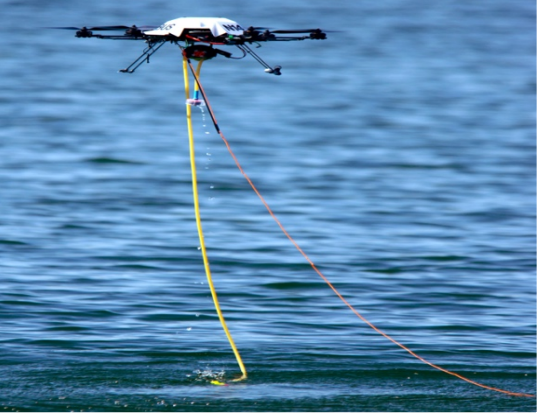

Citizen Science Programs at Environmental Agencies: Best Practices

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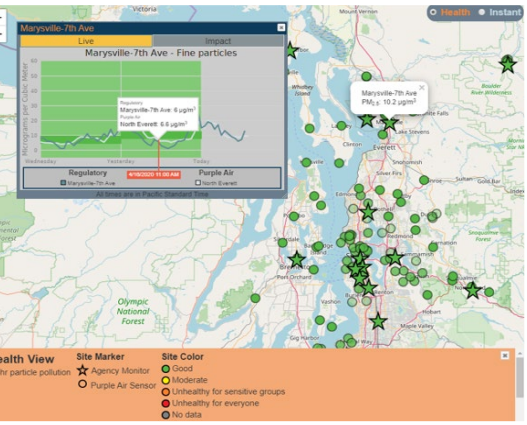





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BACKGROUND

*The involvement of volunteers in scientific monitoring or research is most commonly referred to as "**citizen science**". This form of volunteerism is also known as **community science**, **crowdsourcing** and **civic science.** These are considered more inclusive terms and emphasize that information can be gained by many methods. The term "citizen science" is used here as a common shorthand and recognizes the value of these perspectives.*

The U.S. Environmental Protection Agency (EPA) is charting a new pathway for the use of citizen science. In recent years, the EPA has played an active role in sharing knowledge of and promoting the use of citizen science at state, tribal, and local environmental agencies[1]. A new agency-wide strategy for citizen science is presently under development. To help inform this strategy, the EPA recognized the need to learn more about the uptake of citizen science at environmental agencies and its uses in environmental protection programs, particularly in air, water, and enforcement and compliance programs. A brief research study was undertaken to identify 15 cases of citizen science programs that are representative of the initiatives supported or developed by environmental agencies. These case studies are compiled in a companion report titled: *Citizen Science Programs at Environmental Agencies (September 2020).*

This document presents 8 best practices for environmental agencies that are interested in or actively pursuing citizen science as a tool in environmental protection programs. The best practices are gleaned from the evaluation of the 15 case studies. It is therefore recommended that this best practice document be read in conjunction with the case study report mentioned above.

OVERVIEW: CITIZEN SCIENCE AT ENVIRONMENTAL AGENCIES

Environmental agencies at the state, tribal, and local level are rapidly seeking and developing new approaches to support citizen science. The ability of the public to gather and report reliable data has significant potential to strengthen environmental protection programs. Citizen-generated data can be used to fill information gaps, define research agendas, monitor environmental changes, and assist environmental justice communities.

The 15 agency case studies reveal a diverse set of approaches to citizen science programs, particularly in terms of:

- **The types of environmental issues addressed,** such as monitoring for air and water pollutants;
- **The roles that environmental agencies play**, from leading a program to supporting an external citizen science initiative;
- **The ways in which environmental agencies make use of the data**, including public education, capacity building, research, monitoring, and environmental decision making; and

[1] www.epa.gov/citizen-science

- **The strategies used to engage and support citizen science**, including the use of technologies and hands-on interaction.

The two key lessons from the case studies that helped shape the best practices are:

- **The evolving relationship between citizen scientists and environmental agencies is creating real value for communities and environmental protection programs.** Although this relationship has existed for some time, the emergence of new technologies, an increasingly aware public, and the rise of unexpected pollution events has reinvigorated the way agencies and citizen scientists work together. Environmental agencies are utilizing citizen science as a resource in times of restricted budgets, and to address dispersed or hyperlocal environmental issues that are difficult for agencies to monitor. Citizen scientists are being empowered to gather data and use it to inform personal decisions, community level action, or to support legal enforcement.

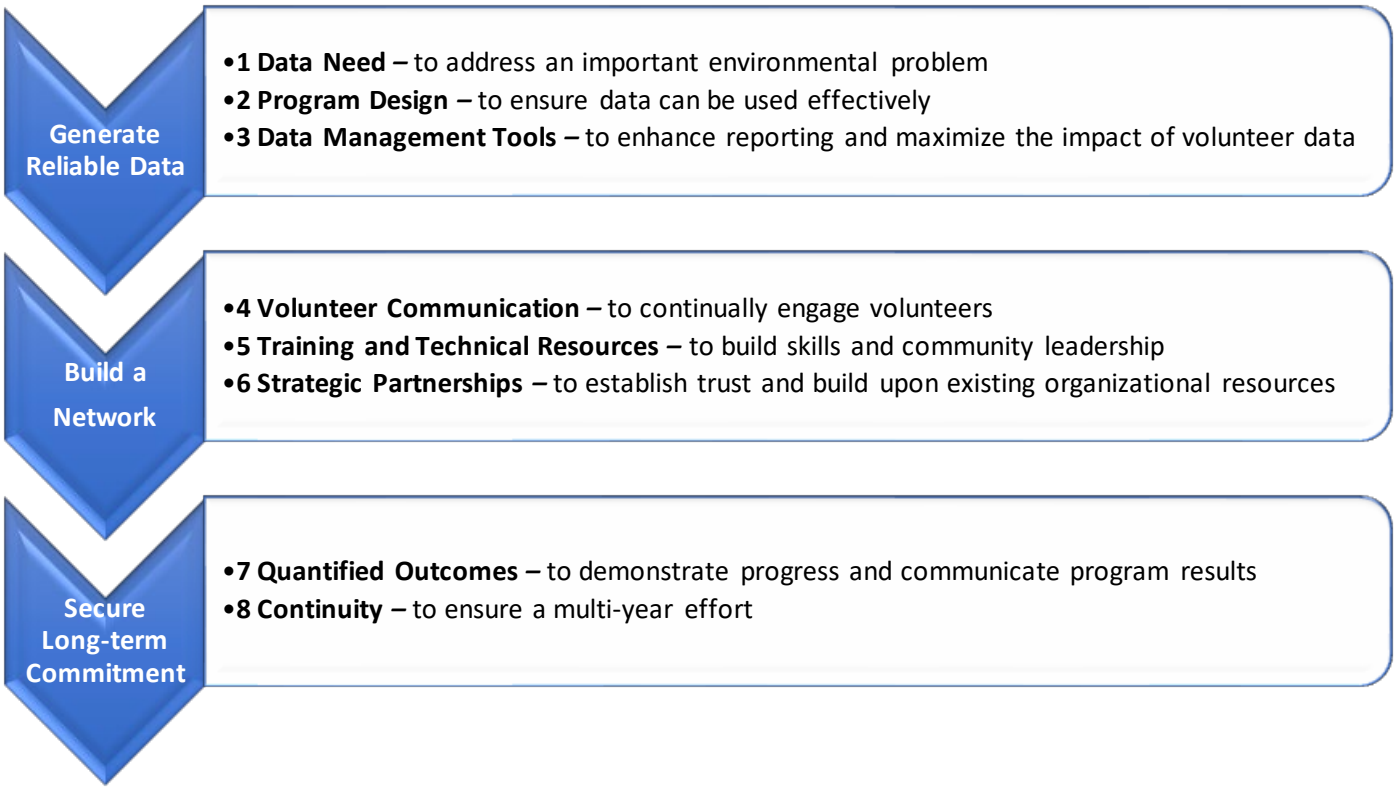
- **Collaboration is critical in any citizen science endeavor.** Agencies reported concerns over data quality, volunteer turnover and program visibility, as well as funding and resource limitations. Through well-designed technical and community partnerships and inter-agency collaborations, citizen science programs have overcome both technical and resource limitations. Academic and non-profit institutions are also playing a key role in these programs through the development of scientific protocols, certifications, volunteer training, and technological developments. Community-based organizations are just as important to ensure the reach and long-term success of these programs.

BEST PRACTICES

Environmental agencies play a variety of roles from leading their own citizen science programs to partnering with and supporting citizen science groups and individuals. No matter the extent of the agency role, the 8 best practices in **Figure 1** are intended to **generate reliable data**, **build a supportive network**, and **secure long-term commitment** for the program**.** All with the intention of creating shared value for environmental agencies and the public.

Each best practice is described in further detail in the sections that follow and have been supplemented with relevant examples from the case studies.

Figure 1: Best Practices for Citizen Science Programs at Environmental Agencies



GENERATE RELIABLE DATA

Involving citizen scientists in the work of an agency presents an important opportunity for environmental agencies. Evaluating that opportunity and capturing its value requires a focus on what data the agency needs, what data members of the public can provide, and what needs to be done to ensure that the data meets its intended purpose.

1. Data Need: To Address an Important Environmental Problem

Citizen science is a valuable resource because it can greatly expand an agency's ability to obtain important information on environmental conditions or events. Agency resources are always limited, even for high priority needs such as assessing regional air quality or water quality in impacted rivers and streams. Some information, such as environmental regulation violations or harmful conditions, is highly localized and difficult for agencies to anticipate. The following steps can be taken to assess the potential of citizen science to contribute to the data needs of agency programs:

- *Scope out the environmental problem with affected communities.* This includes not only the source of environmental impacts, but also its extent in terms of the areas and communities impacted. Understanding the problem being addressed is necessary to assess data needs and

the options for gathering data. Furthermore, citizen scientists are generally most interested in problems they consider important to the community they live in.

- *Identify limitations on the agency's ability to gather data*. There any many factors that may limit an agency's ability to gather needed data, such as the vast resources needed to take water samples in lakes, rivers, and streams statewide or the remoteness or unpredictability of events (e.g., harmful cyanobacteria blooms). Members of the public can help fill these resource gaps.

- *Assess the potential contributions of citizen scientists*. Similarly, consider the capacities (and limitations) of non-governmental volunteers. This may include the degree of technical difficulty involved in data collection, the level of effort required to train them, the ability of volunteers to observe remote or widely dispersed events, and the quantity and quality of data that volunteers might generate.

- *Reach out to local organizations and community groups.* It is often useful, and sometimes essential, to obtain input from the interested public early in the planning process. The public may have concerns or priorities that will affect the program's design or may identify new audiences that had not been anticipated.

- *Outline the agency's role and any resource needs.* To ensure that an initiative involving citizen scientists does not demand more agency effort than is justified, consider what the agency's contributions will have to be to support volunteers over an extended time.

Relevant Case Studies – where there was a data need

- In the *Southwest region of Wisconsin*, private landowners contributed water samples from their wells to inform a local study on groundwater contamination. The study, funded by three local counties, was designed to assess the geographic extent of well contamination, identify sources of pollution, and analyze risk factors associated with well contamination.
- *Idaho* has set up a public reporting system for harmful cyanobacteria blooms, which are a growing and serious problem in a state where recreational water use is popular. The information obtained is used to inform beach closures. The Idaho DEQ depends on these reports to spot problems and provide information that allows state staff to alert the public to dangerous conditions.

2. Program Design: To Ensure Data can be used Effectively

Any citizen science program requires sound, reliable data. The nature of the data required will depend on its intended use. Prior to commencing with a project, it is essential that the agency's expectations be communicated clearly so that volunteers do not spend time and effort gathering information that is not put to effective use.

- *Identify possible uses for data being collected and explain the uses to program volunteers.* There are many ways that citizen-generated data might be used, including:
    - To inform regulatory decision-making (such as determining whether water quality standards are being met);
    - To call attention to the possibility of a violation for further investigation by the agency;
    - To help the agency identify problem areas so it can target its monitoring;
    - To alert the agency to adverse events so that the public can be warned (such as cyanobacteria blooms or fishkills); and
    - To provide general information to the public (such as local air quality conditions).

- *Set clear guidelines to ensure that data is suitable for each use.* The necessary level of reliability and precision of data will vary depending on its intended use. Data used for policy or enforcement decisions must be highly accurate, whereas data that is used for screening or exposure may be moderately reliable since these assessments will be investigated further by the agency. It is critical for the expectations of these uses to be clearly communicated to the public who are gathering the data as well as the necessary protocols to gather such data. If there is confusion, this will undermine data usability, the program efficacy, as well as the morale of volunteers.

- *Use data quality tiers so that outside groups can plan accordingly.* One way to clearly communicate expectations is to define data quality in terms of tiers linked to potential uses. This allows volunteers gathering data to consider the available options relative to their skills and capacities to plan their efforts accordingly. This will also inform the types of technologies and/or instruments needed.

- *Evaluate the study design process and review and approve plans developed by volunteers.* To ensure that data meets the quality requirements, it is important to develop a project-specific research plan that serves as the master protocol for the work of citizen scientists. The study design process should clarify protocols on data gathering, data processing and data management. This is most often seen in the context of water quality monitoring, where such documents are referred to as Quality Assurance Project Plans (QAPPs). In well- designed programs, the agencies review and approve each group's plan before data gathering begins. In addition, develop clear volunteer management plans to ensure that volunteers are adequately trained and informed of the above-mentioned protocols. For more information, refer to the EPA's Handbook for Citizen Science Quality Assurance and Documentation (2019).[2]

[2] www.epa.gov/citizen-science/quality-assurance-handbook-and-guidance-documents-citizen-science-projects

Relevant Case Studies – where there were clear data quality expectations

- *Virginia* has established a tiered set of data quality standards for its volunteer water monitoring program. These range from highly stringent requirements for data to be used in formal reporting under the Clean Water Act, to more flexible standards for data to be used as a general guide for prioritizing the agency's own monitoring, and for data to be used in general public education on water quality issues.
- *New York's program* for citizen reporting of excessive vehicle idling is done through an online system. The system is designed to ensure that the information reported will be satisfactory for purposes of enforcement, including use as evidence in court. This is done by carefully specifying what must be provided (photos and videos) and providing technology that includes a date and time stamp.

3. Data Management Tools: To Enhance Reporting and Maximize the Impact of Volunteer Efforts

The availability of new technological tools and applications have been a leading driver behind the growth of citizen science. The creative use of these tools to report, analyze, display, and widely share data can yield benefits that go beyond the immediate data needs for which the program was created. For example, smartphone apps are increasingly used to enable volunteers to report concerns with a much higher degree of depth and accuracy than in the past, or to allow citizen scientists to immediately transfer readings from instruments in the field. Data systems allow data to be analyzed more deeply, and to create graphic displays that communicate information effectively. Also, publicly available databases attract new audiences and users beyond those originally anticipated. Such opportunities arise at each step of the process:

- *Input systems.* Smartphone apps and online systems can greatly simplify and accelerate the submission of data and information. Beyond benefitting agency objectives, this enhances the experience of citizen scientists by making their work easier. Technology can also allow types of data to be submitted that were not possible in the past, such as precise location information, photos, and videos. Data submission tools often have an educational component; by building in options, structured questions, or other background information, we help ensure volunteers are accurately assessing what they observe. Information is received in the desired form, simplifying its use and automatically interfacing with data systems. Through such systems, the agency also can learn about the interests and/or concerns of participants.

- *Data analysis and display.* Technology also makes it possible to analyze data more deeply than in the past, spotting trends, hotspots, geographic patterns, etc. Data can also be displayed graphically – in tables, charts, or in maps – that make it much more accessible and understandable for the public.

- *Public sharing.* Data can also be made widely available through public databases, reaching much more broadly than the purely internal users for which it may have first been gathered.

Programs find that when this is done, new audiences emerge for whom the information is valuable for personal, economic, or other purposes. Data can also be presented to the public in the form of report cards or dashboards that reveal and track environmental conditions as well as program impacts.

- *Metadata documentation.* Detailed information on the type, quality and ownership of data gathered is important in determining potential uses of that data. Ethical considerations such as cultural sensitivities and accessibility to this data must be recorded. Such documentation should be communicated and shared with program participants and partners to avoid any misuse.

Relevant Case Studies – where data management tools were used

- *Smell Pittsburgh*, a smartphone app, crowdsources reports on offensive odors. App users can rate the smell (1-5 scale), describe the odor (e.g. industrial or wood smoke), and are also given the option to list any symptoms attributed to the odor. Each smell report also includes the location, date, and time of the smell. Once submitted, the smell reports are added to a visual and interactive map that allows users to have access to real-time odor complaints across Pittsburgh.
- *Puget Sound Sensor Map* pulls in data from every PurpleAir sensor (measures particulate matter) from the four-county region. This platform calibrates this crowd-sourced data relative to the nearest regulatory monitor and displays the data from both the regulatory and PurpleAir monitors on the same map. Any time a new PurpleAir monitor comes online within the agency's jurisdiction, it's automatically added.
- *Michigan's Water Monitoring Program*, *MiCorps,* puts data from its volunteers into a public database. Users of the database include other agency programs, volunteers who want to know the conditions of the lake where they live, and realtors who want to advise clients on which lakeshore properties are the most attractive for fishing and swimming.

BUILD A SUPPORTIVE NETWORK

By definition, programs involving citizen science require working with people outside an agency on a shared goal. Teaming up with individuals and with independent organizations is a critical step.

4. Volunteer Communication: To Continually Engage Volunteers

Most citizen science efforts require extensive public outreach to recruit volunteers, make the public aware that their help is needed, and get feedback that can inform program design. Elements of such a campaign can include:

- *Establish clear guidance for community involvement.* To ensure a mutual understanding between members of local communities and agencies, program objectives and expectations must be clearly communicated and documented, particularly on the use of the data gathered. Community input should also be obtained to build a collaborative relationship. Open channels

of communication must be maintained to discuss anticipated challenges and the environmental health risks associated with data obtained.

- *Raise public awareness of the issue.* In some cases, it will be necessary to raise public awareness about an environmental problem and why it is important to the community. Presenting information in creative and interactive ways can attract and sustain participation (e.g., monitoring maps).

- *Seek public input.* Public feedback can provide important insights that shape the design of the program. It can also help identify individuals and groups who are concerned about the issue and may want to work with the agency to address it.

- *Launch the program and invite the public.* Having raised awareness of the issue, the campaign should call attention to the role that citizen scientists play and invite them to join the response. Set up processes to enroll and manage participants; assign at least one person to be the key program contact to build visibility of the program and develop relationships with participants, partners, and data users.

- *Maintain regular communication.* Relationships with participants must be built and sustained over time. Training (discussed below) is one method; ongoing communication is also important. Consider whether incentives or rewards can be created for long-term participation.

Case Studies – where volunteers were continually engaged

- T*he New York State Department of Environmental Conservation (NYSDEC)* pooled complaints from all their air quality offices to reach interested and concerned residents of New York and encourage them to participate in the Community Air Screen program. NYSDEC also set up a four-question volunteer application process to learn about resident interests and needs.
- The *California Department of Pesticide Regulation* conducted extensive public outreach before launching an app to help the public report on possible misuse of pesticides. Those early discussions led to significant changes in the design of the program to make it accessible to a wider public audience.

5. Training and Technical Resources: To Build Skills and Community Leadership

Rigorous training is essential for citizen science programs to have credibility, and training programs are used in most of the models studied. Agencies provide many other kinds of technical support as described below. In some cases, training may be designed around agency objectives; in others it will help community-led efforts achieve their desired goals.

- *Hands on technical training.* Well-designed programs invest heavily in training, usually hands on and in person so that the trainers can observe volunteers and validate their techniques before sending them into the field. Agencies need to have confidence that the data they receive has been generated with methods equivalent to those that would be used by agency staff or professional researchers. Rigorous training also helps build a sense of pride and commitment among volunteers. Training communicates to participants that their work is taken seriously and gives them a sense of professionalism. It also creates a growing body of volunteers who are informed about local environmental challenges and can then serve as advocates in their own communities.

- *Continued access to experts.* Training isn't a one-time event. Volunteers benefit from having experts available to answer questions and reinforce key messages. In some programs, agency staff periodically go into the field with volunteers or conduct field audits to directly oversee citizen scientists' work and ensure they are following proper protocols.

- *Equipment.* Furnishing specialized equipment for volunteers is a basic element of almost all programs. These may include sampling kits, measuring tools, handheld devices, etc. Agencies can also help citizen scientists calibrate and use monitoring devices.

- *Laboratory access*. Water and air samples need to be analyzed in certified laboratories; agencies provide access to these labs and in some cases pay the cost of the analysis.

- *Certification.* A step beyond training, some programs certify community organizations as qualified to collect data that meets the highest data quality standards.

- *Funding.* Grants for citizen efforts are typically small but critical, especially in getting local projects started.

Case Studies - where training and technical resources were provided

- *Minnesota* state and county agencies provide local residents with tools and technical expertise to assess their local wetlands. Although the county leads the effort, volunteers have a high degree of responsibility for wetland health evaluation, including initial identification of plant and animal species.
- The *Mecklenburg County Community Science Station* allows members of the public to test the accuracy of personal air sensors. The data collected is provided to the local air agency to enhance agency and community understanding of personal air sensor equipment and the data generated.

6. Strategic Partnerships: To Establish Trust and Build upon Existing Organizational Resources

In addition to individual volunteers, most citizen science efforts involve working with outside organizations including community groups and other agencies at various levels of government. Partnerships may be with newly formed groups of citizen scientists or may involve connecting with existing organizations to build trust among communities and leverage existing expertise and networks.

- *Identify partners.* Identify and consult with groups that have similar goals or interests. These could be other agencies, community-based organizations, universities, tribal authorities, NGOs, and/or communities. Clearly define roles and responsibilities and how the work of different organizations fits together. Public-private partnerships may also present a unique opportunity to provide the infrastructure needed to support citizen science efforts.

- *Involve partners in program design.* Solicit feedback on the program purpose and plan and assess opportunities to involve key groups who could offer technical expertise and resources, current and past records of data collected, or a connection to affected communities and potential program participants.

- *Use intermediaries.* To leverage agency resources, find (or create) intermediary organizations who can provide hands on assistance. These arrangements can be especially valuable where there is distrust between agencies and communities.

Case Studies – where partnerships were central to the citizen science program

- *The Imperial County Community Air Monitoring project*, a five-year monitoring and research effort, involved a partnership between the California Department of Public Health, Public Health Institute, University of Washington, Comite Civico del Valle (CCV), and affected communities. Each played a key role in leading the program.
- *The Yukon River Inter-Tribal Watershed Council* is a coordinating body led by representatives of Tribes and First Nations. It oversees the work of the Indigenous Observation Network, made up of trained community members who gather water quality data.

SECURE LONG-TERM COMMITMENT

Working with citizen scientists is a relatively recent development in most policy arenas and may be vulnerable to changes in priorities, management, or budgets. Demonstrating the success of the program and building a strong institutional basis for these programs is crucial to sustaining them over the long term.

7. Quantified Outcomes: To Demonstrate Progress and Communicate Program Results

Using key metrics to track activity and results of the program can be a powerful tool in demonstrating its value and potential in the long-term. In addition to informing decision makers, public metrics can be a motivator for participants who can see that their work is making an impact.

- *Intermediate and long-term outcomes and impacts.* It is often difficult to show the ultimate impact of a program in quantitative terms. However, intermediate measures can provide a good indication of progress. Intermediate outcomes might include the percentage of data in a state's Clean Water Act reporting that came from community groups, or the number of times a program's online reporting was accessed by the public.

- *Inputs and activities.* Metrics such as the number of participants in a program, the number of reports filed, or the total number of volunteer hours are easier to collect and can be valuable in demonstrating the amount of work being done and what has been produced.

- *Other measures.* With creative thinking, available data can be used to generate other useful metrics. For example, it may be possible to demonstrate the savings to the agency resulting from the use of volunteers.

- *Sharing successes.* There are valuable lessons to be learned from every experience, sharing success stories not only motivates those involved in the endeavor but also encourages agency counterparts to attempt similar initiatives.

Case Studies – where outcomes have been quantified

- *Virginia* maintains extensive metrics on its volunteer water monitoring program and publishes thorough reports each year on the amount of sampling performed, number of stream miles covered, etc. It has estimated the economic value of these efforts at $ 3.25 million annually.
- *Georgia's Adopt-a-Stream program* publishes data on program activities going back 12 years in a variety of graphic presentations showing trends in activities, number of events by county (displayed on a color-coded map), rankings of volunteer groups by events conducted, and other performance metrics.

8. Continuity: To Ensure a Multi-Year Effort

New programs may be treated as "add-ons" that are not built into the Agency's organizational structure, budget structure, or governing statutes. This can make them vulnerable. There is no single strategy to sustain a program, but there are several mechanisms that can be leveraged. These are:

- *Senior leadership commitment.* An innovative program is unlikely to survive for long unless it has the active endorsement of agency leadership, ideally at multiple levels.

- *External supporters.* Program partners and volunteers represent an important base of support and are a key resource which is available outside of formal budgets. This reinforces the importance of training and investments of time and effort in building a motivated team of volunteers.

- *Sustained funding.* Budgets are usually the main factor determining whether a program survives. To the extent possible, try to build the program into the budget structure, rather than funding it through funds diverted from more longstanding programs. In some cases, dedicated funding sources have been created, which provides some protection, however, if these expire, a program will be at risk. All funding, internal and external, must consider the best way to equitably distribute these funds to benefit the agency, local partners and community groups.

- *Document results.* To the extent possible, it is valuable to document program results -- both quantitatively and through persuasive narratives. Unlike many agency programs, citizen science efforts need to be able to tell a story to funders and to the public. Outcome measurement is a good investment and should be shared widely to promote successes and help garner support for areas in need of improvement.

- *Use report cards.* Periodic reporting of a few key indicators is a good way to capture the public eye, and build awareness of the problem being addressed. Although not limited to citizen science efforts, it can be especially valuable where there is a need to attract and motivate volunteers.

- *Statutory support*. Agencies are driven largely by their governing statutes. A formal statutory authorization is a strong signal that the program can be maintained in the long term.

Case Studies – where efforts are being sustained

- *Virginia's citizen water* monitoring program is embedded in state law, which authorizes grants and technical assistance, requires monitoring to be done consistently with the state's manual, and sets a goal for the number of waters to be assessed.
- *California* has enacted a law requiring agencies to develop comprehensive plans for reducing air pollution in disproportionately affected communities. Although the law does not expressly refer to reliance on citizen science, it created an inclusive process that has allowed independent and well-established community-based data gathering efforts to play a leading role in designing solutions in Imperial Valley and West Oakland.
- *Michigan's MiCorps program* ran successfully for over ten years but faced a difficult budgetary challenge when its dedicated fund expired. After suspending most work for a year, the program

succeeded in finding a new long-term funding source within the agency's budget. MiCorps was able to demonstrate strong support from volunteers and that its data were being used by many audiences such as other agencies and lakefront associations.

SEIZE THE OPPORTUNITY

Citizen science programs are not new to the environmental agency community; there is a long-standing history of its use in monitoring water quality, weather patterns and ecological changes. The recent wave of technological advancements is rapidly transforming our view of the environment and how to protect it. Between expansive sensor networks and the growth of digital platforms, we now can track environmental change in real time. The opportunity that citizen science presents is no different. The ubiquity of low-cost sensor devices, smartphones and our increased connectivity now makes it possible to capture and investigate environmental events as they happen. Citizen science is still emerging with its full potential still to be realized.

While there is still much progress to be made, particularly regarding data quality, and community relations, there is an opportunity to leverage and synchronize the work already being done. The best practices presented here represent a start. State, tribal and local environmental agencies are encouraged to lean on these best practices, explore the opportunity and share the citizen science experience.