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Citizen Science as a Tool for Environmental Scientists and Conservation Managers

REBECCA JORDAN

College of Agriculture and Natural Resources, Michigan State University, East Lansing, Michigan, USA.

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Promoting the publics' ability and desire to use scientific information in the course of daily living is a goal for many science educators and scientific researchers. Reaching this goal, however, requires not only a general understanding of scientific concepts, but also a keen understanding of how scientific evidence and claims are generated. Data regarding the public's ability to generate and interpret data important for environmental concepts are currently lacking (see for example, 1).

Citizen science programs pose excellent opportunities for the public to engage in authentic environmental science learning, while meeting the dual goal of improving environmental conservation outcomes. In citizen science, volunteers engage data collection with tangible results often, but not always, with scientists (see 2 for a review). This process engages the public in scientific investigation through training, education, and outreach. In the past twenty years, there has been a significant rise in the number of research studies using volunteers and an increase in the number of volunteers that participate in these studies in many areas of science and across the globe.[3] Still many researchers are hesitant to seek citizen participation in their work for a suite of reasons. While some these reasons are related to inexperience, time, and fear of compromising their objectivity,[4] others might hesitate because there is not a clear sense of whether such engagement translates to environmental improvement or better conservation outcomes. Below I discuss the different types of citizen science projects and what outcomes might be expected.

Bonney *et al.*[5] define three primary models of citizen science (later refined by 2) that relate to the level of participation in the scientific process: contributory, collaborative, and co-created. For contributory projects, scientists design programs for which members of the public primarily contribute data and engagement can be limited and short-lived. This model tends to have specific goals in mind that may be seen as irrelevant to local communities,[6] providing few connections among the data being collected, management decisions,

CONTACT Rebecca Jordan jordanre@msu.edu College of Agriculture and Natural Resources, Michigan State University, East Lansing, Michigan, USA.

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and the potential for social change that some stakeholders seek.[7, 6, 8] Co-created projects are designed by scientists and the public working together to address research questions of common interest with participants actively involved in most steps of the scientific process. Because these projects are designed to meet specific community needs, they are more likely to draw concerned citizens into science who might not otherwise be involved in such activities.[5] The collaborative model includes projects falling somewhere along the continuum between contributory and co-created projects. This and additional reviews suggest that these programs provide multiple ways to engage in science and result in numerous learning outcomes (Strands[2-6; 9, 5]). However, only a few studies have rigorously assessed the role citizen science can play in changing participant attitudes, behavior, and science literacy.[10,9,5,11,12]

As can be imagined, a number of outcomes will result from the different types of partnerships described above. Two outcomes of special relevance to readers of Current World Environment, are change in personal or group behavior and attitudes and change in management practices. With respect to the former, a meta-analysis of citizen science projects indicates a widespread lack of data on how nature-based citizen science influence conservation attitudes.[13] The limited data that have been published, however, indicate positive conservation orientation following participation in citizen science. The authors speculate that citizen science presents opportunities for a specific type of noticing the external world that may not occur through recreational or other activities. While not sufficient in itself, this positive conservation orientation is related to improved behavior.[14] It is important to note, however, that when critical public behaviors have been identified, targeted strategies should be employed. Part of these strategies relate to learning gains, which again have been documented for those engaged in citizen science.[13] Conservation outcomes have also been noted for citizen science and across the different types of participation described above. Certainly large scale citizen science projects gather data that when properly analyzed will be translated to policy action and change.[15] Large data sets can accommodate experimental error and allow for trends to be discerned. Certainly smaller scale co-created citizen science projects also result in conservation outcomes but tend to do so along a more regional scale where finer grain data and local investment is necessary.[15]

Given the potential for these types of projects to improve conservation and environmental management practices, more data are warranted to discern the time and resource investment on the part of scientific researchers and natural resource managers. Certainly technologies such as those described on collaborativescience.org and participatorymodeling.org can aid investigators in the design and evaluation of such work. In doing so collaboration with local resource agencies and federal agencies/ministries can be attained. This not only serves to better engage the public in learning about conservation, but also can serve as a conduit to help the public engage with these data while tooling them with the means to evaluate these data. Such broader impact is often why environmental scientists engage in the work that they do. Citizen science, therefore, can serve not only to enable difficult-to-gather data collection but also broader satisfaction among environmental science researchers.

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