INTERAGENCY CITIZEN SCIENCE TOOLKIT

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FOREWORD

Science and federal lands go hand in hand. To steward public lands in line with their missions, federal land management agencies rely on scientific information about those lands and the natural and cultural resources they support. To obtain that information, the agencies conduct a broad range of studies—basic research, applied research, scientific inventories, monitoring, etc.—and invite partners from the scientific community to do likewise. Through this work the agencies demonstrate that science is for public lands.

The converse is also true: public lands are for science. Across the states and territories, the federal land management system contains our planet's full range of biomes, physical processes, social-ecological systems, land uses, resource-linked economies, and evolving relationships between human and nonhuman communities. Thus, federally managed public lands provide endless opportunities for scientists and other scholars, and the public at large, to create knowledge and advance our understanding of the world. These lands help everyone engage with science in personally and professionally meaningful ways.

Citizen science sits squarely at the center of this close association between science and federal lands. The agencies need far more scientific information than can be provided by their own staff and other professional scientists. The gap can be filled in part by citizen science projects that invite public volunteers to generate and/or make available scientific information about public lands and their resources. By participating in such projects, anyone—regardless of scientific background or prior knowledge—can help ensure science continues to inform the management of their public lands. They can also build new personal connections to public lands, new understandings of science as an evidence-based way of knowing about our world, and even an enhanced identity as a "science person." Countless benefits come when a visitor sits down amid the grandeur of a mountain meadow and carefully counts the flowers on a small patch of ground for the first time.

Given the relevance of citizen science to their missions, four federal land management agencies (Bureau of Land Management, National Park Service, US Fish & Wildlife Service, US Forest Service) and a partner (Schoodic Institute) collaborated to develop this toolkit and associated training materials. The goal is to stimulate and guide citizen science activities on federal lands, whether projects are led by agencies or by partners. A wide variety of projects are already underway (from dragonflies to historic documents, arctic lands to tropical waters) and more are surely to come. Lessons should be shared. Best practices should be disseminated. Wheels should be invented only once. This toolkit and associated materials will help you build success and avoid pitfalls.

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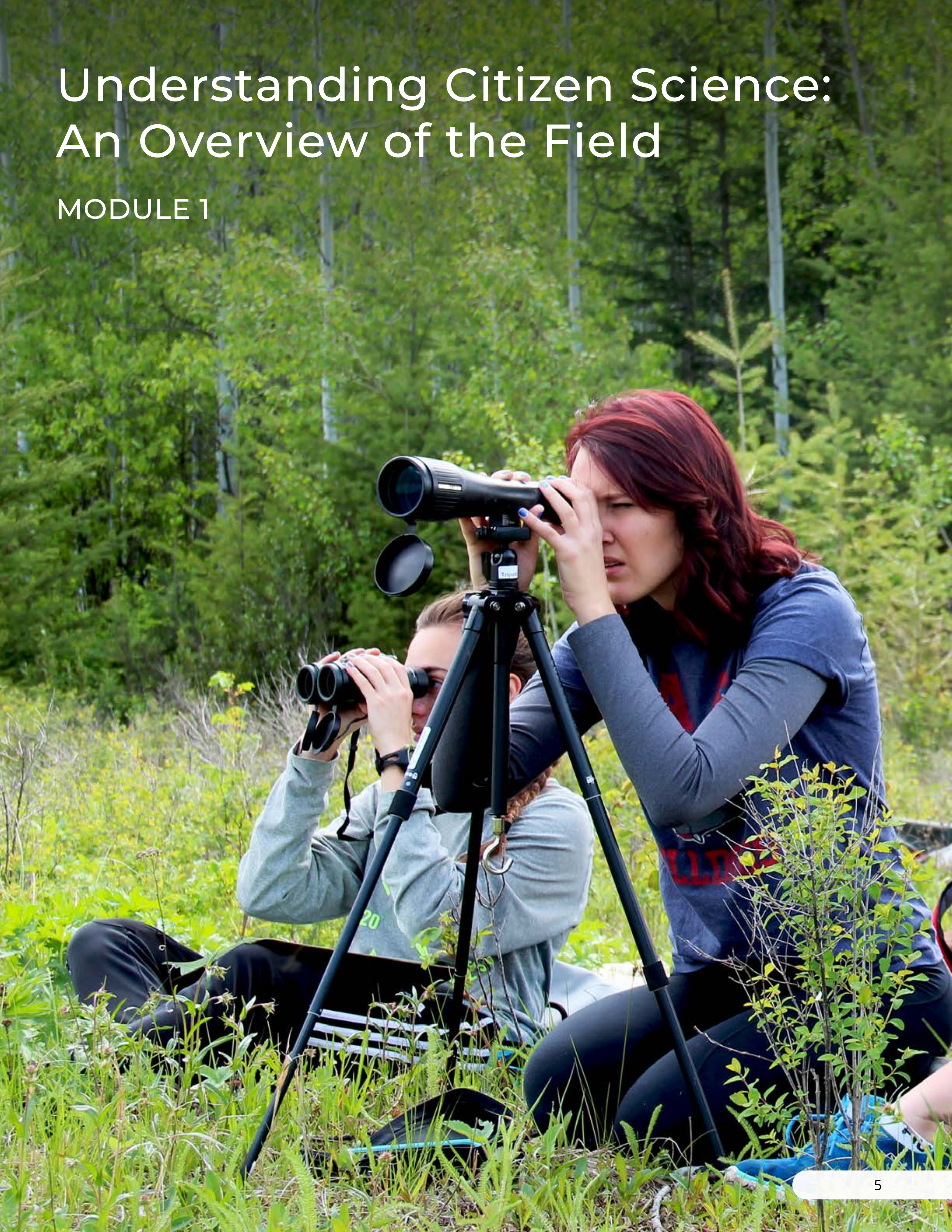
Understanding Citizen Science: An Overview of the Field

MODULE 1



INTRODUCTION

The goal of this module is to provide an overview of citizen science—its scope, breadth, and impacts—and to show how it is being used and can be used by federal land management agencies.

Public lands across the United States (US) face many challenges. Public agencies are tasked with managing the lands under their control for sustainable populations of fish, wildlife, and plants; for clean air and water; for maintenance of cultural sites; and for a variety of uses that may include grazing, energy development, or recreation. Accomplishing this task requires a vast amount of information. Managers need to understand changes in species abundance and distribution across time and space. They need to document changes in phenology over long spans of time. They need to know about the quality of air and water across landscapes, about the movements and distributions of invasive species, and about the locations and status of cultural resources.

How can the information required for informed policy and management be gathered? One way is to facilitate public participation in scientific research, also known as citizen science, which employs the abilities and knowledge of individuals who are willing to pay close attention to their environment, record what they experience, and submit their information to centralized databases where it can be collated and analyzed for the benefit of science and society.

Most federal and state agencies, as well as many nongovernmental organizations, employ citizen science to some degree. In some cases, data collected by volunteers can supplement information already possessed by agency scientists and managers, whereas in other cases, citizen science is the only way that data can be collected in sufficient quantity, geographic expanse, and timeframes to address significant environmental issues.

CITIZEN SCIENCE AND FEDERAL AGENCIES

Citizen science has been used extensively to monitor birds. Visitors to many parks, forests, grasslands, and refuges contribute data to eBird, which began collecting sightings from birders across the country in 2002. Since that year, 624,000 birders have submitted 51 million complete bird checklists including 10,517 species, and papers based on eBird data now number in the hundreds. Agency staff frequently mine the eBird database to learn what birds are present at different times of year on the lands that they are entrusted to manage.

Currently eBird is the largest contributor to the Global Biodiversity Information Facility (GBIF), which is an international data network aimed at providing open access to data about all types of life on Earth. eBird also is a major contributor to the North American State of the Birds Reports, which are used to help set bird conservation priorities across dozens of federal and state agencies. The 2022 State of the Birds Report showed that birds are declining in every habitat except wetlands, where decades of investment and management have resulted in dramatic population gains. Land managers can use the information in this and previous reports to determine which bird species are most in need of management in the areas under their purview.

Citizen science studies far more than birds, however. Some projects focus on entire landscapes. These include bioblitzes, for which teams of participants locate and document as many animals and plants as they can over a specific location, usually over the course of one day. An example is the Basin and Range Bioblitz at the Basin and Range National Monument, which has yielded data used to refine habitat models within the monument and to inform a monument resource management plan. Many bioblitzes are built on a citizen science platform called iNaturalist. This massive data collection tool has more than one million registered participants. Many of these

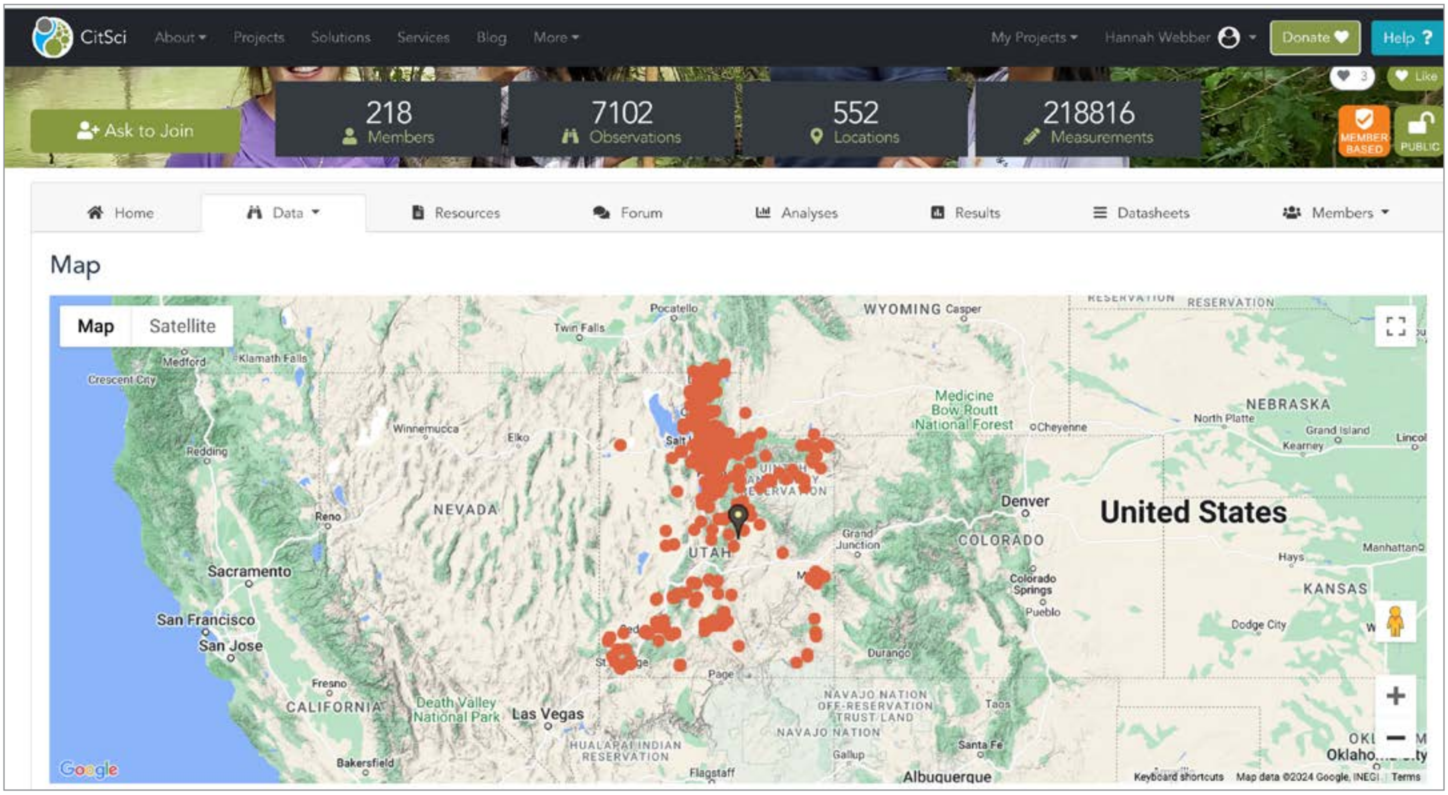


Figure 1.1: Utah Water Watch, managed by Utah State University, monitors the quality of water in multiple locations across the state, including streams and rivers in national forests and on other federal lands.

observers contribute sightings not only during bioblitzes but also on their visits to public lands every day, and their accumulated data can be mined to determine locations of plants and animals across landscapes. Like eBird, iNaturalist is a major contributor to GBIF.

Still other citizen science projects focus on monitoring phenology, that is, seasonal and annual changes in the timing of events in nature. Some parks and refuges have set up phenology trails, such as the Rio Grande Phenology Trail at the Valle de Oro National Wildlife Refuge in Texas and the Gulf Coast Phenology Trail in the Big Branch Marsh, Sandhill Crane, and Grand Bay National Wildlife refuges in Mississippi. Observers along these trails monitor the timing of leaf budding, plant flowering, and bird nesting to document local impacts of climate change. Data collected on these trails are usually submitted to a centralized database housed at [Nature's Notebook](), a project of the USA National Phenology Network. Like contributors to iNaturalist, many observers use Nature's Notebook to contribute sightings not only along phenology trails but also on their regular outings, and these data can be examined to detect changes in phenology on public lands. Nature's Notebook is yet another major contributor to GBIF.

Citizen science also is used to monitor water quality in parks, refuges, and forests. [Alabama Water Watch]() has established a baseline of water quality observations within six priority watersheds in Alabama's national forests, and [Utah Water Watch](), for which the US Forest Service has partnered with Utah State University, monitors the quality of Utah's waterways and provides water quality education.

Citizen science also is applied to studies of cultural significance. For example, a project called Measuring Historic Structures was conducted by the National Park Service Southeast Region in 2016. Participants made structural measurements in Tuskegee Institute National Historic Site, Everglades National Park, Kennesaw Mountain National Battlefield Park, Cape Hatteras National Seashore, Fort Raleigh National Historic Site, and Wright Brothers National Memorial. The data were used to update the Southeast Region's List of Classified Structures database.

These examples show just a few of the myriad ways that citizen science data are being used. Citizen science is growing rapidly around the world, as evidenced by the development of hundreds of projects and the publication of thousands of peer-reviewed papers based on citizen science data. New publications appear in the literature each week—many in top-ranking journals—and several review papers have summarized the impacts of citizen science, for example, "Citizen Science Can Improve Conservation Science, Natural Resource Management, and Environmental Protection" (McKinley et al. 2017).

Figure 1.2: Different types of citizen science are appropriate for different situations. Data collection and data processing projects usually involve large audiences collecting or managing large quantities of data, whereas community-based projects typically focus on environmental issues of concern to local groups of involved individuals.

TYPES OF CITIZEN SCIENCE

All of the projects that we've described so far are data collection projects. These typically start with the need for data about an environmental or cultural phenomenon, such as the size or distribution of an animal population; a defined data collection protocol, so that all data will be collected in the same way and can be combined for analysis; and a willing audience, that is, a group of people with sufficient interest in the subject to be motivated to venture out and collect data. Data collection projects are sometimes called "contributory" projects because the participants contribute data to answer a question or to address an issue defined by scientists or resource managers (Bonney et al. 2009). These are the projects most commonly implemented by federal agencies, and we provide many examples throughout this toolkit.

Another form of contributory citizen science involves participants in working with data that already exist, for example, photos taken by wildlife cams, rather than in collecting new information. Such data processing projects include FISHstory, which engages participants in classifying photos of historic fish catches to study changes in fish harvest over time. Data processing projects are widely employed in the citizen science field but are not commonly developed by land-based federal agencies. Like data collection projects, data processing projects require a defined data management protocol, so that all data can be classified in the same way and combined for analysis; and a willing audience, in this case a group of people disposed to spend hours in front of a computer screen processing images.

Yet another group of citizen science projects are community-based projects, sometimes called community science. These typically start with a question about a local environment that directly affects a community. They often involve a partnership between community members and scientists to design and implement the project, and for this reason are sometimes referred to as co-created projects (Bonney et al. 2009). They generally require an audience with a very direct interest in the project outcome. Some community-based projects are completely run by the community.

While all of these types of citizen science have common goals—to increase scientific knowledge, to inform conservation or policy action, and to increase public scientific literacy—they differ in their techniques and audiences. When designing a citizen science project, it's important to consider which type or model is most appropriate for your situation.

THE TERM "CITIZEN SCIENCE"

Public participation in scientific research goes by many names. In this toolkit we use the term "citizen science," which in the US originated with the Cornell Lab of Ornithology around 1995 when Lab staff desired a new name for what had been called the Lab's "cooperative research program." In Europe, the term also came into use in 1995 when Alan Irwin published his book Citizen Science, which focused less on public data collection and more on what he called "scientific citizenship" (Irwin 1995). Since 1995 the term citizen science has grown and flourished, having slightly different, but complementary, meanings in the different hemispheres. In most parts of the world today, citizen science refers primarily to projects that involve the public in collecting or processing data.

In more recent years, the term has garnered controversy in some circles, primarily because it is perceived as being non inclusive. Indeed, if the Cornell Lab of Ornithology staff in 1995 had any idea how use of the term would grow—even making it into the Oxford Dictionary in 2014—they would have thought harder about using the word "citizen." While they were thinking of project participants as "citizens of the world," it's understandable how some people have found the term problematic in the context of 21st-century politics.

For this reason, some groups have started replacing the term citizen science with the term community science, which can feel more inclusive. However, community science is a specific type of public participation in science that requires meaningful public involvement in multiple aspects of a project. We caution projects that adopt the term community science to be sure that they are employing truly inclusive approaches to project design.

AGENCY SUPPORT FOR CITIZEN SCIENCE

The federal government took a major step toward elevating citizen science through congressional and executive branch actions when it passed The Crowdsourcing and Citizen Science Act of 2017 (15 US Code § 3724), which authorizes federal agencies to invest in and use citizen science to advance agency missions and to stimulate and facilitate broader public participation in science. The Act lists some of the benefits of citizen science. These include: "accelerating scientific research, increasing cost effectiveness to maximize the return on taxpayer dollars, addressing societal needs, providing hands-on learning in STEM (science, technology, engineering, and mathematics), and connecting members of the public directly to Federal science agency missions and to each other." Clearly the federal land management agencies have a green light to employ citizen science in their work.

The four federal land management agencies that are partners in this toolkit—the US Forest Service (USFS), the Bureau of Land Management (BLM), the National Park Service (NPS), and the US Fish and Wildlife Service (USFWS)—have taken this green light to heart.

The USFS has contributed heavily to agency-based citizen science by setting up a Citizen Science Competitive Funding Program (The CitSci Fund) in 2017. This program awards funds to USFS-based projects following a rigorous application process. Many of the projects highlighted in this toolkit have resulted from this program. The USFS also employs a full-time citizen science coordinator and maintains a Citizen Science Community of Practice and a citizen science website, which includes a wealth of information about citizen science (including a toolkit that is the forerunner of the one you are reading).

The BLM operates many citizen science projects, several of which are highlighted in this toolkit. It employs citizen science co-coordinators, and in 2023 released a comprehensive "Crowdsourcing and Citizen Science Action Plan: Public Science for Public Lands Fiscal Years 2023–2028." This report is well worth reading by staff in all public agencies and could be used as a blueprint to develop action plans by any agency desiring to improve the development and power of citizen science throughout their organization.

The NPS has employed citizen science for decades, and many of its projects are discussed in the modules that follow. NPS has citizen science co-coordinators and has developed a white paper outlining a strategic approach to citizen science throughout the service. The USFWS also has employed citizen science for decades, and many USFWS projects also are highlighted in this toolkit. In 2018 the USFWS commissioned a report on the status of citizen science within the agency. It includes numerous recommendations for strengthening USFWS-based citizen science, including establishing an interagency citizen science working group, which led to the development of this toolkit (Bonney and Shirk 2020).

CONCLUSION AND USING THE TOOLKIT

Citizen science is a means of public engagement in scientific work that is expanding the scope, reach, and impact of research throughout federal land management agencies. Citizen science is providing opportunities to collect data at scales not feasible for professional scientists alone, and it is engaging members of the public in compiling and using issue-relevant evidence to effect change. Citizen science has the potential to address major challenges in conservation and natural resource management, particularly those that require attention to both social and scientific aspects of a problem.

We hope that you are inspired to develop a citizen science project or to strengthen one that you are already running, and this toolkit is designed to help.

- Module 2 describes the situations in which citizen science is most appropriate as a research technique. This is a critical module to read and consider before diving into the citizen science project development process.
- Module 3 explains how to set goals and actionable objectives for a project.
- Modules 4 and 5 discuss how to build a project team to develop a project and how to engage participants, stakeholders, and partners in carrying out a project.
- Module 6 delves into collecting and reporting data and designing appropriate surveys.

- Module 7 describes how to get started in citizen science by adopting or adapting existing projects and/or using a citizen science project development platform.
- Module 8 explains how to recruit, train, and engage project participants.
- Module 9 discusses sharing project results with participants and the wider world.
- Finally, Module 10 is about evaluating a project to determine its success.

We hope that all of the information in this toolkit will help you design, implement, or improve a project. But we also hope that it will show you that citizen science is not a simple undertaking. It often demands unexpected time and funding, as well as a willingness to understand what it takes to engage with the public. In resource management in particular, with so much at stake, citizen science provides the opportunity to reflect on and learn about the human dimensions of ecological research and environmental management, as well as about the science. If researchers and managers embrace the opportunity—and the challenge—to listen and learn as well as to interpret and share, we can fulfill the potential of citizen science to expand knowledge for science-based conservation.

FURTHER READING

Bonney, R., Ballard, H., Jordan, R., McCallie, E., Phillips, T., Shirk, J., and Wilderman, C.C. 2009. *Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education*. A CAISE Inquiry Group Report. Washington, D.C.: Center for Advancement of Informal Science Education (CAISE).

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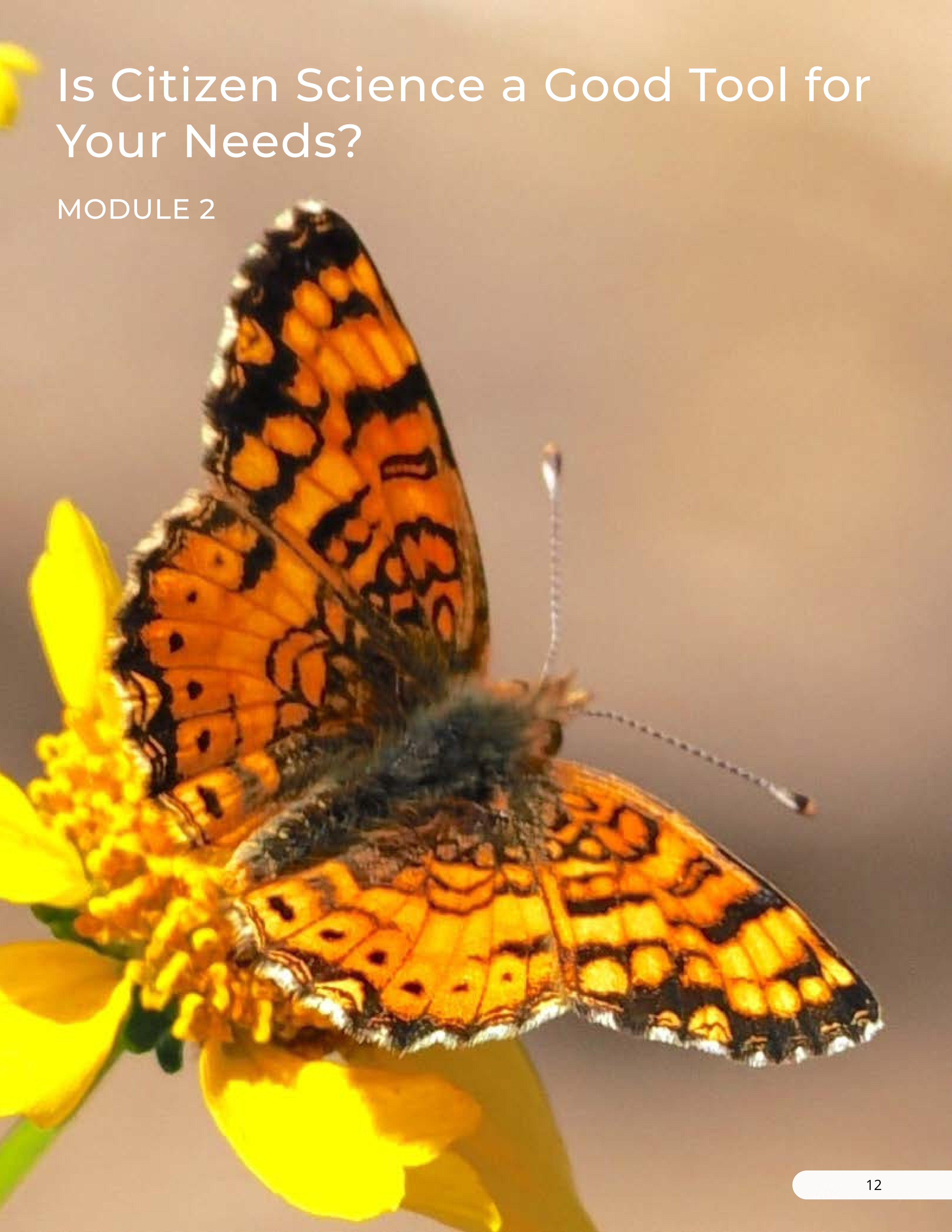
McKinley, D.C., Miller-Rushing, A.J., Ballard, H.L., Bonney, R., Brown, H. Cook-Patton, S.C., Evans, D.M., French, R.A., Parrish, J.K., Phillips, T.B., Ryan, S.F., Shanley, L.A, Shirk, J., Stepenuck, K.F., Weltzin, J.F., Wiggins, A., Boyle, O.D., Briggs, R.D., Chapin III, S.F., Hewitt, D.A., Preuss, P.W., and Soukup, M.A. 2017. Citizen science can improve conservation science, natural resource management, and environmental protection. *Biological Conservation*, 208, pp.15–28. https://doi.org/10.1016/j.biocon.2016.05.015

Is Citizen Science a Good Tool for Your Needs?

MODULE 2



INTRODUCTION

The goal of this module is to help you determine when citizen science can be an appropriate tool for achieving scientific and resource management objectives for parks, forests, refuges, grasslands, or similar lands or waters. We assume that you have come to this module with specific scientific questions or management needs that you wish to address.

Perhaps you want to assess patterns, in space and/or time, of one or more ecosystem components. For example, is a particular species present in an area? How many individuals of that species are present? These types of assessments likely require monitoring. Or perhaps you want to monitor ecosystem functions, for example, to see whether local runoff is causing stream pollution. This type of assessment would likely require a process study. Or, you might want to gather information about hard-to-find species or the impacts of crises such as earthquakes or oil spills, which would likely require observational studies.

All these types of studies are possible with citizen science, but citizen science might not always be the most appropriate method to meet your needs. If your objectives fall into one of the following three categories, you're probably on the right track.

WHAT ARE YOUR NEEDS?

1. You need or desire more or different data than you can collect with staff scientists.

A major strength of citizen science is its ability to collect information across broad areas and over long periods of time, because the number of potential volunteers typically exceeds the number of available staff professionals (including researchers, faculty, and students). Many eyes or ears can help to detect environmental changes such as population declines, incidences of pollution, and the introduction and spread of invasive species. In some cases, volunteers have access to data that government employees do not, such as observations or measurements on private lands near parks or refuges, or information related to individual activities such as hunting or fishing. In addition, when a lot of data are needed quickly—for example, after a large-scale die-off of birds or fish—entire communities of volunteers sometimes can be mobilized to document the cause and scale of the disaster and to determine what areas are most in need of mitigation.

For example, many citizen science projects rely on the huge number of individuals who enjoy keeping track of the birds they see in their yards and neighborhoods or on their travels. One project made possible because of the birder throng is Desert Avicaching. Run by the Bureau of Land Management (BLM), this project is essentially a game that encourages birders to collect data about migrant birds from rarely visited locations in the Mojave and Sonoran deserts where information about bird populations is typically not captured. Because of the large number of birders who enjoy traveling and a birding challenge, in just one season, 72 volunteers submitted 409 surveys from 53 different locations, representing more than 16,000 birds of 102 different species. The data inform management and mitigation planning regarding alternative energy development in southern and eastern California. More information about Desert Avicaching can be found in Module 8.

2. You need to organize or analyze a quantity of data or images that is larger than you have staff to handle.

When properly managed, volunteers can organize and analyze huge amounts of data, particularly when the data are available online. For example, citizen science participants have sorted and analyzed millions of satellite images and photos from web cams. With proper training and guidance, volunteers also can identify specimens and assess population attributes such as species abundance and distribution. In some cases, highly trained volunteers such as retired professionals may be able to contribute to higher-level data analysis.

An example of a data organization and analysis project is FISHstory, run by the South Atlantic Fishery Management Council. For this project, volunteers examine historic photos of dockside fish catches taken prior to the 1990s to classify and document the species and lengths of fish caught during that time period. The data help to explore whether the past decades have shown changes in overall catch composition or in the seasonality of catches and to see whether the sizes of fish caught over time have changed. This information can be used to inform fisheries stock assessments. While anyone can tag FISHstory photos, data verification is performed by experienced fishers and scientists who are trained to work with project data.

3. You want to work with a community to help its members address environmental questions or issues that are personally important to them.

Sometimes scientists and managers determine that to manage resources in parks, forests, grasslands, refuges, or similar lands and waters where communities are deeply invested in the area's resources, they must work closely with the local community. Together they can identify research needs, create data collection protocols, and analyze and disseminate research findings.

Such community-based projects must be undertaken with respect for the community and for its members' concerns and knowledge. Such knowledge is often called local or traditional knowledge, which can greatly enhance the information needed for the land management agency and the community to effectively manage resources. Sometimes questions or issues arise from a community rather than from scientists or managers. In this case, a project is truly "bottom-up."

An example of a community-based project that originated from an Indigenous community is the Tribal Nations Botanical Research Collaborative, which is a partnership among the US Forest Service (USFS), several Arizona Tribes, and Northern Arizona University. For this project, Tribal members collect information on traditionally used plants that have cultural, medicinal, or economic values important to Tribal communities. As part of project development, Tribal members trained federal land managers about the cultural importance and uses of native plants so that USFS staff would understand the needs of the community to use and protect the plants. Project data are used to restore and manage populations of the plants on federal lands and to enhance Tribal access to them. More information on this project is included in Modules 4 and 7.

If one or more of the above three categories fits your situation—you need to collect large amounts of data, you need to organize large amounts of data, or you wish to address environmental concerns of a specific community—then citizen science may be an appropriate endeavor. However, before you dive into project design, we suggest that you consider answering six screening questions.

SCREENING QUESTIONS FOR CITIZEN SCIENCE SUITABILITY

1. Are your project goals and objectives clear and easy to explain to potential volunteers?

Some research or monitoring projects have easily explainable goals and objectives, for example, to determine the timing of plant budding in the spring or to determine whether certain species of animals are found in a specific area. Other scientific projects have goals that are more complex, for example, to determine the species composition of an entire woodland. Projects that have clear goals and objectives that are easy to describe and that will be of interest to your potential participants are the easiest projects to design and to successfully

Figure 2.1: Citizen science is appropriate when agency staff require more or different data—or need to manage more data—than they can collect or manage with staff alone. Citizen science also works well for helping community members address environmental issues of concern to the community.

implement. The project may involve surveillance, monitoring, or hypothesis testing—all are possible through citizen science—but regardless of the approach under consideration, the more straightforward the objectives, the easier it will be to design a citizen science project to meet them.

The goal of the Dragonfly Mercury Project (DMP), for example, is clear and easy to understand: to collect dragonfly larvae for mercury analysis in national parks. Project organizers train volunteers and lead them in collecting samples in various locations throughout the parks. The samples are then shipped to a laboratory for analysis. Land managers use the data to determine what parts of a park might be at greatest risk of contamination. This information can inform where and how to mitigate mercury risk through land management practices. The DMP is described in more detail in Modules 4 and 7.

Setting clear goals and measurable objectives for citizen science projects is the focus of Module 3.

2. Will you be able to recruit participants with appropriate knowledge, skills, and motivations to collect and/or analyze the data that you wish to obtain or manage? Alternatively, will you be able to match the skills of the volunteers that you already have with your data collection needs?

Different types of data collection or data management will appeal to different groups of participants. For example, charismatic species such as wolves, bears, and large birds tend to receive more public interest than other species, including most plants. Similarly, study sites near tourist destinations and college campuses tend to receive more attention than do those in urban and industrial areas. If your project needs include specific participant knowledge, skills, and motivations, those must be matched with the individuals most likely to be recruited. For certain taxa and ecological processes and for some biogeographic regions or geographic locations, citizen science projects may not be sustainable if large or ongoing data sets are required. However, when a community is motivated to engage with an issue, large numbers of participants may be recruited for studies that might at first appear to be of limited interest.

For example, the Mapping Lamprey Distributions in Oregon project for which the USFS is a major partner, might seem at first to be a hard sell to participants. Lampreys aren't particularly cute, and they live in water where they can be hard to see. In this case, project staff focused their recruitment materials on the need for information about barriers to the migrations of lampreys, which are a critical part of native ecosystems. By sending public service announcements to local media outlets, placing flyers on bulletin boards, posting on social media sites, and sending emails to partner groups, the project recruited nearly 50 volunteers over three years, which allowed the creation of a map of lamprey distribution using eDNA collected through water sampling.

Recruiting, engaging, and retaining volunteers is the focus of Module 8.

3. Can the data collection that your project requires be accomplished with protocols that are straightforward and enjoyable for participants to undertake?

Data collection needs must be matched to the capabilities of project participants. Many volunteers will be highly knowledgeable about your subject and will be able to follow detailed data collection protocols. Still, the protocols that you develop for your project should be as simple as possible and easily explainable, to keep participants motivated. Some volunteers will be unable or unwilling to perform tasks that have multiple steps or which require sophisticated analytical instruments or large time commitments. However, the motivations and skills of volunteers may surprise you. While many projects focus on simple protocols such as weekly checklists, others have employed complex protocols with great success. Some volunteers can bring needed expertise or equipment that resource managers do not have.

For example, volunteers in the Hovenweep Debris Field project, which is operated by the BLM, conduct intensive surveys to monitor 120 cultural resources in the Canyons of the Ancients National Monument in Colorado. Working under the supervision of a site steward, the participants follow transects on which they tally and document artifacts with photos. Despite the complexity of the project, 65 volunteers regularly participate four to six times per year. The large volunteer force results in part from the longevity of the parent program—more than 20 years—and the fact that the project leader works closely with the Colorado Archaeological Society, which has a chapter nearby, and the Southwest Colorado Canyons Alliance. Members of both groups are avid avocational archaeologists who are eager to put their expertise to work.

Developing data collection protocols is discussed in Module 6.

4. Will you be able to train participants to follow protocols for data collection or management?

Sometimes volunteers need only minimal training to follow project protocols. For example, how to make simple measurements, such as tree circumference, is easy to explain without extensive instruction. However, following more complex protocols, such as monitoring water quality or documenting archaeological sites, requires more support or even direct supervision. Research has shown that volunteers with proper training and guidance can accurately identify specimens to the level of species and can accurately assess important population attributes such as species abundance and distribution. Some volunteers also can develop the skills needed to use sophisticated analytical instruments. However, well-developed training materials, whether deployed in person or online, are needed to successfully implement nearly all citizen science projects because most of the volunteers will require at least basic instructions.

Training is also essential for project staff, who need to watch over the project and in some cases ensure the safety of volunteers.

A project with strong training programs is Engaging Angler Scientists run by Trout Unlimited in collaboration with the USFS. To inform management of brook trout on National Forest lands, volunteers conduct spawning surveys, which require them to recognize variations in redds (spawning nests). To reduce observer errors owing to inexperience and the challenges of observing redds in turbid waters, project staff hold workshops for monitoring certification. In addition, many online training tools are available to volunteers, including videos, tutorials, publications, and a FAQ page.

Participant training is discussed in Module 8.

5. Will public participation in the scientific process serve your agency's goals for public input and engagement and/or help in agency decision-making?

Federal agencies all have some form of mandate for public input and engagement. Agencies meet these mandates in many ways, from public comment periods following the release of environmental impact statements, to meetings of advisory committees that include members of the public, to town hall meetings. Some parks, forests, refuges, and grasslands may feel that they already have sufficient public input and engagement to make wise management decisions. Others seek more public involvement on a regular basis, or desire to have more public support for the decisions they make.

Citizen science can enhance public input by directly involving members of the public in contributing or analyzing data to help inform management challenges. In some cases, volunteers may comment on a proposed action based on what they learned in a citizen science project, or they might share information within their communities, motivating others to get involved in natural resource and environmental management and policy decisions.

In addition, public participation in research might aid in developing locally appropriate research questions and methods. Local or traditional knowledge can reveal complementary ways of understanding local ecology, environmental trends, and threats to species and livelihoods. When research is informed by the best available knowledge and by multiple perspectives, research questions and methods can be formulated that take into account the integrated social and scientific dimensions that managers and policymakers must address.

6. Do you have the support and funding to engage in citizen science?

Citizen science data are not free. Designing, implementing, and evaluating a citizen science project takes dedicated funding for staff and resources, as you will learn in the next few modules. Attempting to design and implement a citizen science project without funding and support from your agency is likely to lead to frustration.

Citizen science efforts can sometimes be run on a shoestring when a park or refuge adopts an ongoing citizen science project or uses an existing citizen science platform to collect data. If you have limited resources and want to try engaging your visitors in data collection, this is probably the best approach. Using existing resources to bring citizen science into a park, refuge, forest, or other protected land is the focus of Module 7.

One other consideration is the Paperwork Reduction Act (PRA), which requires all agencies to obtain the approval of the Office of Information and Regulatory Affairs (OIRA) in the Office of Management and Budget (OMB) before requesting the same type of information from 10 or more members of the public. Therefore, some agency staff worry that the PRA will make their project challenging if not impossible to develop and carry out. However, as evidenced by the examples provided in the toolkit, many parks, forests, and refuges have successfully received clearance to implement their projects. For Department of the Interior staff, an Information Collection Clearance Officer (ICCO) is available to assist in obtaining OMB approval. In addition, the DOI is working toward a generic clearance that, once approved, will expedite the process for all DOI citizen science projects.

If you can answer yes to all of the above questions, then your needs should align to a citizen science approach! The table below summarizes the questions and should help in determining whether you want to pursue citizen science for your particular needs. If so, Module 3 guides you in setting obtainable goals and measurable objectives for your project, which are important first steps in project design.

Increasing suitability for a citizen science approach.

CLARITY OF GOALS & OBJECTIVES	PARTICIPANT RECRUITMENT	PROTOCOL COMPLEXITY	TRAINING REQUIREMENTS	IMPORTANCE OF ENGAGEMENT	RESOURCES AVAILABLE
✓ Clear goals & objectives?	✓ Easy to recruit?	✓ Simple and/ or enjoyable protocols?	✓ Minimal training needed?	✓ Engagement important?	✓ Resources & staff support available?
✗ Vague goals & objectives?	✗ Challenging to recruit?	✗ Complex or challenging protocols?	✗ In-depth training needed?	✗ One-way communication staff support sufficient?	✗ Resources & staff support minimal?

Figure 2.2: Projects having the characteristics in the shaded areas of this table are typically best suited for citizen science. The table is adapted from Figure 1 of Pocock et al. 2014: *Choosing and Using Citizen Science: A Guide to When and How to Use Citizen Science to Monitor Biodiversity and the Environment* (see further reading).

FURTHER READING

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Project Goals, Project Objectives, and Developing a Project Model

MODULE 3

INTRODUCTION

The goal of this module is to guide you in setting obtainable goals and measurable objectives for your project. Whether you are implementing an existing project—such as the Dragonfly Mercury Project described in Module 2—or developing a brand-new project to meet a specific need for research or management, clearly articulating project goals and objectives is important for two reasons. First, setting goals and determining associated objectives will help you to create a strong project plan. Second, you will measure the success of your project largely by determining whether and how you have achieved your objectives.

GOALS

Goals articulate what you want your project to accomplish. Citizen science practitioners tend to think of project goals in three main categories: Goals for science, goals for management and policy, and goals for public science literacy. A project can meet goals in all three categories if it is carefully designed to do so.

While goals should be visionary, they also should be realistic and relevant with regard to project scale, participant interests, and agency priorities. For citizen science projects, developing goals typically requires determining what data are required, who is likely to collect the data, who is likely to use the data, and what would constitute project success.

For example, a national wildlife refuge might have a goal of improving habitat for wildlife. While a good goal for the refuge, it's too broad for a citizen science project. But if the refuge is suffering from an influx of invasive species that are impairing wildlife habitat, then a possible goal for a citizen science project could be to document the presence and distribution of invasive plant species. Such information could be used to develop an invasive species management plan.

Let's consider three different citizen science projects developed at or in partnership with a federal agency: The Flying Squirrel Project, the Saguaro Census, and Colorado Bat Watch.

The Flying Squirrel Project began in 2014 after the Center for Biological Diversity filed notice of intent to sue the US Fish and Wildlife Service (USFWS) on a claim that the San Bernardino flying squirrel (*Glaucomys sabrinus californicus*) should fall under the protection of the US Endangered Species Act (ESA). At the time, data on the population and range of the species were insufficient to make a ruling under the ESA. The USFWS established the Flying Squirrel Project to determine the squirrel's abundance, distribution, and habitat use.

The Saguaro Census is led every ten years by staff at Saguaro National Park to study the long-term health and vitality of the park's namesake cactus. Begun in 1990 and developed into a citizen science project in 2000, the census aims to understand the impact of environmental factors such as fire, drought, and climate change on saguaro health, distribution, and survival. It also aims to build greater public awareness of long-term ecological processes.

Colorado Bat Watch was started by Rocky Mountain Wild to monitor Colorado bat populations in response to current and emerging threats, especially from white-nose syndrome (WNS), which has killed millions of bats in the eastern and midwestern US since 2006. Volunteers report bat roost site locations and help monitor roost sites, especially maternity roost sites, as a means of understanding impacts of WNS on local populations. The project is intended to provide reliable data to inform bat management efforts and to build public support for bat conservation.

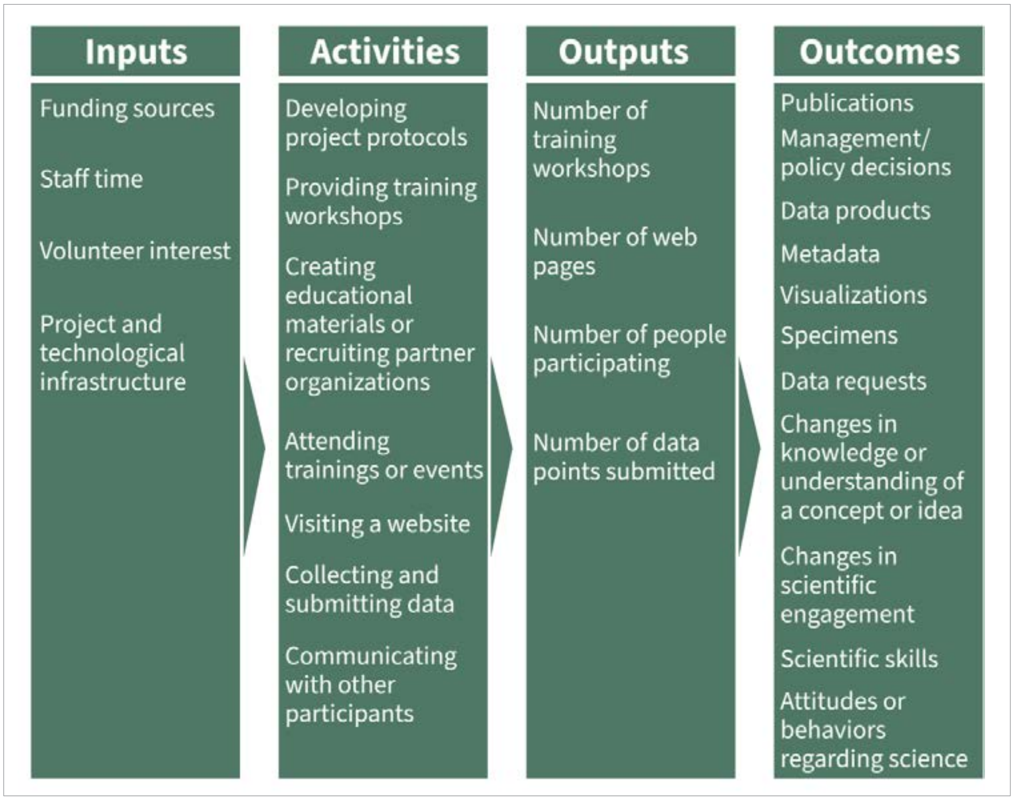

Figure 3.1: A project model is developed to meet project goals and objectives and includes available inputs, planned activities, expected outputs, and desired outcomes.

As each of these projects began, project developers defined their goals:

- Flying Squirrel Project: Determine the distribution and habitat use of the San Bernardino flying squirrel.
- Saguaro Census: Study the long-term abundance, health, and vitality of saguaro cactus throughout Saguaro National Park.
- Colorado Bat Watch: Provide reliable data to meet multi-agency statewide bat monitoring needs.

These goals clearly state what each project is intended to accomplish. As such, they serve as guiding stars. Goals help to keep a project on track and can be visited regularly to ensure that project resources are being used wisely. But as important as goals are, they're not actions. Developing steps to achieve project goals requires setting project objectives.

OBJECTIVES

Objectives are specific, measurable steps that can be taken to achieve desired goals. Let's revisit our hypothetical example of a project whose goal is to document the presence and distribution of invasive plant species. Three objectives to achieve that goal might be:

- Map the parts of the refuge that harbor the highest densities of invasive plants at different times of year.
- Determine which invasive plant species are most abundant in different parts of the refuge.
- Help volunteers understand the impact of invasive species on native flora and fauna.

Sometimes objectives are stated as specific accomplishments. For example, an objective could be "have 50 volunteers visit all areas of the refuge to map the five most common invasive species in each location." However, some designers find this approach a bit too formulaic and not responsive to a project's evolving needs.

To determine the San Bernardino flying squirrel's distribution and habitat use, the Flying Squirrel Project developed these objectives:

- Employ tracking cameras to collect data to determine the squirrel's distribution and habitat use in the San Bernardino and San Jacinto mountains.
- Recruit and engage volunteers in setting out cameras on their properties to ensure data collection across a wide area, particularly on private property.
- Have volunteers send photos from the cameras to the San Diego Natural History Museum for review and storage, and post photos on a project website to allow tracking of flying squirrel locations.
- Analyze the data to determine flying squirrel populations.
- Build trusting relationships and shared understandings with the local community.

To study the long-term health and vitality of saguaro cactus, The Saguaro Census developed these objectives:

- Detect changes in cactus distribution that may be related to climate or other landscape-level processes.
- Study saguaros on randomly distributed study plots across a wide elevation gradient.
- Train volunteers to collect data: Search for, measure, and flag all saguaros encountered along belt transects within each plot.
- Analyze data and make them available on the park's website.

To achieve the goal of providing reliable data to meet statewide bat monitoring needs, organizers of Colorado Bat Watch acted on four objectives:

- Collect baseline data on roost site locations and characteristics, with emphasis on roost sites in anthropogenic structures, talus, trees, and snags.
- Make data on bat roost sites available to agency partners.
- Engage volunteers in monitoring at bat roost sites.
- Generate media around the project and hold trainings and educational events to recruit the public to participate and to teach the public about the value of bats and their conservation.

As you can see, all objectives for all three projects are specific and measurable steps to be taken in service to the project's stated goal.

With goals and objectives generated and defined, project developers can begin to work through the steps of engaging partners, recruiting participants, and designing protocols, data collection mechanisms, and instructional supports to fully engage participants in collecting accurate and meaningful data. These steps are described in Modules 4 through 7. But first, to aid in project design and development, some projects develop a project model.

PROJECT MODELS

A project model is a visual depiction of how a project is intended to work. Project models link goals and objectives to the project inputs—the resources available to develop the project—and to the activities that will be required to achieve project objectives. They also show desired project outputs and outcomes. In addition to informing project design, project models can help with project evaluation, a subject we will return to in Module 10. Meanwhile, to describe project models, we need to define the terms inputs, activities, outputs, and outcomes.

Inputs

Inputs are the resources that are made available to the project. They include funding sources, staff time, volunteer interest, and project and technological infrastructure.

Activities

Activities refer to things that a project will develop, conduct, or make available to meet project objectives. They can be broken down into activities conducted by project staff and activities completed by project participants. Staff activities could include developing project protocols, providing training workshops, creating educational materials, or recruiting partner organizations. Participant activities might include attending trainings or events, visiting a website, collecting and submitting data, and communicating with other participants. Ideally, all planned activities should be defined during project development. Note: Blurring can occur between objectives and activities, and you can spend hours reading about the differences between them with little enlightenment. Don't get too hung up on this.

Outputs

Outputs are the direct products or services of the activities, and typically are easy to quantify. Examples include the number of training workshops that staff deliver, the number of web pages that a project develops, the number of people who participate in a project, and the amount of data that participants submit. Note that outputs are important to plan for and to measure, but in themselves do not constitute project success.

Outcomes

Outcomes are things that happen as a result of activities and outputs. Scientific outcomes can be publications, management/policy decisions, or data products, which could include metadata, visualizations, specimens, and data requests. For example, a scientific outcome could be a new understanding of the speed and depth of the spread of invasive species on a refuge.

Audience outcomes could be changes in knowledge or understanding of a concept or idea resulting from project participation or experience. Audience outcomes also can include changes in scientific engagement, scientific skills, and attitudes or behaviors regarding science. Outcomes are harder to measure than outputs but are critical to a project's success.

All of these items—inputs, activities, outputs, and outcomes—are in service to project goals and objectives and should be included in a project model. Models should be created early in project development and should then guide project design and deployment. Project models should not be static tools, however. As projects evolve to reflect changes in underlying assumptions and theory, models should be updated to reflect this thinking. Some projects create a poster of their project model and then, as the work progresses, use sticky notes to update and "check off" tasks within the model. Or they create an online tool that all team members can access, discuss, and modify.

For example, organizers of the Saguaro Census use Gantt charts in Excel to organize the project. This involves brainstorming, reviewing the goals and objectives, then establishing tasks and timelines (and the person responsible) in the spreadsheet. The Gantt chart becomes the agenda for each planning meeting. Eventually it becomes highly detailed as team members plan how they will accomplish the work on each plot by designating a

GOALS	OBJECTIVES	INPUTS	ACTIVITIES	OUTPUTS	OUTCOMES
Document the presence/ distribution of invasive plant species	Map parts of the refuge with highest densities of invasive species	Amount of staff time available	Train volunteers to identify species	Numbers of plant identified	Refuge managers use maps to understand which parts of the refuge are most in need of mitigation
	Determine which invasive species are most abundant in different parts of the refuge	Dozens of motivated volunteers	Create mapping protocols and data forms	Numbers of maps created	Refuge managers undertake actions to control invasive species
	Help volunteers understand the impact of invasive species on native flora and fauna		Create resource showing photos of areas before and after invasive species became established	Number of times volunteers access online resources	Volunteers gain greater understanding of why invasive species are a problem and what can be done to mitigate the problem

Figure 3.2: Sample project model for a hypothetical project focused on studying the distribution of invasive species on a national wildlife refuge.

group or groups, date or dates, and so forth. They can track the progress of the entire project and adjust as they go to make sure they accomplish the work in the time frame available.

Some things to keep in mind when developing a project model: First, your objectives must be extremely clear. If your objectives are vague, designing activities to achieve them will be challenging. Second, activities must be well aligned to the objectives and are likely to miss a target that is fuzzy or moving. Third, any activity must provide full support to participants to achieve desired outcomes.

Determining goals and objectives and developing a program model that describes project activities can be a collaborative and bonding exercise among team members and partners, leading to a unified project vision including shared understanding of project goals, agreement on targeted project outcomes, and expectations about when those outcomes will occur.

Above is a simplified project model of our hypothetical invasive plant project.

PROJECT RESULTS

The Flying Squirrel Project

The Flying Squirrel Project developed two parallel studies that collected the same types of data. The first study, led by the San Diego Natural History Museum, involved citizen science on private lands. To engage residents across the San Bernardino region in putting out motion sensor cameras to capture photos of the squirrels, museum staff put up wanted posters saying “call this number!” and worked with local news outlets to have articles published in the local paper. From this effort they enlisted numerous volunteers to collect and submit data across the entire range of the squirrels. The second study was carried out by UC San Diego college interns working on the US Forest Service land. By combining data from both studies into a single dataset, sufficient information was generated to determine that the squirrels were not endangered (Clark et al. 2021).

The Saguaro Census

Saguaro Census data are used to develop research grants and to share with other scientists, for example, at gatherings such as the 2023 saguaro research symposium. In addition, the accumulation of data over a long timescale allows ecosystem-wide understanding that can have implications from policy decisions to educational endeavors. For example, the results of the 2020 Census confirm the patterns that emerged from the 2010 Census. The large number of relatively young saguaros just beginning to reach reproductive age is a positive sign and reflects the survival of many saguaros that germinated throughout the park from roughly 1970 to 1990. This trend is offset, though, by a smaller establishment of saguaros since the 1990s, which appears to be strongly associated with drought that is probably driven by temperature extremes. Saguaro census data also are used on a daily basis for interpretive programs and to answer questions from the media—from local to international—about how the saguaros are doing and how they are responding to climate change (Swann et al. 2011).

Colorado Bat Watch

Phase I of Colorado Bat Watch was launched on International Bat Appreciation Day, April 17, 2023. Since then, nearly 50 observations have been submitted to the project’s database, providing information on the location and characteristics of bat roost sites throughout Colorado. Phase II of Colorado Bat Watch will involve conducting emergence counts, that is, counts of the number of bats emerging from a roost in the evening, at select roost sites.

Project staff also have begun placing lockboxes where community members can check out bat monitoring kits, which include a bat detection device that allows volunteers to identify possible bat species and other materials needed to monitor bats. In addition, project staff have held several educational events to engage the public in bat conservation. These have included bat walks and talks with experts from Bat Conservation International during which participants can learn about the ecology of bats, where they live, what they do, and why they're important.

Equally important, as protocols were field tested and data collection began, Bat Watch staff realized that the project needed additional objectives. They added five, which are:

- Increase the number of citizen scientists engaged, emphasizing underrepresented communities, ranchers, and farmers.
- Increase the number of roost sites identified and the geographic distribution of colonies monitored.
- Identify roost sites suitable for WNS vaccine testing.
- Refine protocols and ensure consistency with the North American Bat Monitoring Program, also known as NABat.
- Assess the feasibility of engaging volunteers in acoustic surveys.

These new objectives emphasize the need for a project to be flexible and to change over time as a project comes to life or as it encounters "real-world conditions," and they are emblematic of the changing and adaptive nature of good citizen science.

Module 4 discusses developing a project team to design and carry out your project. It also discusses identifying your audience—that is, the individuals or groups who will participate.

FURTHER READING

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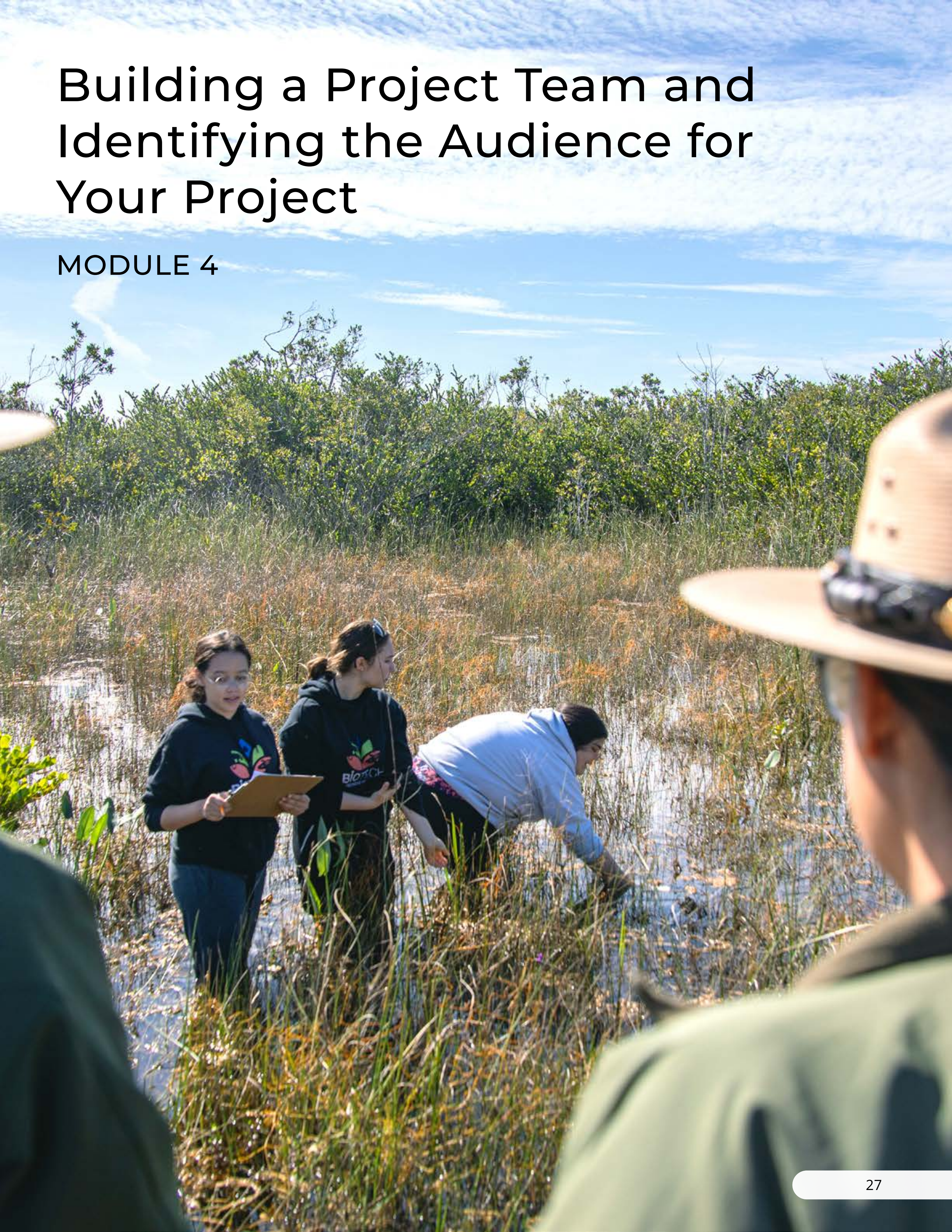
Building a Project Team and Identifying the Audience for Your Project

MODULE 4



INTRODUCTION

This module has two goals. The first is to discuss building a staff team to design and carry out your project and to evaluate its eventual success. The second is to discuss identifying your project audience, that is, the group or groups of volunteers who will collect or manage data for your project and sometimes engage in project design and/or data analysis. We'll call these individuals your project participants.

BUILDING A TEAM

Visioning, designing, implementing, and evaluating a citizen science project can be a big job, and pulling it off requires an interdisciplinary team. Few people have the knowledge and expertise to fill all the needed roles, which may be as varied as scientist, education/communication specialist, volunteer coordinator, technologist, and evaluator.

Assembling a team early in the design process is critical to success. The team can work together to refine the research question(s); evaluate whether existing protocols can be used to collect data; design new protocols if necessary; write clear instructions; test protocols and instructions; design data forms and other project supports; recruit volunteers; collate and analyze data; evaluate success; and more. For community-based projects, the team must include members of the community who can represent the community's needs and interests from the beginning of project conceptualization, and in many cases, who can drive the project.

Let's take a closer look at some of the roles and responsibilities that need to be filled by qualified people to ensure a project's successful design, implementation, and use. Lest the list seem daunting, know that roles sometimes can be filled by partners, a topic that we'll discuss in Module 5. Also, teams can be smaller for projects that are using pre-existing projects or platforms to develop data collection efforts to meet their specific needs, which we will discuss in Module 7.

Figure 4.1: The Alabama Water Watch Team. A full staff team for a citizen science project is interdisciplinary and comprises individuals fulfilling numerous roles including project leader, evaluator, communications specialist, technologist, and volunteer coordinator.

Research Scientist/Resource Manager

Every project requires a leader who is knowledgeable and excited about the research or monitoring that the project conducts. This individual can identify the questions most useful for a project to address and can help to determine the information that volunteers will collect. The research scientist/resource manager also can assess whether the project is providing data and information that will inform land management decisions or answer critical resource questions. This person must be a team player who recognizes and is respectful of the many different areas of expertise that are required to develop and execute a project.

Consider Alabama Water Watch (AWW), a project of the Alabama Extension Service, which operates a network of water quality monitors across Alabama. The US Forest Service (USFS) has established a partnership with AWW to monitor water quality across the four Alabama National Forests.

The USFS lead for this project is Estella Smith, who is the USFS soil scientist for national forests in Alabama. She has diverse experience gained through many years of work for both the USFS and the Natural Resources Conservation Service.

Educator/Communications Specialist

Every project team requires an individual who can clearly communicate the project's aims and desired outcomes and can prepare project support materials. When a "people specialist" co-leads a project, they can make sure that project tasks are clear and easy to follow, that recruited participants have appropriate skills, that relationships with partners are maintained and participants are nurtured, and that project results are widely shared. Educators/people specialists also can manage participant feedback to continuously improve the project so that it appeals to volunteers on an ongoing basis.

The AWW/USFS partnership is co-led by Mona Dominguez, who is AWW's overall program director. For this partnership, Mona coordinates AWW activities, develops training materials, and facilitates workshops. Her academic background in anthropology, environmental studies, and community planning, along with nearly 20 years of experience working in environmental education, helped her gain many of the skills required to lead this project.

Volunteer Coordinator

A key position for large or lengthy projects is a volunteer coordinator who recruits and communicates with volunteers, manages their schedules and training, updates volunteer resources and information on the project website, and recommends volunteers for awards or other recognitions. This position may be filled by an agency staff member or someone at a partner organization.

The AWW volunteer coordinator is Sydney Smith Zinner. Sydney started with AWW as a volunteer water monitor, then became a volunteer trainer, and now works full time as the volunteer coordinator. Her experience as a volunteer gave her a unique perspective and helped her understand how to effectively coordinate project volunteers, and her BS in Environmental Science provided an overall understanding of the need for water monitoring. Carolina Ruiz, the AWW logistics and operations coordinator, assists by maintaining an inventory of project materials to ensure monitors have what they need to collect credible data.

Technologists

Unless you are using a pre-existing project or framework to collect and summarize data, various technology specialists may be required on the team. For example, if you are developing a customized app or using a program such as ArcGIS Online, you may need the services of a GIS specialist who can advise on how to collect spatial data in a way that meshes with existing agency databases. A data manager also may be necessary to enter and upload data into a usable format.

The technologist for the AWW partnership is Sergio Ruiz-Cordova, who developed and manages the AWW database and website. He currently provides technical expertise for selecting monitoring methods and developing the program's quality assurance plan. Sergio joined AWW in 1993 and gained technology skills through his MS in Aquatic Ecology.

Outreach Specialists/Public Affairs Officers

These individuals get the word out about a citizen science project to enlist engaged and enthusiastic volunteers and to promote the results of a successful project. This position could be filled by a staff member from an agency or a partner organization who should be well-versed in a project's talking points and sensitive to potential misinterpretations of issues covered in the research.

For AWW, the communications coordinator is Rachel McGuire. She manages outreach, marketing, and communications, and helps with workshop training. Rachel's degrees (a BS in Fisheries, Wildlife, and Conservation Biology and an MS in Wildlife Science) prepared her well for this position.

Evaluator

An often-overlooked member of a project team is the evaluator, who is critical not only to determine whether a project has met its goals but also to help the team develop goals and measurable objectives early in the project and then stay on track to meet them. Few agency projects have dedicated evaluators, but often a team member has the skills necessary to conduct an evaluation, even if informally. For AWW, evaluation is conducted by project leader Mona Dominguez.

This list of personnel might already seem long, but a few other positions may be needed to execute a successful project.

Team leader | Community partners facilitator/liaison | Partnership coodinators/ Grants and Agreement specialists | Logistics and operations coordinator

Figure 4.2: Some projects are supported by additional team members including partnership coordinators, team leaders, logistics coordinators, and community partners facilitator.

Team Leaders

Some projects have team leaders who instruct and accompany volunteers in the field. For example, in citizen science projects involving youth, local science teachers often lead and assist students in collecting data. A team leader also could be a staff member from an agency or a partner organization.

Partnership Coordinators/Grants and Agreement Specialists

Some projects, such as those that develop formal partnerships, should have a coordinator who interacts with partners and the project leader and who understands how to develop partnerships. A skill set in grants and agreements will help to codify partnerships and make it possible to share funds and resources among federal and non-federal groups. This individual also can advise on negotiating the terms of contracts, agreements, and grants, and should be knowledgeable about policy requirements.

Finally, some citizen science approaches call for partnering closely with communities. This requires additional skills in which scientists often are not trained, and working relationships that even educators and visitor services staff may be challenged to facilitate. Identifying, hiring, or partnering with individuals who can focus on the process of building and maintaining collaborations with community partners is essential for such projects.

Module 5 focuses on expanding your project team still further by working with external stakeholders and partners. But before we go there, let's spend some time considering the potential participants for your project, who in many ways are the most important members of your team!

IDENTIFYING AUDIENCE

The kinds of participants that you'll engage in your project depend in large part on the type of project that you are developing. In Module 1, we discussed three types of citizen science: Data collection projects; data processing projects; and community projects. We pointed out that both data collection and data processing projects are sometimes called "contributory" projects because participants contribute or process data to answer a question designed by scientists, and we mentioned that community projects are sometimes called "co-created" projects because participants work with scientists and land managers to develop and carry out a project.

Data collection projects typically define an issue or question that can be addressed or answered only through large amounts of data collected over a long period of time and across a large geographic area. For example, they may involve determining the abundance and distribution of certain plants or animals in a specific geographic location; documenting phenology, that is, the timing of events in nature; or collecting weather or water quality data across the landscape. In some projects, participants not only collect data but are involved in defining or helping to define a research question or issue, analyzing data to address the question or issue, and/or disseminating information about project results.

Data collection projects are the most common type of project developed by federal agencies, as you will see in the example projects highlighted throughout the modules.

Data processing projects typically involve participants in identifying or classifying online images. For example, they may involve classifying photos taken by wildlife cams; classifying photos taken through remote sensing; or digitizing written data records.

Data processing projects are less commonly developed by federal agencies but are a type of project well worth considering. Most agencies probably have considerable banks of data that could be processed through volunteer assistance. In addition, data processing projects can engage a very different type of participant than data collection projects—people who are less able to go into the field to collect data, for example, or people who would like to engage with a project at varied hours of the day or night. One example of an agency-based data processing project is FISHstory, discussed in Modules 2, 7, and 10.

In community or co-created projects, participants work together with scientists and land managers in many or even all phases of project development. Often such projects originate with a specific community that has a concern about the local environment. For example, many community projects are focused on air quality, water quality, or concerns about perceived changes in the abundance of local resources.

Like data processing projects, community-based projects also are not common in the portfolio of agency-based citizen science. They are well worth considering but involve an even greater degree of project planning. Understanding how to work with communities to help their members address local environmental concerns without prescribing what communities should do is extremely important.

Let's look more closely at defining and understanding the audiences for different types of projects, with a caveat: In practice, these types of projects are not mutually exclusive. A blurring often occurs among and between them, and many techniques for identifying and working with audiences are appropriate and even necessary across project types.

Data Collection Projects

Many project developers consider the audience for data collection projects to be "the general public." Of course, there is no general public—many different publics exist. They have varying degrees of interests and motivations regarding any particular topic. They also have varying degrees of ability to collect data about that topic. For instance, the segment of the public commonly called "birdwatchers" or "birders" includes individuals ranging from beginning or backyard birders to individuals who travel widely in search of birds and may have ornithological expertise on par with professional scientists. Therefore, any project focused on collecting data about birds would need to match the needs for data collection, whether simple or complex, to specific bird-watching audiences and not simply assume that any bird watcher would be interested in or able to collect any kind of bird data.

The same is true for people who like to fish. Consider Engaging Angler Scientists, which we discussed briefly in Module 2 as an example of a project with strong training programs. Engaging Angler Scientists is run by Trout Unlimited in collaboration with the USFS in several national forests throughout the US. For example, in North Carolina and Tennessee, volunteers have assessed the impacts of road infrastructure on fish passage and sediment pollution in coldwater streams, and the data have been used to prioritize management actions, such as the replacement of culverts with fish-friendly structures, to minimize these impacts. In Michigan and Pennsylvania, anglers have conducted spawning surveys, identifying key habitats for reproduction of coldwater fish.

While many individuals like to fish, only a certain type of individual would likely be interested in gathering the types of information that scientists wanted to collect for this project. Therefore, in each forest, project designers consulted with local anglers, fishing guides, and other people who rely on the rivers for their livelihoods. These individuals are able to serve as champions for the project, helping to identify anglers who might be interested in collecting data, and they even helped to design surveys so that their methods would be of interest to local anglers. They also identified focal areas for the surveys. Through this program development strategy, the project developers gained a deep understanding of the project audience and how to work with its members.

Data Processing Projects

Like data collecting projects, many project developers consider the audience for data processing projects to be “the general public.” In this case, the concept has some legitimacy because the individuals willing to process and manage data usually do so from the comfort of their own computer, and may require less motivation to participate than individuals in data collection projects. Many data processing projects are built on the excellent platform Zooniverse, which brings its own audience of individuals willing to participate in data tagging and classification (see Module 7 for more information on Zooniverse).

Data processing projects are ripe for development by agencies. Those that are built on Zooniverse often require less funding and management than full-on data collection projects because of all the support that Zooniverse provides. And most agencies have a lot of data in need of tagging or processing.

The Bureau of Land Management’s (BLM’s) Desert Tortoise Monitoring Project is an agency-based data collection and data processing project that engages participants in studying the tortoise population in Santa Rosa and San Jacinto Mountains National Monument by using a two-pronged approach. The data collection prong involves volunteers who conduct field surveys off-trail with BLM staff, looking for signs of tortoises (scat, burrows, carcasses, and live individuals). They also record information on habitat conditions, including the presence of invasive species. In addition, these volunteers monitor trail cams in the tortoise’s habitat to make sure that the cams are functioning properly and to collect the cameras’ memory cards. For the data processing prong, volunteers review the trail cam footage to observe tortoise behavior near burrows, such as signs of breeding or predators stealing tortoise eggs from nesting sites. This data processing provides a good option for volunteers who may not be comfortable venturing off-trail or whose schedules conflict with that of the field surveys.

Community-Based Projects

Working with communities requires an entirely different approach to thinking about audience. While the audience for a data collection or data processing project may well be a group of people who do not know each other but who share a common interest, concern, or hobby, community projects generally focus on a group of individuals who have many common interests and concerns and may know each other to some degree. To work with a community, you’ll need to learn what motivates its members and why individuals might want to get involved in a community-based project. Learn the ages of your prospective volunteers, their degree of expertise, and their access to resources; this information will help you to design training and support to increase volunteer engagement.

If you are working with a specific community, examine any assumptions that you might have about its members. For example, Tribal communities, students, and self-selected volunteers may have very different worldviews, needs, interests, motivations, and terms of engagement. The ability to listen well is one of the most important skills that you can bring to this exchange. Get to know your project participants, the culture of their community, and the best ways to communicate with them. Avoid assumptions, listen carefully, respect different ways of contributing to a project, and be open to local needs and preferences. And don’t forget to engage the users of the data to be collected.

Areas to think about include the following:

- Sanctity of place: Consider cultural and religious attitudes about particular locations, such as sacred sites. Be aware of restrictions on who can visit places, requirements for how to behave, and the need to ensure historical, cultural, and environmental preservation.
- Gender and age: Some community members may be restricted from certain places or from participating in certain activities, for example, leadership roles may be restricted to men or to individuals of a certain age, so researching the culture is important. Interactions with certain age groups also may require special cultural sensitivity—in many communities, interrupting an elder is considered extremely rude.
- Ethnicity and race: If you are working with particular ethnic or racial groups, including individuals from those groups on your team is very important. The team will gain skills and insights required for a successful project, and the project will be more welcoming to the audience.
- Language: Provide your project participants with information, tools, and instruction in their native language(s). You may need local facilitators or members of the community to translate information.
- Literacy: Your community partners might have a range of literacy skills. Consider providing materials in several formats, such as visual representations and audio instructions, so that individuals with low literacy can access and discuss the same information you've made available in writing.
- Education level and scientific knowledge: Learn how much education your participants have and what they know about your project topic. Those with more scientific training may contribute needed skills and knowledge; they may even serve as full partners with academic researchers. Those with less training may need additional information but also may contribute new understanding of the community or project site or ask questions that highlight gaps in your research planning.
- Income and employment levels: Some participants may have limited time to devote to your project or may require funding to help them cover the cost of transportation, child care, materials, or meals.
- Listening: Get to know your project participants, the culture of their community, and the best ways to communicate with them. Avoid assumptions, listen carefully, respect different ways of contributing to a project, and be open to local needs and preferences.

An example of a community-based project is The Tribal Nations Botanical Research Collaborative, which we discussed in Module 2 as an example of a project that originated from an Indigenous community. This partnership among the USFS, several Arizona Tribes, and Northern Arizona University collects information on traditionally used plants that have cultural, medicinal, or economic values important to Tribal communities. Volunteers record observations of plants on a specified list using their cellphones, and they analyze the data to shape conservation and land management goals for increased sustainability. The project takes place in the Apache-Sitgreaves, Coconino, Kaibab, and Tonto National Forests. The project started in late 2018, and by the end of 2022 more than 1,200 observers had made more than 4,000 observations of 35 species.

This project began with the participants—Arizona-based Indian Tribes—who asked the USFS to work with them to develop management protocols that conserve identified species as restoration treatments, which are conducted on the Four Forest Restoration Initiative (4FRI) project area. The project is therefore 1) enabling 4FRI managers to develop management protocols to ensure long-term sustainability and availability of these resources for Tribes, 2) enhancing Tribal access to traditionally used plants, and 3) providing data to researchers to devise scientifically based management and restoration protocols for these species.

This project has collected significant data that are being used in species distribution modeling, and a project-based article has been published in the journal *Diversity* as part of a special issue on citizen science for biodiversity conservation.

Module 5 focuses on expanding your project team by working with stakeholders and partners.

FURTHER READING

Souther, S., Randall, V., and Lyndon, N. 2021. The use of citizen science to achieve multivariate management goals on public lands. *Diversity*, 13(7), p.293. https://doi.org/10.3390/d13070293

The Thriving Earth Exchange supports community science by helping communities find resources, project managers, and experts to address their pressing concerns. Their goal is to help communities be more empowered, resilient, and responsive.

Partnerships for Impact focuses on how to create equitable partnerships between science institutions and community-based organizations.

Engaging Stakeholders and Project Partners

MODULE 5

INTRODUCTION

The goal of this module is to help you expand your project team by working with stakeholders and partners.

STAKEHOLDERS

What is a stakeholder, and why is identifying and involving stakeholders important to citizen science projects?

The term actually has a large number of definitions. At its simplest, a stakeholder is any individual, group, or party that has an interest in a project and the outcomes of its actions. From that point of view, any citizen science project could have many stakeholders, ranging from individuals who might use the data to groups that may be impacted by project outcomes.

Therefore, after identifying project participants and building a project team, identifying the stakeholders who will be interested in or impacted by your project's outcomes is a valuable next step. You can then determine stakeholder needs related to your goals and may even choose to involve your project's stakeholders in project design or implementation.

Let's note here that some groups, particularly Indigenous groups, should not be referred to as stakeholders in many circumstances. They have native rights and thus more than an interest in what happens on their lands. So, be careful in the way that you use this term!

One robust examination of stakeholders in citizen science was conducted in 2017 by Claudia Göbel, Victoria Martin, and Monica Ramirez-Andreotta under the auspices of the Commons Lab at the Woodrow Wilson International Center for Scholars (Göbel et al. 2017). These authors defined a stakeholder as an individual or organization that contributes to realizing a citizen science project, has a vested interest in a citizen science project, and/or benefits from the research activities and data produced by a project. They recommended that citizen science project developers should invest time at the outset of a project to identify stakeholders who could use, and potentially reuse, data and knowledge. To that end, they identified the following six stakeholder groups:

- civil society organizations, informal groups, and community members;
- academic and research organizations;
- government agencies and departments;
- formal learning institutions (such as schools);
- businesses or industry; and
- project participants.

A simpler way to think about stakeholders for citizen science projects is to identify three stakeholder bins:

- those who are interested in the type of work that your project entails;
- those who have power over the type of work that your project entails; and
- those who will be impacted, either positively or negatively, by the potential outcomes that your project may generate.

Working with stakeholders has several benefits. One is that stakeholders can help ensure that project data and information will be widely shared. Another is that some stakeholders may become partners who play a large role in your project. We'll delve into partners in the second half of this module.

Identifying stakeholders takes work and time. A project team might lack awareness of potential stakeholders, might not know to access stakeholders, might find the process challenging, or might be limited by constraints on time or other resources. Nevertheless, taking time to identify and work with stakeholders typically results in a stronger and more useful project. As examples, let's look at two projects that have considered stakeholders early in their design process.

First let's revisit Colorado Bat Watch, which we discussed in Module 3. This project is being implemented by Rocky Mountain Wild in collaboration with multiple agencies and organizations including the US Forest Service (USFS). Bat Watch aims to collect baseline data on the locations and characteristics of bat roost sites in human structures, talus, trees, and snags. The goals of the project are to provide reliable data to meet multi-agency bat monitoring needs across the state, to inform efforts to address current and emerging threats to bat populations, to build public support for bat conservation, and to increase the capacity of partners to address pressing bat research and conservation needs in Colorado. The project leads have prepared a robust and multifaceted plan for Bat Watch, which is well worth reading for anybody who is designing a citizen science project because the plan covers in detail most of the topics covered in this toolkit (Singer et al. 2020).

In developing the plan, the project leads at Rocky Mountain Wild researched multiple stakeholders including the USFS, Colorado Parks and Wildlife, and the Colorado Natural Heritage Program. Information, needs, and requirements of all these stakeholders were incorporated into the program. For example, information was obtained from the 2018 Colorado Bat Conservation Plan, the USFS Region 2's 2013 White-Nose Syndrome Adaptive Management Strategy Environmental Assessment, Colorado Parks and Wildlife's White-Nose Syndrome Response Plan, the Colorado State Wildlife Action Plan, the North American Bat Monitoring Program (NABat), the Western Bat Working Group, and the Colorado Bat Working Group.

Figure 5.1: Colorado Bat Watch is collecting data relevant to numerous agencies and programs because before they designed the program, project staff reached out to numerous stakeholders to learn about needs for bat data across the state.

The project also reached out directly to stakeholders. Early in the project design process, the team organized a collaborative meeting with the USFS, Colorado Parks and Wildlife, and the Colorado Natural Heritage Program during which agency staff provided input to inform development of the Bat Watch implementation plan. The team also continually solicited input from agency partners through email and conference calls on various aspects of the project plan including data sensitivity.

As a result, Colorado Bat Watch is adding essential capacity to bat research and monitoring efforts throughout the state by addressing research and management needs unmet by existing efforts. Data can be used by all stakeholders, informing research and management efforts for each agency. Furthermore, the project continues to identify opportunities for synergy with NABat.

Another example of a project whose early consideration of stakeholders has enabled largescale growth is the Dragonfly Mercury Project, which works with the public to collect dragonfly larvae for mercury analysis. This nationwide monitoring program is a collaborative effort by the National Park Service, the U.S. Geological Survey (USGS), the US Fish and Wildlife Service, the Appalachian Mountain Club, and the National Park Foundation. Data from this field study help scientists and managers better understand and address mercury contamination, which is responsible for more than three-quarters of US fish consumption advisories and threatens food webs in parks and protected lands. More specifically, the project shows where potential mercury risks are located; determines how well mercury emission reduction programs and policies are working; provides science to inform resource management and risk mitigation techniques; gets people involved in learning about mercury; and spreads the word about mercury issues. Each participating unit or national park engages staff from their resource management or interpretive division, or they link with another partners such as a teacher from their community. These project liaisons coordinate, train, and lead participants in collecting samples, which are shipped to a centralized laboratory for analysis.

The project initially grew out of a local, inquiry-based education program with researchers and a group of teachers in the Northeast US. Leaders expanded the effort by reaching out to USGS scientists in the Ecosystems Mission Area and Environmental Health Program, implementing a national-scale demonstration study to test the efficacy of dragonflies as mercury biosentinels. Together these organizations developed the project plan and protocols and refined the training materials with assistance from the Schoodic Institute at Acadia National Park. Over the course of a decade, program leaders identified and reached out to stakeholders to enhance engagement opportunities. Stakeholders included the National Park Foundation, other federal and state agencies, academic institutions, local municipalities, resource managers, and recreational and subsistence consumers of fish.

So far, more than 140 national parks, 20 national wildlife refuges, 2 national forests, and 2 Tribal lands have participated. Land managers use the data to determine what parts of the unit or park might be at greatest risk of contamination, which can inform where and how to mitigate, manage, or remediate mercury risk with land management practices such as managing dam releases, prescribing fire, and restoring wetlands.

PARTNERING WITH OTHER ORGANIZATIONS

Running a project is clearly a big effort, and partnering with other organizations is a smart approach to project efficiency. Establishing partnerships yields benefits such as strengthening financial and technical support, linking the agency and stakeholders, educating the public, and increasing common activities across land ownerships. Partners also may help to recruit and manage volunteers, develop research questions, and analyze data.

With a wealth of citizen science projects and infrastructure now available, it's a good idea to review what already exists in relationship to your goals and objectives before you make a decision about where to invest. You may be able to find partners among the projects and resources listed on SciStarter and CitizenScience.gov.

If you already have identified, for example, that your primary need for citizen science is to study plant phenology on your park, refuge, or forest, partnering with Nature's Notebook—a project of the National Phenology Network—would make sense because the Nature's Notebook platform provides much of what you need to build and operate a phenology-based project. This is exactly what the Midway Atoll National Wildlife Refuge Golden Crownbeard Phenology Project did (Taylor et al. 2020). To eradicate this invasive plant, refuge biologists needed to know how quickly the plant grows and the timing of its movement from one life stage to the next. To determine this, they built a project on the Nature's Notebook platform that involved volunteers recording data about crownbeard growth, flowering, fruiting, and seed drop. The results showed that they needed to institute a 28-day rotation between herbicide treatments in different sectors of the refuge.

Even if you have the capacity to build new project infrastructure, partnering with complementary efforts can enhance—rather than segregate—datasets, amplifying the research potential in addition to saving resources.

Beyond existing citizen science efforts, consider how your envisioned project would fit with other research and monitoring that is already under way within your agency, your region, or both. Federal, state, Tribal, and local government partners can enhance the ability to collect, disseminate, and use data for management and decision-making.

Building strong partnerships can be one strategy for project sustainability. Partners will put in their own funding and time if they are invested in shared goals. Consider other divisions within your own agency, along with municipalities, universities, and friends' groups—any organization with symbiotic interests can help to provide a diverse funding stream, build a base of supporters for your project, and fill roles on the project team such as those described in Module 4.

Project Tanager was among the first citizen science projects developed by the Cornell Lab of Ornithology (Rosenberg et al. 1999a). Begun in 1993, the project enlisted volunteers in exploring the effects of forest fragmentation on the four species of tanagers that breed in the contiguous United States. The goal was to determine the minimum size of forest patch required for successful breeding of each of these species. Project Tanager was part of a larger effort called Partners in Flight, the Neotropical migratory bird program, which is ongoing.

Tanagers were chosen as the subject of this study for several reasons. First, they are an attractive and easily recognized Neotropical migratory bird. Second, the scarlet tanager previously had been shown to be area-sensitive and was declining in parts of its range as shown by data from the Breeding Bird Survey. Third, at least one of the four species of North American tanagers can be found during the breeding season across much of the United States and southern Canada.

The protocol for conducting Project Tanager involved two-minute point counts during which observers watched and listened for the presence of tanagers and recorded signs of breeding for any tanagers they located. Organizers knew that to make this work, the project would require multiple partners.

First, although the organizers felt that birders could be trained to conduct point counts and look for signs of breeding, they also knew that the birders would need help identifying and locating suitably sized forest patches. Thus, they partnered with the USFS, which detailed a full-time staff person to the Lab of Ornithology in Ithaca, New York. This person played a major role on the project team, working with individual forest staff to identify suitable patches on USFS lands across the country.

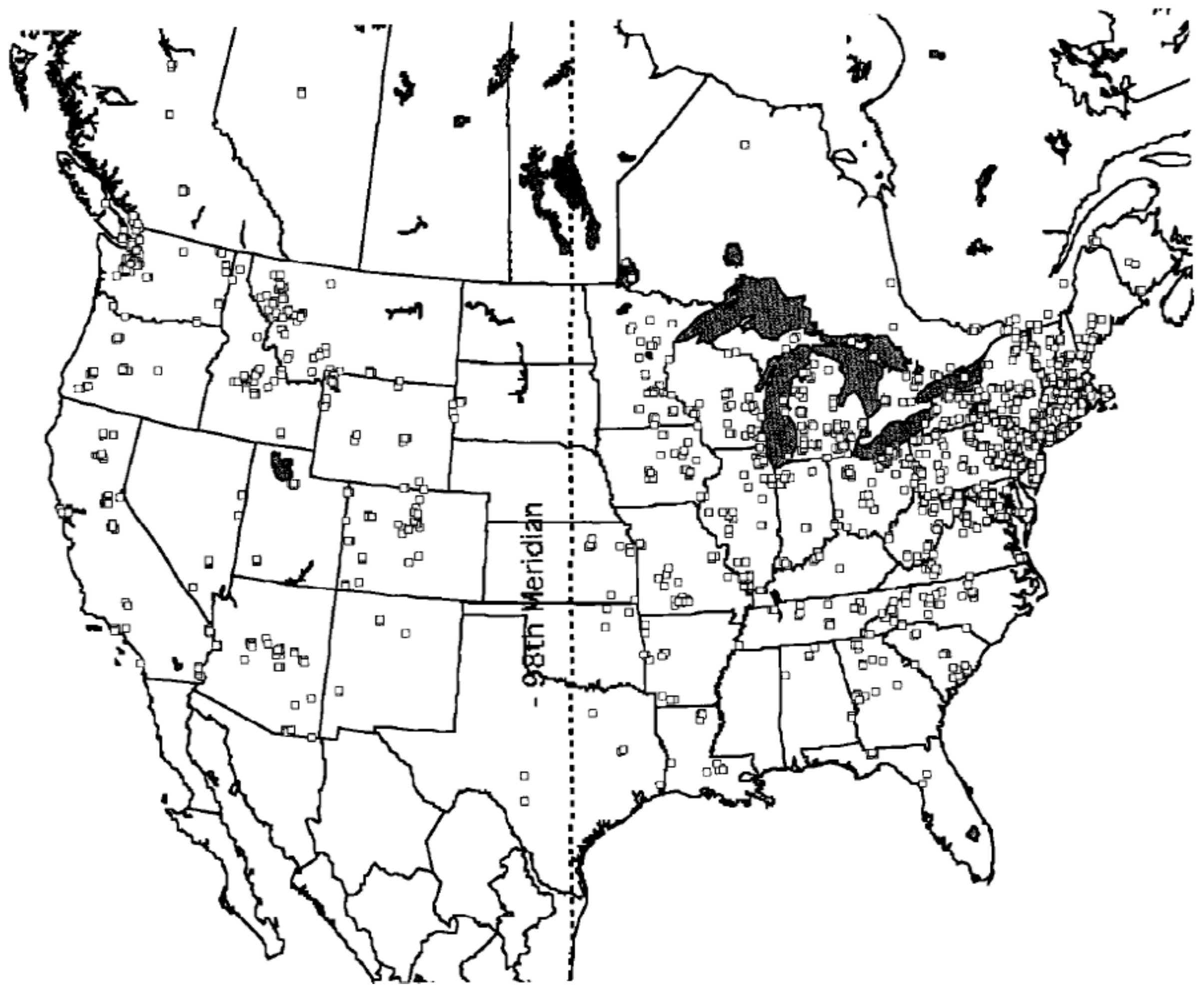


Figure 5.2: Project Tanager was an early but highly successful citizen science project that documented the effects of different-sized forest patches on the breeding success of North American tanagers. The geographic scale of data collection, shown in this research publication, was possible only through partnership between the Cornell Lab of Ornithology, the US Forest Service, the National Audubon Society, and the forest products industry. Figure from Hames et al. 2002.

Second, the organizers knew that many different-sized forest patches occur on private lands. They reached out to the forest products industry for help in locating such lands suitable for the study. This had the dual effect of identifying additional study sites and bringing industry representatives into the project, which was important because some of them were skeptical of its intent, believing that the Lab of Ornithology was out to show negative effects of logging.

Third, the organizers knew that recruiting birders with sufficient skills to conduct the protocols would be challenging. To recruit participants and to consult on project design they reached out to other science and environmental organizations, including local and regional bird clubs and chapters of the National Audubon Society, for help in recruiting suitable observers.

Finally, the organizers knew that skepticism about volunteer-collected data would rear its head for this project. At the time, researchers and organizers were just beginning to discover participants' ability to collect quality data, and Project Tanager employed fairly complex observation protocols. To head off critics, the organizers involved them, informing professional ornithologists about the project and its results through news releases and presentations at meetings of professional organizations such as the American Ornithologists' Union.

The pilot for Project Tanager began in the summer of 1993, when 70 teams of birders conducted counts at nearly 1,000 individual sites, searching for signs of tanager breeding in forests of four size classes—1, 10, 100, and 1,000 hectares. Data were received for all four tanager species from 31 states and two Canadian provinces. During the following summer, several hundred teams participated and censused nearly 2,000 sites located on public, private, and corporate lands in 44 states and 4 Canadian provinces.

Results revealed that forest patch size and degree of isolation from other patches influenced tanager distribution and breeding success. Together these findings had implications for managing populations of Neotropical migrants that breed in forests, and the data were used to create a guide to habitat management for forest managers (Rosenberg et al. 1999b).

INDIGENOUS COMMUNITIES AND TRIBES

The federal government is committed to strengthening its relationships with Indigenous communities and federally recognized Indian Tribes. Such partnerships can create a mutually beneficial relationship in which Tribes have more opportunities to benefit from Federal programs, and land management agencies benefit from Indigenous community guidance and multi-generational knowledge systems.

Agencies may enter into agreements, grants, or contracts with Tribes, just as they can with other organizations or agencies. It is important to remember, however, that when a Tribe joins a partnership or collaborative process, it maintains a separate sovereign governmental relationship with the agency; the partnership or collaborative process is always conducted in addition to the separate process of government-to-government consultation between the agency and the Tribe. It is important for members participating in a collaborative process or partnership to understand and respect the unique relationship and trust responsibility that federal agencies have with Tribes.

More information on working with Tribes is available at: https://www.fs.usda.gov/working-with-us/Tribal-relations and Tribal Leaders Directory.

AGREEMENTS, MEMORANDA OF UNDERSTANDING, AND PROCUREMENTS

If your team has external partners, and if your project will include the exchange of something of value (i.e., funds or services), then you need to develop an agreement. Agreements document roles, responsibilities, and the intent and scale of your project.

If the project does not include the exchange of funds, services, or something of value, then you may want to develop a memorandum of understanding. This is used to document a framework for cooperation between your agency and other parties for carrying out activities in a coordinated and mutually beneficial manner, though each party directs its own activities and uses its own resources.

If the project primarily benefits your agency and no cost sharing is anticipated, it may be a procurement. If the project is of mutual benefit to your agency and a non-federal party, and if there is an exchange of something of value that meets the purpose of both parties, it may be a partnership agreement. If the project serves a public good and meets the intent of a specified assistance authority, then it may be a grant or cooperative agreement.

A very helpful resource for learning more about the above topics is the USFS Partnership Guide, which includes detailed information about establishing agreements with partners along with a decision tree illustrating the kinds of agreements used in USFS citizen science projects. Much of the information in the Guide, however, also is relevant to non-USFS agencies. The decision tree can be a useful tool to start out with; however, it should not replace discussions among the partner, program staff, and grants and agreements specialists. Those discussions should start early, be ongoing, and continue even after the agreement is executed.

Successful partnerships thrive on mutual benefits and objectives, so when contacting potential partners, make your goals and intended outcomes clear. Focus on similarities among your groups and strive to understand potential partners' perspectives. Plan regular meetings with your partners and stakeholders to evaluate your work and solve problems—the more communication and feedback, the better—and prepare to adapt to changing needs and goals of your partners.

Together, stakeholders and partners should help to expand the depth and reach of your project.

Now that you have developed goals and objectives, gathered a project team, defined your audience, and enlisted the help of stakeholders and partners, it's time to think about data collection and management, which is the focus of Module 6.

FURTHER READING

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Collecting and Managing Citizen Science Data

MODULE 6

INTRODUCTION

The goal of this module is to explore the broad topic of collecting and managing citizen science data.

Among the most successful environmental citizen science projects are those that collect observations or measurements of phenomena such as locations of plants, animals, or other artifacts; measurements of air or water quality; and presence of seasonal occurrences such as leaves, flowers, or antlers. Volunteers can easily observe or measure such phenomena, either casually in their daily lives or more deliberately by searching for or measuring specific items, either independently or under the guidance of a team leader.

However, observations and measurements made by volunteers must be accurate if the data are to be used for science or management. Furthermore, citizen science project developers must create thoughtful data collection protocols so that information collected by different users can be combined, compared, and analyzed to draw conclusions. Data do not always need to be perfect, but they do need to be "fit for purpose," that is, they need to be accurate enough to address the question or issue that they are intended to address. Otherwise, the data could well end up stuffed in a drawer or an unused computer file, a poor result for any project.

The guidelines presented in this module assume that you already have or are considering a scientific question or management issue that you wish to address; that you have determined that citizen science is an appropriate approach to addressing your question or issue; and that you know what data you want to collect and analyze. If you are not well versed in data collection, management, and analysis, a team member or partner who is data proficient will be essential to create a successful project.

This module can provide only an overview of data topics; indeed, entire books have been written, and entire courses are taught, about the many facets of data. One resource that can help you dive deeper into this subject is the DataONE repository's *Data Management Guide for Public Participation in Scientific Research*. Another valuable reference is a paper published in *Citizen Science: Theory and Practice* called "Still in Need of Norms: The State of the Data in Citizen Science."

DATA COLLECTION

Collecting data involves getting information from participants into usable data files. To do this efficiently, you'll need to determine how observations will be made and how the resulting data will be recorded and organized.

The first step is to identify what data to collect, which should be influenced by the anticipated uses of the information. Keep in mind the FAIR principles within the open data movement: findable, accessible, interoperable, and reusable, and the CARE principles for Indigenous Data Governance: collective benefit, authority to control, responsibility, and ethics.

You also will need to determine a protocol to use for collecting data. Here we discuss three general types of protocol design: unstructured surveys, semi-structured surveys, and structured surveys. These survey types are not mutually exclusive and can overlap.

Unstructured Surveys

Unstructured surveys have few requirements for data collection; participants report data when and where they choose and are not required to identify everything that they see. For instance, they may note the presence of certain birds or flowers in walks around their neighborhood or along a hiking trail, they might keep track of the kinds and numbers of fish that they catch in a favorite lake or stream, or they may document invasive plants or structural damage along a trail. Unstructured surveys do require observers to note what, when, and where, which are the basic items of information required for any observation to be useful (this information is referred to as metadata). For instance, somebody might see a crow on a walk around their neighborhood. They might make a note of the what—a common crow—the when—the time and date—and the where—an address, a park, or even a GPS point. This observation, or data point, is considered "unstructured" because it is opportunistic, and by itself, this sighting of a crow is not exceptionally useful because it lacks context. Was the crow the only one seen that day? Was it solitary or part of a large flock? Might more crows have been seen had the observer looked more carefully?

Unstructured surveys can have significant value, however. For example, they can be used to build distribution maps, to document the spread of invasive species, or to alert researchers to the presence of organisms in an area that they might want to study more deeply. In addition, unstructured surveys become increasingly more powerful as the number of observations increases. That is, a large amount of useful information can be collected by seeking a small amount of data from a large number of people.

Unstructured surveys are common in citizen science, partly because they are easiest to develop and carry out. An example is the Basin and Range Bioblitz that was developed in 2021 by the Bureau of Land Management (BLM). Agency staff had begun modeling and mapping wildlife habitat at the Basin and Range National Monument in 2018, and three years later realized that they needed more observational data on their focal species than they were able to gather themselves. Therefore, they decided to enlist volunteers in gathering data through a bioblitz, which they built on a platform called iNaturalist (see Module 7 for information on iNaturalist and other project-building platforms, which can greatly simplify the process of building and managing a citizen science project). One hundred individuals participated in the three-day event, resulting in data on 406 species. The event's success led BLM staff to run a second bioblitz in 2023 for which 50 observers made observations on 183 species. For these events, volunteers did not follow transects or record information about the effort that they expended in making observations. Nevertheless, the BLM staff gathered data about locations of many species that they would not otherwise have been able to document. These data were used to refine habitat models for wildlife within the monument and to begin writing a monument resource management plan.

Another project using an unstructured survey approach is Glacier National Park's Common Loon Project, which enlists volunteers in mapping locations of loon territories, nests, and nursery areas. Since 2005, park volunteers have completed 2,479 one-hour surveys at locations that they choose based on personal hiking ability and preference. They record their data using Survey 123, which standardizes the data collection (see Module 7). Data gathered by volunteers provides baseline information on loon population size and reproductive success at 45 lakes throughout the park.

Semi-Structured Surveys

Semi-structured surveys are next along the survey continuum. For these, volunteers gather data when and where they choose but include additional metadata with their submissions. This includes who they are and typically their location. It also includes how they collected data, for example, the length of time spent birding or fishing in a given area, or the number of birders or anglers making observations or catching fish. The how is sometimes described as volunteer effort. Semi-structured surveys also may include information on habitat or location, such as distance from a developed area.

The information about observer identity and where and how observations were made allows researchers to statistically account for biases inherent in opportunistic data collection. For example, semi-structured surveys not only show where species are located but also can be used to infer frequency of species occurrence and changes in abundance over time and location. Data from the same participants can be tracked over time, and project designers can contact the participants when data discrepancies are noted or other data issues arise. An advantage of semi-structured surveys is that they can be simple enough to appeal to a wide audience while still collecting sufficient information to account for variation and bias in the data collection process.

eBird is an example of a semi-structured survey that allows open participation and observer-selected sites. Tens of thousands of individuals keep track of their bird sightings with eBird, and many agencies use eBird to document bird populations in their parks, forests, or refuges. For example, The US Fish and Wildlife Service partnered with eBird to enable data visualizations for all national wildlife refuges. As a result, anybody can visit the “Explore” section of the eBird website and create checklists or bar graphs from any refuge, as shown in the example below.

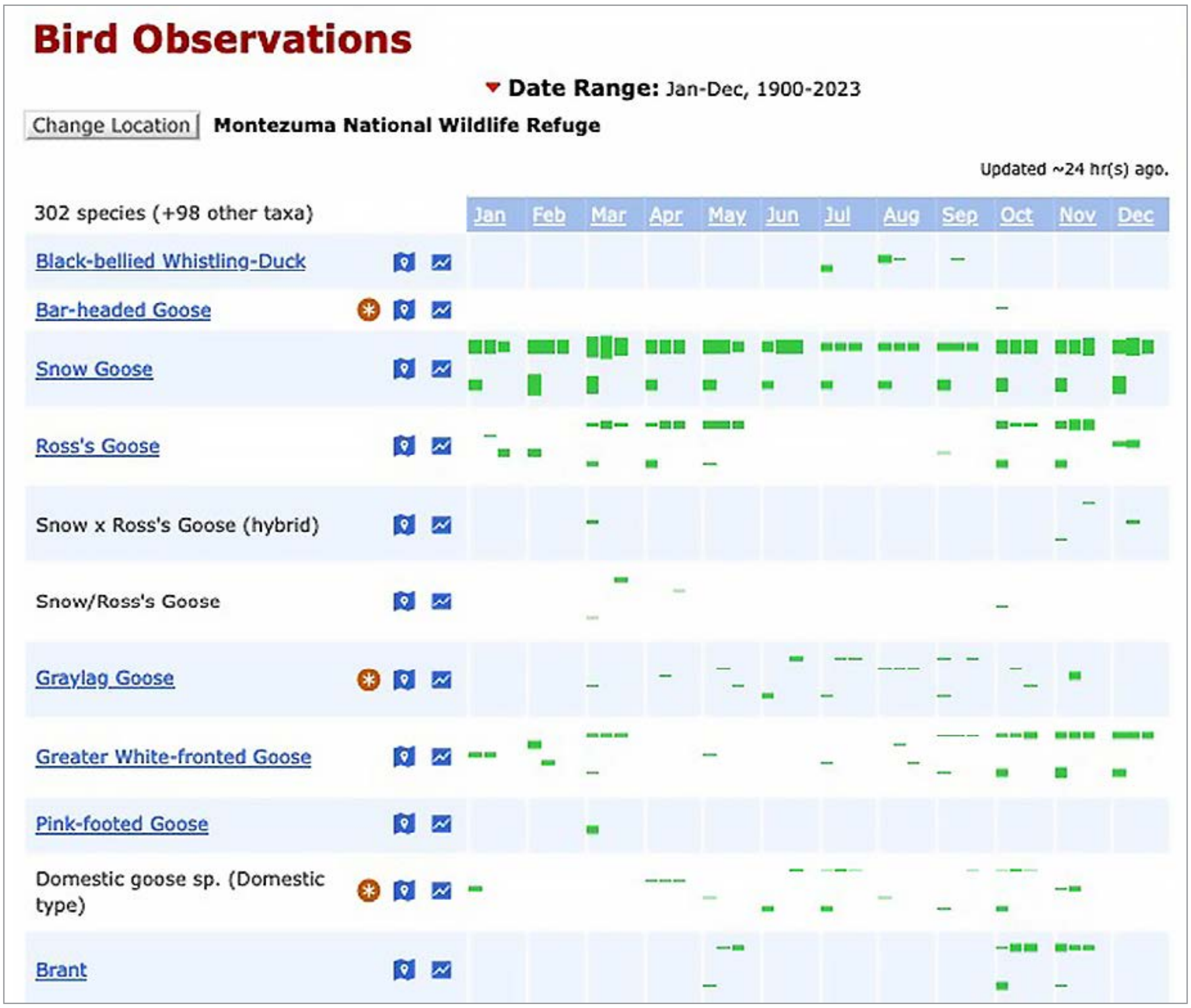

Figure 6.1: eBird can be used to create bar graphs of species abundance at any location, including national wildlife refuges. This graph showing the abundance of various species of waterfowl every month at the Montezuma National Wildlife Refuge was created in seconds using the “Explore Regions” in the “Explore” ection of the eBird website. Data on eBird are updated nearly as quickly as data are input by the many thousands of eBird contributors.

eBird is considered a semi-structured survey because, in addition to allowing users to submit checklists indicating the kinds and numbers of birds they see, it also collects information on how the participants made their observations. For example, the eBird app asks for the duration of data collection and the distance that an observer traveled while collecting observations, both of which can affect the probability that a species will be detected, identified, and recorded. The app also asks whether the observer is submitting a checklist of every bird they saw during their survey, which is important for analysts to infer that certain species were not detected. This information makes sophisticated data analyses possible, including eBird Trends maps like the one shown here for the house wren.

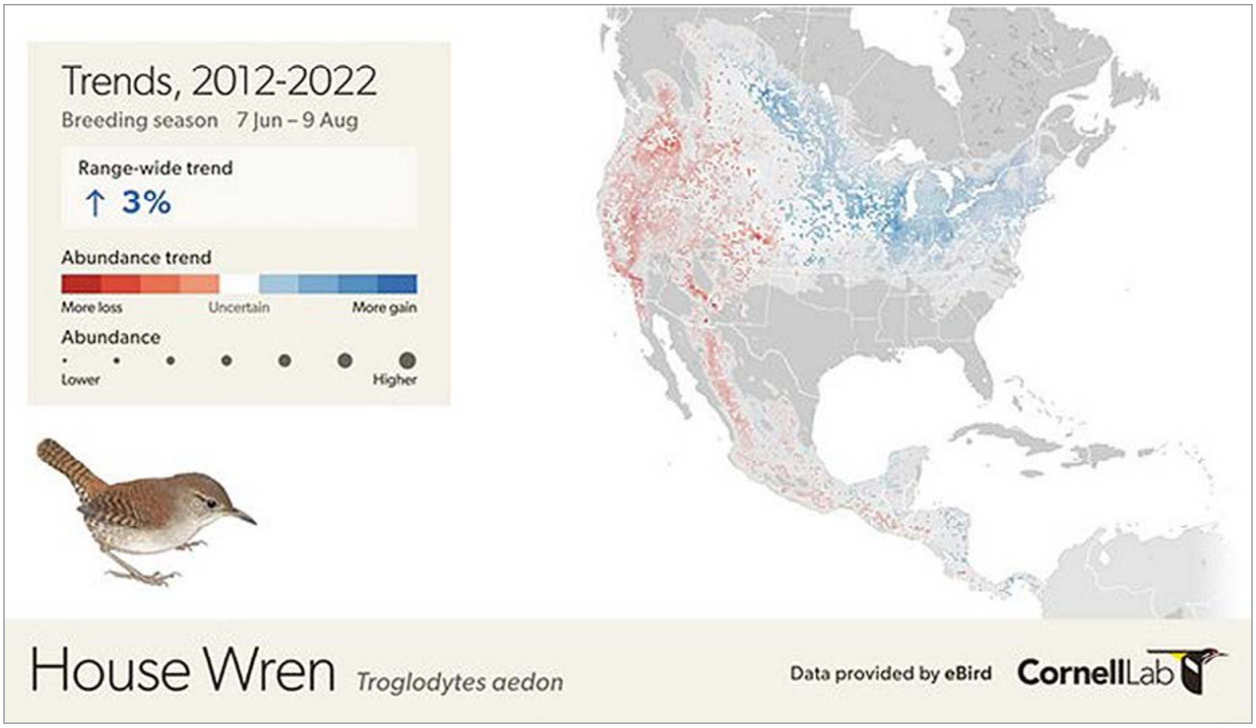

Figure 6.2: eBird Trends map for house wren populations across North America downloaded from “Status and Trends” in the “Science” section of the eBird website. The data to create this trend map came from thousands of eBird contributors across the continent.

Semi-structured survey platforms such as eBird are popular with participants, and the volume of data that they gather now provides the largest and fastest-growing information on species occurrence around the world. They also can be used to build specialized data collection projects, such as the Desert Avicaching Project, which is built on eBird and described in Modules 2, 6, and 8.

Structured Surveys

Structured surveys are at the other end of the survey design continuum. These comprise rigorous protocols designed to collect data in a very specific way. For example, participants might collect data along randomly set transects or in specified study plots, typically at specified times and for specific lengths of time. Project designers thus need to direct participants to the right places at the right times and must provide training to collect the data according to protocol. Structured surveys are developed because the precise location in which data are collected can be very important, for example, birds heard or seen along a trail through a forest may not be the same as birds that would be encountered in the forest interior. If conclusions about bird populations in a forest are made with data collected only along trails, the data may not be representative.

Structured surveys are not common in citizen science, but with appropriate up-front planning and volunteer training—or the recruitment of highly knowledgeable volunteers—they can be done effectively. One example is Cascades Pika Watch, a partnership between the US Forest Service and the Oregon Zoo, which from 2018 to 2021 gathered data needed to understand changes to pika populations and distribution in the Columbia River Gorge related to impacts from a large forest fire known as the Eagle Creek Fire. Volunteers were trained to walk transects on talus slopes, to count pikas, to identify signs of burn damage, and to count the most common plants. The volunteers were required to undergo extensive in-person training and large-group excursions before conducting surveys in small groups.

Typically, projects that employ structured surveys include fewer participants than projects that employ unstructured surveys, but the detailed protocols and trained or otherwise knowledgeable participants allow for sophisticated data analysis and detailed conclusions. Also note that most projects that measure water or air quality generally must be set up as structured projects to allow for trends to be seen over time. However, even unstructured measurements can sometimes be helpful, such as documentation of algal blooms.

If determining how to design a project to gather data in an organized fashion sounds daunting to your project team, know that collecting and managing data for a citizen science project can be facilitated by building the project on an existing citizen science platform. Such platforms are described in Module 7.

RECORDING AND SUBMITTING DATA

Once you have determined exactly what data you want to obtain and where on the survey continuum your project protocol will fall, you need to decide how participants will record and submit the information that they collect. Data can be recorded on paper, on computers, on smartphones, or on some combination thereof.

Paper data forms were the backbone of citizen science projects prior to the 1990s, and they can still be a valuable data collection tool. They do not require owning a computer or a smartphone, and they don't run out of power. They also can provide a physical data backup even if data are later submitted electronically. However, they can be lost, illegible, or never submitted. And if a project accepts paper forms, whether handed in or mailed in, then the project team needs to include somebody who can enter the data into a computer for storage and analysis. Many projects ask participants to record their data on paper forms for ease in the field and to later submit the data electronically.

With the rise of the World Wide Web in the 1990s, many projects began developing online data entry forms, which offer huge advantages over paper, at least for participants who have access to the internet. The internet allows data to be entered and submitted rapidly, and online databases allow consistency of format, quick analysis, and display of submitted data. However, developing databases and online data forms might require programming expertise that smaller projects may not have. That said, cloud-based data sharing and storage tools offer a relatively simple way to receive and share information with volunteers. Customizable platforms designed for citizen science also exist and are discussed in Module 7. Some projects might ask participants to use a combined approach, recording data on paper forms in the field and later entering the information into an online tool. This technique has some risk in that some volunteers might not be diligent in entering their data online after collecting it in the field.

Many projects have developed smartphone apps, which allow volunteers to submit data directly from the field. This approach can minimize the loss of data and can require less work on the part of the volunteer. However, a project that seeks to collect data in this way must have an app developer on its team, or at least have access to one, unless the project is using existing data collection apps such as iNaturalist or eBird (see Module 7). In addition, the volunteer must have access to a cell signal, or the app must be capable of accepting and storing data until a signal is available. Customizable apps are now being developed that can support a range of projects.

Remember that not all potential participants will have smartphones, so you may wish to develop and maintain alternative methods of data collection and submission.

DATA QUALITY

Data quality is of high concern for all federally based monitoring and research projects. The federal land-based agencies are science-informed organizations, and their credibility would be damaged if the data used to make land management decisions were found to be unreliable. Also, data can have legal implications. Volunteers can be just as effective and accurate as professional scientists and technicians as long as project protocols are clear and well defined and volunteers understand how to follow them. Sometimes volunteers may be more conscientious data collectors than professionals because they do not rely on professional judgement.

Quality assurance (QA) and quality control (QC) procedures minimize introduction of errors and identify and treat erroneous data. Strategies used before and during data collection are typically referred to as QA, while those applied after data collection are called QC.

QA begins with clear protocols that limit opportunities for human error. Keep tasks as simple as possible, and use terms and measurements that easily make sense to the volunteers recruited to your project. For example, documenting the presence of one type of rare plant could be significantly easier than identifying numerous species. Avoid involving non-professionals for complicated data collection that cannot easily be checked for accuracy. But don’t underestimate volunteers, either.

Data verification, or groundtruthing, is an additional, usually manual, QA process. For example, a photograph of a plant, animal, or physical feature (e.g., the amount of water in a stream) can be checked visually to confirm that the information that has been provided is correct. Asking participants to submit photos can add huge value to the data by allowing verification. Another approach is to verify a subset of the data, for example, by requesting samples to be sent in or by accompanying a few participants and observing the measurements that they take. Verification also can be crowdsourced, for example, by asking people to assess each other’s photographs or asking pairs of people to take measurements at the same site.

Testing your protocol with a subset of volunteers is critical before a project is fully implemented. A pilot phase will give you feedback to determine if your protocol is easily understandable and collects useful information. You might find, for example, that your protocol has been built on an unrealistic expectation of the abilities of your volunteers, or that volunteers are observing lots of features that you thought would be rare but are now cluttering your data. Testing also can identify whether a data form is overwhelming for volunteers, which could limit engagement. After a pilot phase, you can modify the protocol as appropriate.

Volunteer training and support also are essential to maintaining data quality. These topics are discussed in Module 8.

QC is a set of processes to evaluate the quality of data after they are collected. These include data cleaning and deciding how to handle missing data or estimated values. QC is typically more difficult and resource-intensive than QA; preventing problems is easier and usually cheaper than repairing them.

QC can include expert review, automatically flagging unusual records for review, and/or using photographs for ad hoc validation. Some projects automate the process of evaluating data points to ensure that criteria are met for successful data interpretation. Validation checks can be added to web-based data entry forms or apps to ensure that dates, grid references, or postal codes are given in the correct format and within valid ranges.

The aforementioned eBird provides an excellent example of web-based QC. When a user clicks on “submit data,” whether on the website or in the app, they are served a checklist of birds likely to be seen at the time and location from which they are submitting information. They can report species not on the list, but if they do, they are likely to get an alert requesting further information in the form of a written description or a photo. They also receive an alert if they report a species in higher numbers than might be expected so they can be sure they are entering the number that they intended. In this way, potential errors in the data can be identified and removed by the participant.

DATA PRESERVATION AND ANALYSIS

Data preservation involves submitting data to an appropriate long-term archive, such as a data center or repository. Preservation should be an ongoing process and should take place at both short- and long-term scales. Upload your data to your relevant agency enterprise database if possible. Evaluate ahead of time which data need to be restricted from public access (e.g., heritage or wildlife data) and confirm that your data collection tool and/or method of sharing allows for privacy regarding sensitive information.

More information about data repositories is included in Module 9.

Data analysis should be guided by the project’s goals and data needs and by the expectations of intended audiences, such as policy makers and the scientific community, for project results. Many software tools can support data analysis and visualizations. Some are available online either free or at low cost. Many projects turn to partners or specialized staff within their agency to perform this task. More information about data analysis also is included in Module 9.

Most of the topics that we have covered in this module thus far are treated in more depth in the aforementioned DataONE *Data Management Guide for Public Participation in Scientific Research*.

DATA POLICIES

Another topic regarding data is data policies. These include user agreements, terms of use, legal policies, and privacy policies. All are important to consider.

User agreements are contracts between a project and a user that outline the acceptable behavior of both parties. User agreements cover both online and offline behavior.

Terms of use dictate how a website and its contents can be used. They include information on data ownership, data access, data reuse, citation, and other forms of attribution.

Legal policies describe how a project adheres to relevant national and local laws and also may include ethical guidelines.

Privacy policies describe how a project gathers, discloses, and manages user and volunteer data, including the use of data gathered by cookies and web logs, personal data gathered during registration, and data contributed by volunteers.

All of these issues are important for citizen science, but a detailed discussion is beyond the scope of this toolkit. To dig into these topics, consult the aforementioned DataONE *Data Management Guide for Public Participation in Scientific Research*.

DATA ETHICS

Data ethics is our final topic regarding citizen science data. Some aspects of ethics are interwoven throughout this module. Others are beyond its scope. Citizen science data ethics is an emerging field that is being thoughtfully developed through the efforts of many interested parties. For more information, refer to the *Data Ethics in the Participatory Sciences Toolkit*, found on the website of the Association for the Advancement of Participatory Sciences. In the words of the toolkit designers, the data ethics toolkit aims to help project leaders understand their role as data handlers in identifying, satisfying, and/or balancing ethical obligations of a project to participants, partners, science, and society.

Module 7 examines projects and platforms that can be adapted or used to build citizen science projects so that you don't need to start your project from scratch.

FURTHER READING

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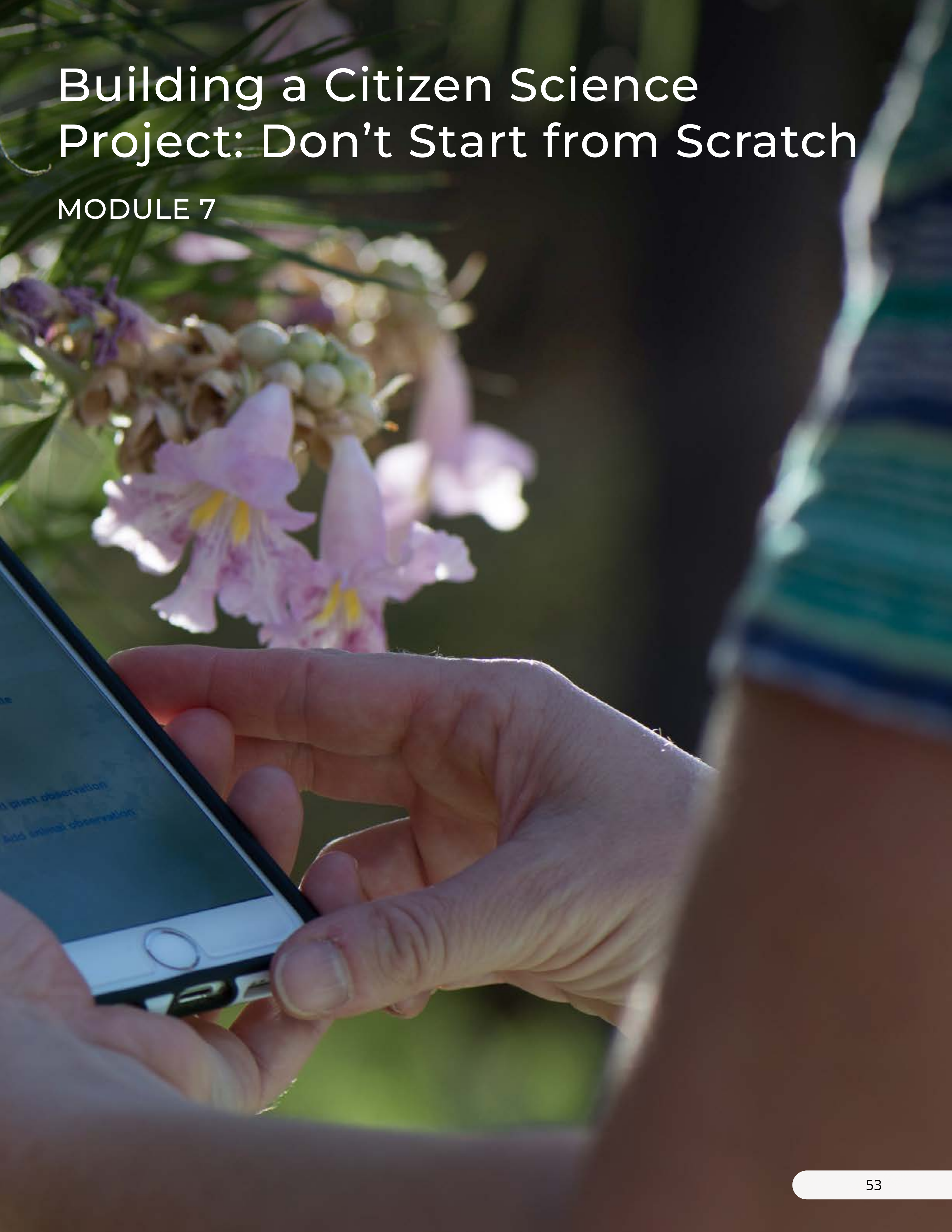
Building a Citizen Science Project: Don’t Start from Scratch

MODULE 7



INTRODUCTION

The goal of this module is to examine projects and platforms that can be adapted or used to build citizen science projects so that you don't need to start your project from scratch.

Assembling a citizen science project involves many steps. As we have seen in Module 6, the process includes determining what data your project participants will collect, designing a data collection protocol and data submission mechanism, building a data housing and storage system, and creating a data display mechanism. The process can be simplified, however, by adopting or adapting a citizen science project that already exists or by using a project-design platform to create and maintain a new project. These approaches can save time and money and ensure that the data your project collects will be useful for their intended purpose.

Your project goals and objectives (see Module 3) will help you choose a sensible approach for obtaining the data that you desire. Perhaps you want to collect data that already are being collected in other locations. For example, if you want to learn more about the birds that inhabit your park or refuge, you might consider engaging your visitors in eBird, a bird checklist project for which all of the tools that your participants need to submit and examine bird data already are in place. There is no need to develop a bird checklist program from scratch, no matter your location.

As another example, you may want to measure the quality of stream water in your forest. In this case, no project would likely be available for immediate adoption; however, many existing water quality projects, such as Alabama Water Watch or Adventure Scientists Wild and Scenic Rivers Project could be adapted for your specific needs, saving you from developing your protocols from a blank slate.

In other cases, you will want to collect data that are not being obtained by an existing project or approach, meaning that you will need to develop a novel project. Even in this situation, you might be able to facilitate project design and management by using a citizen science platform, which is an online tool that allows you to build a project by answering questions about your project design and populating fields that will allow the platform to create and manage the tools that you need to run your project.

ADOPTING OR ADAPTING A PROJECT

Hundreds of citizen science projects already exist, and many can be implemented in a variety of settings either "as is" or through simple modifications.

Consider NestWatch, a Cornell Lab of Ornithology project that collects data about the breeding biology of nesting birds across North America. This project has been adopted by numerous organizations including the Nestucca Bay National Wildlife Refuge, which hosts 20 nest boxes in varied refuge habitats. Volunteers manage and monitor the boxes and record data including nest site location, habitat, species using the box, and the numbers of eggs, young, and fledglings. Data are submitted through the NestWatch website and are thus entered into the continental NestWatch database. In this way, refuge staff learn more about the birds nesting on the refuge—including tree and violet-green swallows, nesting bluebirds, and chestnut-backed chickadees—while adding observations to those of other participants across the continent to better understand and manage the impacts of environmental change on bird populations.

Another example of a project that can be adopted is the Dragonfly Mercury Project (DMP), which monitors mercury pollution in US national parks and other protected areas using dragonfly larvae as biosentinels, that is, organisms that measurably reflect environmental change. Dozens of national parks are implementing the project or have done so in the past. For this project, park staff and local volunteers collect dragonfly larvae from various park locations. Data are gathered about each specimen in the field. Then the collected larvae are preserved and shipped to a U.S. Geological Survey lab where they are analyzed for mercury. Since 2009, more than 6,000 volunteers have helped to collect dragonfly larvae at more than 140 parks and other protected areas across the US. The DMP is now the nation's largest assessment of mercury contamination and environmental risk, and more parks and waterbodies are added each year.

One location that has implemented DMP is Indiana Dunes National Park, which uses the project to measure water quality in the park so that potential threats to wildlife and humans can be identified. Park staff also use the project to engage volunteers in science and to connect them to the park's natural resources. The volunteers commit to work in small teams for at least one day for up to five hours. Wearing waders and nitrile gloves, they use nets to capture dragonfly nymphs longer than 15 millimeters. They identify the nymphs to the family level, measure their length, prepare labels, store the larvae on ice, and complete data sheets. In 2021, the eighth year that the park ran the project, 14 participants spent more than 50 hours in the field. Park researchers determined that the volunteers were 100 percent accurate in their identifications of the larvae, and that the average concentration of mercury at Indiana Dunes was lower than the average concentration across all other participating parks.

Implementing the DMP is easy because the project organizers have produced [a detailed protocol implementation plan](). Materials include a field sampling guide, a dragonfly identification key, lessons on mercury and entering and retrieving data, additional materials for teachers to use with their students, and more.

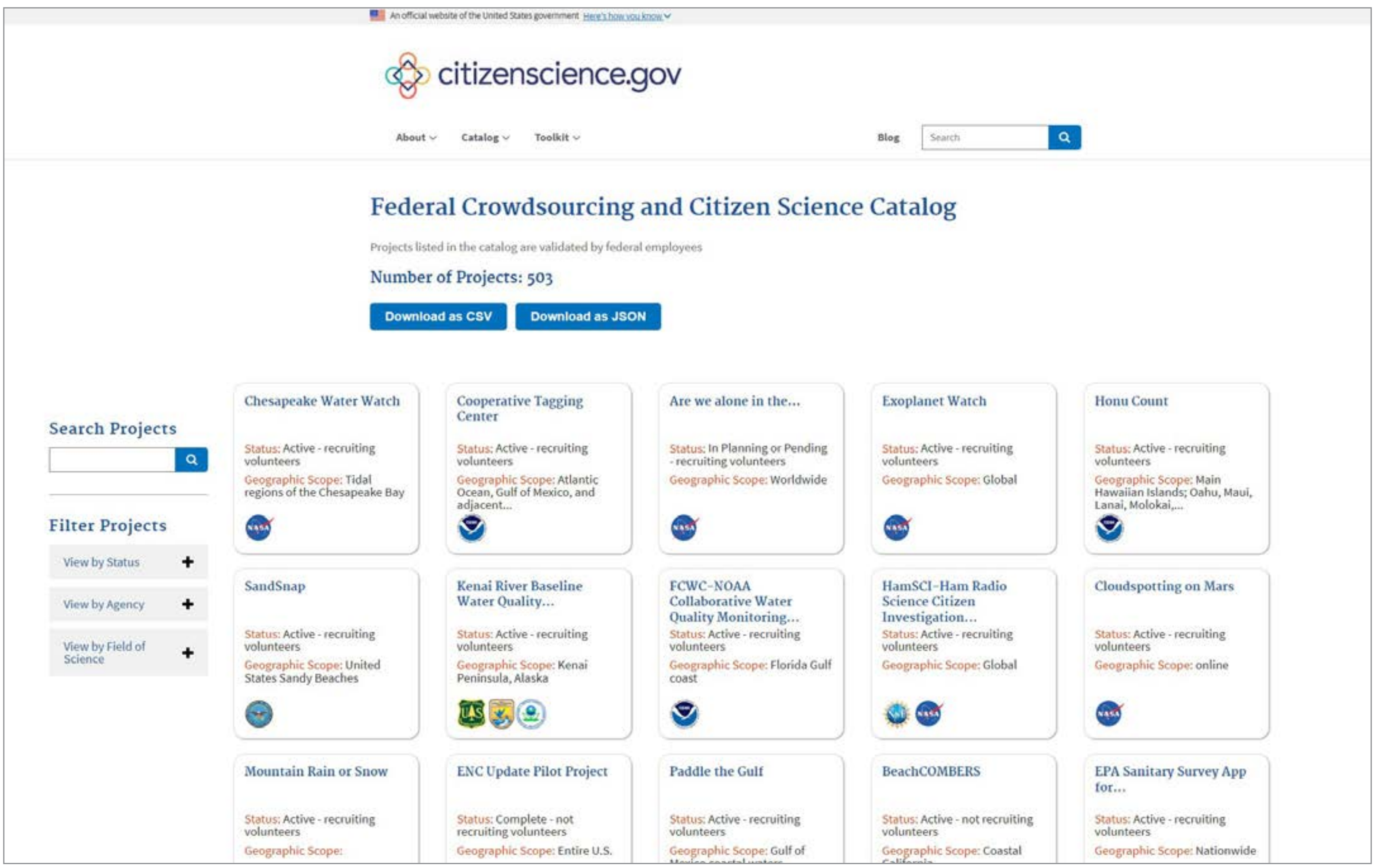


Figure 7.1: The website citizenscience.gov provides an option to "view by Field of Science." Clicking on the "Ecology and environment" category yields several projects. A portion of them is shown in this screenshot.

Many other science projects also can be adopted for implementation by staff at federal, state, and local agencies. Several directories are available for locating projects that you can use at your park, refuge, or forest. These include the Federal Citizen Science and Crowdsourcing Catalog, SciStarter, and CitSci.org (which also serves as a data management platform; see the CitSci.org section below).

Federal Citizen Science and Crowdsourcing Catalog

The Federal Citizen Science and Crowdsourcing Catalog lists citizen science projects involving federal government agencies. Projects can be searched by status (active or complete), by agency, or by field of science (i.e., animals, archaeology and culture, climate and weather).

For example, sorting the catalog by the keyword "Ecology and environment" would yield several projects including some, such as the Tribal Nations Botanical Research Collaborative, which are discussed in several places in this toolkit. Clicking on one of these boxes would take you to full details about the project.

SciStarter

The website scistarter.org features a list of thousands of citizen science projects searchable by location, topic, age level, and more. These are generally not projects run by federal agencies, but many of the projects can be implemented on federal lands. In addition, the site has numerous other resources, primarily for people who wish to participate in citizen science. It also markets projects to increase volunteer recruitment and offers a dashboard for participants to track their engagement in multiple citizen science projects.

CitSci.org

CitSci.org is a platform for building and maintaining citizen science projects and is discussed in detail in the next section, "Building a project using a platform." However, the website also contains a searchable database of more than 1,000 projects, many of which would be possible to implement on federal lands.

Implementing an existing project is almost always easier than developing a new project from scratch, and it enables you to use protocols and data forms that have been tested and revised for ease of use and accuracy in data reporting. You can have confidence that project datasets are well documented and relevant to those who will be using the data.

Understand, though, that implementing any project that you discover in any online directory or database still requires addressing each of the steps, or modules, in this toolkit. That is, even when using a well-designed, pre-existing project with its own data protocols, forms, and data management and display capabilities, you still need to set goals and objectives for your own implementation of the project, define your audience, recruit and train participants, and provide them with appropriate feedback. Additionally, you should reach out to the individuals or groups who created the pre-existing project to gain insights about adapting the project to specific situations.

BUILDING A PROJECT USING A PLATFORM

Several platforms have been developed to collect citizen science data by accepting them directly into a national or international database. Some platforms also can be used to build projects using the platform's online tools. eBird, which was discussed in detail in Module 6, is a platform through which individuals can submit bird checklists that they collect any time in any location, from their backyards to birding trips around the world. However, eBird also can be used to build customized bird data collection projects, such as the Sagebrush Songbird Survey that

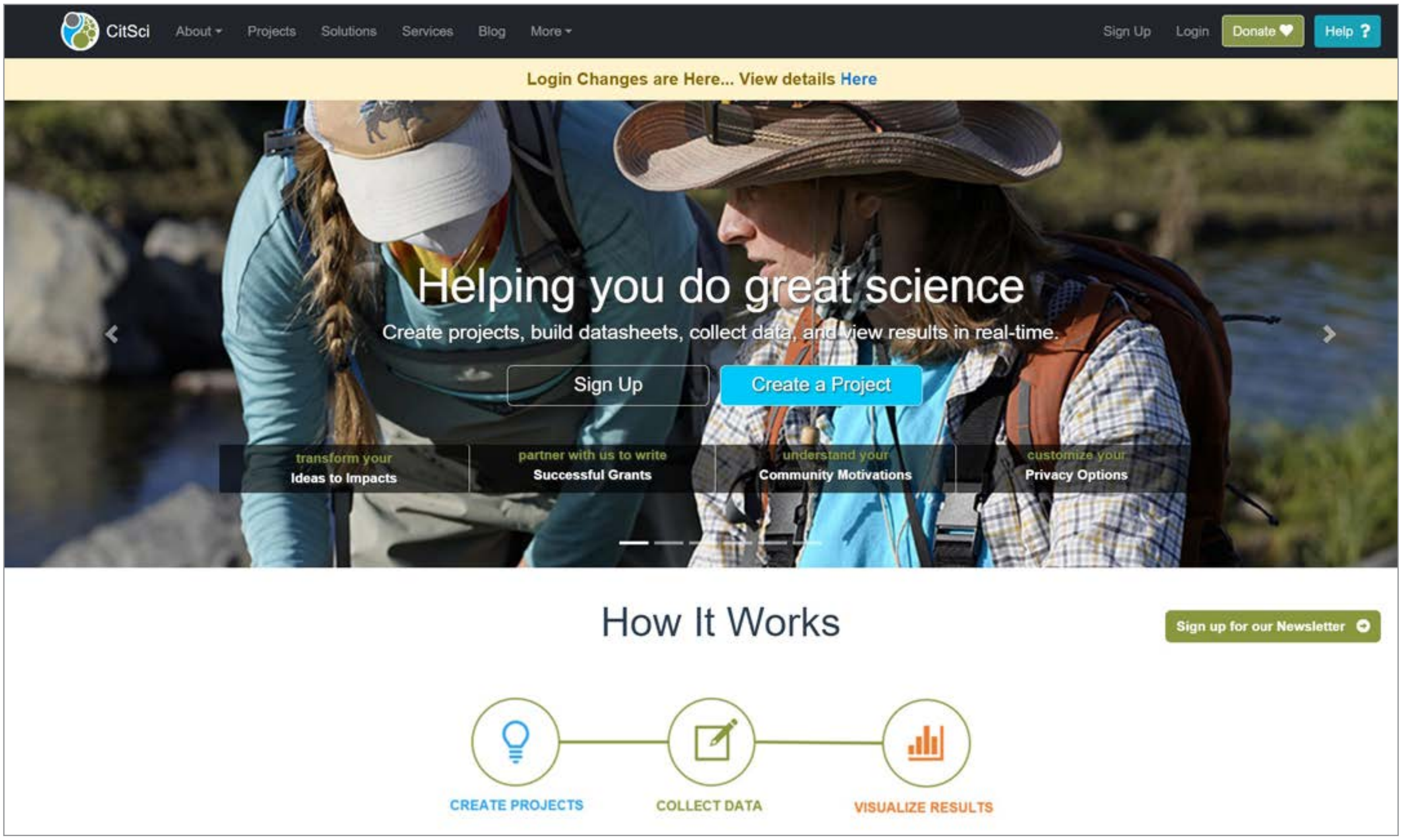


Figure 7.2: The website CitSci.org has a searchable database of more than 1,000 projects. Many of these projects take place on federal lands, and several have been developed in partnership with federal agencies. Before developing a citizen science project from scratch, look through these projects to see if you can adopt or adapt one of them to meet your needs.

took place over five years in Washington. Some platforms offer a large degree of customization opportunities and allow projects to be built more quickly and easily than if they were built from scratch. Three platforms that seem to be most regularly used by federal agencies to develop citizen science projects are iNaturalist, Nature's Notebook, and CitSci.org.

iNaturalist

iNaturalist is a social network for sharing biodiversity observations and for crowdsourcing identifications. When participants encounter a living or recently living organism, or evidence of a living organism such as tracks, they can use the website to record who they are, what they saw, where they saw it, when they saw it, and evidence—such as a photo or sound recording—of what they saw. If participants use the iNaturalist app, much of the required information, such as time and location, is recorded automatically. A large community of volunteers corrects mistakes, thus monitoring and improving the quality of the data.

Because iNaturalist accepts observations made in any location and does not record information about effort, such as how much time was spent searching, it typically supports unstructured surveys, for example, presence only or species distribution studies. For this reason, iNaturalist is often used to document bioblitzes. One massive iNaturalist-based bioblitz took place on March 28 and 29, 2014 within the 80,000 acres of the "Golden Gate National Parks," which includes the Golden Gate National Recreation Area, Muir Woods National Monument, and

Fort Point National Historic Site. The event was a collaboration between the National Park Service, the Golden Gate National Parks Conservancy, the Presidio Trust, and National Geographic. For this event, 9,000 participants documented 2,350 species, which were recorded in the iNaturalist database. Highlights included the first canopy survey of redwoods at Muir Woods; the first park sighting of a climbing salamander in Muir Woods; sightings of great horned, spotted, barred, and saw-whet owls; and a mountain lion sighting at Corral de Tierra. These data added tremendously to the park scientists' knowledge of the flora and fauna of the area.

More recently, the Bureau of Land Management (BLM) has set up an iNaturalist page to monitor species in the Santa Rosa and San Jacinto Mountains National Monument, which the BLM manages. Since 2019, more than 2,000 observers have submitted nearly 80,000 observations. Highlights in 2021 included sightings of the federally endangered Peninsular bighorn sheep, Abert's towhee, zebra-tailed lizard, and hedgehog cactus, all of which are permanently recorded in the monument's data records.

iNaturalist also can be customized to create specialized citizen science projects, saving project developers time and money and allowing them to build their project on a tried-and-tested web platform. The Tribal Nations Botanical Research Collaborative did just that. This US Forest Service program collects information on traditionally used plants that have cultural, medicinal, or economic values important to Tribal communities and was discussed in Modules 2 and 4 as an example of a community-based project. Volunteers record observations of plants on a specified list using their mobile phones, and the data are analyzed to shape conservation and land management goals for increased sustainability of these important plants. The project takes place in the Apache-Sitgreaves, Coconino, Kaibab, and Tonto National Forests. It started in late 2018 and by the end of 2022, more than 1,200 observers had made more than 4,000 observations of 35 species.

The project developers built this collaborative on iNaturalist because the platform made developing and managing the project easy, including communicating with participants and building a leaderboard. They also found that it provided data security as well as data quality because other people in the iNaturalist community help with identifications and flag data quality issues such as incorrect locations.

The iNaturalist project page highlights many of the projects built on this platform and is well worth exploring. In addition, the iNaturalist website includes a page with detailed information on how to start and run a project. To learn about all of the different project formats and to see if iNaturalist is an appropriate tool to build a project for your situation, visit https://www.inaturalist.org/pages/managing-projects.

USA National Phenology Network: Nature's Notebook

Nature's Notebook, part of the USA National Phenology Network (USA-NPN), is a national platform on which volunteer and professional scientists record observations of plant and animal life cycle events, which are known as phenophases. Flowering plant phenophases include budburst, first flower, last flower, first ripe fruit, and leaf shedding. Animal phenophases include molting, mating, egg-laying or birthing, fledging, emergence from hibernation, and migration. Currently, Nature's Notebook includes more than 25,000 active users at more than 18,000 sites and has collected more than 31 million records. The data are used to improve invasive species management, inform the timing of fire, forecast the activity of insect pests, show the timing of food resources for wildlife, and inform the timing of seed harvest.

Contributors to Nature's Notebook collect data using standardized protocols for the 1,276 plants and 374 animal species currently on the Nature's Notebook species list. These protocols include a list of questions about the phenology activity occurring on an individual plant or observed in an animal. Each phenophase is defined in detail, and observers answer whether they see the phenophases occurring. They also can answer an optional question about the intensity or degree to which a phenophase is occurring.

Observers can enter data either directly into the Nature's Notebook mobile app or with traditional paper datasheets that they then enter into a web browser application. Nature's Notebook has various measures to ensure high-quality data, all of which are freely available for visualization and download on the Nature's Notebook website.

Like iNaturalist, users can submit incidental observations to Nature's Notebook, although the platform is designed primarily for repeated, long-term observations on the same individual plants, or for animals, on the same locations. A national coordinating office based at the University of Arizona maintains the platform and assists federal agencies and other organizations in implementing Nature's Notebook according to their scientific, management, or educational objectives.

Nature's Notebook currently includes more than ten data collection campaigns that are focused on species of special interest to scientists and natural resource managers. These campaigns include regular email communications that can be leveraged to engage citizen science participants. The USA-NPN also offers a local phenology program infrastructure, which supports federal agencies and other organizations in long-term phenology program planning and offers an online certification course and community of practice for local phenology leaders. The network operates a collaboration specifically for the US Fish and Wildlife Service, which includes help getting started with a local phenology program, a customized refuge dashboard, and a forecast of spring arrival at individual refuges.

One example of agency use of Nature's Notebook is a program on Midway Atoll National Wildlife Refuge. This Pacific Island refuge is a globally important Seabird Conservation Site, which is threatened by an invasive species called golden crownbeard (*Verbesina encelioides*). To eradicate this plant, refuge staff needed to understand how quickly the plant grows and moves from one stage to the next. To gather this information, they developed a citizen science project on the Nature's Notebook platform. Volunteer-collected data allowed them to determine that the plants took a minimum of 30 days to go from leaves to seed drop, information that was critical to developing a management plan that is keeping the plant at or below one percent land cover on the refuge.

CitSci.org

While iNaturalist and Nature's Notebook are excellent tools for building projects based on observations and phenology, respectively, some platforms allow a user to build a project with essentially no pre-defined data structure. One such platform is CitSci.org, which allows users to define what they wish to measure, to document how they measure, and to build customized datasheets for data entry either online or via mobile applications. Like iNaturalist and Nature's Notebook, the CitSci platform also provides data exploration and visualization tools so that project organizers can create their own visualizations of data trends, relationships, and comparisons. Also on the platform are tools for volunteer communications, for bulk uploading legacy data, and for downloading data.

CitSci.org provides a tutorial that walks a user through the project-building experience. The user specifies a project title, adds a banner and logo image, then adds the project goal, purposes, and tasks. The project builder has settings for project governance (open or member-based), for data privacy (public or private), and for opt-in integrations with SciStarter and another platform called Zooniverse (see below). The project builder also manages members and creates datasheets for specific protocols that can be text, image, numerical, categorical, or dropdown. When a volunteer enters data onto the sheets, the data are uploaded and shared on the citsci.org platform. Currently, CitSci.org hosts more than 1,000 cumulative projects engaging more than 14,000 volunteers who have collectively amassed over 1,654,979 scientific measurements of diverse phenomena.

One example of a citizen science project built on the citsci.org platform is Utah Water Watch (UWW), a water quality data collection and education program that seeks to increase awareness about the importance of water quality and to promote stewardship of Utah's aquatic resources. Two “tiers” of monitoring offer both beginners and those with a background in environmental monitoring to contribute data. All volunteers attend a workshop, become certified, and then choose a site to monitor once a month for seven months out of the year, usually April to October. Volunteers monitor more frequently if desired or if needed to meet specific monitoring objectives. Data are used to track water quality trends and changes over time and are used for presentations to state and federal agencies, to local communities, and for academic research.

Building this project on CitSci.org allowed the project developers to easily create a complex project with the platform’s online tools. The platform also allows individuals to view the data with graphs, charts, and maps and to download raw data. Starting in 2012, UWW has trained well over 1,000 volunteers.

ArcGIS Survey 123

Another resource for building citizen science projects is Survey 123. While not a full platform, this tool does allow custom building of surveys and web forms. It also allows combining protocols from different programs. Many federally based citizen science projects have employed Survey 123 including three projects previously discussed in this toolkit: Alabama Water Watch, Engaging Angler Scientists, and Glacier National Park’s Common Loon Project.

The loon project is designed to enlist the help of park staff and volunteers to improve data accuracy and to increase survey coverage of priority lakes during the common loon breeding season. Volunteers map locations of territories, nests, and nursery areas, and document disturbance behaviors to identify potential factors affecting loon nesting success. Since 2005, park volunteers have spent more than 40,000 hours and completed 2,479 surveys.

Project staff used the Survey 123 application so that submitted data are instantly viewable in a Loon Survey Priority web map, which informs the participants about where surveys are needed and helps them determine which survey sites match their interest and ability. Participants also can see immediately how their contributions are making a difference.

Note that unlike the other tools described above, use of Survey 123 requires a fee.

Zooniverse

Zooniverse is an excellent tool for building data management projects. It is best suited for projects based on camera traps or other large collections of photos and for projects that transcribe text from scanned documents or images. It can be used to develop “living room” projects that are wonderful for engaging participants with mobility issues or who are physically distant from a park or refuge. Few examples of federal agency projects built on Zooniverse are available, and the potential for building highly useful projects on this platform is tremendous.

One project that has successfully used Zooniverse is FISHstory, a project of the South Atlantic Fisheries Management Council. For this project, volunteers examine historic photos of dockside fish catches taken prior to the 1990s to document the species and lengths of fish caught during that time period. The data help to explore whether the past decades have shown changes in overall catch composition or the seasonality of catches and to see whether the size of fish caught over time have changed. This information can be used to inform both historical and current fishery stock assessments.

Additional Platforms

Several other platforms can be used to build citizen science projects.

Anecdata is a free citizen science platform developed by the Community Lab at the Mount Desert Island Biological Laboratory in Bar Harbor, Maine. Project managers can use it to create projects and to create datasheets for volunteer use. Participants can submit data using the website or mobile app, and anyone can view and download the data.

Fieldscope creates a digital homepage for contributory projects that facilitates datasheets, data storage, and visualization. To begin using the platform, a meeting with the organization is required to determine project needs.

Chronolog involves installing physical infrastructures to allow for crowdsourced photos of a particular location. The tool compiles submissions to create a timelapse of a standard scene and is best suited for long-term projects with a permanent location of interest. This platform requires a fee for use.

Module 8 discusses recruiting, training, and engaging project participants once your project is designed and ready to get under way.

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Recruiting, Training, and Engaging Project Participants

MODULE 8

INTRODUCTION

The goal of this module is to discuss how to recruit, train, and engage project participants once your project gets under way.

No matter how important your goals and how well designed your protocols, the success of your project depends on recruiting, training, and engaging sufficient participants. Consider the challenge: First, potential participants have to find out about the project. Next, they must decide whether to participate. Then they have to learn how. Finally, they must determine that volunteering to collect and submit data is worth their time and effort, and if the project is more than a one-time event, they need to continue to submit data over time.

Before you begin the process of recruiting, training, and engaging participants, you need to have a clear understanding of who those participants are most likely to be, including their needs, motivations, and skill levels. You also need to understand what they know about your agency, why they think you are implementing a citizen science project, and why you would like them to be involved. Most projects and their recruitment and support materials must be tailored to specific audiences, and “hooks” to attract and engage participants will vary from audience to audience.

For contributory projects—those that begin with a well-defined question or issue—your participants may be a group of people who do not know each other but who share a common interest, concern, or hobby. In some cases, willing groups of volunteers may be fairly easy to identify, for example, when implementing studies of birds or butterflies, which many people watch as a hobby. The challenge in working with these individuals is creating a project that is fun, engaging, and meets their needs in multiple ways.

For community-based projects—those that arise when a community chooses to address a local issue of concern—participants may include a group of individuals who have many common interests and concerns and may know each other to some degree. The challenge for these projects is building and sustaining a trusting relationship with the community, which will include people with different reasons for participating and varied strengths to contribute. Some members of the community may have limited experience with science and may even be mistrustful of scientists.

In practice, working with audiences in both types of projects has common themes. Even motivated volunteers with deep subject knowledge must be treated with sensitivity and respect and must understand the reasons for and importance of the project in which they are engaging. And volunteers in community projects require projects to be appealing and to meet their needs in various ways. Many surveys of existing projects have shown that individuals are primarily motivated by contributing to meaningful, useful science. However, many people participate in citizen science projects for social reasons—to meet new people or to gain a sense of belonging—whereas others wish to increase their practical skills, for example, identification of flowers or insects. Still others volunteer because they want to share the skills they gained during their professional career. Understanding and honoring varied motivations is crucial to project success.

Knowing and understanding your potential participants, then, is a critical first step in participant recruitment. See Module 4 for additional thoughts about this topic.

RECRUITING PARTICIPANTS

Once you have developed an understanding of your desired audience, you need to identify and/or recruit project participants. If you already have a community of individuals ready to get started, you're a step ahead in the process. If you have only an idea of the types of people who would be suited to your project, you probably need to spend significant time recruiting. And even if you have a community of participants identified, you'll likely want to reach as many members as possible to engage the widest audience possible.

The effort that you must put into recruitment will depend largely on how many volunteers you need and what special interests or skills you require your volunteers to have. Once you have determined that information you can start recruitment, which is basically a form of marketing. You must appeal directly to the interests and motivations of potential participants and describe the benefits of participation, such as the satisfaction of being productive or the enjoyment of interacting with others during project activities. Be upfront about the time commitment and type of work that you are asking of volunteers. Also consider that typically you need to recruit more volunteers than you think you will need because of inevitable attrition.

Volunteers can be recruited from partner communities such as natural history clubs, public service groups, church groups, master naturalists, retiree groups, afterschool programs, libraries, science museums, recreation groups such as hikers and bikers, and community organizations.

Consider the following recruitment techniques:

- **Online media:** Use social media, blogs, and videos. Most agencies have accounts on multiple platforms, as do many individual parks, forests, and refuges.
- **Volunteer.gov:** Volunteer.gov is an online portal for federal agencies to list volunteer opportunities and to connect with interested volunteers.
- **Printed media:** Many volunteers are interested in working at a place that they have personally visited. To let them know about citizen science opportunities, post fliers on message boards in popular locations on the unit (e.g., visitor centers, campgrounds, and trailheads). Many visitors can use QR codes to access information.
- **Events:** Engage diverse audiences through community organizations and large "walk-in" events such as town events, career fairs, and farmer's markets.
- **K–12 classrooms:** Talk to teachers and principals to collaborate with classrooms focused on STEM topics or hands-on activities for students.
- **Volunteer groups:** Many parks, refuges, forests, and other lands have Friends groups or other local organizations that serve as partners, and many of these groups include individuals who may be interested in participating in a citizen science project.
- **Partners:** Past citizen science projects have had success in recruiting volunteers through partner organizations with strong volunteer bases or through working with local teachers and schools. One example is Adventure Scientists, an organization that recruits highly skilled volunteers (such as mountaineers) to collect conservation data for partners such as the US Forest Service (USFS). Making yourself visible and engaging with folks while you are out collecting data also can generate participants.

Two projects that invested carefully in recruitment are Desert Avicaching, described in Module 2, and Bumblebee Watch.

Figure 8.1: Desert Avicaching enlisted birders to visit areas of the Mojave and Sonoran deserts they usually did not, and to report bird observations. The project used multiple forms of recruitment, which resulted in 409 birder checklists. Data from those checklists are used to study bird mortality around solar installations.

Desert Avicaching built on the eBird platform by the Sonoran Joint Venture (SJV). The goal of the project was to encourage birders to collect data about migrant birds from under-visited locations in the Mojave and Sonoran deserts. The data were intended to inform management and mitigation planning regarding alternative energy development in southern and eastern California.

To recruit participants, the SJV started by creating a bilingual webpage hosted on the SJV website that provided background information on the game, its objectives and rules, a map of the Desert Avicaching locations, a list of potential prizes, and a real-time leaderboard to keep track of volunteers' scores. The SJV also published two articles, one hosted on its web page and promoted through its newsletter, and one on the eBird website. They also developed a social media toolkit to share with their partners, which offered guidelines for how to promote the game on social media outlets. The toolkit also included a series of suggested posts and graphics for partners to use on their websites and in social media accounts. The SJV made sure to "tag" its major partners (Point Blue, Great Basin Bird Observatory, the Bureau of Land Management) as well as the prize sponsors to reach a larger audience. They also developed a series of hashtags for maintaining wording consistency in tracking project use.

These recruitment tactics worked: During the winter and spring of 2018, 72 observers submitted 409 checklists representing more than 500 cumulative survey hours. Observers reported more than 16,000 birds of 102 species in migration at 53 avicaching sites, which were chosen for their proximity to planned or operating solar facilities. Observers recorded up to eight migrating individuals per minute at these sites. These data are being used in ongoing studies of migration and mortality around solar installations.

Bumble Bee Watch is a collaborative effort of the Xerces Society and multiple partners, including several national parks, to track and conserve North America's bumble bees. Participants upload photos of bumble bees, identify the bees in the photos, and have their identifications verified by experts. The project has an intensive recruitment process. Its public project webpage includes several tools to make it easy for people to learn about and join the project, including a FAQ page, an easy step-by-step how-to video guide showing how to join the project, a sign-up page, tips for how to photograph bees, and a contact email address for questions.

TRAINING PARTICIPANTS

Before participants can engage in your project, they need to understand its purpose, protocol (or protocols), required skills, safety concerns, and how the data they collect will be used. Indeed, the quality of your data will depend on the volunteers' knowledge of the protocol and their commitment to following it correctly. Therefore, you need to ensure that volunteers understand the protocol well enough to contribute accurate and usable data.

Typically, this requires the development of supporting materials and appropriate training to use them. A written instruction manual/protocol helps to ensure that all participants are clear about what data are to be collected and how. Clear and concise materials can increase volunteers' confidence in their data. Pointing out common data collection mistakes and letting your participants know what to watch for also can boost confidence in and willingness to submit the data that they collect. Don't forget to design for accessibility when appropriate.

When designing materials, seek input from volunteers to ensure clarity and completeness. Use as many visual aids as possible, for example, plant identification guides and step-by-step visual instructions for using measuring instruments. Training videos also are helpful for volunteers to reference throughout the project. When possible, show participants who are engaged in the project explaining what they are doing. If you are implementing a project that you have adopted or adapted from another program, or if you are building a project using an established platform (see Module 7), supporting materials might already be available to use "as is" or with some modification. Contact groups that specialize in the species, environmental topics, or training that you are investigating and ask their advice. They may be happy to share their resources.

Actual project training can take many forms, from simply providing your instructions online to holding in-depth, in-person workshops. The training that you provide will be determined by the knowledge and skill levels of your participants, the complexity of your project protocols, and whether in-person workshops are needed for field training, safety concerns, or development of content knowledge. If you are unable to provide extensive training, then while you are recruiting volunteers, be clear and explicit with them about the knowledge and skills they'll need to bring to the table to participate successfully. If your project is simple, or if volunteers work in groups and you have team leaders on site with volunteers already well-versed in the protocol, then a set of instructions at the beginning of the field day may suffice.

One very successful citizen science project is the Coastal Observation and Survey Team (COASST), which was established to identify the carcasses of marine birds found on beaches along the coast of Oregon, Washington, and Alaska. This University of Washington project partners with state, Tribal, and federal agencies, environmental organizations, and community groups. COASST volunteers conduct surveys for bird carcasses that they measure, identify, photograph, and mark. COASST data are used to detect unusual events such as increased mortality due to low food availability, weather, harmful algal blooms, and oil spills. COAAST data also can be used to identify long-term changes in the status of resident marine bird populations.

COASST volunteers require substantial training. Nearly all COASST volunteers are trained at an in-person, hands-on event hosted at a local community center or event space. COASST staff travel to teach new participants how to survey their assigned beach, to document beached birds in a standardized way, and to use a custom beached-bird field guide to measure and identify marine bird species. Undoubtably such training events remain the best and most effective way to train volunteers; there is no substitute for handling specimens to practice the process of seabird identification.

However, during the height of COVID-19 restrictions, COASST staff developed a virtual training system that provides a great model for other projects that focus on environmental data collection. This training breaks the approximately 5 hours of in-person training into two levels. After learning the basics of survey methodology in Level 1, participants try their hand at surveys on their own, while relying on the COASST office team to identify the birds they encounter. After completing two surveys, participants are invited to attend a Level 2 training where they learn the techniques of measuring and identifying a bird. While the Level 2 training may take place in a virtual space, COASST participants are encouraged to attend in-person trainings at this stage, or at their earliest opportunity, to practice their identification skills.

We'll talk more about COASST in Module 9.

As another example of training, consider Alabama Water Watch (AWW). In the initial phase of this project, AWW conducted in-person, multi-day workshops. Currently, AWW conducts hybrid trainings that combine online, self-paced coursework and in-person field sessions to certify new monitors. In the online portion of the training, AWW provides an overview of the project and information related to the water environment, forests and watershed health, pollution, and water quality standards. Following completion of the online coursework, participants attend a field session during which they conduct monitoring at a national forest. Forest Service district staff give presentations that highlight the ecological history, flora, and fauna of the national forest during the field session. They also provide volunteers with additional safety guidelines and protocols for working in the forest and certify the volunteers as water chemistry and bacteriological monitors. Each training takes a total of around 10 hours and includes a visit to the local US Department of Agriculture Forest Service Ranger District Office. Approximately one year after their initial certification, volunteer monitors must complete recertification requirements including a short training session or online test, depending on the monitoring type. After the initial recertification, volunteers are required to recertify every two years.

If you decide to hold in-person trainings for your project, consider the following pointers:

- The more connected that new volunteers feel at the beginning of the project, the higher your retention rate is likely to be. Introduce volunteers to each other. Then explain the project's purpose and goals, along with any data or trends documented so far.
- Get volunteers used to the environment. An on-site field orientation is the best choice, especially for new volunteers. It doesn't have to be at the exact site of your project but should be a good representation.
- Provide additional training. Give volunteers the option of furthering their knowledge of the training material with online resources, webinars, books, and local presentations.

- Let volunteers learn from each other. Consider having new participants join seasoned volunteers for the first couple of dates or for the full season rather than starting new volunteers on their own site right away. If a volunteer feels too intimidated as a beginner, they are more likely to drop out of a project. In addition, when experienced volunteers teach others, they learn even more about the project and hone their skills. You might consider requiring all experienced volunteers to announce their first monitoring dates and allow newer volunteers to join. This provides mentoring for new volunteers as well as several options for dates and a diversity of sites at which to train.

Use photography and video. Encourage volunteers to take photos of themselves and of artifacts that represent the program so they can be used in presentations or success story articles. Ask specifically for photographs showing faces and actions to get the most usable images. Make sure that participants know the expectations for video content, including using the proper protective equipment. Remember to provide a photo release form. Photographing minors requires special planning and might not be worth the needed effort.

If you run in-person workshops, consider developing "train the trainer" workshops, so that the people you train can in turn train others. You also might want to establish and maintain a network of local training hubs and expertise. Some projects build a network of regional mentors, coordinators, or champions.

One program that relies on a train-the-trainer approach is the USA National Phenology Network, also discussed in Modules 5 and 7. Because it is a national program with a small staff, the network has developed the Local Phenology Leader Program. Local leaders who wish to be certified complete an interactive 10-week course that requires participation in a combination of online assignments, group discussions, and the development of an individualized program plan for monitoring phenology with Nature's Notebook. These individuals can then train others in using the program. Any agency staff person who wants to set up a phenology monitoring program will be well served by participating in this program.

For community-based projects, trainers and liaisons who can speak the community's primary language and understand the culture are critical. Make sure that trainers who aren't from the community have an understanding of and respect for the people with whom they'll be working.

Before diving into participant engagement, you'll need to consider two additional important factors: volunteer safety and data usage and ownership.

Safety is paramount! Be sure to include safety measures while training volunteers. Ensure that volunteers understand relevant safety risks. Immediately after an accident or a near miss, notify the appropriate authorities in the manner specified by your agency.

Data usage and ownership were discussed in Module 6, which focuses on citizen science data. However, for completeness in this section on recruitment and training, we reiterate that the Crowdsourcing and Citizen Science Act of 2017 requires that "As part of the consent process, the Federal science agency shall notify all participants (i) of the expected uses of the data compiled through the project; (ii) if the Federal science agency will retain ownership of such data; (iii) if and how the data and results from the project would be made available for public or third party use; and (iv) if participants are authorized to publish such data." Make sure that you take these actions!

Figure 8.2: Training is an essential part of any citizen science project. Some trainings can be accomplished with simple online materials, but sometimes in-person training is valuable, and some projects have developed train-the-trainer programs. Participants in the National Phenology Network's Local Phenology Leader Program learn the skills they need to train others in using Nature's Notebook, a platform for reporting data on the timing of events in nature.

ENGAGING PARTICIPANTS

Your work is not done when your participants are identified, trained, and beginning to collect data or otherwise participate in your project. You will need to continually engage your volunteers to keep them actively involved. You'll want to thank them on a regular basis for their contributions, and make sure they know that their contributions to the project make a difference. Volunteers are much more likely to stay involved if they know how and why their data are being used. And keeping participants motivated and informed is not only courteous but also advantageous: Well-supported participants will gain more from their participation, from increased skills to improved confidence to new social networks. Also, long-term volunteers collect higher-quality data and can help to train new recruits. It takes a lot of effort to recruit participants—do all you can to retain them!

The specific tools that you use for engagement will depend on your project and whether its participants are dispersed or working together on a community-based project.

For dispersed, typically contributory projects, you need to rely primarily on email, newsletters, and social media. Personalized messages to participants are particularly appreciated—even if they are automated—but a regular online newsletter also will inform participants about project findings and the significance of their data. More information about providing project results to participants is included in Module 9.

You also can create an online community of project participants using various social media. You'll probably need a staff person to keep up with that media, answering questions and ensuring that information provided by participants is accurate.

Many projects have created strong online communities that are worth exploring for ideas. Consider the aforementioned Bumble Bee Watch. A public webpage shows recent sightings, links to explore data, a gallery of photos, and an interactive map of sightings with a tool to filter pictures. The webpage also includes a "Top Contributors" table, links to social media accounts, blog posts, and a rotating photo display of bee sightings with credit given to the volunteer who took the photo. Other projects/platforms with strong online communities include iNaturalist, eBird, and Nature's Notebook, which can be mined for community-building ideas.

For community-based projects, participants can meet in person for workshops and social gatherings to share project findings and volunteer experiences. At such events, participants can present their own findings. You also can provide decision-making and governance opportunities for participants, to take advantage of their expertise and to show respect for their contributions.

For example, the Imperial County Community Air Monitoring Project is a community-based research and monitoring project designed to address residents' concern about the historically polluted air in their county. To create this project, Tracking California (a program of the Public Health Institute and the California Department of Public Health) partnered with Comite Civico del Valle (CCV), a community-based organization, and the University of Washington to engage community members in efforts to collect real-time air quality data specific to their county. In addition to collecting data, community members participated in the design and direction of the project. Facilitated by CCV, a Community Steering Committee was formed to invite community voices into the project's decisions. This committee of local residents used their knowledge of the community to guide project activities such as identifying priority areas in which to install air monitors.

This project has been successful in many ways. For example, these Imperial County communities were selected by the CARB (California Air Resources Board) Community Air Protection Program to develop a community emissions reduction plan, which was approved by CARB in 2019 and adopted by the Imperial County Air Pollution Control District.

Whatever model your project follows, recognizing participants for their effort and hard work is critical. Some projects use rewards toward this end. For the USFS, some of the awards that can be used—either online or at in-person events—include:

- President's Volunteer Service Award, which recognizes US citizens and lawfully admitted permanent residents who achieve the required number of volunteer service hours over a 12-month time period or cumulative hours over the course of a lifetime;
- Volunteers and Service Annual Awards Program, which recognizes partners, volunteers, and staff for their contributions in five categories: Citizen Stewardship & Partnerships, Cultural Diversity, Enduring Service, Leadership, and Restoration. Awards include letters from the Chief;
- Chief's Honor Award, which is the highest honor in the Forest Service and recognizes agency employees who find innovative ways to perform work according to our national priorities and strategic plan; and
- Rise to the Future Award, which recognizes outstanding individual and group achievements by natural resource professionals in the Forest Service, as well as partners in the fisheries, hydrology, soil, and air programs.

Other reward ideas include:

- Interagency Volunteer Pass, which covers federal public lands site fees for 12 months;
- 1,000 Hour Certificate, which is a one-time recognition signed by the Chief;
- Volunteers & Service Appreciation Certificate, which can be signed by a Forest Service Unit;
- Potluck/picnic ceremony, which can be held on the day of the event or at the end of a season, and
- Story Share, which is a blog post or an email sharing volunteers' stories (be sure to use photo releases).

Despite your best engagement efforts and whatever your project model, some participants will not participate very much, and others may leave the project completely. It's important to determine how many project participants stay or leave, why they do so, and what they are getting out of your project. We'll discuss these concerns in Module 10, which covers project evaluation. Here we offer a few pointers to help you target known issues early on.

Some of the reasons that people drop out, particularly in community projects, relate to their degree of comfort with that community in terms of age, culture, and skill level. Therefore, welcoming new participants into a project is essential, and introducing them to other participants such that they feel welcome is critical. Such welcome messages can be done even in online projects.

Another factor that influences continued engagement is the match between a project's activities and a participant's motivations and expectations. For example, many participants join a project to contribute useful information to science. If project data are not shared in an effective and timely manner, participants may become frustrated. Also, most participants expect some degree of acknowledgment for their work. If this is not forthcoming, participants may become disheartened. Therefore, assessing what determines project satisfaction, and attending to this information, is necessary to retain participants.

Regardless of the depth of participation, always consider issues of reciprocity. This has both practical and ethical dimensions. Practically, participants who don't feel valued, listened to, or supported will not remain involved. From an ethical perspective, keep in mind the power dynamics that are inherent when a government agency leads monitoring efforts with implications for local economic security or environmental justice. Taking an asset-based approach to collaboration, focused on the strengths that different players bring to the table, can help build trust and relationships.

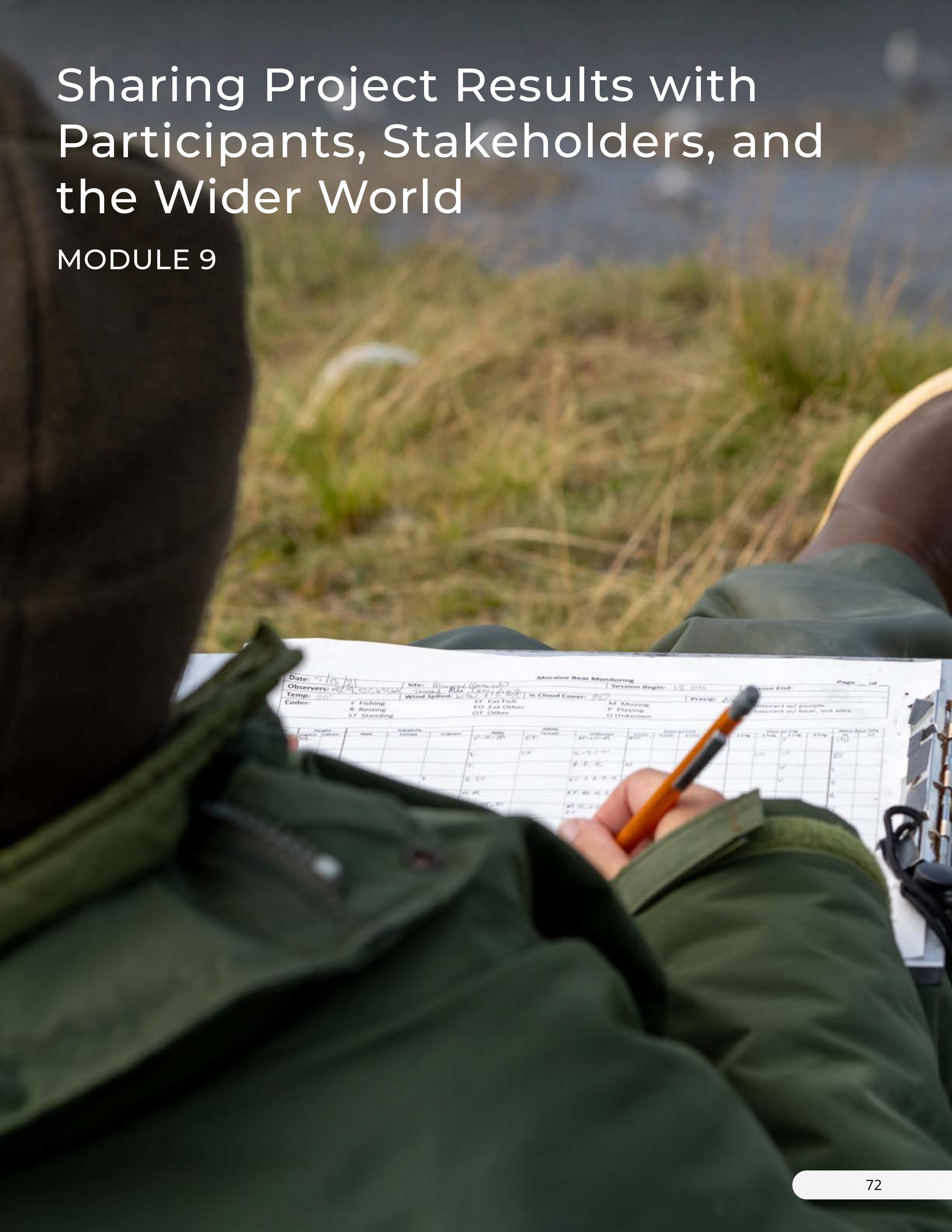
For community-based projects, individual check-ins with volunteers on an annual basis can be highly beneficial. For example, if a volunteer is not happy doing data collection, you might offer to have them switch to a different role—become a mentor, help with developing training materials, take photographs, or write up stories of other volunteers that can be used in social media.

Ultimately, be genuine in approaching public engagement as a relationship. Don't just "check the box" of expectations for public outreach. Earning the trust of the community and the respect and dedication of individual participants will set up the project to be more efficient and sustainable.

Module 9 covers sharing your project with the wider world.

Sharing Project Results with Participants, Stakeholders, and the Wider World

MODULE 9



INTRODUCTION

The goal of this module is to help you make your project results known by sharing data and results in multiple formats, ranging from emails sent to project participants to detailed data reports aimed at decision- and policy-makers. Of course, many project participants also will be interested in detailed reports, and many policy-makers will appreciate data summaries.

PROVIDING DATA SUMMARIES

For most projects, rapid feedback about project data and results will be appreciated by all interested audiences. One of the most effective ways to thank volunteers for their help in generating the information is to share it with them on a regular basis. If they believe that their data are important and useful, they will feel a sense of achievement and be encouraged to stay engaged in the project.

For projects with online data submission, providing real-time results is an extremely effective way to show that data have been received and are being incorporated into the project database. Many online citizen science platforms such as iNaturalist, Nature's Notebook, and Citsci.org prepare data summaries automatically, and their built-in data summaries offer instant rewards to participants.

For example, the Rio Grande Phenology Trail conducts weekly phenology monitoring on a suite of focal species including the Rio Grande cottonwood (*Populus deltoides wizlensii*) and Siberian elm (*Ulmus pumila*) on the Valle de Oro National Wildlife Refuge. Project data are intended to inform refuge management decisions concerning ecological restoration goals. Because the project was built using Nature's Notebook (see Module 7) it can use the platform's visualization tool, and participants can easily view project data.

An example of a project built on the Citsci.org platform is Utah Water Watch (UWW), described in Module 7. Citsci.org allows visitors to view individual observations by clicking on an interactive Google Map that shows details including time, date, and location coordinates as well as photos and all observational data. In addition, participants can create graphs by choosing location, type of data (numerical or categorical), and type of numerical measurements. The project website also includes a page dedicated to watershed interpretation that explains how to explore water quality in the individual's watershed using UWW data.

Some projects have built their own data collection and display tools. For instance, the Coastal Observation and Seabird Survey Team (COASST), which was described in Module 8, has its own app that allows participants to view interactive representations of COASST data. This includes graphs showing regional differences in beached birds, trends in time, species composition, and much more.

For community-based projects or projects that do not have online data management capabilities, participants and other stakeholders will have to wait until you are able to summarize findings for distribution. Once prepared, these can be disseminated on a project website or via email, newsletters, or various social media. And even projects that do have online data visualization often provide various types of summaries. COASST, for example, has a monthly newsletter, a blog, and links to news articles and documentaries featuring COASST data.

When preparing summaries and visualizations, present your results in a manner that shows their relevance to the participants. Translate your results into plain language and use graphs, tables, charts, and other visualization techniques to help participants understand the information. Usually, simpler is better to illustrate project findings. Plain language and clear, concise visualizations and explanations are interpreted faster and are better at getting people's attention no matter their level of expertise.

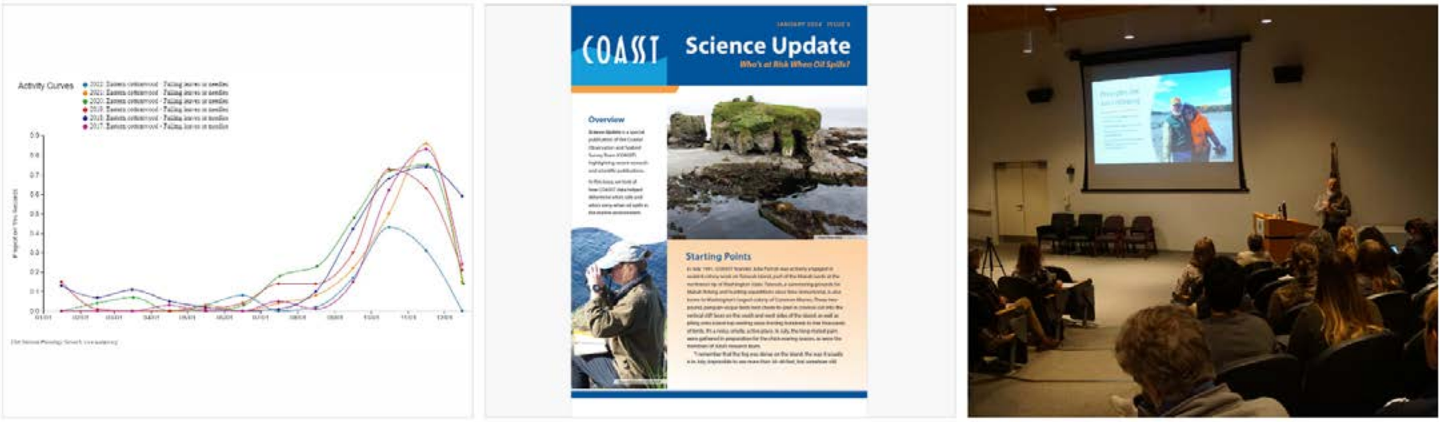


Figure 9.1: Project data and results can be shared in many ways. Projects built on the Nature's Notebook platform, such as the Rio Grande Phenology Trail, allow creation of data visualizations such as the graph on the left showing the timing of leaf drop of eastern cottonwoods. Many projects prepare data summaries either online or in a newsletter such as the one from COAAST in the middle photo. And many projects offer talks presenting data and findings to local audiences.

Some projects, such as the National Phenology Network, [prepare extremely short annual reports]() that include pages that can be repurposed as standalone graphics for sharing on social media. Indeed, social media has opened up many new opportunities for building and promoting projects, communicating with participants, and providing project results. Advantages of social media include rapid dissemination of information and the opportunity for project participants to interact and form an online community, which can bring cohesion to a project. However, social media must be employed carefully because most social media platforms are not particularly controllable and can sometimes be hijacked, either through misinformed comments or when information is shared out of context.

When providing project summaries, remember to circle back to your project goals and objectives. If you have recruited participants to gather data to address a specific issue, they will want to know that the issue is being addressed using the data, and if it is not, how come. For example, a project focused on measuring stream quality may document a problem that is beyond the scope of the project organizers to influence. Issues surrounding use of data can be avoided by starting out with realistic expectations.

Also, project results may lead to actions that some participants may not agree with, such as eradication of a beautiful but unfortunately noxious invasive species. Again, considering participant expectations from the outset of a project is critically important. Citizen science is only one of many threads of information used when making management decisions. Sometimes a decision may not align precisely with the science, but the science still may inform how a decision is implemented.

Reporting project findings also should help participants understand how the results apply to them. For this reason, you need to understand the interests and motivations of your participants as discussed in Modules 4 and 8. Then you can share results and their meaning in ways that make sense to the participants and are relevant to what they want or need to know.

When feasible, face-to-face presentations and question-and-answer sessions are a wonderful way to provide results to participants. These are most doable for community-based projects. Incorporating social events is a good practice, as is inviting participants to make their own presentations about their findings and experiences.

PROVIDING RAW DATA

In addition to data summaries, many projects make full project data available. Typically, this is good practice. While data openness and transparency require investments in infrastructure and time, as discussed in Module 6, data sharing can be critical in allowing others to examine the information and can build community/participant trust, ongoing participation, and sometimes even unique insights or actions that you may not have considered.

Remember, though, that as discussed in Module 6, some data are sensitive because of where they were collected or because the species on which they focus are threatened or endangered. Additionally, data sensitivity may vary among communities, such as information that pertains to a Tribe's ancestral or sacred lands or to an area that is subject to commercial activity. Before releasing data, consider any intellectual property rights and protection requirements to which your data may be subject. In addition, ask yourself what the outcomes might be if volunteers forwarded these data to 100 people or posted them to social media.

One citizen science project that provides raw data is eBird. Many refuges, parks, and other public lands use eBird to keep track of the birds in their area, and several focused projects have been built on the eBird platform (see Module 7). Anyone can request to download raw eBird data, or at least those data that are not deemed sensitive, by filling out a simple request form. This form allows project staff at the Cornell Lab of Ornithology to keep track of data downloads for analyses of how the data are being used. As a result of the open data policy, eBird data have been used in hundreds of publications.

If you do plan to make your data available for public use, be sure that you do so in accordance with your agency's legal and policy requirements and in a manner consistent with any agreements from financial supporters for open data and open access. Request or require that participants share original images under an unrestrictive license, such as CC-BY, that permits redistribution. If necessary, restrict access to certain information. And be sure to know your organization's standard review, approval, and release policies.

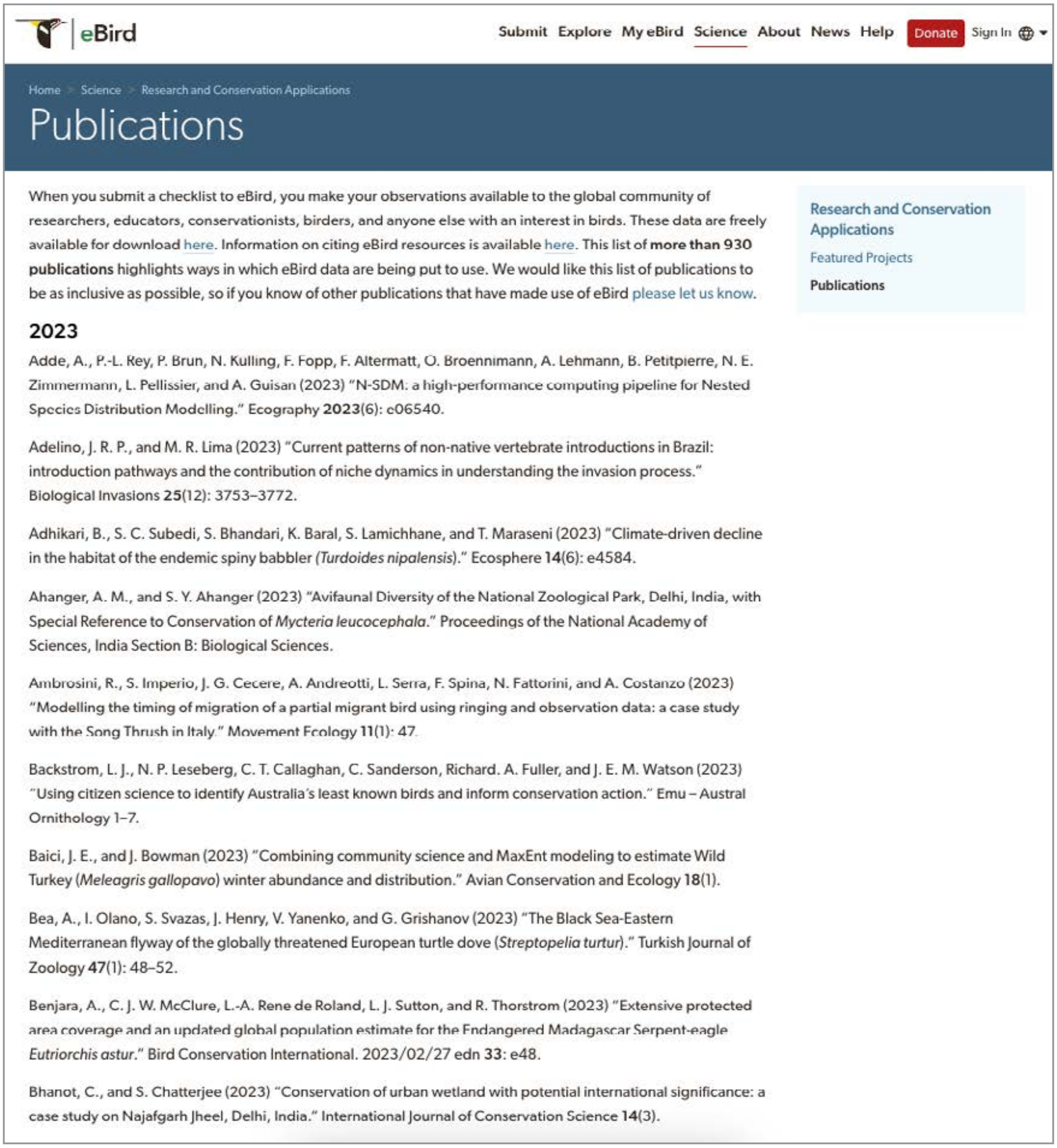
You can make your data available via download, either as compressed packages of pre-selected, documented data or as CSV files for custom query results. Make sure that data recipients can access complete metadata and other documentation so that they can evaluate, replicate, and make the best possible use of your results. Identify the sources, license, methods, and contents of the data. An example of a data Terms of Use Policy is available from Nature's Notebook. Acknowledging the participants who collected the data is usually a good idea.

Most agencies have an approval process that data must go through to become open data. Make sure that you consider those requirements when designing your project and ensure that you are collecting appropriate metadata. Such requirements may be less restrictive when project partners host data.

In addition to making data available through a project website, agency results from citizen science can be served in several databases.

Enterprise Data Warehouse (EDW): The EDW is a repository of the US Forest Service (USFS) data with the goal of integrating data from various sources in formats that can be easily used for reporting and analysis and that can be shared across the agency. Data entered into the Natural Resources Manual (NRM) are automatically refreshed in the EDW. Additionally, these authoritative datasets are made accessible to everyone through applications such as ESRI ArcGIS Online.

The NatureWatch Interpretation and Conservation Education database (NICE): NICE is used to report all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2023

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Figure 9.2: This screen shot from the eBird website shows recent publications based on eBird data. Many more publications are shown on the website.

Conservation Education, NatureWatch Interpretation, and related programs data for which the USFS provides funds and/or staff time. For the purposes of reporting, an accomplishment is defined as an educational program, experience, or activity that enables people to understand and appreciate natural resources and learn how to conserve them for future generations.

Data.gov: This website provides descriptions of the federal datasets (metadata), information about how to access the datasets, and tools that leverage government datasets. Data from the EDW is also shared with data.gov.

Geospatial Platform: The Geospatial Platform is a managed portfolio of common geospatial data, services, and applications contributed and administered by authoritative sources and hosted on a shared infrastructure for use by government agencies and partners to meet their mission needs.

Natural Resource Manager (NRM): The NRM is a system of database tools for managing agency data across the USFS and for most of the agency's natural resource business areas. The NRM includes Forest Service Activity Tracking System (FACTS), Infrastructure (Infra), Natural Resource Information System (NRIS), and Timber Information Manager (TIM) applications.

Treesearch: The Forest Service tracks citizen science research through keywords in research publications. Published academic papers that use “citizen science” in article keywords can be found easily in Treesearch.

Additional Repositories: Data also can be hosted in repositories such as Dryad and listed on international initiatives such as DataONE, a repository that describes where different environmental datasets are stored and how they can be accessed by others. Archiving datasets in a way that complies with modern data storage guidelines ensures that the data are stored in a secure and accessible place and will reassure participants of the long-term value of their data.

PROVIDING DATA REPORTS

Beyond providing data summaries and raw data when appropriate, you'll want to report full project results that discuss how the data can be used to further land management or science. You can do this through written project reports, technical guides, peer-reviewed publications, presentations at conferences, public webinars, or by using technologies such as ESRI StoryMaps.

In some cases your stakeholders will require that results be submitted in a certain format, for example, documents submitted for court proceedings. Take time to research any formatting requirements for your data. Importantly, when in doubt, seek outside advice and guidance.

Sometimes data will have implications for species management, habitat restoration, or game harvest. Such data will be valuable for holding an agency accountable for its actions. However, they also could be used in unanticipated or potentially inappropriate ways. Any report must be clear about its intent and should point out any limitations in the data or data analyses.

When putting together a report, don't forget about content repurposing. If you already have taken the time to put together data summaries, graphics, or related content, use the same information as the starting place for your report or paper.

Project Tanager, described in detail in Module 5, is an example of a project for which staff prepared multiple reports and papers about project results. They began by publishing the *Land Manager's Guide to Improving Habitat for Scarlet Tanagers and other Forest-Interior Birds*. This detailed report included information about minimum forest patches required to support successful breeding of tanagers in different regions across the United States. For example, in the northern forest region, in an area with only 10 percent forest in a 2,500-acre block, a block of at least 117 acres is required to provide habitat of moderate suitability for tanagers. But in an area with 70 percent forest in a 2,500-acre block, providing habitat of moderate suitability can be accomplished with a block of only 21 acres.

In addition, project staff published a series of papers about project results. One is "Effects of Forest Fragmentation on Breeding Tanagers" in the journal *Conservation Biology*. This paper not only provided detailed project reports but also helped to establish the legitimacy of citizen science as a research tool.

More recent publications of results from citizen science projects with agency connections include one from the Saguaro Census Project described in Module 3, "The Interaction of Drought and Habitat Explain Space–Time Patterns of Establishment in Saguaro (*Carnegiea gigantea*)" in the journal *Ecology*, and one from COASST, described in Module 8, "Using Beached Bird Data to Assess Seabird Oiling Susceptibility" in the *Marine Pollution Bulletin*.

SHARING YOUR RESULTS WITH THE WIDER WORLD

Beyond your participants, fellow staff, and other stakeholders, you might have findings worth sharing with the outside world. At the local level, this might involve providing a talk about project results to local organizations such as the Rotary Club, the Chamber of Commerce, or a youth group. The presentation and delivery would of course need to be tailored to the specific audience.

For example, the Desert Tortoise Program mentioned in Module 4 shares information in a few ways. When park visitors add tortoise sightings to a data book in the visitor center, park staff members look at Google maps with the visitor to determine exactly where the animal was sighted. Project staff also share information with a local Friends group and with local Tribes about where species are found on their lands.

In some cases, local sharing might be the entirety of the results sharing, especially if the project is focused on collecting data to address a local concern. Focusing on a larger audience generally requires working with the media.

When preparing results for public consumption, you'll need to make them relevant to the audience by explaining results in a way that will capture the interest and imagination of readers and viewers. Data visualizations and maps are particularly powerful in this regard as long as the intended audience can readily interpret and understand the visualizations. For example, the Saguaro Census Project regularly provides updates through its social media pages, especially on Facebook and Instagram, and some of their Instagram posts have reached more than 50,000 people. They also developed a range of interpretive products ranging from brochures to refrigerator magnets to recruitment posters. They give a number of community talks and school pre-visits as well as presentations to interpreters. As a result, they have received significant media attention, with two front page articles in the *Arizona Daily Star* and an episode on local public television's *Arizona Illustrated*. The Census also was featured in an article on saguaros and climate change in the *Washington Post*.

Whether stories are picked up by journalists depends on their perception of the potential interest in the story, and may depend on circumstances outside of your control, for example, other items that are dominating the news. Regional press will be most interested in local stories—what your results mean for local communities.

Consider developing a relationship with journalists. Is there a local or national reporter who covers topics in line with your citizen science program? Make contact with them early in project development and show them that you are a reliable contact and source of information. When you have results, pitch them ideas for covering your project that are in line with their interests ("I know that you are interested in xx because I saw your story xx, and I think you might be interested in our program xx). If they feature your program once, they may be inclined to do so again, so send them short updates when you have relevant news or exciting results. They might not always bite, but they will appreciate that you offered them the scoop.

When developing news or press releases about your project, try to provide a human element: Feature a participant to make the story more personal; link your program to something going on in local or national news; and look at the kinds of stories that journalists have published in the past and find a connection to your work. Plan content for holidays and events (such as Pollinator Week), include that context when you make your pitch, and pitch in advance. A journalist may need time to re-pitch the idea to an editor, and very close to a popular holiday, a publication may already have a related story lined up.

Also consider identifying media-ready participants. Journalists often love talking with volunteers and data users to give their story a strong human component. If you get permission ahead of time from your participants, you can quickly put the journalist in touch with them for an interview or quote. Don't forget to let your participants know when the article is published, and thank them for their efforts to represent your project!

Seeking advice from an agency communications office is an excellent approach to making your results more broadly known. Communications experts in your agency can help put together a media kit to make certain items immediately available such as names, titles, affiliations of key contacts, logos, and images (if photos include people, make sure that you have media releases and proper permissions).

Module 10 explains the process of determining the successes of your project as well as ways that it can be improved.

FURTHER READING

https://www.usanpn.org/about/reports

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Measuring Success

MODULE 10

INTRODUCTION

Evaluation is actually a pretty simple concept: The idea is to find out if your project is successful. Did it meet its goals and accomplish what you hoped it would? If so, great! What ideas and tips can you pass on to other project leaders so that their projects will be successful as well? If your project did not meet its goals, why not? How can you modify it to make it successful?

Of course, to determine whether a project has met its goals, you need to have previously determined what those goals are. Module 3 describes how to set project goals and determine project objectives. If you identify goals and objectives early in the project development process, you can see whether they are being achieved by compiling information about your project's participants and findings as the project unfolds. At its end, you should have solid evidence for project success as well as information about opportunities for project improvement.

Most evaluations seek to document project outputs and project outcomes. These terms are explained in Module 3. To reiterate, outputs are the direct products or services of project activities and typically are easy to quantify. The number of training workshops that staff deliver, the number of web pages that a project develops, the number of individuals who participate in a project, and the number of data points that participants submit are all outputs. These are important to measure, but in and of themselves do not constitute project success. For example, a project may recruit numerous participants who submit large quantities of data, but if the data are not useable for their intended purpose, then the project has been only partly successful.

In contrast, outcomes are things that happen as a result of project activities and outputs. Although more difficult to measure than outputs, outcomes are true measures of a project's success. Scientific outcomes include publications, increased understanding of scientific concepts, management/policy decisions, and data products such as data visualizations or requests for data. For example, a scientific outcome could be a new understanding of the speed and depth of the spread of an invasive species on a refuge.

Participant outcomes also are possible; in fact, they are a main goal for some citizen science projects. Participant outcomes may include changes in knowledge or understanding of a concept or idea, changes in attitudes toward science or in behaviors related to science; increased scientific engagement; and/or an increase in scientific skills.

Most current citizen science projects have not conducted formal evaluations, and reports and publications documenting the success (or failures) of citizen science projects are few and far between. The formal evaluations that have been conducted typically focus on audience or learning outcomes. This is because grants to develop projects focused on learning, such as those awarded by the National Science Foundation, usually include funding for evaluation, whereas grants to develop projects focused on scientific outcomes typically do not. As a result, most current guidelines for citizen science project evaluation focus on measuring participant outcomes.

However, at its core, citizen science is science. Therefore, measures of science or management outcomes that result from projects that do not involve volunteers also are relevant to citizen science projects.

Evaluation can be a highly formal and complex process involving trained evaluators, but it doesn't need to be. As explained in Module 3, project evaluation is intertwined with project development, and for best results, evaluation starts in the project design phase with the development of goals and measurable and actionable objectives. Revisit Module 3 if you want to refresh your knowledge of these topics.

Project evaluations often are considered in three types or phases: front-end, formative, and summative. In practice these types of evaluations can overlap, but each has a distinct function.

EVALUATION PHASES AND MEASURES

Front-end evaluation takes place at the beginning of a project or even before a project starts, and focuses on gathering background or baseline information about potential project participants, cultural context, resource policy or management strategies, and data needs. Front-end research may be thought of as audience or market research.

We discuss the importance of understanding audience and project participants in detail in Module 4 and return to that subject in Module 8. Without a clear understanding of the needs, intentions, and desires of potential project participants—or the data needed to inform policy or resource issues—designing appropriate project activities is very challenging.

Formative evaluation, also known as implementation or process evaluation, takes place during project development and execution to examine whether the plan for project design and implementation is being followed. It also determines whether the project is functioning as desired. Formative evaluation thus provides direction for improving project operation, and highlights strengths and weaknesses.

This toolkit covers the steps or phases of project design and delivery. Formative evaluation should check to see that each has been done by answering the following questions:

Goals and objectives (Module 3)

- Does the project have a clearly defined goal or goals?
- Will the goal(s) influence conservation or management outcomes?
- Is the goal supported by clearly defined objectives?
- Are the goals measurable?

Project team and definition of audience (Module 4)

- Does the team include scientists, technologists, and educators/communicators?
- Do project staff have adequate training?
- Are all team roles filled by staff or partners?
- Has the audience been clearly defined and have steps been taken to understand audience needs, concerns, and aspirations?

Stakeholders and partners (Module 5)

- Have key stakeholders been included in project development and implementation?
- Are needed project partners identified and engaged in the project?

Data needs and project protocols (Module 6)

- Does the project have a conceptual design?
- Have data needs been adequately assessed?
- Are sampling protocols well designed to collect the needed data?
- Is the sampling design easy for volunteers to follow?
- Have the protocols been tested by volunteers?

- Is the data-entry method easy to use?
- Are methods for assuring data quality in place?
- Is an appropriate amount of data being collected?
- Are methods of downloading data simple and clear?
- Are data property and rules of access clear?

Participant recruitment and training (Module 8)

- Have appropriate methods been used to recruit sufficient volunteers?
- Have the volunteers received appropriate support, either through project resources or specific training?
- Have training and support materials been tested for clarity and effectiveness?

Data reporting and dissemination (Module 9)

- Does the project have a communication strategy for disseminating results to project participants?
- Does the project have a communication strategy for disseminating results to stakeholders?
- Does the project report results on a regular basis?
- Are results being reported such that they can be used for management and conservation?

Evaluation (Module 10)

- Are project outcomes being assessed and measured?

Some projects may want to develop a rubric to aid in formative evaluation. Resources to assist in this effort for citizen science projects are extremely limited, but one that may be helpful to developing projects is a paper published in *Bioscience*, "A Rubric to Evaluate Citizen-Science Programs for Long-Term Ecological Monitoring" (Tredick et al. 2018). A portion of that rubric is shown here. In addition to delineating steps in project development it addresses how well each step is being carried out.

Formative evaluation has been used effectively by FISHstory, which was described in Modules 2 and 7. During the development of the project on the Zooniverse platform, the project developers incorporated feedback from the FISHstory design team, Zooniverse staff, and Zooniverse beta test volunteers to refine data collection protocols, to improve volunteer training resources, and to provide mechanisms for data quality review. Adapting the project during the design stage based on this varied feedback proved critical to improving the data subsequently collected.

Summative evaluation, also known as outcomes or impact evaluation, is conducted after a project is established or completed, and describes project outcomes, determines a project's effectiveness, and describes project value. Findings from summative evaluation help to determine if a project has met its desired outcomes and accomplished its stated goals.

In the context of agency-involved citizen science projects as we've described them, summative evaluation asks the questions:

- Are the results of a project contributing to the scientific literature, either formally or informally?
- Are the results of a project informing management or conservation?
- Is a project contributing to participant learning and engagement, if this is a desired outcome?

Element	Aspect of program being reviewed	Poor	Fair	Good	Excellent
(5) Reporting and dissemination	Considers overall communication strategy and the mode and frequency of reporting technical and nontechnical results. Assesses the efficacy of the communication strategy and describes stakeholder uptake.	No communication plan in place. Little or no dissemination of program outcomes or findings to stakeholders. Poor commitment to communication to the general public or the scientific community.	A communication plan is in place. Reports or materials produced that describe outcomes or findings are infrequent or cursory in nature. Some communication with the general public and the scientific community.	A well-defined communication plan is in place. Some aspects of the program are described in materials that are prepared and disseminated fairly regularly with the general public and the scientific community.	A well-defined communication plan is in place. Comprehensive and accessible reports and materials are produced regularly and shared with stakeholders, the general public, and the scientific community.
(6) Outcome evaluation and program review	Determines how the outcomes of the program are assessed and evaluated on the basis of on scientific products, use of data by decision-makers, learning and engagement outcomes of participants, and the frequency and extent of formal and informal internal and external review.	Little or no evidence of contribution to ongoing research or conservation or management decisions. No opportunity to solicit or collect stakeholder feedback on strengths or weaknesses. No formal or informal evaluation process in place or conducted.	Some evidence of contribution to ongoing research or conservation or management decisions. Some opportunities to solicit or collect stakeholder feedback on strengths or weaknesses. Limited periodic review of aspects of the program but no comprehensive review.	Clear evidence of contribution to ongoing research or conservation or management decisions. Multiple opportunities to solicit or collect stakeholder feedback on strengths or weaknesses. Periodic internal review of program, with results used to improve the program.	Clear and direct evidence of contribution to ongoing research or conservation or management decisions. Established and periodic opportunities to solicit or collect stakeholder feedback on strengths or weaknesses. Established protocol for both internal and external review of program, with an established feedback mechanism by which results from the review are used to improve the program.

Figure 10.1: This figure shows a portion of a table, used by permission, from the publication “A Rubric to Evaluate Citizen Science Programs for Long-Term Ecological Monitoring” (Tredick et al. 2018). In addition to delineating steps in project development, the rubric addresses how well each step is being carried out. This rubric could be adapted to aid formative evaluation of a citizen science project.

Category	Product	Definition
Written	Dissertations, theses (#)	Number of theses and dissertations using data from or reporting on the project
Written	Scholarly publications (#)	Number of published peer-reviewed science papers that report on the project or apply its data
Written	Reports (#)	Number of formal reports reporting results, such as white papers, technical, and other reports
Written	Grants awarded (#, $)	Existence (or total monetary value) of competitive funding awards from private or public funders
Data	APIs (Y/N)	Existence of technologies for automated data exchange between computers
Data	Data packages (#)	Number of curated exports of data and related documentation, usually as a downloadable zip file
Data	Metadata (Y/N)	Existence of documentation describing data structure, formats, and contents
Data	Visualizations (Y/N)	Existence of visual representations of data, such as graphs, maps, and animations
Data	Specimens/samples (#)	Number of material data points in the form of physical specimens or samples
Data	Requests (# requests, transfer volume)	Number of individuals or technical systems requesting data, or volume of transferred data
Management and Policy	Regulatory action (Y/N)	Existence of legal rulings or regulation enforcement based on project data and findings
Management and Policy	Decision support (Y/N)	Existence of decisions based on project data and findings (e.g., for policy or management)
Management and Policy	Forecasting/models (Y/N)	Existence of models based on project data that simulate or predict complex phenomena
Communication	Blogs (Y/N)	Existence of online informal written communications about project processes and findings
Communication	Newsletters (Y/N)	Existence of structured publications for project stakeholders, produced in hard copy or digitally
Communication	Videos (Y/N)	Existence of publicly available digital videos on project content, activities, and findings
Communication	Presentations (Y/N)	Existence (or number) of oral presentations at conferences or public events
Communication	Website (Y/N)	Existence of dedicated website for the project

Figure 10.2: This figure, reproduced from the publication “A Science Products Inventory for Citizen Science Planning and Evaluation” (Wiggins et al. 2019), shows a variety of “science products” outcomes that are possible to achieve through citizen science. Scholarly publications are but one of the many possible products.

Category	Practice	Definitions
Findable	Data available from project website (Y/N)	Availability of data from the project's own website in a downloadable or queryable format
Findable	Data available from repositories or registries (Y/N)	Availability of data in a research data repository or via a data clearinghouse or registry
Accessible	Downloadable data file(s) available (Y/N)	Existence of download data files via project website, repository, or third party
Accessible	Tools for data exploration (Y/N)	Existence of tools for visualizing, summarizing, or querying project data via an app or website
Accessible	Data licensing specified (Y/N)	Existence of text specifying terms and conditions for data use
Accessible	Metadata available (Y/N)	Existence of documents with descriptive metadata such as known problems and data cleaning tips
Accessible	API documentation (Y/N)	Existence of documentation to support users of an API, where applicable
Interoperable	Data recorded in standard formats for discipline (Y/N)	Application of disciplinary standards for structural metadata and data formatting
Reusable	Uniqueness of data (describe)	Description of the unique contributions and features of the project's data
Reusable	Time scale of data (# yrs)	Number of years of records in the data set; may include historical data
Reusable	Spatial scale of data (describe)	Description of the geographic range for project data, such as continent, country, state, city, or watershed
Reusable	How much data (# data points, describe)	Description of data volume in terms relevant to the data collected, such as number of data points
Reusable	Errors documented (Y/N)	Existence of documentation for known errors in the data set
Reusable	Quality assurance or quality control documented (Y/N)	Existence of documentation for quality-assurance and quality-control processes
Reusable	Changes documented (Y/N)	Existence of documentation for data edited after initial receipt
Reusable	Questionable data flagged (Y/N)	Existence of documentation for data considered questionable or problematic
Reusable	Software or platform development (Y/N)	Existence of software or hosted technologies (platforms) that support external projects

Figure 10.3: This figure, reproduced from the publication "A Science Products Inventory for Citizen Science Planning and Evaluation" (Wiggins et al. 2019), shows a variety of "data practices" that can be part of a citizen science project. Projects should strive to implement as many of these practices as possible.

Summative evaluations need to be tailored for specific projects, and differ widely depending on the audience, context, and kinds of outputs and outcomes they are seeking to document. Here, we'll take a broad look at evaluating for both science/management and audience learning.

EVALUATION FOR SCIENCE/MANAGEMENT

Another paper published in *BioScience*, "A Science Products Inventory for Citizen Science Planning and Evaluation" (Wiggins et al. 2019), may be helpful for summative evaluation. The authors set out to show many types of important outputs and outcomes beyond peer-reviewed scientific publications. While these are often considered the gold standard in terms of successful outcomes, peer-reviewed papers are not the goal for many citizen science projects (and even for many "regular" science projects). Other kinds of scientific outcomes are not only possible but desirable.

Wiggins et al. divide potential outputs and outcomes into "science products" and "data practices."

Science products are divided into written products, data products, management and policy products, and communication products. For instance, management and policy products might include regulatory actions, decision support tools, or forecasting or modeling tools.

A written product resulting from a citizen science project on lampreys is *Mapping the Distributions of Pacific and Western Brook Lampreys Along the Oregon South Coast using eDNA and Community Science: 2021 Report* and is described in Module 2.

Examples of projects that have successfully developed management and policy products are Project Tanager, described in detail in Modules 5 and 9, and the Imperial County Community Air Monitoring Project discussed in Module 5, which has produced a guidebook that covers monitor siting criteria, stakeholder engagement strategies, and technical advice on data storage and processing.

Data practices are divided into findable practices, accessible practices, interoperable practices, and reusable practices. For example, accessible practices include downloadable data files, tools for data exploration, and metadata. Reusable practices include development of software or platforms or detailed data descriptions.

A project that has successfully developed accessible data practices is Mountain Birdwatch. Data are publicly available through the State of Mountain Birds Report, where the information is offered in three downloadable forms: raw data, a table of results for all ten species and regions, and condensed data. Data are also organized into species-specific web pages with graphs and tables that show population change over time. The State of Mountain Birds homepage also links to data held at the Knowledge Network for Biocomplexity, where raw data and metadata can be downloaded. Data also are archived on the eBird platform.

A project that has successfully developed reusable data practices is Engaging Angler Scientists, which was described in Modules 2 and 4. This project developed a mobile application and database for surveying trout nests (redds) and developed a redd survey protocol and handbook, which can be used by any groups wanting to set up redd surveys.

Not all of these products will be appropriate for your project. But knowing what these potential outputs and outcomes are will allow you to design for and evaluate achievements.

EVALUATION FOR LEARNING OUTCOMES

If you wish to increase audience knowledge and understanding of an environmental issue or concern through your project, summative evaluation typically focuses on whether participants gained knowledge, improved their data skills, or changed aspects of their behavior as a result of project participation. Detailed information on how to evaluate whether such outcomes have occurred is included in the *User's Guide for Evaluating Learning Outcomes from Citizen Science* (Phillips et al. 2014). This guide includes information on planning, implementing, and sharing an evaluation, along with sample goals, outcomes, and indicator worksheets; a logic model worksheet; data collection strategies; and much more. This guide has been used successfully by many citizen science projects to conduct evaluations, some of which have been published. Many of the strategies in this guide would be helpful in evaluating science outcomes as well as learning outcomes for citizen science projects.

TYPES OF EVALUATORS

Evaluations can be carried out by an internal evaluator, an external evaluator, or both. There are pros and cons to all approaches. For example, internal staff who conduct evaluations are likely to have a high degree of knowledge of the culture of the organization and subject matter, be more accessible for ongoing dialogue and meetings, and are typically less expensive than external evaluators. However, internal evaluators may be seen as biased because they may have a vested interest in the outcome of the evaluation and also may face internal political challenges. External evaluators are generally more expensive, and maintaining regular communication with them can be challenging, but they are less prone to bias because they are not directly influenced by an evaluation's outcome.

Some projects blend these approaches by having internal staff conduct evaluations under the guidance of an independent evaluator who reviews the evaluation design and assesses the validity of the findings and conclusions. This approach can maintain external expertise and impartiality along with the benefit of an internal person's first-hand project knowledge.

This is the final module in this toolkit/course. We hope that it has helped or will help to guide you in developing, implementing, and evaluating a citizen science project.

FURTHER READING

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APPENDIX A

LIST OF ABBREVIATIONS

AWW	Alabama Water Watch
BLM	Bureau of Land Management
CARB	California Air Resources Board
CARE	Collective benefit, Authority to control, Responsibility, Ethics
COASST	Coastal Observation and Seabird Survey Team
CCV	Comite Civico del Valle
DMP	Dragonfly Mercury Project
DOI	Department of the Interior
EDW	Enterprise Data Warehouse
ESA	Endangered Species Act
FACTS	Forest Service Activity Tracking System
FAIR	Findable, Accessible, Interoperable, Reusable
FAQ	Frequently asked question
GBIF	Global Biodiversity Information Facility
NABat	North American Bat Monitoring Program
NPS	National Park Service
NRIS	Natural Resource Information System
NRM	Natural Resources Manual
OIRA	Office of Information and Regulatory Affairs
OMB	Office of Management and Budget
PRA	Paperwork Reduction Act
QA	Quality assurance
QC	Quality control
SJV	Sonoran Joint Venture
STEM	Science, Technology, Engineering, and Mathematics
TIM	Timber Information Manager
USFS	US Forest Service
USFWS	US Fish and Wildlife Service
USGS	U.S. Geological Survey
UWW	Utah Water Watch
WNS	White-nose syndrome

APPENDIX B

IMAGE CREDITS (PHOTOS ONLY)

Front cover

Sydney Smith, AWW

Module 1

Page 1 NPS, Public domain

Page 3 Figure 1.1, Retrieved from: https://citsci.org/projects/utah-water-watch/map

Page 4 Figure 1.2:

a. Sydney Smith, AWW
b. Bryan Fluech
c. Tribal Nations Botanical Research Collaborative Facebook page

Module 2

Page 9 “Photo 354297403” by desertnaturalist (CC BY 4.0)

Page 12 Figure 2.1:

a. Hannah Webber
b. Russell Hudson
c. Tribal Nations Botanical Research Collaborative Facebook page

Module 3

Page 17 Joe Parks (CC BY-NC 2.0)

Module 4

Page 25 NPS, Public domain

Page 26 Figure 4.1, AWW (bottom left photo credit: Rachel McGuire, AWW)

Page 28 Figure 4.2:

a. NPS, Public domain
b. Hannah Webber
c. Kelly Hattori, NPS, Public domain
d. AWW

Module 5

Page 35 NPS, Public domain

Page 37 NPS, Shawn Thomas, Public domain

Module 6

Page 43 NPS, Public domain

Module 7

Page 53 Brian F. Powell, USA-NPN, Public domain

Module 8

Page 63 Rachel McGuire, AWW

Page 66 Hannah Webber

Page 70 Brian F. Powell, USA-NPN, Public domain

Module 9

Page 73 NPS, Public domain

Page 75 Figure 9.1c, Schoodic Institute

Module 10

Page 81 Jon Brack, USFWS, Public domain

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