This 16-page document is an abridged version of the 63-page full monograph available from the Association of Nature Center Administrators (www.natctr.org). This version is intended to provide an overview of best practices for citizen science programming. The full document contains detailed descriptions of each of the best practices, case studies, and solutions for many of the challenges commonly encountered in citizen science programs.

Director's Guide to Best Practices

Programming - Citizen Science

by

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Contributions from the participants of the 2003 Citizen Science Forum at Great Smoky Mountains Institute at Tremont

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In 1998, Great Smoky Mountains Institute at Tremont started a program to involve youth and adults in some of the exciting scientific studies happening within Great Smoky Mountains National Park. That same year marked the beginning of the All Taxa Biodiversity Inventory, an enormous scientific endeavor that has involved citizens in its efforts from the start. In 2001, the Appalachian Highlands Science Learning Center opened, serving as a focal point for research and education efforts in the park. The Smokies was soon recognized as a model for engaging citizens in inventory, monitoring, and research in a national park. The many requests for advice on setting up citizen science programs inspired Great Smoky Mountains Institute at Tremont to hold a Citizen Science Forum in November 2003. This forum was targeted towards national park learning centers, environmental education centers, nature centers, museums, and other non-formal education institutions seeking to or already including citizen science as a part of their programming. Over the several days of the forum, 24 representatives from 20 institutions across the country shared their best practices for citizen science. We identified common questions, challenges, and issues and shared strategies for dealing with them. This guide is a result of those roundtable discussions, and in many ways it serves as the proceedings from the forum. It represents input from all of the forum participants, along with many observations and experiences from citizen science programs in Great Smoky Mountains National Park.

Susan Sachs (Appalachian Highlands Science Learning Center, National Park Service) made significant contributions to the section on evaluations. Doug Wachob (Teton Science Schools) contributed the case study on elk migrations. Ken Voorhis (Great Smoky Mountains Institute at Tremont) provided feedback and support for this project.

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In memory of Richard D. Haley, 1962 to 2006; a lifetime dedicated to the study of the natural world and sharing what he learned through education and citizen science.

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DIRECTOR'S GUIDE TO BEST PRACTICES

PROGRAMMING - CITIZEN SCIENCE

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Introduction

Amateur birdwatchers visit their local nature center and record observations for a one hundred year old national study to monitor bird populations. Schoolchildren sample stream invertebrates for a long-term study of water quality in Yosemite National Park. Park visitors collect and identify fungi for an All Taxa Biodiversity Inventory in Great Smoky Mountains National Park. Coastal residents work with the North Carolina Aquarium to survey for horseshoe crabs. Youth at an Audubon summer camp track wood turtle movement and use the data to suggest an alternative, turtle-friendly design for a new shopping center development.

These examples are all forms of "citizen science" happening at environmental education centers, National Park Research Learning Centers, nature centers, and other non-formal education institutions. Citizen science is a research and education tool that involves everyday people in real and meaningful forms of science, including biological inventory, long-term monitoring, and research. All of these examples demonstrate ways that these institutions are using citizen science as a tool for furthering their missions of educating the public about the environment, teaching people about the process of science, and connecting people to the natural world. They also demonstrate ways that citizens are helping to generate reliable, useful data for science.

These types of institutions have long used active, hands-on, and inquiry-based programming to engage the public in learning about science and the environment. Citizen science is by nature hands-on, but represents a different approach because of its focus on real science that is intended to answer pertinent research questions

or inform natural resource management decisions.

While this approach is known by many names (e.g. citizen monitoring, collaborative research), citizen science is a term in wide use and recognized by many individuals in both the education and science community. Citizen science can take many different forms, but typically includes several elements that make it distinct from other education and research tools.

Basic Elements of Citizen Science

(1) Citizen science actively involves the public, everyday people who are not professional scientists.

A key component of citizen science is, of course, the citizens. The citizens may be youth or adults and come from backgrounds as varied as the citizenry itself. Often the citizens are considered volunteers. At environmental education and nature centers that typically offer fee-based public programs, the citizens may be paying participants of a program that includes a citizen science component, such as a science camp for youth or an ornithology program for adults.

The citizens' roles in a citizen science project can vary widely as well. Citizens may participate in only the data collection step of the scientific process. This scenario is the case with many of the most recognized citizen science programs, such as the Christmas Bird Count. Citizens also can play larger roles by posing their own research questions, designing protocols and collecting data to answer them, and sharing their results with interested stakeholders. Citizen science is not about citizens watching the research process, but about active involvement. Although watching professional scientists do their work can be an excellent way to expose people to science or to educate them about a particular environmental issue or species, citizen science must involve citizens more actively than as casual observers of the process.

(2) Citizen science involves professional scientists at some level.

Even for those cases in which citizens are involved in many steps of the scientific process, citizen science projects typically are done under the direction of professional scientists. This involvement helps to keep the research "real", ensuring a connection to the greater scientific community. Like the citizen participants, the roles for scientists may vary greatly. Often the scientist plays the role of primary investigator, identifying the research questions, designing protocols, analyzing data, and publishing the results. In other cases, the professional scientist may play more of an advisory role, helping guide the citizens and educators to ask their own scientific questions and answer them through the research process. In this case, the scientist's role is still critical in order to keep the questions relevant and the protocols appropriate.

(3) Citizen science results in meaningful, useful data that aim to advance scientific understanding and can be applied to real world problems.

This quality is what makes citizen science different from a canned laboratory or field activity that produces data but is just an educational exercise. It is what makes citizen science such a powerful tool for both scientists and educators. That real world problem might be a need for a biological inventory of an area in order to make management decisions. It could be the need for small studies to establish baseline environmental data in order to do more in-depth studies. It could be the need for long-term monitoring data to meet governmental guidelines. Or, it could be the need for an experiment or comparative study to answer specific research questions. Sometimes the data are not analyzed or published for a long time; many monitoring projects, for example, require ten or more years of data to produce meaningful results. Other studies may be much shorter term. Regardless of the length of study, the ultimate goal of using the data is critical, whether in a peer-reviewed publication or the management plan for a natural area or some other significant use.

(4) Citizen science has a clearly defined education component.

A citizen science project must have objectives that include education of the citizenry, whether it is education about a specific organism or study system, education about the scientific process, or education about conservation and natural resource management. A project that uses citizen volunteers to collect data but does not include educational objectives and strategies for achieving them is not a successful citizen science project. In this type of project, the citizens may not be aware that their activities are part of the scientific process and thus are no more than unpaid data collectors.

Why Use This Tool…and Why Not

Citizen science requires patience, time, energy, and financial resources for managing volunteers. It requires educators who are science-savvy and the involvement of professional scientists to be effective. It requires follow-through. A scientist working alone only has to live up to his or her own expectations and perhaps those of his or her funding source, while a scientist working with citizen scientists has to meet their expectations as well. If the citizens never learn of the research results or, worse yet, if the data are simply discarded or filed away never to be analyzed or published, then the participants likely will feel that their efforts were wasted. Citizen science can result in messy data, data with gaps and holes, and data with errors. It requires additional quality control and quality assurance protocols. Certain research questions (such as those requiring a very high level of precision in data collection) may not be appropriate for citizen science. In essence, citizen science is not the best method for every scientist or every educator.

With all these negatives, why try it? First, from a scientist's perspective, citizen

science is a powerful tool that can expand the capacity to address many research questions and data needs. With this tool, a scientist can address questions that are otherwise unfeasible, such as those that require simultaneous sampling across a wide geographic range or very large sample sizes. Citizen science can also be used to produce data that supplement a more traditional scientific study or generate 'red flags' to indicate where to focus more rigorous efforts. Public involvement can promote awareness of the study system, perhaps generating new research funding or additional support for habitat and species protection. Furthermore, citizen science can help meet funders' requirements (such as those of the National Science Foundation) of an educational component to every research project. Although working with the public requires funding, it also opens up new funding sources as citizen science projects may be funded by science-focused, education-focused, or community development-focused funders.

From an educator's perspective, particularly a non-formal educator teaching about the environment, citizen science is also a powerful tool. Most Standards of Learning include objectives relating to understanding the process of science, and citizen science is one tool for achieving these objectives, as it actively involves citizens in that process. It creates opportunities for hands-on, memorable experiences in nature—perhaps holding a live animal or visiting a remote area not typically used by an average visitor. Helping scientists and land managers can foster a sense of place and caring feeling towards the environment. In addition, much of the traditional environmental education curriculum is geared towards younger students. Citizen science is a way to engage older teens and adults who often desire to make a real contribution rather than participate in something they perceive as a canned activity. Citizen science may open up new avenues for funding (such as science-based grants) not typically garnered by nature centers and the like.

Perhaps most importantly, citizen science can be fun and rewarding for everyone involved: scientists, educators, adult participants and youth. In particular, working with citizen volunteers can provide a real-world connection that many scientists otherwise would not find in their research. As an example, one taxonomist working with the All Taxa Biodiversity Inventory in Great Smoky Mountains National Park spent a month living and conducting research in the park. Although based at the Appalachian Highlands Science Learning Center, a main site for educational programs in the park, he had little interest in working with youth or talking to the public. Finally, after some coaxing, he reluctantly agreed to do a program on his beetle survey work for a group of high school students. Their excitement and enthusiasm inspired him, and he is now one of the taxonomists most heavily engaged in public programs and teaching students the methods for collecting beetles. There's a scientific payoff as well: some of those collections have resulted in new park records and even undescribed species—discoveries that may have not been made without the assistance of the citizen scientists who initially collected the samples.

CHECKLIST OF RECOMMENDED PRACTICES

I. Ensuring Scientific Validity

- ❑ Practice 1 Define Research Questions and Objectives
- ❑ Practice 2 Define the End Users and Uses
- ❑ Practice 3 Identify the Scope
- ❑ Practice 4 Involve Experts
- ❑ Practice 5 Plan for Data Analysis and Distribution, Publication, And Publicity
- ❑ Practice 6 Develop Quality Assurance/Quality Control Plan (QA/QC)

II. Ensuring Quality Educational Experiences

- ❑ Practice 7 Identify the Educational Objectives
- ❑ Practice 8 Identify the Audience for The Educational Objectives
- ❑ Practice 9 Ensure a Match
- ❑ Practice 10 Develop Curriculum
- ❑ Practice 11 Facilitate Participation of School Groups

III. Designing Protocols

- ❑ Practice 12 Establish Clear Protocols and Data Sheets
- ❑ Practice 13 Address Equipment and Field Site Needs
- ❑ Practice 14 Test Protocols and Data Sheets
- ❑ Practice 15 Include Several Participation Levels
- ❑ Practice 16 Develop a Plan for Data Submission

IV. Working with Citizen Scientists

- ❑ Practice 17 Write a Job Description
- ❑ Practice 18 Develop a Recruitment Plan
- ❑ Practice 19 Develop a Training Plan
- ❑ Practice 20 Create and Follow a Safety Plan and Risk Management Procedures

V. Ensuring Sustainability

- ❑ Practice 21 Develop a Funding Plan
- ❑ Practice 22 Develop Partnerships and Communication Strategies
- ❑ Practice 23 Develop a Volunteer Retention Plan
- ❑ Practice 24 Maintain Institutional and Staff Support
- ❑ Practice 25 Document All Steps of the Project
- ❑ Practice 26 Evaluate

RECOMMENDED PRACTICES

We believe that most people thinking about starting a citizen science project begin either with a research question that they are considering using non-scientists to help answer—a question in search of a research team—or with a group of non-scientists who want to contribute to our understanding of the world by collecting useful data—a research team in search of a question. This series of best practices is designed for the first situation with the expectation that in the second situation, the prospective citizen scientists can link themselves with an existing citizen science program that has already gone through these steps (see the Reference List). If that is the case, the prospective citizen scientists can use these best practices as guidelines for choosing a program. Alternatively, once the research team finds a question, they can proceed through the steps as if they started with the question. If, upon proceeding through the steps, the research team in search of a question finds that their question is a poor fit for the nature of their group, they should look for a different question. This may help prevent the frustration of setting out on a research project that your group cannot complete.

Interspersed with the best practices, we have included a series of common challenges for citizen science projects, along with strategies for addressing them. We have also included several case studies that illustrate some of the best practices as well as some of the common challenges.

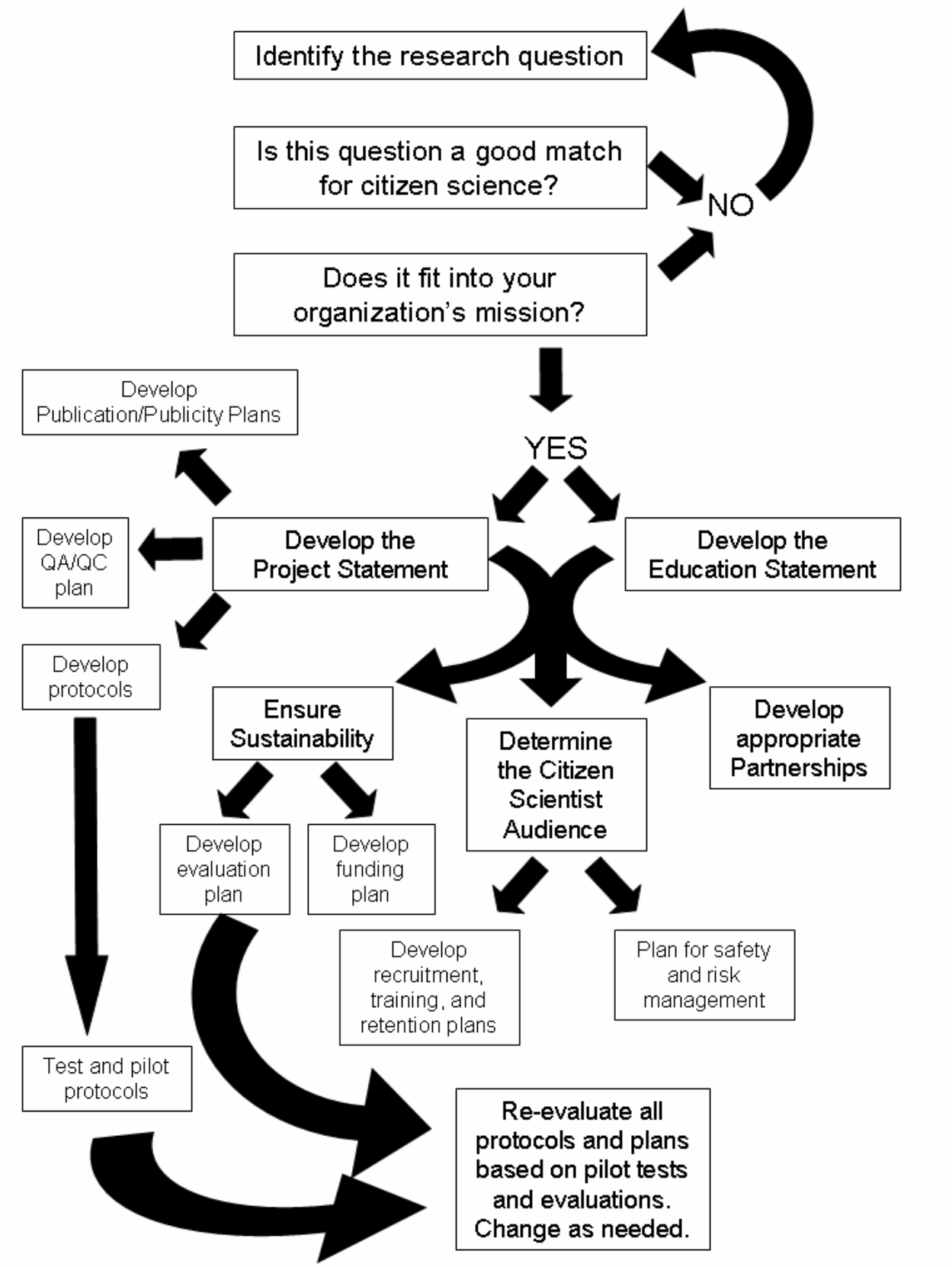

Figure 1. A flow chart view of developing a citizen science project

References

If you are looking for citizen science examples, ideas, and assistance, one of the best places to start is by reviewing some of the established citizen science programs and projects. The Forum Participant Directory at the beginning of this monograph has contact information for many environmental education centers engaged in citizen science. This reference list has Web bookmarks for many projects into which nature centers may link. This list is not comprehensive, as there are new citizen science projects starting often, particularly on the local level, but it does identify well-established projects that have been done at centers.

Bird Projects

- National Audubon Society: Christmas Bird Count, Great Backyard Bird Count, eBird http://www.audubon.org/bird/citizen/index.html
- Breeding Bird Survey http://www.pwrc.usgs.gov/bbs/
- Monitoring Avian Productivity and Survivorship (MAPS) http://www.birdpop.org/maps.htm
- Cornell Lab of Ornithology: FeederWatch, Great Backyard Bird Count, Urban Bird Studies, and more http://www.birds.cornell.edu/LabPrograms/CitSci/

Butterfly Projects

- Monarch Larva Monitoring Project http://www.mlmp.org
- Fourth of July Butterfly Count http://www.naba.org/counts.html
- Monarch Watch http://www.monarchwatch.org

Phenology and Weather

- Journey North http://www.learner.org/jnorth
- GLOBE http://www.globe.gov
- USA National Phenology Network http://www.uwm.edu/Dept/Geography/npn/index.html

Water Quality Monitoring

- There are hundreds of water monitoring programs across the county. A good place to start for finding one near you is the database kept by the Environmental Protection Agency at http://www.epa.gov/owow/monitoring/vol.html.

Amphibians

- FrogWatch USA http://www.frogwatch.org
- North American Amphibian Monitoring Program http://www.pwrc.usgs.gov/naamp/

General Wildlife and Biodiversity

- NatureMapping http://depts.washington.edu/natmap/about/participants.html
- Discover Life in America/All Taxa Biodiversity Inventory http://www.dlia.org/
- University of Connecticut BioBlitz http://web.uconn.edu/mnh/bioblitz/

Various Projects in National Parks

Natural Resource Year in Review-2002. National Park Service, U.S. Department of the Interior. ISSN 1544-5437. **http://www2.nature.nps.gov/YearinReview/yir2002/index.html**.

Clearinghouse Sites

- Citizen Science Network (Canada) http://dev.stewardshipcanada.ca/communities/citizenScience/home/csnIndex.asp
- Citizen Science Central (in development) http://www.birds.cornell.edu/citscitoolkit/