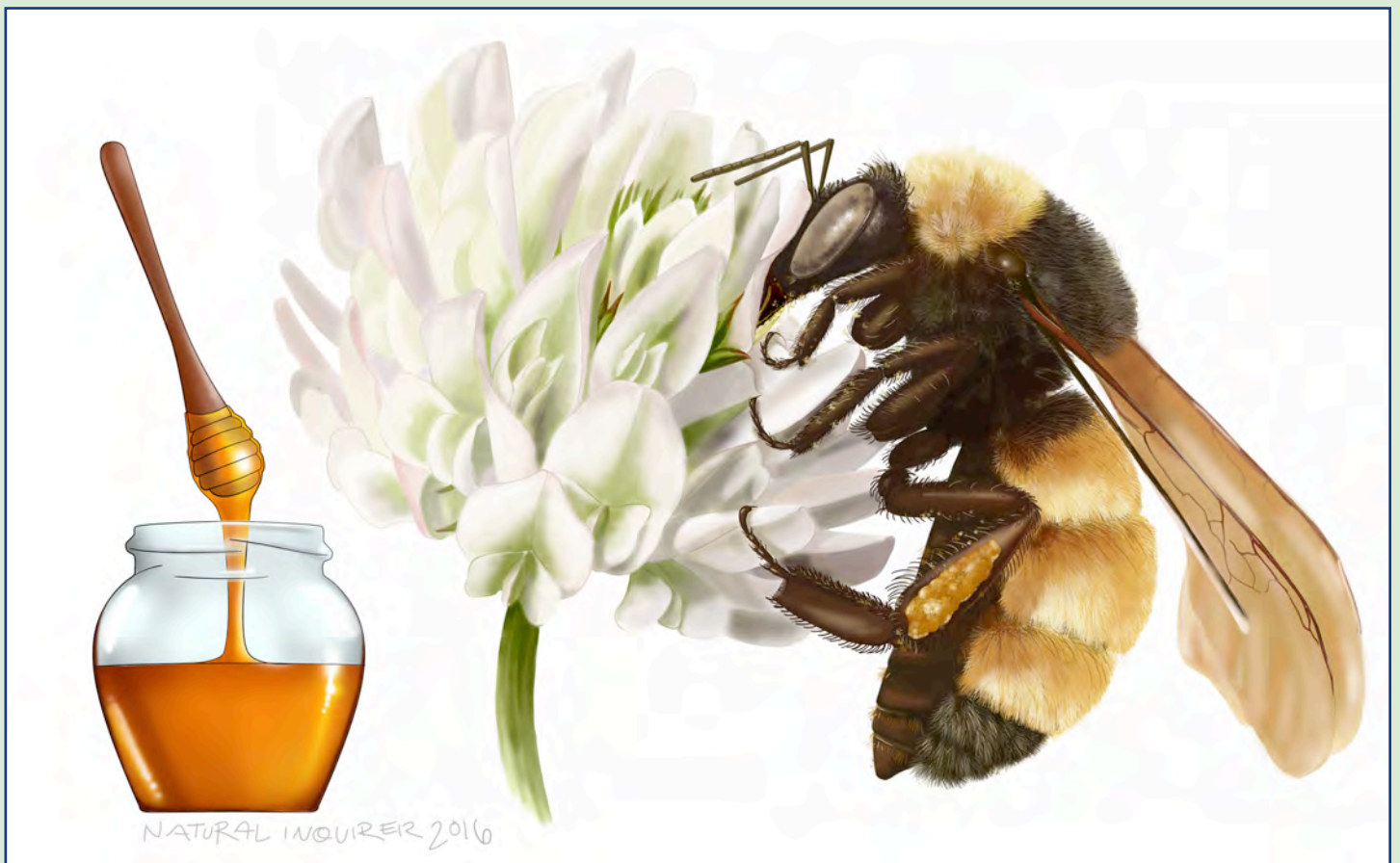


Figure 3. Ecosystem services have become an important topic for natural resource scientists. Ecosystem services are the benefits that nature provides through natural processes. People benefit from ecosystem services, such as flower pollination. Illustration by Stephanie Pfeiffer.

Introduction

Before the introduction of personal computers, tablets, cell phones, and other mobile devices, scientific findings were more difficult to share widely. People read about some scientific advances in magazines and newspapers or learned about them on TV or the radio (**figure 4**). Scientists presented findings in person to other scientists or to people interested in their topic. Scientists wrote about their findings and published them in hard-copy science journals. These journals are similar to *Natural Inquirer*, but are written for other scientists (**figure 5**). Ordinary citizens, however, had a more difficult time gaining

access to a wide range of recent scientific results. Now that most people have access to computers and mobile devices, getting recent scientific information is easier (**figure 6**). These devices also make it easier for citizens to communicate with scientists.

The scientists in this study wanted to know how new technology has affected the relationship among scientists, science, and citizens. The scientists wanted to understand how the Forest Service can more effectively involve citizens with their scientific projects. (Learn more about the Forest Service by reading the inside back cover of this journal.)

Who Is a Citizen?

Often the word “citizen” means a legal member of a particular country, such as a U.S. citizen. Merriam-Webster’s dictionary also defines “citizen” as a person who lives in a particular place. In this article, the word “citizen” refers to any person who lives in a community.

Reflection Section

- What questions did the scientists want to answer?
- Name one way that better computer access has changed the relationship among scientists, science, and citizens.



Figure 4. In the past, when citizens were interested in recent scientific findings, they usually read about them in newspapers and magazines. People also learned about scientific findings on TV and the radio. Photo courtesy of Babs McDonald.

ISSUES IN ECOLOGY

Published by the Ecological Society of America

Investing in Citizen Science Can Improve Natural Resource Management and Environmental Protection

Duncan C. McKinley, Abraham J. Miller-Rushing, Heidi L. Ballard, Rick Bonney, Hutch Brown, Daniel M. Evans, Rebecca A. French, Julia K. Parrish, Tina B. Phillips, Sean F. Ryan, Lea A. Shanley, Jennifer L. Shirk, Kristine E. Stepenuck, Jake F. Weltzin, Andrea Wiggins, Owen D. Boyle, Russell D. Briggs, Stuart F. Chapin III, David A. Hewitt, Peter W. Preuss, and Michael A. Soukup



Figure 5. Scientific papers published in science journals are usually more challenging for nonscientists to read. Photo courtesy of Babs McDonald.

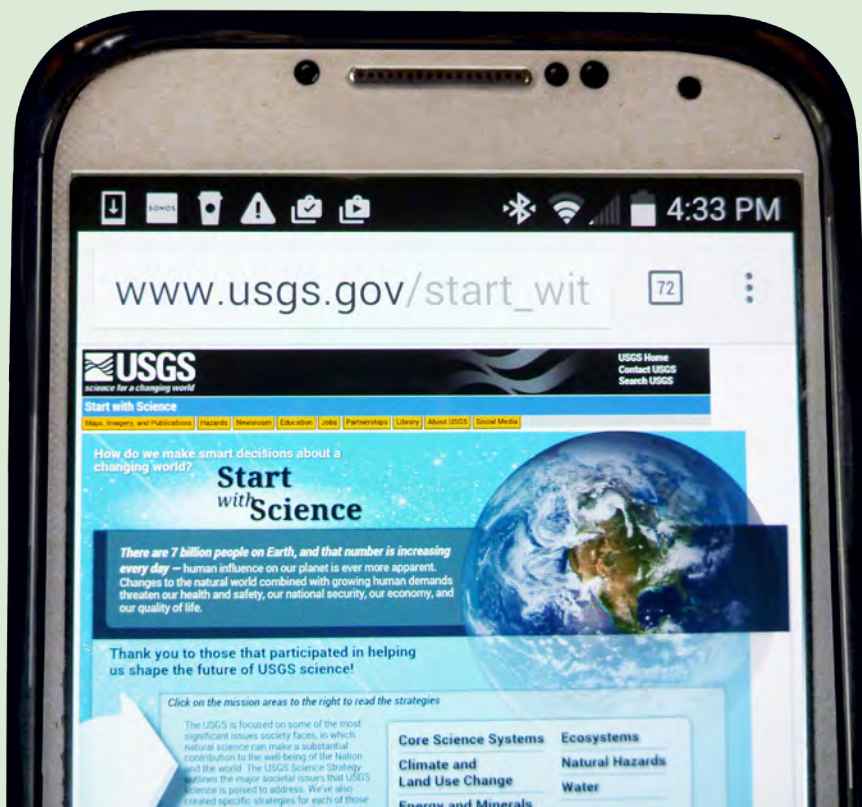


Figure 6. Getting access to recent scientific findings is easier today because of personal computers and mobile devices. Photo courtesy of Babs McDonald.

Methods

The scientists searched online and through printed science journals for information related to their questions. They read more than 100 papers discussing citizen involvement with science projects (**figure 7**). The scientists conducted interviews and spoke with people practicing citizen science. Citizen science is the practice of including volunteers in the process of scientific study (**figure 8**). The scientists also relied on their own experience to better understand the involvement of citizens in the scientific process.

The scientists read about the ways that scientists share their results and how citizens

learn about scientific results. Using all of the information they collected, the scientists explored different ways that citizens have been involved in scientific projects.

The scientists examined how new technology has made it easier for citizens to participate in science projects. For example, citizens can use their cell phones and tablets to record and submit data. Citizens can also use their tablets and cell phones to identify plant and animal species. Finally, the scientists considered whether using citizens to help with science projects is a **viable** way for Forest Service scientists to do their research.

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The Reliability of Citizen Science: A Case Study of Oregon White Oak Stand Surveys

AARON W. E. GALLOWAY^{1,2a}, MARGARET T. TUDOR^b, and W. MATTHEW VANDER HAEGEN^c

Abstract

We trained students (grades 3–10) through classroom presentations to survey an Oregon white oak (*Quercus garryana*) stand in Washington, USA, and compared their data to those obtained from professionals. In May and July 2002, 607 students and 8 professionals surveyed 59 and 22 50-m transects, respectively. We enumerated oaks and ponderosa pines (*Pinus ponderosa*), measured diameter at breast height, and rated the crown shape of oaks. Oak diameter at breast height measurements and tree counts were consistent between students and professionals ($\alpha = 0.05$), but subjective crown assessments and live or dead status differed. Students tended to overreport relatively rare pines and larger oaks relative to professionals. This project provided resource managers with data describing oak diameter at breast height and distribution while educating students about the ecology of local wildlife habitat.

West, Associate Editor

Published: December 2006

Keywords: [citizen science](#), [data reliability](#), [Oregon white oak](#), [Quercus garryana](#), [Washington](#)

Figure 7. The scientists read more than 100 papers like this one related to the topic of citizen science. This study compared data, or information, collected by students with data collected by scientists. Image courtesy of Babs McDonald.



Figure 8. Citizen science projects usually engage citizens with data collection for scientific projects. Photo courtesy of the Forest Service, Northern Region.

Reflection Section



- ❦ Pretend you are one of the scientists in this study. What would you ask other scientists if you were interested in whether citizen science can be a successful way to conduct research?
- ❦ Name two ways that new technology makes it easier for citizens to participate in citizen science projects.



Lend a Hand
Care for the Land

Citizen Science Connections

Volcanic ash consists of tiny, sharp particles of rock and natural glass that are blasted into the air during a volcanic eruption. Volcanic ash can threaten the health of people, livestock, and wildlife. It also poses a hazard to flying jets, can damage electronics and machinery, and can interrupt electric power and telecommunications. Alaska has many active volcanoes, averaging two eruptions per year.

Is Ash Falling? is a citizen science project that helps scientists better understand volcanic activity. Scientists ask citizens to collect data about ash fall in Alaska.

Is Ash Falling? lets citizen scientists:

- Report observations of volcanic ash online;
- Collect ash samples and send them to the Alaska Volcano Observatory;
- Contribute to public health and safety;
- Contribute to science.

For more information, visit <https://www.avo.alaska.edu/ashfall/ashreport.php>.



Photo courtesy of Game McGimsey, the Alaska Volcano Observatory and the U.S. Geological Survey.

Findings

The scientists found that professional scientists still conduct most of the scientific research. However, citizens can help professional scientists by collecting data, sharing results, and understanding the findings.

The scientists discovered that working with citizens enables professional scientists to expand the **spatial** or **temporal** scope of their research. Citizens may rapidly collect information, and since they are volunteers, costs may be lower. Another benefit of involving citizens in science projects is that citizens sometimes have a lot of experience with and knowledge about the topic. These citizens might know a lot about the local environment. This experience and knowledge helps scientists to understand their results (**figure 9**).

The scientists found a few barriers to involving citizens in some science projects.

Some kinds of data collection, for example, require too much specialized training. For projects that can include citizens, however, citizens benefit by learning about the research topic. Citizen scientists also benefit by learning the scientific method and improving their observation skills (**figure 10**).



Figure 9. Citizens can help scientists understand findings because of their knowledge or experience with a topic. These local citizens are measuring the diameter of a live oak tree in coastal Georgia. Photo courtesy of James Holland.

Reflection Section



Brainstorm a number of natural events that your class could observe, record, and submit to scientists. Discuss why having this information might be helpful to scientists.



Think of a person who has a lot of knowledge and experience with a particular topic. How could that person's knowledge and experience help a scientist?



	Regular Science	Citizen Science
What is the research for?	Scientific understanding: potential application to management.	Scientific understanding: public involvement and improved science understanding and potential application to management.
Who is the research for?	The public, institutions, and professionals.	The public, institutions, professionals, individual citizens, and citizen groups.
Whose knowledge matters?	Scientists.	Scientists and citizens.
The scientific method used is chosen for...	Proper scientific methods.	Proper scientific methods: public involvement and learning.
The main research purpose is...	Hypothesis testing; discovery.	Monitoring and biological understanding.

Figure 10. The scientists compared regular science with citizen science.

Discussion

Access to science is increasing with new technology. Many citizen science projects, however, do not require new technology to be involved. This technology is also supporting public interest in and concern about the natural environment. More often, these interests and concerns influence which topics environmental scientists study.

New technology also makes it easier for citizens to contribute to certain kinds of environmental science projects. Citizen involvement in science projects can increase

the amount of information available to scientists. Citizen involvement can also improve scientists' understanding of their topic.

Citizen scientist projects enable citizens to learn more about the environmental topics that interest them. These projects enable citizens to contribute to both science and the environment. Finally, citizen science projects may increase the efficiency of collecting information by expanding the area being studied and the number of observations that can be made.



Reflection Section

- ✿ Think about your own access to technological devices. To which environmental science topic would you like to contribute? How do you think you could contribute?
- ✿ How would you benefit from being involved in an environmental citizen science project?

Glossary

analyze (ə nə līz): To study or examine carefully.

conservation (kän sər vā shən): The care and protection of natural resources such as forests and water.

conserve (kən sərɪv): To avoid wasteful or destructive use of something.

dataset (dā tə set): A comprehensive collection of related data organized for convenient access, generally in a computer.

decomposition (dē kəm pō zi shən): The act or process of breaking up, as by decaying or rotting.

hypothesis (hī pă thə səs): (1) An unproven idea that is accepted for the time being and is often tested during a scientific study; (2) An educated guess about the solution to a question or problem based on existing knowledge.

monitor (mä nə tər): To watch, observe, listen to, or check (something) for a special purpose over a period of time.

priority (prī or ə tē): Something that is more important than other things and that needs to be done or dealt with first.

spatial (spā shəl): Of or relating to space and the relationship of objects within it.

sustainable (sə stā nə blē): Of, relating to, or being a method of using a resource so that the resource is not depleted or permanently damaged.

synthesize (sīn thə sīz): To make something by combining different things.

temporal (təm p(ə) rəl): Of or relating to time as opposed to space.

viable (vī ə bəl): Capable of being done or used.

Accented syllables are in **bold**. Marks and definitions are from <http://www.merriam-webster.com>. Definitions are limited to the word's meaning in the article.

Adapted from McKinley, D.C.; Briggs, R.D.; Bartuska, A.M. 2012. When peer-reviewed publications are not enough! Delivering science for natural resource management. *Forest Policy and Economics*. 21: 1-11.



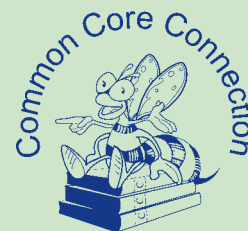
Time Needed

One class period

Materials

(for each student or group of students)

- Device-ive Science Graphic Organizers on page 19



The questions you will answer in this FACTivity are: What are the advantages and disadvantages of having citizen scientists perform data collection and reporting for the community? Would you vote for or against having citizen scientists help with local data collection and reporting in your community?

Methods

You are the manager of your community's water supply. Part of your job is to measure the local reservoir's (re zə **vwärz**) water depth to ensure that enough water is available for your community's needs. A reservoir is a place where water is stored for use (**figure 11**). During the summer when less rain is falling, an employee must measure and record the water level at the same time every day. The employee who performed this work reports to you and provides you with the information.

You have just been told that your budget has been cut and you need to reduce costs. You decide to set up a citizen science project to help you get your job done. You plan to have seven adult citizens measure the water level and record the water depth into an online system. Each of the seven citizens will come once a week, on their assigned day. If the level falls below a certain depth, the citizen scientist must immediately report this information to you.

You want to present this idea to your boss, but you know she will want to know the advantages and disadvantages of having community members serve as citizen scientists. In small groups, complete the following forms. Use correct grammar, spelling, and punctuation when writing in the forms. Following the exercise, each group will give a short presentation to the class.

You will first brainstorm a list of considerations and write these considerations in the following form. These considerations are things that might impact the project's success. Examples include: (1) citizens will be motivated to measure and record accurate levels because they need the water, too; and (2) citizens may not know how to accurately measure and record water depth. Then organize these considerations into advantages and disadvantages.



Figure 11. A reservoir is an area where water is stored for use. Many reservoirs are large, human-made lakes. Photo courtesy of Babs McDonald.

Device-ive Science Graphic Organizer

Group Members: _____

Considerations

Advantages of Having Citizens Test the Water Level

Disadvantages of Having Citizens Test the Water Level

After listening to the advantages and disadvantages identified by all groups, hold a class vote on whether to invite citizens to test your community's water supply level.



FACTivity Extension

Note: You must have online access to do this FACTivity Extension.

Pick one of the citizen science projects listed in the Citizen Science Resources section on page 89. Go to the listed website and explore the project so that you become familiar with it.

How might the same advantages and disadvantages you identified in the FACTivity apply to this citizen science project? What other considerations might apply to the citizen science project?

Natural Inquirer Connections

You may want to refer to these *Natural Inquirer* resources for additional information and FACTivities related to this article:

- “The Morel of the Story” *Natural Inquirer* monograph. This monograph compares the knowledge of local mushroom gatherers with scientific information.
- For more information about ecosystem services, see the *Natural Inquirer* Ecosystem Services edition.



These resources, along with others, can be found at <http://www.naturalinquirer.org/all-issues.html>.

What's in a Name?

This article's title is a play on the word, “divisive.” Divisive means to cause disagreement among people. In this article, device-ive refers to the use of technological devices to conduct citizen science.

Web Resources

Forest Service Citizen Science

<https://www.fs.fed.us/working-with-us/citizen-science>

Federal Citizen Science Resources

<https://www.citizenscience.gov>

Science for Citizens

<https://scistarter.com/>

Student Conservation Association

<http://www.thesca.org>



If you are a trained Project Learning Tree educator, you may use “Publicize It!” as an additional resource.

