<TITLE>Building a more scientifically informed community in the Delaware River Basin

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Citizen Science (CS) programs inherently broaden societal science literacy by providing experiential scientific learning opportunities to a diverse cross-section of the public. Here we describe an expanding CS program that supports more than 50 nonprofit organizations in the Delaware River Basin (DRB). The motivation for this effort has been generated by investment from the William Penn Foundation to create the Delaware River Watershed Initiative (DRWI), a multi-year effort to support organizations working to protect and restore stream health in the DRB. In direct support of this initiative, Stroud Water Research Center is facilitating CS efforts to improve capacity of watershed groups to conduct scientific investigations associated with DRWI watershed protection and restoration projects, as well as to build general knowledge on the ecology of their watersheds and the broader DRB.

This project benefits from cooperative efforts among a wide variety of citizen scientists, as well as professional scientists and environmental planners. Participants in these CS activities have diverse backgrounds ranging from volunteers with minimal or no formal training in science to retired Ph.D.-level scientists. There are full-time and part-time environmental professionals who volunteer in their spare time, college and high school students, teachers and professors, and many other individuals from a wide variety of science and non-science backgrounds. Some volunteers work multiple days per week carrying out or assisting the goals of the DRWI, while others put in a few hours per month—all helping to build valuable datasets on water quality and related outcomes of restoration and land protection. Through their engagement, these citizen scientists gain personal knowledge and experience that can inform the greater community and influence local environmental policy.

Citizen Science depends on the experience and expertise of the individuals involved. In our case, professional scientists, environmental planners, and even environmental regulators help to frame monitoring approaches and guide groups and individuals on collecting samples, doing field measurements, analyzing data, and researching policy. Our vision of success is a collaborative environment that supports watershed groups and their citizen scientists in asking and answering their own ecological questions about local streams and rivers, and in translating this knowledge and experience into regional policies and practices that result in healthier streams and, subsequently, cleaner drinking water for future generations. Volunteers contributing to this initiative are not exclusively collecting data to feed into a single large study; nonetheless, combined across tributaries, this effort is also building an increasingly comprehensive and publicly accessible dataset for the whole DRB.

Citizen Science enables certain things that conventional science does not. We are supporting CS programs to not only generate robust data sets but also to build a scientifically informed community in the DRB. Citizen Science is no different than ordinary science in that it follows the same processes of developing and testing hypotheses (i.e., asking questions, making predictions, and coming up with ways to answer the questions), Quality Assurance (QA) and Quality Control (QC)(i.e., making plans to ensure data accuracy [QA] and then confirming data accuracy [QC] via specific data replication protocols), and summarizing and communicating results (i.e., preparing data summaries, reports, etc.). Citizen Science is different from ordinary science, however, in that it involves a far greater diversity of individuals with wide-ranging backgrounds and skills. From certain professional science perspectives, this variation among individuals may be considered a hindrance to the science. However, with improvements in technology and with people more often changing careers and increasing volunteer involvement during these transitions, in spare time, and in retirement, there continue to be more opportunities to build large viable datasets with new and unconventional CS methods. Perhaps most importantly, as societal and cultural pursuits are increasingly directed toward improving the environmental awareness and science knowledge of the general population, CS not only presents opportunities to build useful datasets but also to make strides in building a scientifically informed community, which is rarely a goal in conventional science endeavors. Ideally, this building of science literacy then leads to communities making better environmental decisions in planning, management, and protection of their water resources.

In our case, we are collaborating with watershed groups throughout the DRB. These groups work with volunteers, host workshops, educate and engage communities, and are the most informed about neighborhood and regional history, politics and culture. As such, these watershed groups are well positioned to communicate and cooperate with these communities on science efforts that support the health of local water resources. Our work with these groups has focused on helping them build their own science capacity so they can pass these skills and knowledge on to local communities. Because these watershed groups are already often experienced in community outreach, education, and engagement, we see the development of science skills and acumen as a key component to pulling together citizen science efforts that not only generate viable research-quality data but also catalyze broad science education and action in the community.

<A>Unique challenges for Citizen Science in water and watersheds

The process of coming to know a watershed for oneself is the most important part of our CS program. As described, the goal is for citizen scientists, through persistent questioning and investigation, to become the authorities on their watersheds so they can serve as powerful advocates and influence decision-making of local and regional managers via science-based knowledge about their watersheds. The primary challenges in our CS work relate to education and training in watershed ecology, project purposes and goals, time allocation and management, and project organization, prioritization and coordination. This type of preparation—forming of hypotheses and clearly defining goals, researching existing information, data and publications, organizing personnel duties and time commitments, and collaborating with experts—is an area where we think new watershed CS efforts can make significant strides.

<b>Background and training

Citizen Science watershed studies are inherently complicated because of the dynamic abiotic and biotic interactions that define stream and river conditions. The more that is understood about the chemical, physical and biological interactions in a watershed, the better able individuals and groups will be in articulating science goals and hypotheses and knowing what information (i.e., data) is necessary to reach these goals and answer ecological questions. To address this type of challenge, we are building science knowledge among CS groups via regional workshops, trainings and direct one-on-one dialogue on foundational watershed hydrology, chemistry, biology and geomorphology concepts. These types of guidance meetings also address field methods, data management and analysis, and QA/QC procedures used to generate quantitative descriptions of watersheds. Along with continued development of guidance materials (manuals, presentations, task checklists, diagrams, videos, etc.), the idea is to “train the trainer”—collaborating with watershed group coordinators and providing them with resources to educate and build ecological and project knowledge among their citizen scientists.

<b>Purpose and goals

A challenge for many organizations has been in developing programs that go beyond “engagement” (i.e., activities designed simply to get people outside on the water, making anecdotal qualitative observations). If the goal of a program is to collect data needed in research and management, a key first step is to clearly define a simple question or goal and then do the necessary background research to determine the best way(s) to answer the question. Many times CS organizations rally around potential ecological threats such as water withdrawals, pollutant discharges, road building and development—these scenarios present clear problems around which CS monitoring in a watershed can be focused. One of the goals with our program has been to support watershed groups in investigating their own local waterways and identifying these types of scenarios—defining watershed-specific questions and developing detailed plans to answer these questions.

This type of approach relates to broader goals in the DRWI for groups to go beyond citizen engagement to collection of purposeful data for answering specific ecological questions. When going out to collect data from streams and rivers (i.e., “monitoring”), it’s relatively easy to go to your site and write down miscellaneous observations—color of the stream bottom, foam on the water surface, trash, eroded banks, tree cover and so on. It’s much more difficult to identify specific factors that are important for understanding that particular ecosystem and to then know how to record information about those factors in a way that is useful for understanding the ecological relationships. Because of the commitment of many of the watershed groups in the DRB to delving deeper into the details of cause and effect in their local watersheds, we have been able to make progress on this front. Groups are gathering more and more information on the specific relationship of the landscape to the water within their individual watershed study areas. They do research on historical activities, investigate known pollutant sources, identify potential sources of yet-to-be-identified aquatic stressors, and do field scouting of the landscape and river channel to develop a firsthand understanding of the watershed.

<b>Time, organization, and coordination

A major challenge with our CS efforts has been time availability and coordination of the individuals involved. In most research, scientists are full-time professionals who can focus almost entirely on the aforementioned scientific processes, whereas individual citizen scientists may have much less to spend on the work. Collectively, however, the time that a group of citizen scientists dedicate to a program may be substantial. But developing a program that makes effective use of this time has been challenging. Guidance materials are regularly being refined, condensed and better articulated so that key ecological, field sampling and data processing concepts can be communicated as effectively as possible. This challenge has proved to be beneficial to the broader science education goals because it has forced us to address the same educational challenges faced in school environments—primarily issues related to making complex ecological systems understandable, relatable and compelling to novices. Technology such as online water monitoring stations, large data storage and waterproof digital cameras and video recorders, and inexpensive hand-held water chemistry probes have supported the assembling of high-quality ecological information. Online sharing platforms such Google Docs and online custom data-sharing sites such as the Stroud Center's WikiWatershed.org have allowed us to share and update guidance documents, presentations and manuals. These types of technology have also allowed groups to share data and access automated data analysis and summarization tools not available even just five years ago, conserving time and resources.

With watershed monitoring, there often are specific activities that need to happen according to weather, water levels, and episodic fluxes of pollutants. Because citizen scientists often only have certain time periods available for CS work, coordinating watershed monitoring efforts according to somewhat unpredictable natural and anthropogenic events requires creativity in scheduling and support. Many of the groups we're working with are doing storm sampling, which requires specific equipment, supplies, training, attention to personal safety, and of course, strategic planning and timing of visits to streams when storm flows are actually occurring. Storm sampling is difficult even for professionals who have 40 hours or more a week available. Ideal sampling times may be at night and on weekends and holidays; therefore, it is critical to organize individual involvement so as to compensate for these factors. We are facilitating this type of preparation for storm sampling by providing supplies with streamlined usage directions, guidance materials for understanding the ecological and analytical importance of timing and procedures for sampling, and conducting field training sessions and direct assistance on field sampling activities. The watershed groups have begun organizing teams of individuals and communications chains so that those individuals who are available according to daily or hourly notices can be ready and deploy for sampling with situation-specific equipment and supply kits.

The aforementioned unique challenges in CS would all be good to consider when starting a new program. But we'd like to emphasize the importance of (1) starting out by having a specific question/goal to be addressed, (2) having at least one person who is dedicated to coordination and management of the CS team, and (3) reevaluating the plan with the team and adjusting and revising according to new data, information, and people.

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